Towards a Smart City Model for South African Metropolitan Municipalities: The Case of Gauteng-based Metropolitan Municipalities

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DECLARATION

I, Mukundi Maphangwa (Student number: 36667528), declare that the thesis entitled "Towards a Smart City Model for South African Metropolitan Municipalities: The Case of Gauteng-based Metropolitan Municipalities" submitted for the degree, Doctor of Philosophy in Public Management and Governance at the North-West University, Potchefstroom Campus, is my own work and has not been submitted before by me to any other university. All the sources used in this thesis have been acknowledged by means of complete referencing.

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M Maphangwa

Date: 27 July 2022

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ABSTRACT

Although some studies have shown that there are benefits that a developing country such as South Africa can accrue as a result of embracing the Fourth Industrial Revolution, the Internet of Things and information and communication technology, there are a number of challenges facing cities in this regard. These challenges include outdated ICT-related infrastructure, limited technological expertise, and the high costs involved in new or revised technologies. There is also increasing pressure to involve the community in city decision-making processes as well as to provide accurate, up-to-date information to other government institutions, communities and city stakeholders on a regular basis.

South African cities are currently en-route toward smart technology and 4IR readiness, but much still needs to be done to be on par with investment-competing cities around the globe. There is a dire need for cities in the country to invest in ICT infrastructure, such as broadband to improve connectivity, as well as to capitalise on human capital for the required ICT skills. This requires political will, a common approach, and a shared vision. A model is thus required to incorporate these dimensions, making it possible for cities to follow a clear pathway towards e-readiness. Such a model should also make it possible to assess risks, such as Eskom power disruptions, data security, and privacy concerns of citizens. The model furthermore should foster the Internet of things (IoT) functionality and ensure that city management information data is efficiently and accurately collected, stored, distributed and analysed for better city governance. Smart cities should be able to generate data continuously from a number of applications that are deployed throughout cities, such as sensors, cognitive radio technologies (5G), traffic information, e-health, IoT and environment monitoring amongst others.

The problem that this study investigated is the lack of a uniform approach or model in applying smart city technologies by metropolitan municipalities. A preliminary survey of existing smart city readiness models revealed that existing models are designed by particular countries and cities under unique circumstances. Furthermore, cities apply their own models and approaches in an uncoordinated and silo fashion. This causes city governance related challenges, such as limited interoperability of systems and hampered sharing of statistics, data and information. Joint planning, strategic programme alignment,

and general cross-border coordination are furthermore problematic, especially for the three Gauteng-based metropolitan municipalities which are located in close geographical proximity to the Gauteng City Region (GCR). An integrated smart city model is thus required to enhance a uniform approach towards e-readiness and transformation required to adapt to 4IR demands.

The primary objective of this study was towards the development of such a smart city model for metropolitan municipalities. This study looked at the meta-theoretical and theoretical underpinnings of smart cities, lessons and best practice approaches and praxis from leading international smart cities, as well as statutory and regulatory frameworks governing smart city applications. The study also incorporated opinions and perspectives of key stakeholders and role-players in the smart city arena. The aim of the study was to ensure that municipalities are informed and guided by a model in their endeavours to implement smart city initiatives.

KEY WORDS

Smart cities, Smart city readiness, Metropolitan municipalities, South Africa, Gauteng, e-Governance, ICT, Fourth Industrial Revolution, 4IR technologies

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4IR	Fourth Industrial Revolution
ANT	Actor-Network Theory
AI	Artificial Intelligence
AR	Augmented Reality
ASC	Amsterdam Smart City
AV	Autonomous Vehicles
BCSW	Boyd Cohen Smart Cities Wheel
BMS	Bus Management System
BRICS	Brazil, Russia, India, China and South Africa
BWA	Broadband Wireless Access
CCTV	Close Circuit TV
COBOL	Common Business Oriented Language
CODEX	Core Operations Development Environment and Exchange
CoE	City of Ekurhuleni Metropolitan Municipality
CoJ	City of Johannesburg Metropolitan Municipality
CoT	City of Tshwane Metropolitan Municipality
CPSs	Cyber-Physical Systems
CRM	Citizenship Relation Management
DCDT	Department of Communications and Digital Technologies
DOI	Diffusion of Innovation
DPSA	Department of Public Service and Administration
ECT	Electronic Communication and Transaction
EU	European Union
G2B	Government to Businesses
G2C	Government to Citizens
G2E	Government to the Employee
G2G	Government to Government
GICT	Group Information & Communication Technology and Management department
GCR	Gauteng City Region
GCRO	Gauteng City Region Observatory

GIS	Geographic Information System
GPG	Gauteng Provincial Government
GPS	Global Positioning Systems
GWEA	Government Wide Enterprise Architecture
ICT	Information and Communication Technologies
IDP	Integrated Development Planning
IESE	Industrial Economics and Strategy
IFMSCR	Integrated Framework to Measure Smart City Readiness
IMD	Institute for Management Development
IO	Input-Output
IoT	Internet of Things
ITS	Intelligent Traffic System
ITU	International Telecommunication Union
KPIs	Key Performance Indicators
MAC	Media Access Control
MFMA	Municipal Finance Management Act 56 of 2003
MIOS	Minimum Interoperability Standards
MISS	Minimum Information Security Standards handbook
MPSA	Minister of Public Services and Administration
MTSF	Medium Term Strategic Framework
NDP	National Development Plan
NGOs	Non-Governmental Organisations
NIIPWP	National Integrated ICT Policy White Paper
NPA	New Public Administration
NPG	New Public Governance
NPM	New Public Management
NPS	New Public Service
NSCI	Nigeria Smart City Initiative
NSI	National System of Innovation
OECD	Organisation for Economic Cooperation and Development
PC4IR	Presidential Commission on the Fourth Industrial Revolution
POPI Act	Protection of Personal Information Act 4 of 2013
RFID	Radio Frequency Identification

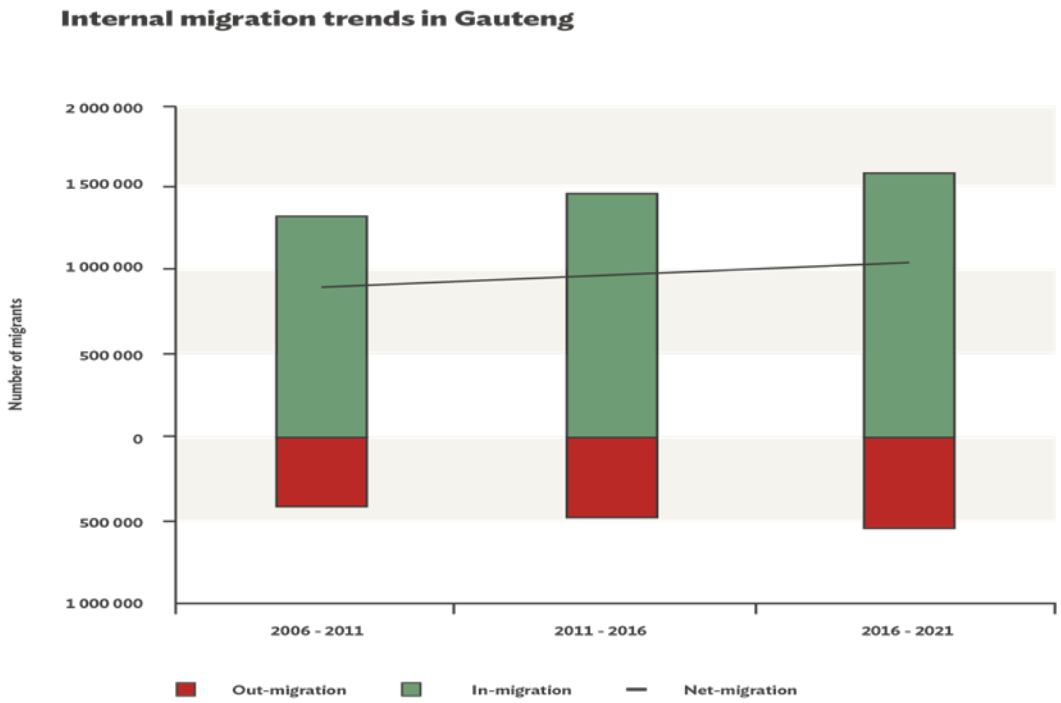
RRF	Resource Recovery Facility
SALGA	South African Local Government Association
SCB	Smart City Blueprint
SCC	Smart Cities Council
SCF	Smart Cities Framework
SCIF	Smart City Integrative Framework
SCM	Smart Cities Mission
SCMM	Smart Cities Maturity Model
SCRG	Smart Cities Readiness Guide®
SCRM	Smart City Reference Model
SDGs	Sustainable Development Goals
SITA	State Information Technology Agency
SLP	Smart London Plan
SNI	Smart Nation initiative
STI	Science, Technology, and Innovation
TOE	Technology-Organisation-Environmental Framework
ToRs	Terms of Reference
UK	United Kingdom
UN	United Nations
UN DESA	United Nations Department of Economic and Social Affairs
UNDP	United Nations Development Programme
VR	Virtual Reality
WAN	Wide-area Information Technology Networks
WEF	World Economic Forum
WiFi	Wireless Fidelity

CHAPTER 1: ORIENTATION

1.1 INTRODUCTION AND BACKGROUND

There is a worldwide trend of people moving into cities to pursue employment and other socio-economic opportunities and benefits. The 2018 Revision of World Urbanisation Prospects produced by the Population Division of the United Nations Department of Economic and Social Affairs (UN DESA) notes that 55% of the world's population already resides in urban areas, a proportion that is expected to increase to 68% by 2050 (United Nations, 2018). This is also the case in developing countries like South Africa, where people move from rural provinces, such as Limpopo, KwaZulu-Natal and Eastern Cape, to more economic-active provinces such as Gauteng and the Western Cape. Immigrants, mainly from neighbouring countries, also move to these economic hubs to improve their quality of life. For 2016-2021, Gauteng and Western Cape are estimated to experience the largest inflow of migrants of approximately 1 048 500 and 311 000 respectively (Statistics South Africa, 2018). According to the Mid-Year Population Estimates Report for 2018 released by Statistics South Africa, the country is estimated to receive net immigration of 1.02 million people between 2016 and 2021, with most international migrants expected to settle in Gauteng (47.5%). Generally, most of the net immigration ends up in metropolitan municipalities, such as the City of Johannesburg, the City of Ekurhuleni, and the City of Tshwane. Figure 1 outlines these migration trends in Gauteng as the locus of this study.

Figure 1:Migration trends in Gauteng



Source: Statistics South Africa (2017)

These migration trends make it vital for cities (i.e. metropolitan municipalities) to adopt innovative practices to enhance their capacity and capability in providing essential services to inhabitants. This is outlined in Section 52 of the Constitution of the Republic of South Africa, 1996, which states that the objectives of local government are to ensure the provision of basic services, a safe and healthy environment, promote social and economic development, amongst other priorities (Republic of South Africa, 1996). However, the adherence to these Constitutional obligations is hampered by the fact that rapid urbanisation puts pressure on cities' existing systems, structures, and infrastructure to serve a growing population adequately. In addition to these challenges, a more technologically-progressive citizenry increasingly demands better services on a 24/7 basis.

In South Africa, a metropolitan or Category A municipality is a municipality that executes all the local government's functions for an urban area as specified in the Local Government: Municipal Structures Act 17 of 1998. Metropolitan municipalities (metros) are the main centres of economic activity and areas for which integrated development planning is essential. South Africa currently has eight urban municipalities, namely

Buffalo City (East London), the City of Cape Town, Ekurhuleni Metropolitan Municipality (East Rand), the City of eThekwini (Durban), the City of Johannesburg, Mangaung Municipality (Bloemfontein), Nelson Mandela Metropolitan Municipality (Port Elizabeth), and the City of Tshwane (Pretoria). Three of these metros, namely the City of Johannesburg, the City of Ekurhuleni, and the City of Tshwane, reside within Gauteng and act as cases for the purpose of analysis for this study.

Rapid population growth into metropolitan areas due to urban migration leads to a wide range of environmental, social and economic problems, as seen by city planners and dwellers (Guest, 1994-37). Due to many inhabitants, more land is needed to accommodate an increasing population, and there is augmented pressure on natural resources, such as access to clean water. People with low or no skills tend to suffer due to a lack of economic opportunities, leading to a life of poverty. This is stressed by Sharifi and Hosseingholizadeh (2019:1063), who believe that urbanisation into cities can exacerbate the problems of poverty, slum development, and social disruption that often affect the most vulnerable segments of the population. Over and above these challenges, cities have to provide basic services to an increased population. In the case of South African municipalities, they have to contend with issues of providing housing, electricity, water, refuse collection, public transport services, road infrastructure, and local economic development opportunities to citizens and businesses operating in such areas. One way in which cities can more effectively deal with challenges brought about by urban migration and service delivery issues, such as lack of adequate housing, employment opportunities, safe and reliable water supply, amongst others, is to utilise smart city technologies. According to the McKinsey Global Institute's study called "Smart cities: Digital solutions for a more liveable future", smart city technologies have substantial unrealised potential to improve the quality of life of urban communities. Thus, this study's premise is that the effective utilisation of the current generation of smart city applications could aid cities toward meeting 70% of the United Nation's post-2015 Sustainable Development Goals (McKinsey Global Institute, 2018). This implies that smart city applications, if utilised effectively, can have the potential to contribute significantly to achieving 70% of the UN's post-2015 Sustainable Development Goals, which includes targets related to sustainable cities and communities, climate action, clean energy, and more. It suggests that smart

city technologies can play a crucial role in addressing many of the global challenges faced by cities today.

According to Cocchia (2014:13), many smart city definitions exist, but no one definition has been universally acknowledged. Cocchia (2014:13) argues that from a literature analysis, it is evident that the notions “smart” city and “digital” city are the terminologies most often used. Boykova *et al.* (2016:66) regard a “smart” city as involving the active use of information and communications technology (ICT) in response to emerging urban development challenges, such as those mentioned earlier. Boykova *et al.* (2016) further state that smart city concepts were introduced in the early 1990s to highlight the increasing dependence of cities on technological and other innovations. This view is shared by the International Telecommunication Union (ITU, 2016), which regards a smart city as an innovative city that uses ICTs and other means to improve quality of life, the efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations concerning economic, social, environmental, as well as cultural aspects (ITU-T Recommendation Y.4900/L.1600, 2016). Similar views are held by others, such as the South African Local Government Association (SALGA, 2015), which describes a smart city as a city that uses digital technologies to enhance performance and well-being, to reduce costs and resource consumption, and to engage more effectively and actively with its citizens. It can be deduced that there is a relative consensus that making cities “smarter” could lead to improved service delivery and other enhanced city capabilities and capacities. For the purposes of this study, a smart city can be regarded as a city that incorporates Fourth Industrial Revolution (4IR) enabled ICTs to enhance the quality and performance of urban services, such as energy, transportation, and utilities, to reduce resource consumption, wastage and overall costs. The overarching aim of a smart city is to enhance the quality of living for its citizens through smart technology (Techopedia, 2020).

Embracing information and communication technologies (ICT) in municipalities can be linked to the New Public Management (NPM) paradigm. This paradigm serves as a grand theory for this study. NPM is a paradigm shift that emerged in the 1980s and 1990s, which aimed to introduce business-like management practices into the public sector. NPM is a grand theory of public management that proposes the application of private sector

management techniques, such as performance measurement, market-based competition, and decentralized decision-making, to improve the efficiency and effectiveness of public services. NPM principles are evident in governance arrangements worldwide to modernise processes and become efficient and effective in delivering public sector services. Hope (2001:119) refers to NPM as a “framework or paradigm through which governments are modernised, and the public sector re-engineered”. Kapucu (2006:887) is of the view that NPM and its reforms are conceived as deliberate policies and actions to alter organisational structures, processes, and behaviours to improve administrative capacity for efficient and effective public-sector performance. Embracing 4IR and smart city technologies by cities worldwide is an aspect of the NPM and in this particular study, the concept of NPM is linked to the adoption of smart city technologies in municipalities. In support, Adams and Smith (2008) argue that the main premise of the NPM is to ensure that “the public system functions equivalent to the private sector”. To function like the private sector, there is a need for the public sector to employ similar ICT as that which is used by their private-sector counterparts. From a philosophical perspective, NPM normatively asserts instrumental rationality, which emphasizes efficiency, effectiveness, and performance. This perspective assumes that organizations can achieve their goals by adopting rational and scientific methods that maximize outputs and minimize inputs. NPM advocates for the use of performance measures to evaluate the effectiveness of public services, which encourages a focus on measurable outcomes and results.

The Diffusion of Innovation (DOI) theory is one of the oldest social science theories. It explains how, over time, an idea or product gains momentum and diffuses or spreads through a specific population or social system. The result of this diffusion is that people adopt a new idea, behaviour, or product (LaMorte, 2019). Again, the same can be said of the smart cities concept that is taking the world by storm as cities increasingly adopt these concepts to increase the efficiency and effectiveness of service delivery provisioning.

This study explored smart city technologies in the context of a NPM by using digital governance (e-Governance) and the Diffusion of Innovation Theory. 4IR, the Internet of Things (IoT), and smart city technologies are recent phenomena within the Public Management domain, just as businesses within the private sector are also still in the early

stages of adopting such innovations to increase quality and competitiveness. Cities have also embraced the use of these technologies. According to Mohanty (2016:01), the use of ICT in cities in various forms for different city activities has increased the effectiveness of city operations. This diffusion results in other cities adopting this new idea and related technologies as part of a local government system. As suggested by the DOI theory, the key to adopting a concept like the 4IR and ICT technologies is that other municipalities who are not currently applying the concept, must perceive the idea as new or innovative. Table 1 outlines the theoretical framework for this study. It should be noted that the NPM paradigm is a broad framework that encompasses various management practices aimed at improving the efficiency and effectiveness of public services by adopting private sector management techniques and the NPM grand theory, on the other hand, is a specific theoretical perspective that advocates for market-based competition, performance measurement, and decentralized decision-making to achieve these goals.

While the NPM paradigm is a general framework that encompasses a range of management practices, the NPM grand theory is a specific perspective that focuses on particular techniques and practices. The conceptual difference between the NPM paradigm and the NPM grand theory lies in the level of specificity and detail. The NPM paradigm provides a broad framework for improving public services, while the NPM grand theory offers a more detailed and specific set of principles and practices for achieving these goals.

Table 1: Meta-approaches and grand theory for this study

Technological applications in the New Public Management paradigm		
Unit of analysis/focus of study	Meta-approaches/Key issues	Grand theories
ICT e-Governance Smart city models and frameworks	Digital-era governance Early adopters	Diffusion of Innovation Theory

Source: Adopted from Van der Waldt (2018:198)

Smart cities depend on the adoption of 4IR technologies. The key technologies powering Industry 4.0 or 4IR include artificial intelligence (AI), augmented/ virtual reality (AR & VR), and the IoT, which are reshaping business processes, unlocking opportunities and encouraging new business partnerships (Madangombe, 2019). The 4IR represents a fundamental change in the way people live, work and relate to one another (Davis, 2016). Davis (2016) further points out that 4IR is about more than just technology-driven change; it is rather an opportunity to help everyone, including leaders, policy-makers and people from all income groups and nations, to harness converging technologies to create an inclusive, human-centred future.

Castells (2000) in Sandor (2012:156) mentions that “authors speak about the world as entering the Information Society, centred around the production, storage, retrieval and utilisation of information, in which a ‘network society’ appears as transforming politics, economics, culture, family and individuals” (Sandor, 2012). The diffusing of smart cities concepts is mainly related to technological “determinism”, which Thorstein Veblen (1857-1929) regards to be “technological development following a predictable, traceable path that is beyond any cultural or political influence; and that the technology, in turn, organises society in a way to further develop itself” (Kline, 2015). Sandor (2012:156) adds that “in discussing technology adoption in society, one should carefully consider technological reasons for adoption and social forces behind or against such developments. Different social, political, economic, cultural or religious factors can lead to the adoption or the rejection of technological innovation”. Many cities around the world have adopted smart city technologies due to the perceived benefits of “advanced and innovative services to

citizens in order to improve the overall quality of their life" (López-Quiles and Bolíva, 2018:3).

The National Development Plan (NDP) identifies ICT as a critical enabler of economic activity and also recognises access to, and the application of, ICT as critical enablers in the fight against poverty (NDP, 2030). The Gauteng Provincial Government (GPG) recognised this and opted to establish an e-Government department, with the vision to create a "connected" Gauteng City Region (GCR) that leverages technology to provide quality services to citizens. The GPG is the first provincial government to set up such a department in the country as part of the drive to become a smart, innovation-driven and knowledge-based economy (Makhura, 2018). It is also envisaged that the efforts of this department will foster the province's 4IR readiness. In this regard, Roberge (2018) maintains that 4IR could lead to a more effective, leaner and cheaper government. All this could lead to improved policy-making and increased effectiveness and efficiency in service delivery.

Closely related to the notion of smart cities is the umbrella term electronic(e-)government. According to the Western Cape's e-Government Strategy (2016), e-Government refers to the sustainable use of ICT to enable improved information and service delivery as well as encourage citizen participation in decision-making. e-Governance in turn, as the functions of e-Government, can be regarded as the application of ICT to the system of governance. This generally ensures a wider participation and deeper involvement of citizens, institutions, non-government and non-profit organisations as well as private sector organisations in government decision-making processes. The State Information Technology Agency (SITA) refers to the purpose of e-Government as making government services more accessible online, reducing the cost of accessing those services, streamlining administrative processes, improving turnaround times, and strengthening accountability and responsiveness (SITA, 2017).

Lombardi *et al.* (2012) outline six dimensions of smart cities which are closely related with e-Government. These six dimensions outline the typical actions aimed at transforming and strengthening a municipality's governance capacity. This includes strengthening the connections and interactions with city stakeholders. Similarly, the Smart Cities Council®

released a Smart Cities Readiness Guide® (SCRG) in 2015 to strengthen cities e-readiness. The SCRG is a collaborative and comprehensive framework against which cities can assess their readiness to innovate and identify an incremental path towards e-readiness. The SCRG can be regarded as a conceptual roadmap to address growth strategies by focusing on universal principles that unite key areas, such as energy, transportation, water and public safety (Smart Cities Council®, 2015). Further impetus in this regard was the development of the Smart Cities Maturity Model (SCMM), which was commissioned by the Scottish Government in conjunction with the Scottish Cities Alliance. This Model outlines five maturing levels that lead to an optimised smart cities approach, based on the five key dimensions, which are strategic intent, data, technology, governance and service delivery models and stakeholder engagement (Scottish Government, 2014). The five maturity levels range from Level 1 to Level 5 as building blocks towards smart city readiness.

1.2 PROBLEM STATEMENT

Although some studies have shown that there are benefits that a developing country such as South Africa can accrue as a result of embracing 4IR, IoT and ICT related initiatives, there are a number of challenges facing cities in this regard. These challenges include outdated ICT-related infrastructure, limited technological expertise, and the high costs involved in new or revised technologies. There is also increasing pressure to involve the community in city decision-making processes as well as to provide accurate, up-to-date information to other government institutions, communities and city stakeholders on a regular basis (Mametja, 2015).

The problem that this study seeks to address is the lack of a uniform approach or model in applying smart city technologies by metropolitan municipalities. A preliminary survey of existing smart city readiness models revealed that existing models are designed by particular countries and cities under unique circumstances. Furthermore, cities apply their own models and approaches in an uncoordinated and silo fashion. This causes city governance related challenges, such as limited interoperability of systems and hampered sharing of statistics, data and information. Joint planning, strategic programme alignment, and general cross-border coordination are furthermore problematic, especially for the

three Gauteng-based metropolitan municipalities which are located in close geographical proximity with the Gauteng City Region (GCR). In this regard, the Gauteng City Region Observatory (GCRO) states that the GCR is South Africa's economic heartland with 15.2 million inhabitants that generate a third of South Africa's gross domestic product (GDP) (GCRO, 2018; Statistics South Africa, 2019). An integrated smart city model is thus required to enhance a uniform approach towards e-readiness and transformation required to adapt to 4IR demands.

Adhikari (2019) insists that there are a number of ways that developing countries can participate in the 4IR. Some of these avenues include enhancing accessibility to technologies and infrastructure, making technology more affordable, developing "future-proof" skills, introducing enabling and mitigating policies and regulations as well as harnessing the potential of public private partnership (Adhikari, 2019:2). In an effort to improve the 4IR readiness of the country, the President of South Africa, Mr Cyril Ramaphosa, appointed a Presidential Commission on the 4IR on 9 April 2019 in order to oversee solutions to some of the challenges faced with the implementation of 4IR solutions in both the private and public sectors. A further challenge as far as smart city readiness is concerned is what Madakam *et al.* (2015:167) describe as technologies and infrastructure required to support cities. The successful implementation of smart technologies requires suitable hardware, middleware and presentation. Smart hardware refers to sensors, actuators, IP (Internet Protocol) cameras, and the utilisation of close-circuit television (CCTV) monitors. Middleware, in turn, refers to the storage capacity and computing tools required for advanced data analytics including Cloud and Big Data computing. Presentation refers to the visualisation and interpretation tools required for different management and service delivery planning applications (Madakam *et al*., 2015).

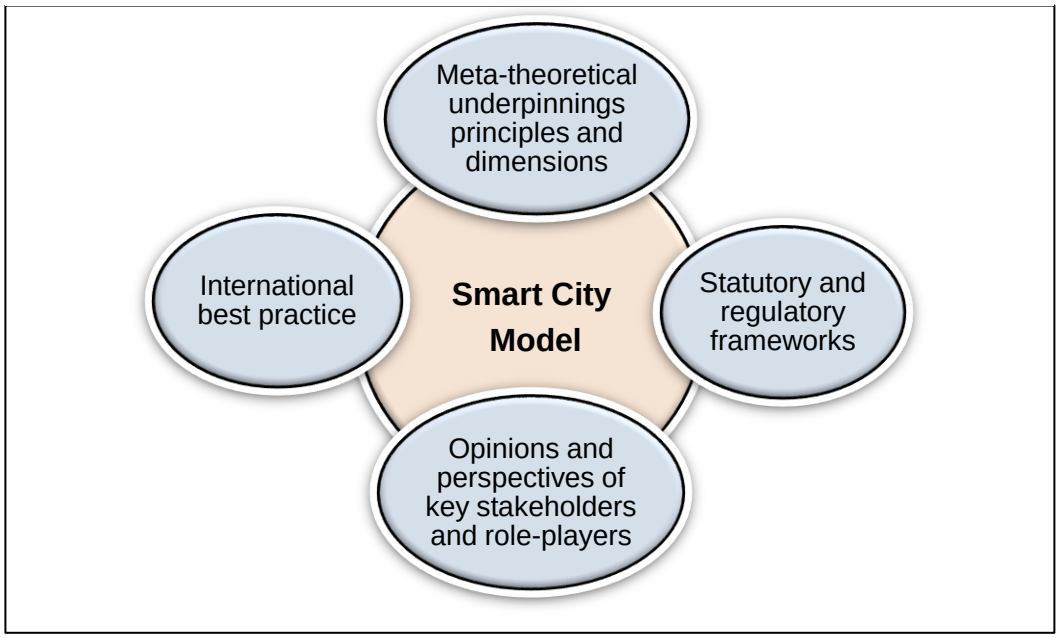
South African cities currently are en-route towards smart technology and 4IR readiness, but much still needs to be done to be *on par* with investment-competing cities around the globe. There is a dire need for cities in the country to invest in ICT infrastructure, such as broadband to improve connectivity, as well as to capitalise on human capital for the required ICT skills. This requires political will, a common approach, and a shared vision. A model is thus required to incorporate these dimensions making it possible for cities to follow a clear pathway towards e-readiness. Such a model should also make it possible

to assess risks, such as Eskom power disruptions, data security, and privacy concerns of citizens. The model furthermore should foster IoT functionality and ensure that city management information data is efficiently and accurately collected, stored, distributed and analysed for better city governance. Smart cities should be able to generate data continuously from a number of applications that are deployed throughout cities such as sensors, cognitive radio technologies (5G), traffic information, e-health, IoT and environment monitoring amongst others.

Furthermore, the strategies and frameworks that are being followed by these Gauteng-based metropolitan municipalities should be evaluated and recommendations provided. The insight gained from the analysis of meta-theoretical underpinnings, principles and dimensions of smart cities within the context of 4IR as well as international best practice approaches and praxis from leading smart cities in the world, will help in the development of a suitable model for a South African context.

The problem thus is a lack of integration and uniform application of smart cities technologies by Gauteng-based metropolitan municipalities, mainly due to the absence of a smart city model. It is thus necessary to analyse the current smart cities processes and initiatives undertaken by these metros. These processes and initiatives were compared with international best practises from leading cities in the world as well as current literature on this subject matter. Figure 2 portrays the respective “data sources” that the study will explore in order to design the proposed smart city model.

Figure 2:Conceptual framework for the study



Source: Researcher's own

This conceptual framework was used to design a smart city implementation model that is suitable for the South African city governance context.

1.3 RESEARCH OBJECTIVES

The primary objective of the study is to develop a smart city model for South African metropolitan municipalities. The aim is to ensure that metros are informed and guided by a model in their endeavours to implement smart city initiatives.

The secondary objectives of this research study are:

a) To explore the meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of the Fourth Industrial Revolution.
b) To evaluate international smart city models and best practice approaches and praxis from leading smart cities in the world.
c) To analyse the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives.

d) To determine the e-readiness of Gauteng-based Metropolitan Municipalities by obtaining the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain.
e) To design a smart city model that can be adopted and implemented by South African metropolitan municipalities to improve their overall e-readiness.

1.4 RESEARCH QUESTIONS

The research questions for this study are:

a) What are the meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of the Fourth Industrial Revolution?
b) What lessons can be learned from international smart city models and best practice approaches and praxis from leading smart cities in the world?
c) What are the nature and content of the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives?
d) What are the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain with regards to the e-readiness of Gauteng-based Metropolitan Municipalities?
e) Which smart city dimensions and elements should be incorporated in a smart city model that can be adopted and implemented by South African metropolitan municipalities to improve their overall e-readiness?

1.5 CENTRAL THEORETICAL STATEMENTS

The Third Industrial Revolution or Industry 3.0 was concerned with the use of information technology and the internet to digitise production, distribution and services, while 4IR is more about the application of AI, ubiquitous digital networks and cyber physical systems. 4IR utilises cyber physical systems like IoT, which is a network of inter-connected smart devices that allow each separate device to send or receive data from other devices on the network. Many researchers agree that in order for government to take full advantage

of this advance in technologies it is necessary to have adequate investment in the required ICT infrastructure as well as human capital.

With almost every municipality, particularly metropolitan municipalities, in South Africa claiming to be “smart”, “digital”, “intelligent” or other related terms, it is necessary to understand what these municipalities mean by being “smart”. Against which backdrop do they classify themselves as smart? And what framework, process or model are they implementing? Is there a required commitment from political principals? Are there resources in place, including qualified and competent people to drive the process?

It is important to understand the reasons for pursuing “smartness” and the perceived benefits to society at large of this move. Ojo *et al.* (2015:2326) write that “extensive experience from practice clearly indicates that the smart city concept represents attempts by various city governments to exploit different kinds of innovations to make cities function better and be more liveable”. Furthermore, from a DOI theory perspective, a smart city as an innovation must be communicated among relevant city stakeholders, particularly the departments or sections that are expected to contribute to the smart city initiatives. Another dimension is whether this is also the case for Gauteng-based metropolitan municipalities.

1.6 RESEARCH METHODOLOGY

Research methodology can be regarded as specific procedures or techniques used to identify, select, process, and analyse information about a topic (University of the Witwatersand, 2020). This section covers details of the literature review and the empirical investigation to be followed.

1.6.1 Literature review

Blaxter *et al*. (2006:123) refer to a literature review as a critical summary and assessment of the range of existing materials dealing with knowledge and understanding in a given field. This view is shared by Flick (2014), who writes that a literature review surveys books, scholarly articles, and any other sources relevant to a particular issue, area of

research, or theory, and by so doing, provides a description, summary, and critical evaluation of these works in relation to the research problem being investigated. In the current study, primary literature will be used as the foundation of this research.

Meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of 4IR will be reviewed. Statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives as well as international smart city models and best practice approaches and praxis from leading smart cities in the world, will be analysed, and summarised within applicable conceptual categories. This section will provide an overview of sources mentioned above as well as any other relevant sources that will come up during the research process.

1.6.2 Data bases consulted

The following databases, amongst others, have been consulted to ascertain the availability of material for the purpose of this research study:

a) Emerald Insight
b) Jstor
c) Google Scholar
d) Sabinet
e) Research gate
f) Academia

1.6.3 Empirical investigation

This section covers the research design, sampling, data collection instruments, data analysis and limitations and delimitations of the study.

1.6.4 Research design

Saunders *et al.* (2016:163) describe a research design as “a framework for the collection and analysis of data to answer research questions and meet research objectives by providing reasoned justification for the choice of data sources, collection methods and analysis techniques”. These authors further state that a research design is a general plan of how the researcher will go about answering the research questions. The research design contains clear objectives derived from research questions and specifies the sources from which the researcher intends to collect data and how the collected data will be analysed.

Shields and Rangarajan (2013) refer to exploratory research as research conducted for a problem that has not been studied more clearly, intended to establish priorities, develop operational definitions and improve the final research design.

This study followed an exploratory qualitative research design. An exploratory study is highly applicable due to the aim of ascertaining the context, dimensions and strategic aspects of smart city maturity amongst Gauteng-based metropolitan municipalities.

1.6.5 Data collection

Qualitative data collection can be regarded as the selection and production of linguistic or visual material for analysing and understanding phenomena, social fields, subjective and collective experiences and related meaning making processes (Flick , 2018), while instrumentation refers to the tools or means by which investigators attempt to measure variables or items of interest in the data-collection process (Salkind, 2010). When undertaking qualitative studies, researchers frequently use instruments such as interviews, observations and focus groups.

This study collected data using semi-structured interviews. Adams (2015:493) mentions that semi-structured interviews are conducted conversationally with one respondent at a time by employing a blend of closed and open-ended questions, often accompanied by follow up why or how questions. An interview schedule was designed with the intention

of asking critical questions to key stakeholders and role-players in the ICT and city governance domain.

1.6.6 Instrumentation, population and sampling

An interview schedule was used as a data collection instrument. According to Murchison (2010), an interview schedule generally is a list of interview questions organised in a particular order to guide the interview from start to finish. An interview schedule can be an important tool to ensure that the researcher has a good set of questions and an appropriate plan for asking those questions in the course of an interview. There were 30 participants interviewed for the current study. There were 10 participants interviewed for each of the three metros.

1.6.7 Data analysis

Flick (2018:03) describes data analysis as the central step in qualitative research. This is due to the fact that whatever the data is, it is its analysis that, in a decisive way, informs the outcome of the research. This exploratory qualitative research utilised content and thematic analysis to determine the exposition of smart city technology on cities, including ascertaining how far Gauteng based metropolitan municipalities are with regards to exploring and utilising ICT-enabled solutions to deal with the challenges facing these metropolitan municipalities. Qualitative content analysis is an approach to analysis that focusses on meaningfully interpreting and describing the topics and themes that are evident in the contents of communications when framed against the research objectives of the study (Williamson *et al.*, 2018). Smart city technology content found in documents, books, journals, government policy and frameworks, and any other material will be used for the analysis of critical information to be used to support the outcomes of this study.

According to Braun and Clarke (2006), thematic analysis is a method for identifying, analysing, organising, describing, and reporting themes found within a data set. In support, Saunders *et al.* (2016) regard thematic analysis as a process which involves a researcher coding her or his qualitative data to identify themes or patterns for further analysis, related to his or her research question. Nowell *et al.* (2017) furthermore assert

that thematic analysis can be widely used across a range of epistemologies and research questions.

1.7 LIMITATION AND DELIMITATIONS

Limitations refer to limiting conditions which are unavoidably present in the study's design, while delimitations mean defining the limits of or drawing the boundaries around a study and showing clearly what is and what is not included (Punch, 2016). This study is limited to the three metropolitan municipalities located with the Gauteng province and also uses smart city models as a tool to determine the level of smart city maturity and levels of readiness of these municipalities. The results can thus not be generalised to other cities or municipalities in the country or those abroad. The proposed Smart City Model is thus specifically framed for the South African municipal environment, especially metropolitan municipalities.

1.8 ETHICAL CONSIDERATIONS

Ethics are considered as the norms or standards for conduct that generally distinguish between right and wrong in society. This study will also take into account required research ethics. An ethical clearance certificate was obtained from the Ethics Committee of North-West University before interviews were conducted with sampled participants. Permission to conduct the study were obtained from gatekeepers in the City of Johannesburg, City of Ekurhuleni and the City of Tshwane. Furthermore, the researcher ensured that participants were fully informed about the nature and purpose of the study. All participants signed a consent form before the interviews and were informed that their anonymity would be ensured. All responses are treated as confidential.

1.9 SIGNIFICANCE OF THE STUDY

This study determined whether Gauteng-based metropolitan municipalities are e-ready for the smart city arena and whether they have embraced IoT and 4IR in an effort to improve service delivery. It is important to undertake this study so that government is

informed about the status of its economic hub with regards to its e-readiness, as envisaged in the National Development Plan: Vision 2030.

From a theoretical perspective the study made a significant contribution to theories, models and approaches applicable to robust analyses of the IoT, 4IR and other smart city technologies. The application of ICT in cities is a fairly recent phenomenon that still requires significant research to uncover the potential impact thereof on city governance. An assessment of meta-theoretical underpinnings, principles and dimensions of smart cities within the context of 4IR as well as how international smart city models and best practice approaches and praxis from leading smart cities in the world could be applied to local challenges facing South African cities, will further add considerable value. The statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives will also provide a basis from which to design a model suited for local conditions.

From an operational point of view, the benefits gained from this study could be useful to all municipalities as the intention is to increase knowledge and application of smart technologies in South Africa for the benefit of its citizens. The proposed model will chart a pathway for municipalities to become 4IR compliant and improve the overall e-readiness and organisational ICT maturity of cities.

1.10 CHAPTER LAYOUT

Chapter 1: Orientation

This chapter introduces and outlines the orientation of this study. It provides the problem statement, aim, research objectives and questions as well as the research methodology to be followed.

Chapter 2: Meta-theoretical underpinnings, principles and dimensions of smart cities within the context of the Fourth Industrial Revolution

This chapter provides a review of the literature, meta-theoretical underpinning, principles and dimensions of smart cities within the context of the 4IR.

Chapter 3: International smart city models and best practice approaches and praxis from leading smart cities in the world

This chapter provides an exploration of international smart city models and best practice approaches and praxis from leading smart cities in the world.

Chapter 4: The statutory and regulatory frameworks governing the application of ICT in South African cities

In this chapter, the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives are outlined.

Chapter 5: e-Readiness of Gauteng-based metropolitan municipalities: Empirical findings

In this chapter, the e-readiness of Gauteng-based metropolitan municipalities is ascertained by obtaining the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain. Chapter 5 also outlines the research methodology and design chosen for conducting this study.

Chapter 6: Conclusions and recommendations: A Smart City Model for South African Metropolitan Municipalities

The final chapter provides conclusions and recommendations from the study. This includes the design of a proposed Smart City Model as per data obtained from key stakeholders and role-players in the ICT and city governance arena.

1.11 CONCLUSION

The purpose of this chapter was to contextualise the aims of this study by providing background to the locus and focus of the scholarly investigation. It outlined the problem to be explored, the primary aim of the study as well as associated research objectives and questions. Finally, the chapter clarified the research methodology to be followed.

In the next chapter, the first research objective will be operationalised by exploring literature regarding the meta-theoretical underpinning, principles and dimensions of smart cities within the context of the Fourth Industrial Revolution.

CHAPTER 2: META-THEORETICAL UNDERPINNINGS, PRINCIPLES AND DIMENSIONS OF SMART CITIES WITHIN THE CONTEXT OF THE FOURTH INDUSTRIAL REVOLUTION

2.1 INTRODUCTION

Chapter 1 focused on the orientation of this study of what a smart city is and how leading cities in the world embrace this concept to be more efficient and effective in providing basic municipal services. A description of the research problem, a brief outline of the research objectives and questions, the central theoretical statements and the research methodology followed in this study were provided. The significance and contribution of this study were also outlined, and it was indicated that it is crucial for South African metropolitan municipalities, particularly Gauteng-based metros, to have proper guidelines to follow when undertaking and implementing a smart city model suitable for local conditions.

This chapter builds on the orientation chapter and focuses on the meta-theoretical underpinnings, principles, and dimensions of smart cities within the context of the 4IR. It starts by outlining the concepts of cities, metropolitan municipalities, smart cities, and the 4IR. As Maree (2012:34) recommended in Van der Waldt (2020:02), a detailed conceptual framework is essential to clarify key concepts and constructs derived from the focus and locus of the study. Similarly, a theoretical framework embeds the study in a sound philosophical discourse regarding the nature of the phenomenon under investigation. It also serves to uncover key theoretical models, approaches, and dimensions against which existing praxis can be gauged. As such, it serves as a valuable data set for source, method, and data triangulation. The design of both conceptual and theoretical frameworks is highly dependent on a robust literature review.

The chapter also provides a philosophical or meta-theoretical perspective of the role of a government in society. Further, it explores the theoretical underpinnings of drives behind embracing ICT in governance settings. The conceptual and theoretical frameworks from the literature review will finally be used to uncover core dimensions of notions of a “smart

city". These dimensions are essential for the eventual design of a Smart City Model as the main contribution of this study.

2.2 CONCEPTUAL CLARIFICATION OF METROPOLITAN MUNICIPALITIES, CITIES, SMART CITIES, AND THE FOURTH INDUSTRIAL REVOLUTION

It is imperative for key concepts and terminologies used in this study to be clarified within the ambits of the context in which they are utilised. The conceptualisation of these key terms will entail building sophistication, from elementary to comprehensive.

2.2.1 Metropolitan municipalities

Squires (2002) defines a metropolitan area or a metro as "a region consisting of the densely populated urban core and its less-populated surrounding territories under the same administrative division, sharing industry, infrastructure and housing." The term "metropolitan" comes from the Greek word that means a mother city. It is an area that consists of an urban core inner city, which is surrounded and connected to smaller pockets of urban civilisation within the region. Metropolitan areas usually contribute significantly to economic activities in many countries. They play a significant role in economic, political, and technological innovation and are important hubs for regional and international economic activities.

Metropolitan areas evolved from villages, towns, and cities as society started to see the benefits of urban living. More and more people wanted to move to urban areas for better economic prospects. Duncan *et al.* (1960:04) insist that the metros concept was "not a creation of a government nor is it an artefact of bureaucratic statistical procedures", but rather that a metropolitan area grows or evolves throughout several generations. This section concentrates on generic perspectives of the local sphere of government and how different theories have developed into the concept of metropolitan cities.

2.2.1.1 Local State Theory

In the opinion of Cockburn (1977:36), a local state "is about working-class interests in the community" and it "operates as a key part of the central state, not to provide services for individual local citizens, but to perform the function of serving the labour force (and its supportive institutions, such as the family) to reproduce both the forces and the existing relations of production in capitalism". Cockburn's local state theory suggests that the local state in a capitalist state is merely the "local presence of the national state agencies, such as the police and the courts, and those functions, such as housing and education that are defined as local responsibilities". In this type of local state, the basic municipal services, typically administered by local councils, is undertaken within the parameters as defined by the central or national government. The distinction between local and central states is that the local state implements the initiatives of a capitalist central state locally.

Local state theory views the provincial government's role as securing conditions favourable to capitalist accumulation, mainly through collective reproduction, which provides welfare services, such as poverty, housing, public safety, education, health, and others required to resolve inherent tensions within capitalism. The local state theory attests that corporate planning and community development are used as a flexible strategy to engage constituents in decisions about how local services should be shaped and to encourage responsibility for service delivery, thereby performing the role of extending the reproduction of the labour force by servicing it with the required services (Barnett, 2013:05; Mowbray, 2016:155). However, Duncan and Goodwin (1982:157) insist that the term local state can "equally refer to autonomous local state or local institution of the central state" and that both means are present in the literature. Duncan and Goodwin (1982:157) maintain that a local state distinguishes a particular social and political interest area, subject to analysis apart from the central state. Local refers to "the importance of local variations in action and consciousness". According to Duncan and Goodwin (1982:158), the local state is related to the overall concerns of social relations and social change. It "emerged as part of conflict and compromise between intimately linked groups of varying interests, ideas and powers".

The premise of Cockburn's local state is that local government is designed to be an agent for the capitalist, which ensures that the community's interest is represented at the local council level. In this way, the community, which comes mostly from labour to capitalist ventures, feels consulted and thus "controlled" to ensure that they abide by the rules of the corporate way of capitalists. The local state role becomes that of guaranteeing the ongoing situation in which capitalists continue to accumulate wealth while being seen to accommodate the socio-economic needs of citizens of the local state. The effort by the local state to contribute to the socio-economic upliftment of the community, is to ensure that there is an adequate supply of suitable labour from communities to meet the demand of capitalistic enterprises. This makes it difficult for the districts to want a different arrangement, as they are made to believe that the current way of doing things is in their best interests.

Scholars, such as Saunders, regard Cockburn's Marxist literature as unrealistic, in the sense that it is problematic to apply the 'general theory of the capitalist state' to the local level and that "local government agencies can simply be treated as the central state writ small''. Saunders (1982:56) contends that "it appears, therefore, that the strengths of the Marxist literature are the weaknesses of the political science literature". Saunders (1982:57) states that similarly with the general class theories of political conflict, it can not be assumed that they apply equally and in the same way in the local state as it is a central and regional government since conditions and factors are different and may differ substantially between the two.

2.2.1.2 General Theory of the State

General theory of the state, as advocated by Georg Jellinek in Aroney (2010:682), is an approach to state-theory that emphasises "the idea of sovereignty as an essential characteristic of a state". Jellinek in Aroney (2010:682) believes that a state arises historically when people who are conscious of organic unity amongst themselves establish themselves as a collective judicial personality "with fully constituted organs of government which the people recognise as giving effect to the will of the nation". In this view, the sovereignty of a state involves a dominant relationship the state has over "all

individuals and groups within its territorial jurisdiction, as well as a condition of independence from the will of any other state" (Aroney, 2010:682).

Jellinek in Aroney (2010:682) asserts that central government institutions assist in managing a country's affairs and could be created, through laws and acts of administration, in both a confederation and a federal state. Such spheres of government can be made through a constitutional division of competencies between the central and regional governments, enforced by the courts. However, Jellinek argues that in a confederation state, unlike a federal state, each "state retains the right to exercise its judgment about the scope of the powers of the central organs of government and a capacity to deem central laws and acts of administration null and void, and if necessary to secede at will from the confederation as a whole" (Aroney, 2010:684). Furthermore, Jellinek insists on the two-sided nature of the state, which incorporates legal and social functions. The legal aspect of the state comes from sovereignty and constitutional enactment. In contrast, from a social perspective, the state is created by individuals limiting their will and establishing fundamental rights, inclusive of defence of minority rights and individual freedom (Lagi, 2016:118). Central, regional, and local governments are thus created as part of the central government or as independent sovereign states that only cede certain powers centrally for a common cause. The regional and, by extension, the local spheres of government will then conduct their business to benefit their citizenry that are affected by its establishment.

2.2.1.3 Dual State Theory

Unlike local state theory, dual-state theory denies class issues in local state politics. Whereas, as per the local state theory, capitalists influence the working class to maintain the status quo, while in the dual state theory developed by Peter Saunders (1986), the state's role can be both be of advocating wealth creation in a capitalist society as well as ensuring satisfactory levels of consumption for society. The state, in this instance, uses more than one policy, which often overlaps to address concerns of producers of wealth and the consumption needs of the working class (Saunders, 1981:238).

Dual state theory essentially divides state activity into production and consumption fields, with local government being responsible for the consumption elements, mainly welfare services provided at a local level, including housing. Saunders (1981) claims that production and wealth creation are organised at central and regional government, while consumption politics happens at the local level of the state. In this way, a conflict that affects production and wealth creation mainly occurs at the central and regional levels. In contrast, other issues with less impact and low risk for the capitalists and which mostly affect consumption, occur locally. Local-level issues generally comprise of social welfare public services' deliverables (Barnett, 2013:05). Barnett (2013:05) agrees and indicates that a dual state theory attests that the central and regional government is dominated by capitalists, who compete for resources amongst themselves, and with the local state "being inevitably more pluralist and open to contestation". Therefore, the local state has a diverse group of stakeholders with various needs. Thus, whilst there is scope for resistance, it is necessarily fragmented and focussed around issues, and thus it is difficult to "scale up to a coherent resistance movement" (Barnett, 2013:05).

Saunders (1982:57) disputes the straightforward application of central state policies in the local state and argues that the functional specificity of local government, which is primarily concerned with the provision of social consumption, means that "local political struggles are generally not constituted class struggles". Moreover, Saunders (1982:57) is of the view that local state has its "own specificity in terms of its function, its mode of discharging this function, and the ideology which surrounds this function and that the necessary implication of this specificity is that it does not constitute an arena of class struggle".

2.2.1.4 Principal Agency Theory

The first scholars to propose, explicitly, that a theory of agency be created, and to begin its creation, were Stephen Ross (1973) and Barry Mitnick (1975), independently and roughly concurrently (Mitnick, 2007:03). The agency theory deals with all relations in a society where one party acts for another (Mitnick, 1985:02). In applying principal agency theory, the "principal" is the owner of a resource, who then delegates authority over the

utilisation of the resource to the “an agent” who is supposed to make decisions and act in the principal’s best interests. Mitnick (1985:02) indicates that the principal-agency relationship can be regarded as a building block of several societal institutions.

Principal agency theory deals with economic incentives and institutional structures, respectively, as asserted by Ross and Mitnick. From an economic perspective, the main concern is finding a compensation system that incentivises the agent to act consistent with the principal's preferences. On the other hand, the institutional structures of the principal agency theory are concerned with the institutions that form around the agency and “evolve to deal with the agency in response to the essential imperfection of agency relationships” (Mitnick, 2007:3).

The state is regarded “as an agent and as consisting of agents; agents in the state, i.e., representatives and officials; agency in the relation between constituencies and government; bureaucrats as agents; agency in implementation and compliance”; and agency in regulation (Mitnick, 1985:01). Similarly, the local state is seen as an agent of the central or regional state and carries on work and activities for the key benefit of meeting the principal’s objectives. Again, the central state is also an agent of the constituencies that legitimise the central government. Hence the state can be regarded as an agent and also consists of many other agents, such as municipalities.

2.2.1.5 Regulation Theory

Regulation theory is concerned with the “way in which the economy is embedded in social, cultural, political and other contexts” and was devised to analyse and account for the unequal socio-economic development in societies because of wealth accumulation in capitalist society (Halford *et al*., 1993:67). According to the initial insight of this approach, “continued capital accumulation depends on a series of social, cultural and political support” that keeps the wheels turning (Goodwin, 2001:72). The regulation theory therefore tries to legitimately link “the traditional concerns of political economy with analyses of the state and civil society” (Goodwin, 2001:84).

The state is key to any regulation nationally, regionally or at a local level of government. Through this regulation, socio-economic variables in society are affected and impacted, resulting in capitalist state activities. Halford *et al*. (1993:67) contend that law is operated at a national level and is also practised at the local level of the state. At the local level, local agencies are often the medium through which "regulatory practices are interpreted and ultimately delivered". Halford *et al*. (1993), in their study of the changing nature of urban politics in Britain, concluded that the local state is both an object and an agent of regulation. The authors further alluded that the economy at the local sphere of the state is said to be self-regulating. In this instance, capitalism is not the source of the prevailing social structure, but it is a product of the social structure and therefore the local state should also be regulated to ensure that it delivers the desired outputs and outcomes required of such regulations.

2.2.1.6 Theories of local planning and spatial development

Duncan and Goodwin (1982:157) further developed Cockburn's conception of the local state and believed the local state is more "than just denoting a methodological approach or an area of social and political interest", but rather the local state can be related to social relations and change within the local sphere of a capitalist state. The local state according to this view is not static, but it is dynamic and is more than a set of physical institutions found within in a local area. Duncan and Goodwin's theory focuses on social changes, rather than the description of social institutions, which according to this theory, results in social institutions. Duncan and Goodwin (1982:159) maintain that the local state is another type of capitalist social relation that draws attention to the importance of the local variation in state action, class relations and political consciousness. Duncan and Goodwin (1982:77) conclude that the local state is influenced by the central government and that local issues are not necessarily local, and that some can stem from central government's policy priorities, which were mostly capitalistic in nature at that time.

2.2.1.7 Public Institutional Theory

Public institutional theory can be regarded as “a way of explaining how organisations work in interaction with the world around them” (Furusten, 2013: VII). Public institutional theory is concerned with how public institutions come about and how they go about providing public services to society. March and Olsen (1984) in Frederickson *et al.* (2016:70) describe institutions as “the beliefs, paradigms, codes, cultures, and knowledge that support rules and routines”. Scott (1987:493) asserts that there are two primary actors that shape institutional environments in modern societies, the state and professional bodies. Scott (1987:493) argues that the mode of action and interests of the state and professional bodies shape institutional patterns and mechanisms.

Frederickson *et al.* (2016:70) claim that in institutionalism, organisations are “bounded social constructs of rules, roles, norms, and the expectations that constrain individual and group choice and behaviour”. This is mainly because institutions and the professional bodies or representatives of the collective societal needs are affected by their social, economic, and political context in which they practice, and they are also in turn a powerful stakeholder that affects and influences the direction to be undertaken by institutions. Wendt (2017:01) insists that “institutional theory contributes to a better understanding of modern societies” and includes the local government institutions as well. They too are as result of social relations and regulations “that symbolise principles and claim validity of a social order” (Wendt,2017:01). They were designed to meet and facilitate the objectives of the state as envisioned by society.

Jepperson (1991) in Wendt (2017:02), views an institution as “a social pattern that is regulated by rewards and sanctions”. Rewards accrue to an institution, if its actions are aligned and deliver the mandate of those who advocate for it. Similarly, sanctions ensue, if the institution’s actions do not deliver on the mandate as required. There is thus a close relationship between institutions and social behaviour. In terms of the local state, public institutional theory therefore focuses on the roles of social, political and economic systems in which local public institutions operate and gain their legitimacy. It is to be expected that local government institutions would act for the benefit of individuals, and

entities that reside within the their locality and that local social interactions will determine the legitimacy in the long run of any actitivies of local institutions. If such action promotes values and principles of the local citizenry, such institutions would be uphled and if not, sanctions will follow, until institutions are in place that will value and place local needs above every other objective.

2.2.1.8 Structural-Functionalism

The structural functional theory views society as composed of a complex system of interrelated parts, which are interdependent on each other to work together in the interest of meeting societal needs. The structural functional theory "assumes that social systems are relatively determinate, boundary-maintaining systems in which the parts are interdependent in certain ways to preserve one another and the character of the system as a whole" (Barber,1956:130). This theory holds that social systems are composed of interconnected parts and that the parts of a system can be understood in terms of how each contributes to meeting the needs of the whole. These social systems tend to remain in equilibrium, with changes in one part of the system leading to changes in other parts of the system, in a way that the various parts of society work together to keep society functioning. The various parts of society referred to in this theory are institutions such as the economy, the state, education, social welfare, religion, and other related institutions that are focused on meeting societal needs.

The structural functional theory focuses on structure, which is the patterning of roles, the form of institutions, and the overall articulation of institutions in a society, and seeks to explain these structures in terms of their functions, and how they contribute to the stability and persistence of societies. The central element of the social functional theory is based on the assumptions that society is an integrated whole with a series of interconnected parts that rests on the consensus of its members, who generally agree on what is good and just for society (Lucas, 2007:4860). However, this theory has been criticised as a theoretical framework by its element of reducing the effect of social conflict and normalising social structures that can be seen as problematic or oppressive as well as its

inability to adequately address social changes in a dynamic society (Lucas, 2007; Kitchen, 2016).

The purpose of the state in structural functional theory is to meet societal needs by ensuring that social institutions interact in a manner that stabilises society for the benefit of all social relations. It views the state and politics as enforcing acceptable norms and regulating conflict amongst social institutions. If the outcomes are not what society expects, it will result in conflict, which will eventually lead to changes in social institutions in favour of what is acceptable norms and values of society.

This section provided several local government theories that attempt to explain and predict the functioning of the local sphere of government. There was a common theme in these theories, patterning that the local sphere of government is influenced to a large extent by national policy direction as devised by national politics. Furthermore, the legitimacy of the local states stems from a conscious support by the citizenry, in that they believe such an institution can give effect to the needs of society. These theories provide insights into how local government transacts and functions towards achieving societal needs. Several principles that local authorities work towards appeasing were identified and it was discussed how municipalities are agents in pursuit of agent's objectives as well as their own agenda. Similarly, the adoption of 4IR enabled smart city solutions depends largely on the perceived benefits to accrue towards society. Further to that is how the local government sphere is structured and the influence of the central government on it, as well as local government legitimacy as provided by the citizenry, who are the voters who elect municipal councillors. Utilising the theories above, local government functions and transactions can be analysed, and such information used to aid decision-making in the long run.

2.2.2 City as concept

According to the United Nations' World Cities Report (2018), a city consists of hubs of government, commerce and transportation and it is an area where large numbers of people live and work. A city can be described according to an "administrative boundary" or to the "extent of the contiguous urban area to delineate its boundaries", as well as by

“the degree of economic and social interconnectedness of nearby areas, identified by interlinked commerce or commuting patterns, for example” (United Nations, 2016: 01). In keeping with this view, Parr (2007:381) maintains that a city can be viewed as “a physical entity or an area devoted to primarily urban uses”. According to Parr (2007:381), within the city area, consumption of goods and services will occur and the bulk of the employed people producing these goods and services will also reside within the area and entities will thus also draw their labour required for producing goods and services from this area.

However, some countries use a statistical definition of city, wherein an area is designated as a city depending on the number of people residing within the area. If such an area is densely populated and has a “population of at least 50,000 inhabitants in contiguous dense grid cells (>1,500 inhabitants per km2)”, such an area can be labelled as a city (UN Statistical Commission, 2020). There are many countries that use “a minimum population size to define an urban area, but that size can be 200 (as in Denmark), 2,000 (Argentina), 5,000 (India) or 50,000 (Japan) or even 100,000 (China)” (Dijkstra *et al.,* 2020). Therefore, population size as a measure to define a city is relative.

Mumford (2011:94) on the other hand, describes a city using a theatrical description and claims that “a city is a theatre of social action and everything else such as art, politics, education, commerce only serves to make the social drama more significant in intensifying and underlining the gestures of actors and the action of the play’. Mumford views a city as a “related collection of primary groups and purposive associations” such as families, neighbourhoods, private and public organisations who support themselves through some sort of economic activities and are located permanently or for the long-term in a specific area. These stakeholders residing or doing activities within this area will have differentiated opportunities and challenges, that creates economic activities within the area, which would result in a common and accepted way of doing things, including a collective administration of public goods and services for the benefit of the collective society. However, there should be a limitation on several things for a city to be economic and effective. Mumford (2011:95), argues that “limitations on size, density and area are absolutely necessary to effective social intercourse”, as such factors are one of the “most important instruments of rational economic and civic planning”. These items should be

expressed as a function of economic interactions to be supported and served in such a city.

2.2.3 Smart city

The notion “smart” typically refers to the mental capability or intelligence that enables a way of doing things better (Dictionary.com, 2021). In the case of a city, smartness is about how a city as an institution can better be managed to deliver on its mandate efficiently and effectively from an integrated and holistic approach comprising of a collective of residence, labour, public and private entities operating within the boundaries of a city (OECD, 2020). Giffinger *et al. (*2007:10) contemplate that the “smart” in a smart city is about being taking a forward-looking development approach which considers issues such as "awareness, flexibility, transformability, synergy, individuality, self-decisive, strategic behaviour" in how cities are designed or managed. Similarly, Greene (2020) reasons that smart is about “progressive, inclusive, sustainable, and forward-thinking policies that leverage technology, human capital, and social responsibility” within a local state environment. It is about how technology can be utilised to improve the processes of electing political representatives to run cities' administration and the actual provision of public services. Logan and Molotch (1987) in Hoe (2016:324) maintain that the origin of smart cities can be traced back to the 1980s, as, during that time, urban planners advocated for the development of entrepreneurial and well-managed cities. Essentially the smart city concept is used as “an umbrella term for a range of technological, governance, management and ecological concerns about urban living” (Backhouse and Cohen, 2014:129; Winkowska *et al*., 2019:78). In the opinion of Ash and Chandrasekaran (2017), “smart cities strive to bring together government, commerce, society, and technology, enabling smart living and community engagement that enhances and supports human existence”. There are several smart city definitions in the literature, and some refer to such cities as digital, intelligent, virtual, knowledge, creative or ubiquitous city. This is because they view and value certain important characteristics of a city. However, in this study, the term smart city is preferred because it includes human, institutional and technological aspects that enhance basic public services in a city.

Dameri (2013:2549) proposes the following definition of a smart city: “A smart city is a well-defined geographical area, in which high technologies such as ICT, logistics and energy production, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality and intelligent development”. Dameri (2013:2549) emphasises that a smart city should be “governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development” for it to be effective. Rouse *et al*. (2017) refer to a smart city as a one that uses ICT "to increase operational efficiency, share information with the public and improves both the quality of government services and citizen welfare". This definition implies that the foundation of a smart city is its effectiveness in applying ICT technology to urban issues. However, Pardo and Nam (2011:286) argue that a smart city should not be focused solely on technology and that human and institutional factors such as governance and the people using the technology are just as important. Similarly, in line with this view, Giffinger *et al.* (2007: 11) have earlier referred to a smart city as "a well-performing city built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens". Accordingly, the smart combinations necessary for a functional smart city include "smart people, governance, environment, economy, mobility and living”. Some of the definitions of a smart city are provided in table 2 below, from the ten most-cited smart city source documents between 1992 and 2012 as per the outcomes of a study undertaken by Mora and Deakin (2019).

Table 2: Smart city definitions from 10 most cited smart city source documents

SMART CITY DEFINITIONS	
1.	A smart city is a city well performing in a forward-looking way in six characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent, and aware citizens (Giffinger *et al.,* 2007). The six characteristics are Smart Economy, Smart People, Smart Governance, Smart Mobility, Smart Environment, and Smart Living.
2.	"A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu *et al.,* 2009).

3.	Intelligent cities create multi-level systems of innovation where the knowledge functions of innovation are deployed in physical, institutional, and digital spaces. “Cities create multi-level systems of innovation where the knowledge functions of innovation are deployed in physical, institutional and digital spaces” (Komninos, 2002).
4.	A smart city might use IT to enhance democratic debates "about the kind of city it wants to be and what kind of city people want to live in - a type of virtual public culture" (Hollands, 2008).
5.	Cities are based on six core systems: people, business, transport, communication, water, and energy. A smarter city is, thus, one that uses technology to transform its core systems and optimise the return from largely finite resources (Dirks and Keeling, 2009).
6.	The IoT must necessarily be the result of synergetic activities conducted in different fields of knowledge, such as telecommunications, informatics, electronics, and social science. Atzori *et al.* (2010) imply that using IoT, a smart city can develop a City Information Model (CIM) and that can be used to infer population changes, as can movement patterns, environmental performance, as well as the overall efficiency of products and buildings within a city (Atzori *et al.,* 2010).
7.	Smart and intelligent cities have modernisation potential because they are not events in the cybersphere, but integrated social, physical, institutional, and digital spaces, in which digital components improve the functioning of socio-economic activities, and the management of physical infrastructures of cities, while also enhancing the problem-solving capacities of urban communities (Schaffers *et al.,* 2011).
8.	Cities offer skills, institutions and virtual spaces of cooperation sustaining the creation of new knowledge (research), monitoring knowledge flows (intelligence), disseminating existing knowledge (technology transfer), applying knowledge (innovation), developing new activities based on knowledge (incubation) and managing knowledge remotely (e-Government) (Komninos, 2008).
9.	Areas with more educated populations experience more rapid growth in the quality of life. This might occur because more-educated individuals spur on the growth of consumption amenities in cities where they reside or because their influence on the political process leads to desirable outcomes such as reductions in crime and pollution (Shapiro, 2006).
10.	The combined use of software systems, server infrastructure, network infrastructure, and client devices to make the critical infrastructure components and services of a city, which include city administration, education, healthcare, public safety, real estate,

	transportation, and utilities, more intelligent, interconnected, and efficient (Washburn *et al.,* 2010).

Source: Researchers' own

Generally, as shown in the table above, several smart city definitions have been used over the years, and the main emphasis on these definitions is the use of technology (ICT). However, no one smart city definition is universally accepted and acknowledged as all-inclusive. A quick review of the table also suggests that there are indeed differences in interpreting the smart city concept during the 20 years. This trend continues even today, as reflected on by Albino *et al*. (2015), whose in-depth analysis of smart city literature revealed that the meaning of a smart city is "multi-faceted and that descriptions of smart cities are now including qualities of people and communities" as well as ICTs. Various scholars have attempted to formulate the definition of a "smart city" by binding it with different terms, which is "indicative of the lack of a uniform or widely accepted definition" (Winkowska *et al*., 2019:72). Mora and Deakin (2019), however, are of the view that an initial common understanding has emerged, and representatives of academia, industry, government and civil society organisations all now expect smart city development to become a technology-enabled approach to urban sustainability in which the smart city is seen as an urban environment in which an ICT-driven approach to urban sustainability is activated. Greene (2020) concurs and insists that most smart city theoretical models and definitions point towards the ultimate benefits of a smart city as improved competitiveness and sustainability because of the transformative power of technology.

However, some are sceptical about the smart city concept, such as Allam and Newman (2018:01), who insists that the smart city concept is "a branding exercise by big corporations" within the ICT industry which are mostly concerned with selling their products and services to cities around the world. Kim *et al.* (2017) in Duan *et al*. (2019:488) are quoted as stating that the smart city industry is projected to receive a 400-billion-dollar market by 2040, covering more than 600 cities worldwide. Allam and Newman (2018:20) believe that the smart cities concept promoted by big ICT companies does not consider the values, cultural and historical profiles that some cities hold as legacies and that ICT companies offer "a one-size-fits-all model without considering broader economic development policies" within such cities.

2.2.4 The Fourth Industrial Revolution

The 4IR (4IR) or Industry 4.0 is a concept coined by Klaus Schwab, the founder and executive chairman of the World Economic Forum (WEF). It refers to how technologies like AI, autonomous vehicles and the IoT are merging with humans' physical lives (Schulze, 2019). "The first industrial revolution changed our lives and economy from an agrarian and handicraft economy to one dominated by industry and machine manufacturing. Oil and electricity facilitated mass production in the second industrial revolution. In the third industrial revolution, information technology was used to automate production" (Xu *et al*., 2018:90). The 4IR is building on the past revolutions. It is "characterised by a fusion of technologies that is blurring the lines between the physical, digital and biological spheres" (Schwab, 2016). Rouse *et al*. (2017) refer to 4IR as the "current and developing environment in which disruptive technologies and trends such as the IoT, robotics, virtual reality (VR) and AI are changing the way people live and work". The WEF views 4IR as a combination of technologies that change how people live, work, and interact with each other. This is due to the interconnectedness of the technology, which allows for AI systems to share information in real-time amongst themselves and with people. These systems can then solve complex problems and challenges that take an extended time to analyse and find suitable solutions.

"Leading researchers argue that Industry 4.0 will shape the future through its impact on government and business" (Xu *et al*., 2018:91). This is due to 4IR's progress embedded in technology diffusion, which is "expected to grow exponentially in terms of technical change and socio-economic impact" (Morrar *et al*., 2017:12). The technology innovation within the era of Industry 4.0 is evolving at an exponential rate. It is "disrupting almost every industry in every country, and the breadth and depth of these changes herald the transformation of entire systems of production, management, and governance" Furthermore, 4IR "has the potential to raise global income levels and improve the quality of life for populations around the world", as it can create new open markets and thus drive economic growth (Schwab, 2016).

Industry 4.0 could also lead to higher inequalities, as it can also disrupt labour markets as machines and AI could easily replace labour. Labour is then displaced, which will lead

to socio-economic problems for society. For a country or a region to benefit from 4IR, it is imperative to invest in ICT skills and development initiatives, such as researchers, scientists, artisans and the like who will work with the 4IR industry. Other issues of concern as a result of 4IR technologies diffusion is privacy concerns, hacking, cybersecurity and manipulation of big data for the enrichment of a few. Due to connectivity and sharing of data amongst devices and systems such as cellphones, smart cars, smart homes, smart security cameras and the like, the risk of someone having access to the data that these devices generate increases and makes internet networks vulnerable. Waidner and Kasper (2016) in Manda and Dhaou (2019:247) mention that "security and data privacy issues have arguably become one of the most significant concerns" as far as 4IR is concerned. Industry 4.0 also requires significant investment in infrastructure to support and operate IoT technologies. Furthermore, proper governance systems should be in place to ensure the practical use of these technologies for the benefit of society.

4IR is an important consideration for policy-makers at national, provincial, and local spheres of government in a country like South Africa. There is a high potential for 4IR to be disruptive to businesses and public sector industries, with positive externalities expected to effectively and efficiently do things, including providing basic municipality services at a local level. However, on the downside, some challenges come with such technologies, such as job losses as a result of industries being disrupted, increased inequality, increased cybersecurity threats as a result of IoT and AI systems that can be manipulated, and ethical dilemmas caused by infringement of privacy rights, amongst other issues.

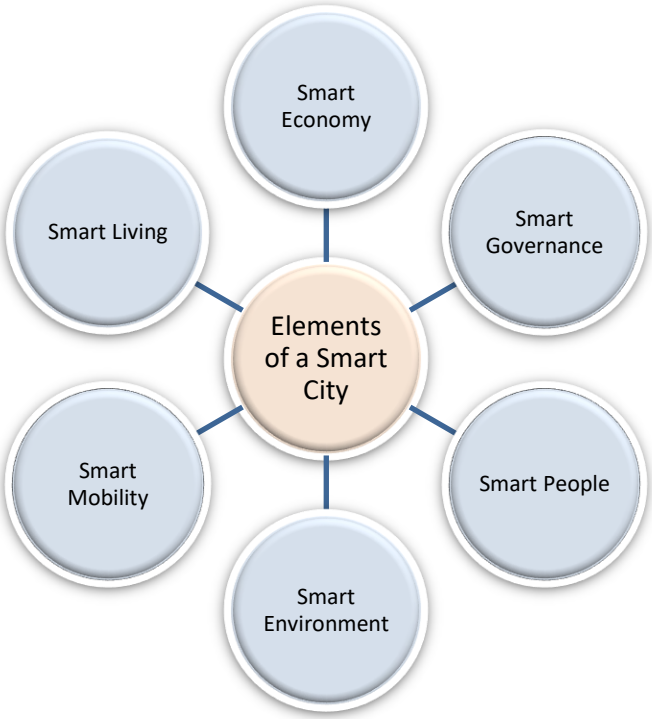
4IR is part of the smart cities concept and provides cyber-physical systems (CPSs) and the IoTs that allow the integration of computation, networking, and physical process, as well as connecting devices to the internet and to each other (Nagy *et al.,* 2018:02; Cowie *et al*., 2020:167). The notion of a smart city corresponds to the city perceived through the lens of the 4IR (Soeiro, 2020:55). Kim *et al.* (2017:159) concur and confirm that IoT applications are "enabling smart city initiatives worldwide" and that IoTs "provides the ability to monitor, manage remotely and control devices and to create new insights and actionable information from massive streams of real-time data". Smart products are developed and operated in these systems to generate, store, and analyse the data to aid

decision-making. As attested by Hobcraft (2019), the 4IR also “enables more effective applications and reduces dependences on overburdening infrastructure through its focus on efficiency and effectiveness in its production”. The application of 4IR within the local government sector is outlined in further detail in section 2.7.

2.3 ELEMENTS OF A SMART CITY

A smart city is a “developed urban area that excels in the area of economy, governance, people and life through strong human capital, social capital and ICT infrastructure” (Dlodlo *et al*., 2016:01). It is an approach to “managing the complexity of city life, increasing efficiency, reducing expenses, and improving citizens' quality of life” (Dlodlo *et al*., 2016:01). According to Lombardi *et al.* (2012:138), “although there is no agreement on the exact definition of a smart city, several main dimensions of a smart city have been identified through a literature review” and include elements such as smart economy, smart people, smart governance, smart mobility, smart environment, and smart living (Giffinger *et al.,* 2007:11; Cohen, 2018). This section focuses on these smart city elements, as depicted in figure 3 below.

Figure 3: Elements of a smart city



Source: Adapted from Duan *et al*. (2019:489)

2.3.1 Smart economy

The smart economy uses emerging technologies to transform and strengthen a city's economy to be economically competitive. It is “focused on businesses and the effect of the business results on the urban area” (Nemtanu *et al.,* 2016:428). A smart economy is “driven by innovation and supported by universities, which provide an ecosystem to grow the entrepreneurial spirit of the people in a society” (Gupta *et al.,* 2017:24). The smart economy deals with “factors all-around economic competitiveness such as innovation, entrepreneurship, trademarks, productivity and flexibility of the labour market as well as the integration in the (inter-)national market” (Giffinger *et al.,* 2007:11). The challenge is considering and integrating all these issues into a city to attract businesses that can aid in increasing economic opportunities for residents and hence the city’s economy in general.

2.3.2 Smart People

The smart people are about the “people who live in the city, who work in the city and the people who have hopes and dreams for the kind of city they will leave for future generations” (Smart Cities Council, 2015:33). Smart people are a fundamental element because “all activities and things in urban areas are the result of human activity”, and thus there is a need to educate people and have a "participative approach of citizen involvement" in all aspects of a smart city (Nemtanu *et al.,* 2016:428). In conformity, Nam and Pardo (2011:287) mention that various human factors, such as “affinity to lifelong learning, social and ethnic plurality, flexibility, creativity, cosmopolitanism or open-mindedness, and participation in public life” are central to the operation of smart cities. Furthermore, issues such as the percentage of the population with secondary-level education, with foreign language skills, with computer skills, invested in lifelong learning and amongst others, a proportion of the population working in the research and development sector, with patents, also contribute to a city’s competitiveness and attractiveness to foreign direct investments (Giffinger *et al.,* 2007:11). Kumar and Dahiya (2017:11) elaborate and argue that although some authors may treat the smart city elements as equals, they disagree and prefer to give prominence to smart people, as they consider smart people to be a fundamental building block of a smart city and that without active participation and involvement of smart people, a smart city would not function efficiently.

2.3.3 Smart Governance

Smart governance comprises of “aspects of political participation, services for citizens as well as the functioning of the administration”. It is about transparent governance and involves public participation in decision-making regarding public and other social services (Giffinger *et al*., 2007:12). Utilising smart governance allows for “an advanced form of e-Governance”, which is about making and implementing the right policy choices by being “open to sharing information and its use” in transparent, collaborative, and participatory decision-making for improved government services, and “operations using intelligent technologies” (Gupta *et al*., 2017:24). Smart governance should not only be seen as a technology issue but rather as "a complex process of institutional change and

acknowledge the political nature of appealing visions of socio-technical governance". It is about “crafting new forms of human collaboration through the use of ICTs to obtain better outcomes and more open governance processes” (Meijer and Bolivar, 2016:392). The fact that smart governance entails a wide range of “technologies, people, policies, practices, resources, social norms and information that interact to support city governing activities” means that it is a critical element and thus represents an important challenge for smart city initiatives (Chourabi *et al.,* 2012:2292).

2.3.4 Smart Mobility

Within the concept of a smart city, smart mobility is about using ICTs to advance transport mechanisms within a city. Giffinger *et al.* (2007:12) emphasise the importance of international and local accessibility to a city as part and parcel of smart mobility. If a city is accessible and there is adequate investment in ICTs and transportation systems, this can lead to innovations that can lead to better, safer, and more sustainable transport systems, which will make a city attractive and competitive. The use of ICTs in designing and operating a city's transport systems can have many benefits for society, such as reducing traffic congestion, which would lead to society not wasting time in traffic, rather using the time productively, which can increase economic growth. Smart mobility innovations for individuals in recent times include ICT-enabled carpooling, car-sharing, on-demand ride services, and bicycle commuting. These initiatives also reduce traffic congestion and foster faster, greener and cheaper transportation options for society.

However, Papa and Lauwers (2015:545) argue that smart mobility is more than just focusing on "techno-centric "and the "consumer-centric" aspects of transport systems. Papa and Lauwers (2015:543) insist that using ICTs to improve a city's transport system's design and operations and cater to transport consumers is just one aspect of a more complex system. They are also of the view that “smart mobility is sometimes used as an evocative slogan lacking some fundamental connection with other central aspects of mobility planning and governance”. According to Campbell (2012) in Papa and Lauwers (2015:547), smart mobility should rather be viewed as an integration between technological, social innovation and the capacity of cities to create the conditions of a continuous process of learning and innovation. In this way, Papa and Lauwers (2015:547)

hold that this approach looks “at smart mobility as a system capable of using ICT extensively and intelligently, to improve the overall urban performances and, above all, the quality of life of citizens”.

2.3.5 Smart Environment

A smart environment is about taking care of the natural resources within cities by using such resources efficiently to ensure sustainability. Issues such as pollution, natural environment protection, waste management, greenery and the efficient use of natural resources take prominence (Giffinger *et al*., 2007:12). The use of innovative technologies such as “solar energy and other renewable sources of electricity can also enhance the natural environment” (Letaifa, 2015:1416). Essentially, for a smart city to be sustainable, “all urban components (from transport to housing) have to be environmentally friendly and be able to regenerate the environment” (Nemtanu *et al*., 2016:428). Ensuring a smart environment allows a city to better manage the built and natural environment to improve citizens and visitors' liveability and competitiveness.

2.3.6 Smart Living

Smart living is about security and quality of life for citizens of a smart city. It comprises various aspects of improving quality of life, such as housing, culture, health, safety, schools, museums, and sports facilities. The availability and access to such facilities enhance attractiveness to the city for tourists and investors and promotes social cohesion amongst society (Giffinger *et al*., 2007; Lombardi *et al*., 2012; Albino *et al*., 2015; Letaifa, 2015; Gupta *et al*., 2017).

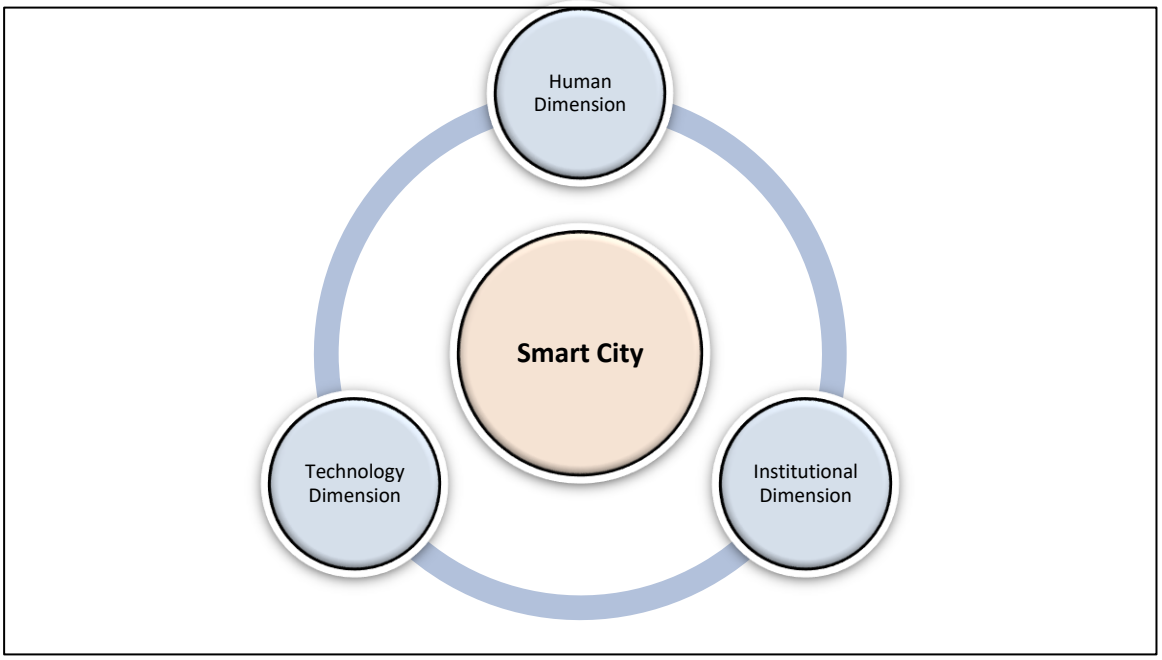
2.4 CORE DIMENSIONS OF A SMART CITY

There has been an increased use of the word smart city and related terms since the early 1990s, and this concept has become more and more popular “in scientific literature and international policies” (Albino *et al*., 2015:03). An in-depth analysis of the smart city literature by Albino *et al*. (2015) reveals that the meaning of a smart city is multi-faceted; however, the labels of such a city can be "largely categorised into three dimensions of

technology, people, and community". Nam and Pardo (2011:282) conform and state that there is "a set of common multidimensional components" in most smart city definitions, with attributes of “technology, people, and institutions” (Nam and Pardo, 2011:282). The technology aspect infuses integrated infrastructure and technology-enabled services, while social learning strengthens human infrastructure, and the governance aspect is for “institutional improvement and citizen engagement” (Nam and Pardo, 2011:282).

Technology, in this instance, is the enabling hardware and software infrastructure, while people are about creativity, diversity, and education of people managing the city. The institution element refers to the necessary governance frameworks and policies that must be in place for a smart city to succeed. Caragliu *et al*. (2011:65), in their research paper, found that “the presence of a creative class, the quality of and dedicated attention to the urban environment, the level of education, multimodal accessibility, and the use of ICTs for public administration are all positively correlated with urban wealth”. This means that cities that can effectively use technology, human capital and have good e-Governance policies and frameworks to oversee these activities, are better positioned to provide sustainable living conditions for citizens. Hence, Caragliu *et al*. (2011:70) believe that a city is smart when it "invests in human and social capital, traditional transport, natural resource management, and modern ICT communication infrastructure as well as participatory governance", which in turn fuels sustainable economic growth and high quality of life for citizens. This section looks at these three key components or dimensions of a smart city identified in the literature, as depicted in figure 4 below.

Figure 4: Core dimensions of a smart city



Source: Adopted from Pozdniakova (2016:2)

2.4.1 Technology dimensions

Most academics, public and private sector researchers such as Giffinger *et al*. (2007), Caragliu *et al*. (2009) and Washburn *et al.* (2010), amongst others, agree that for a city to be smart, there is a need to embrace technological innovation in planning and managing cities. Pozdniakova (2016:01) asserts that the "technology dimension focuses on mobile and smart technologies, physical infrastructure and digital networks and presupposes commercial application of smart products and solutions". Sikora-Fernandez and Stawasz (2016:87) also indicate that "the role of advanced technologies in the city's functioning is a characteristic and significant element" of a smart city. Since smart cities rely on Industry 4.0 ICT technologies such as IoT and cyber-physical systems, which allow applications such as AI, big data analysis, nanotechnology, and others to collect data, store data, analyse data and provide possible solutions to challenges faced by cities, cities need to invest in technological infrastructure. ICT technology is a requirement in the process of building a smart city, and this means that cities that want to follow this route are to invest heavily in technological infrastructure, including hardware and

software, to enable ICT devices to communicate, share, analyse and provide proposed solutions to city management and public policy analysts.

2.4.2 Human dimensions

Even though a city can have an abundance of world-class ICT infrastructure, enabling it to use 4IR tools, if there are no humans available to oversee the technological aspects, then such a city would fail. It is important to have qualified and skilled personnel who can apply technology to solve societal problems. Duan *et al*. (2019:489) view creativity as the main driver of a smart city, and human beings pose that creativity. Through education, learning and knowledge transfer, which are central to the importance of the smart city concept, humans become smarter and more creative and use technology to improve public service delivery. Nam and Pardo (2011:287) emphasise that problems associated with urban agglomerations can be solved through creativity, human capital, cooperation among relevant stakeholders, and bright scientific ideas to solve challenges faced by cities.

2.4.3 Institutional dimensions

The institutional dimension of a smart city includes “smart governance and policy to build a smart community where each actor such as government, business and society understands the potential of ICTs and is willing to use them to make the environment around a better place for living and developing” (Pozdniakova, 2016). Good governance frameworks and policies should be developed and adopted to ensure public participation in all critical city decision-making processes for a smart city to be effective. Transparency is necessary to ensure that stakeholders feel and own the smart city initiatives. In this instance, governance, according to Misuraca (2010) in Castelnovo *et al*. (2016:725), is the "use of ICTs to simplify and improve the internal administrative operations of government comprehensively; facilitate public service interaction between government, citizens, and other stakeholders; enable citizen participation, and ensure inclusiveness and equal opportunity for all”. The institutional dimension deals with non-technological factors at individual, cultural, organisational, and societal levels to consider when implementing a smart city.

2.5 PHILOSOPHICAL PERSPECTIVES TO THE ROLE OF GOVERNMENT IN SOCIETY

A government is a “group of people who officially rule or control a country” (Reynolds *et al.*, 2019:275). These people undertake certain activities to produce value for citizens. Governments use public administration as a means of providing desired values of citizens. Peters and Pierre (2012:03) describe public administration as “an explication of the collective interest” and argue that its legitimacy to a significant extent hinges on its “ability to play a part in the pursuit of those interests”. The primary reason for public administration is to improve the general welfare of the public, and it entails certain activities necessary to improve the material and personal social welfare of communities (Van der Waldt and Du Toit, 1999:307). Levi (2006:05) supports this view of a government and its implementation tool, and he argues that a good government is the one that is “representative and accountable to the population it is meant to serve”.

Furthermore, Levi (2006:05) mentions that a good government is effective if it can "protect the population from violence, ensure the security of property rights, and supply other public goods that the populace needs and desires”. In this section, the philosophical dimensions of the role of government in society and how resources, inclusive of technology, are utilised to adhere to its mandate will be briefly discussed from the classical views of the State in the western world, through paradigmatic development of public administration theory, from public administration until the new public service approach to governance until the modern-day good governance-based philosophies. This section thus provides valuable insights into how technological evolutions contributed to the role of government in society. It traces the early origins and the emergence of technological applications in governance and how they transformed the role of government in society. The government-society interaction, policy-making, and gradually transforming governance praxis are also explored.

2.5.1 Classical views of the State in the western world

Classical philosophers lay a solid foundation for the contemporary scholarly discourse regarding the role of the state in society. Below, is a brief summary of some of the most prominent philosophies.

2.5.1.1 Socrates, Plato, and Aristotle (470 BCE – 322 BC)

Plato's political thought was the legacy of his mentor, Socrates, who was a pivotal figure in the history of ancient philosophy (Devereux, 2011:98). Comprehension of Socrates's philosophical activities and ideas mainly emanates from reports of others, such as Plato and Xenophon. According to Socrates, the aim of a political community is the happiness of its members, and as such, the laws and institutions of the community should be designed with this overarching aim in mind (Devereux, 2011:99). Similarly, Plato believed that the purpose of a political community is to attain the best possible life for its inhabitants and that the way to achieve this is to ensure that those who rule have an accurate understanding of human nature and of what makes human life truly worthwhile (Devereux, 2011:98). Aristotle, a protégé of Plato, also thought that the state was created as the highest community to achieve happiness (Aliu, 2018:39).

The old political debate between Plato and Aristotle is important to modern political philosophy as it is the basis of modern political theories (Aliu, 2018:36). Ancient philosophers were interested in studying social phenomena by which society functions. Plato thought the state was created because of people's inadequacy as individuals, while Aristotle thought the state was created as the highest community to achieve happiness (Aliu, 2018:39). Plato and Aristotle were against democracy, a government in which the "supreme power is vested in the people and exercised by them directly or indirectly through a system of representation usually involving periodically held free elections" (Merriam-Webster, 2020). According to Aliu (2018:37), they were against democratic practices since they believed it was an inappropriate form of government. Plato believed that democracy does not provide governance from the most capable people and contains many deficiencies through general equality. On the other hand, Aristotle loathed

democracy because it did not yield successful leadership for citizens. Instead, Plato and Aristotle preferred aristocracy, which is “a government by a relatively small, privileged class or by a minority consisting of a high social class of those presumed to be best qualified to rule” (Merriam-Webster, 2020). Plato believed that aristocracy provided the leadership of the most capable and prepared people for this task, while the main reason for Aristotle was that the aristocracy ensures the proper dependence of all people as per their social strata (Aliu, 2018:37).

2.5.1.2 Marcus Tullius Cicero (106 BCE– 403 BCE)

Like Socrates, Plato and Aristotle, Marcus Tullius Cicero also believed that a government or a republic is a collection of society brought together by agreement on justice and a partnership for the common good of society, including the protection of property rights of each member citizen.

Cicero advocated for a government based on the consent of the governed, the people. He recognised that some deliberative body must govern every republic if it is to be permanent and that this governing body can either be a kingdom, aristocracy, or a popular government, where all the power is in the hands of the people. If the bond which originally joined the citizens together in the partnership of the state holds fast, any of these three forms of government may be tolerable. Cicero believed that the rule of law is central to a government and that the rule of law will guarantee property rights to individuals and entities. "According to Cicero, the state exists to uphold laws which are in harmony with the universal principles of nature. If a state does not uphold right reason in agreement with nature, it is not a state” (Meany, 2018).

2.5.1.3 Dante Alighieri (1265– 1321) and Niccole Machiavelli (1469 – 1527)

Dante advocated for a necessity of “a single ruling power, a universal monarchy, reverent toward but independent of the Church, capable of ordering the will of collective humanity in peace and concord”. Dante argued that wars and all their causes would be eliminated

if “the whole earth and all those humans can be possessed to be a monarchy”, that is, one government under one ruler. Dante argued that there must be an individual leader to act as both lawgiver and enforcer of the peace, in alignment with Aristotelian philosophy that social groupings most thrive under the leadership of a single person (Reiner 2010:351). The universal monarch would possess everything and would not desire to possess anything further, and thus, he would “hold kings contentedly within the borders of their kingdoms and keep peace among them” (Lederman and Forman, 2000:169). Similarly, Machiavelli believed that as a ruler, it was better to be widely feared than to be greatly loved and that a loved ruler retains authority by obligation, while a feared leader rules by fear of punishment (Machiavelli, 1532:120). Furthermore, to retain power, the hereditary prince must carefully balance the interests of various institutions to which the people are accustomed.

2.5.1.4 Thomas Hobbes (1588 –1679), John Locke (1632–1704) and Jean-Jacques Rousseau (1712-1778)

According to Thomas Hobbes, for there to be peace, it is necessary to “establish a common power through mutual agreements” of individuals of a society. For society to maintain peace, laws that established the institution of common power must be adhered to. The purpose of establishing this common power is to “escape from the condition of war, which seriously threatens each person’s conservation” (Finn, 2020). Just as the common power was established by society, it can be dissolved again by individuals who make up society; if this is “not possible, then the commonwealth will revert to a state of war” (Finn, 2020). Similarly, John Locke’s political philosophy defended the claim that men are by nature free and equal against claims that God had made all people naturally subject to a monarch (Alex and Locke, 2020). Locke justified a legitimate political government, as he advocated for the principles of majority rule and the separation of legislative and executive powers. He viewed a government as legitimate because of a social contract where people in the state of nature conditionally transfer some of their rights to the government to ensure better the stable, comfortable enjoyment of their lives, liberty, and property (Alex and Locke, 2020; William and Locke, 2020). It implied that a government exists by the consent of the people, who transfer some of their rights to the state to protect the rights of society and promote the public good. Locke argued that if a

government fails to protect rights such as the right to life, liberty, and property, such a government can be resisted and replaced with another new government that can protect these rights of citizens. Jean-Jacques Rousseau, like Hobbes and Locke before him, believed that all men are made by nature to be equals; therefore, no one has a natural right to govern others, and therefore the only justified authority is the authority that is generated out of agreements or covenants (Friend, 2020). Furthermore, Rousseau saw property rights as another reason to form agreements to protect these property rights. These agreements or contracts that led to men ceding some of their rights to this representative body, the government, is purported to guarantee equality and protection for all, which Rousseau referred to as a naturalised social contract. Rousseau argues that laws are binding only when supported by the people's general will (British Library, 2020).

2.5.1.5 Charles-Louis de Secondat (1689-1755)

Charles-Louis de Secondat, popularly known as Montesquieu, in his book, the spirit of laws, maintained that there were three types of government, a monarchy (ruled by a king or queen), a republic (ruled by an elected leader), and a despotism (ruled by a dictator). Montesquieu believed that a government elected by the people was the best form of government (Trussell, 2012). Montesquieu felt that a republic's success depended on maintaining the right balance of power and that there should be a separation of power. According to Trussell (2012:121), Montesquieu advocated creating three separate government branches with equal but different powers. This way, the government would avoid placing too much power on one individual or group of individuals. Under Montesquieu's model, the state's political authority should be divided into legislative, executive, and judicial powers, and these three powers must be separated and act independently. The separation of powers means dividing government responsibilities into distinct branches to limit any one branch from exercising the core functions. The intent is to prevent the concentration of power and provide for checks and balances (NCSL, 2019).

2.5.2 Modern conceptions of the state

Built upon the early conceptions of the role of the state, more contemporary theories inform scholarly inquiry into statehood, governments and governance.

2.5.2.1 Public Administration Theory

Traditional public administration "comprises of all those activities involved in carrying out the policies and programmes of governments" (Naidu, 1996:4). Frederickson (1980:5) contends that traditional public administration was about "efficient, economical and coordinated management" of public services and focused on top management or the basic auxiliary staff services such as "budgeting, organisation and management, systems analysis, planning, personnel, purchasing". Frederickson (1980:5) maintains that the rationale for classical public administration was almost always to have better and more efficient or economic management. Hughes (2012:44) reiterated this view and indicated that the classical theory of public administration could be characterised as a strict administration "under the formal control of political leadership, based on a rigid hierarchical model of bureaucracy, staffed by permanent neutral and anonymous officials motivated only by the public interest, serving any governing political party equally, and not contributing to policy but merely administrating those policies decided by the politicians".

The key element of traditional public administration included dominance of the rule of law, complete with standardised procedures, separating thinking and action, separating policy formulation and implementation, political and administrative dichotomy and the government solely taking charge of public goods and services, amongst others (Osborne, 2006:378; Xu *et al.*, 2015:12). Woodrow Wilson's politics-administration dichotomy that viewed politics and administration as separate in undertaking public administration and Max Weber's model of bureaucracy were some of the main theoretical foundations of traditional public administration (Hughes, 1992:294). Wilson believed that the administrators of executive institutions needed to operate professionally and involve themselves purely with governments' business and operational aspects and be removed

from the disharmony of politics (Naidu, 1996:36). It saw politicians developing policies that are then supposed to be implemented by trained, skilled administrators.

Traditional public administration theory was criticised for emphasising bureaucratic practices and treating public administrators as mechanical pawns that do not involve themselves on policy issues but only concentrate on implementing, without interference, the political agenda of politicians (Hughes, 1998:22). This was viewed as unrealistic and not representative of dynamic government thought-out the world. Traditional public administration “reached its high point in the UK in the post-1945 era of the welfare state, when the state was confidently expected to meet all the social and economic needs of the citizenry”. The traditional public administration theory came under criticism by academics and political elites of the time due to its inedibility to solve the socio-economic needs of society at that time (Osborne, 2006:378). The theoretical pillars of public administration were no longer seen as being adequate to analyse and solve the realities of governments (Hughes, 2012:72). Hughes (1992:286) had earlier argued that the traditional model of public administration had been irrelevant for many years and had “outlived its usefulness” and was “never efficient or effective and deserved to be replaced”. Furthermore, Rosenbloom *et al.* (1994:41) in Sindane (2004:669) insist that the traditional theory of public administration was criticised for its inability to implement and achieve public administration goals, and the argument was "premised on the proposition that public administration had little to offer anyone studying performance”. According to Sindane (2004:669), implementation in traditional public administration focused on bureaucracy issues such as public agencies and employees’ behaviours and outcomes of public programmes.

2.5.2.2 New Public Administration Theory

Traditional or old public administration relied on centralised control, set rules and guidelines, separated policy-making from implementation, and employed a hierarchical organisational structure (Osborne, 2006). However, it "failed to provide effective theoretical guidance for the contemporary government management" (Xu *et al.*, 2015:12),

which led to developing a new public administration theory to address these shortcomings. According to Frederickson (1980:06):

> “New Public Administration adds social equity to the classic objectives and rationale. The Conventional or classic Public Administration seeks to answer: 1. How can we offer more or better services with available resources (efficiency)? 2. How can we maintain our level of services while spending less money (economy)? Nevertheless, NPA adds another question: Does this service enhance social equity?"

Later on, Frederickson *et al. (*2012:133) upheld that the new public administration is different when compared to classical public administration in that "public administrators and public agencies are not and cannot be either neutral or objective; bureaucratic hierarchy is often ineffective as an organisational strategy; cooperation, consensus, and democratic administration are more likely than the simple exercise of administrative authority to result in organisational effectiveness, and that modern public administration must be more democratic, more adaptable and more responsive to changing social, economic, and political circumstances" (Frederickson *et al.,* 2012:133).

2.5.2.3 Public Management Theory

Frederickson (1980:5) attests that NPA is not ‘new’ and that "parts of NPA would be recognised by Plato, Hobbes, Machiavelli", as well as many other modern behavioural theorists. The key was introducing a management aspect to new public administration and shifting the focus towards public management. Hughes (1992:286) argues that the work now carried out by public services is management rather than administration. According to Van der Waldt and Du Toit (1999: 16), public management is regarded as part of public administration. Public management or managerialism is about the work of only those engaged in performing the managerial functions in a public organisation. Public management focuses on planning, leading, organising, controlling, and coordinating government operations. Public management emerged as a new approach to management in the public sector in the 1980s and 1990s, as a direct response to what

many have regarded as inadequacies of the traditional public administration model. Public management was not "derived by simply transferring private management techniques to the public sector, but rather by consideration of what management entails, what the key features of public sector management are, and derivation of a new system of management for the public sector" (Hughes, 1992:294).

Managerialism rests upon the assumption that “better management (rather than better policies, new technologies, and different kinds of constitutional arrangements) offers societies the best chance of material progress” (Pollitt, 1998:47). Hartley (1983:26) in Pollitt (1998:47) emphasises that managerialism ideology consists of values and beliefs or ideas about the state of the world and what it should be, and it concerns itself with "social groups and social arranges, and how resources are to be ordered and distributed". Hartley (1983:26) argues that managerialism is developed and maintained by social groups and thus is a socially derived link between the individual and the group. Adding more emphasis to the evaluation of government programmes to ascertain whether government programmes are working or not in meeting their desired goals is another defining feature of public management that is not emphasised in classical public administration theory.

2.5.2.4 New Public Management Theory

New Public Management (NPM) is about “a cluster of ideas and practices that seek, at their core, to use private-sector and business approaches in the public sector” (Denhardt and Denhardt, 2000:550). Pollitt and Bouckaert (2011) in Christensen (2012:01) argue that under NPM, politicians have "a strategic, goal-setting role, and civil servants are supposed to be autonomous managers held to account through performance arrangements and incentives", such as is the case in private sector environments. Robinson (2015:07) of the UNDP Global Centre for Public Service Excellence maintains that the NPM paradigm arose in reaction to the limitations of the old public administration in adjusting to the demands of a competitive market economy. It uses competitive market principles to address and avoid failures in the public sector and be more responsive to

citizens by offering value for money, the flexibility of choice and transparency (Kalimullah *et al*., 2012:7; Çolak, 2019:520).

Parker and Guthrie (1993) in James (2005:4) assert that NPM, in essence, is grounded in two fundamental philosophies of managerialism and economic rationalism. Unlike classical public administration, managerialism views management as a distinct and separate activity that plays the crucial integrative role in bringing together plans, people and technology to achieve desired results (Pollitt, 1998:47). At the same time, economic rationalism is "an economic policy based on the supposed efficiency of market forces, characterised by minimal government intervention, tax cuts, privatisation and deregulation of labour markets" (Collins Dictionary, 2020). NPM originated from such crisis of the Keynesian welfare state in the 1970s in developed countries such as the UK, Australia and New Zealand, and it marked a shift from public administration to public management, intending to slim down the state and make it more efficient and effective (Larbi, 1999). Early advocates of NPM include the UK's Prime Minister between 1979 and 1990, Margaret Thatcher. In the opinion of Osborne (2006:378), Thatcher (1995) "asserted the superiority of private-sector managerial techniques over those of traditional public administration and with the assumption that the application of such techniques to public services would automatically lead to improvements in the efficiency and effectiveness of these services".

The key elements of the NPM include "attention to lessons from private-sector management; the growth of both hands-on management and arm's length organisations where policy implementation is organisationally distanced from the policy-makers; a focus upon entrepreneurial leadership within public service organisations; an emphasis on input and output control and evaluation and upon performance management and audit; the disaggregation of public services to their most basic units and a focus on their cost management; and the growth of the use of markets, competition and contracts for resource allocation and service delivery within public services" (Osborne, 2006:378). Thus, the proponents of NPM are in favour and argue that the use of free-market principles is the best way to improve efficiency and effectiveness by the government.

One of the most representative theories of the new public management theory system was the Entrepreneurial Government proposed by Osborne and Gaebler (1993) in “Reform of the Government” (Xu *et al.,* 2015:12). Osborne and Gaebler (1993) made the case that a government can be transformed in much the same way that many corporations have been transformed, to become more attuned to customer needs, less bureaucratic, more flexible, more innovative, more entrepreneurial and more effective. Furthermore, Osborne and Gaebler (1993) suggest that governments should steer, not row the boat, implying that the role of government should rather be ensuring that service delivery is provided, not necessarily be the one to provide it. Osborne and Gaebler (1993) believe that the government could achieve this by empowering communities to solve their problems rather than simply delivering services. The government could be more effective by encouraging competition rather than monopolies, being driven by missions rather than rules, and being results-oriented by funding outcomes rather than inputs. Osborne and Gaebler (1993) insist that the government should not be bureaucratic; rather, it should concentrate on meeting customers' needs by earning money rather than spending it and investing it in preventing problems rather than curing crises. Osborne and Gaebler (1993) advocate for government authority to be decentralised and for the government to solve problems by influencing market forces rather than creating public programmes.

Critics of NPM have lambasted the contradictions within the NPM movement. A literature review conducted by Androniceanu (2007:154) suggests that NPM is not a homogenous whole but has several and sometimes overlapping elements that represent trends in public management reforms in OECD countries. Denhardt and Denhardt (2000:550) insist that “the values promoted by NPM and the tensions between the emphasis on decentralisation promoted in the market model and the need for coordination in the public sector, the implied roles and relationships of the executive and legislative branches and the implications of the privatisation movement for democratic values and the public interest” are contradictory. Osborne (2006) also notes that other scholars view NPM as not one paradigm but rather as representative of a cluster of ideas, depending on the audience. Many others argue that NPM was only limed to the UK, New Zealand and in some instance in the USA, although in a different format, thus it cannot be regarded as a school of thought but rather a subset of public administration. Furthermore, Denhardt and Denhardt (2000) reiterate that other scholars have suggested that public

entrepreneurship could threaten and undermine democratic and constitutional values such as fairness, justice, representation, and participation.

2.5.2.5 Public Governance Theory

Christensen *et al.* (2007) in Christensen (2012:08) reflect that the emergence of post-NPM reforms is because of a combination of "external pressure from the technical and institutional environments, learnings from problematic elements of NPM reforms and deliberate choices by political executives, based on concerns about political control and capacity, scepticism on whether NPM can deliver on their promises, the fear factor and social concerns". Post-NPM reforms include governance and new public service. Governance, new governance, or new public governance (NPG), as defined by Xu *et al*. (2015), as the post-NPM paradigm that emphasises pluralism and attaches great importance to the links between internal and external organisations to organisational governance issues. Osborne (2006:377) contends that NPM was a transitory phase in the evolution of public administration from traditional to new public governance. According to the OECD:

> “Public governance refers to the formal and informal arrangements that determine how public decisions are made and how public actions are carried out, from the perspective of maintaining a country’s constitutional values when facing changing problems and environments. The principal elements of good governance refer to accountability, transparency, efficiency, effectiveness, responsiveness, and the rule of law. There are clear links between good public governance, investment, and development. The greatest current challenge is to adapt public governance to social change in the global economy. Thus, the evolving role of the State needs a flexible approach in the design and implementation of public governance” (OECD, 2015:2).

Similarly, Xu *et al.* (2015:14) mention that public governance emphasises the dispersion of power between the government, the market, and non-profit organisations within society. All these players have the right to participate in public affairs and provide suitable

solutions to societal problems. It conforms with the World Bank (1991), which emphasises that governance is "how power is exercised in managing a country's economic and social resources for development". Governance beyond the public sector has to do with the management of the rules and institutions to create "a predictable and transparent framework for the conduct of public and private business, as well as accountability for economic and financial performance". Practising good governance, therefore, involves the interaction between the formal institution and those in civil society and refers to a process whereby elements in society wield power, authority and influence and enact policies and decisions concerning public life and social upliftment (Sharma, 2004:10). Graham *et al*. (2003) also reiterate that governance is not synonymous with the government; rather, it is partly about "how governments and other social organisations interact, how they relate to citizens, and how decisions are taken in a complex world".

Public governance theory, in this instance, places the role of coordination within the area of responsibility of the government. Instead of the government being the centre and the source of policy formulation and implementation, the government plays a coordination role considering inputs from other role-players and thus integrates social organisations and individuals to form a complex network. This complex network "is based on the resource exchange" and "relies on trust and stability of the contracts", as well as being formed by public products and services that can provide network members with abundant social resources to exchange currency, information, and technology. Therefore, public governance theory values the role of public social organisations, over and above the output and result of the public sector and the emphasis of the market role in providing public goods and service processes by the NPM (Xu *et al.,* 2015:14).

The government approach must be small instead of big within public governance, which is more suitable to current government public administrations that use complex networks to provide public services. A government operating within a public governance environment focuses on its operations and pays particular attention to the efficiency of the public administration and citizens' participation in governance issues.

2.5.2.6 New Public Service Theory

The New Public Service (NPS) "describes a set of norms and practices that emphasise democracy and citizenship as the basis for public administration theory and practice" (Denhardt and Denhardt, 2000:664). NPS philosophy places citizens, citizenship, and the public interest at the forefront of the role of a government. The NPS philosophy was introduced as a set of norms and practices in 2000 by Janet and Robert Denhardt. According to Denhardt and Denhardt (2015:664), NPS “argues that the explicit consideration of democratic values and citizenship by public administrators will have benefits in terms of building communities, engaging citizens, and doing government work more effectively". Essentially, NPS is “a set of ideas about the role of public administration in the governance system that places citizens at the centre” (Denhardt and Denhardt, 2000:550).

The NPS approach advocates for public interest as the "aim and not a by-product" of public services. In this way, the role of public administrators is to contribute to building a shared collective and responsibility of the notion of public interest, instead of attempting to control, influence and steer society in any direction preferred by the public administrator. Policies and programmes meeting the public interest and needs can then be pursued and achieved through strategic collective efforts and collaborative processes. The NPS insists on "building relationships of trust and collaboration with and amongst citizens" by the public administrator to serve society's needs better. Unlike the NPM, which places market mechanisms in high regard, the NPS attests that the public administrator should also be more attentive to "statutory and constitutional law, community values, political norms, professional standards, and citizen interests". In the opinion of Denhardt and Denhardt (2000), the NPS, from a theoretical perspective, is "an alternative that has been built based on theoretical explorations and practical innovations” and “offers an important and viable alternative to both the traditional and the now-dominant managerialist models”. Like NPM, NPS also values democratic principles and views such principles as important in how a democratic system of governance should be designed. Additionally, values advocated by NPM, such as efficiency and productivity, should not be lost but should be placed in the larger context of democracy, community, and the public interest (Denhardt and Denhardt, 2000:557). However, since the

establishment of NPS theory was based on the criticism of the theory of NPM, some critics of it are of the view that NPS's theory source is thin and lacks originality, and that will make it hard to survive and be developed further under complex public management backgrounds (Xu *et al.*, 2015:12).

Based on the above orientation, it is evident that Socrates, Plato, and Aristotle all agree that skilled and knowledgeable people should administer the state or government to achieve happiness for society's best. It means that these philosophers were concerned with the efficiency and effectiveness of producing public goods in the best interests of society. Therefore, available resources must be employed using the best available methods and processes. ICT has proven to do just that in the private sector, and as such, its employment within the public sector to improve public service delivery is aligned to Socrates, Plato, and Aristotle's views. Similarly, if a government could access a better way to administrate the rule of law, Cicero believed that such a government would hold fast. Mechanisms such as ICT would be acceptable, in this case. Other philosophers also advocated for a government that protects property rights and provides safety to citizens.

This section focused on governance models that advocated for the separation of politics and administration and incorporating private-sector principles into the public sector environment to make government better and more effective in providing services. The role of government in society is advanced by employing capable and qualified people to run the administration using effective means such as ICTs. From the above, it can be seen that paradigms, such as the NPM, Governance and NPS, embrace market principles and try to move away from the old and slow bureaucratic way of doing things, which results in weaknesses such as big unmanageably sized public service, managerial inefficiency, public inaccessibility, economic inertia, excessive corruption, and self-serving agenda (Haque, 2004). Since the introduction of NPM, society has seen an increased use of technology to overcome some of the weaknesses of the earlier paradigms of public administration. Initiatives such as e-Government and e-Governance were introduced to make governmental transactions more consumer-friendly cost-effective, and increase inter-organisational communication (Adams and Smith, 2008). Since the time of the NPM era, there has been an increased usage of ICTs to meet the requirements of citizens and business entities as customers of government. In recent

times, investments in 4IR and smart city initiatives by the government around the world was a response to try new ways of providing government service as advocated by the NPS's supporters. The role of government is to provide public services and provide conditions for private entities to thrive. Therefore, it is the responsibility of the government to find efficient and effective ways of using its power of regulation and influence to run an administration that is sustainably backed up by technology advancement mechanisms such as 4IR and smart cities technologies. Therefore, the usage of ICT and smart cities is an extension of government services in alignment with the role of government in society.

2.5.3 Chronicles of the advancement and application of ICT in government settings

There have been several technological innovations in recent times, and such innovations have found their way into public sector settings. Innovation to the computer, computer language and software is at the heart of ICT and the 4IR developments that followed. ICT refers to technologies such as the internet, intranets, extranets, ERP, and other such technologies that cover the spectrum from basic infrastructure implementation to technologies that improve services and operations in an organisation (Gupta *et al.*, 2008). Yates and Van Maanen (2001: XII) view information technology as simply those mechanisms used to organise, store, manipulate, present, send and retrieve information. Using ICT allows society to deal with their needs simpler, easier, and faster. Technology offers new opportunities for government to deliver services to citizens and businesses while connecting with civil society to increase transparency and accountability (Republic of South Africa, 2017:01). ICTs allow governments to offer public services and provide information and policies more efficiently (OECD, 2002:78).

The modern computer can be traced back to 1930, and this innovation was incremental, with dozens of scientists and mathematicians building on their predecessors (Olito, 2019). As technology innovation increased, so did computing. The 1930s marked the beginning of calculating machines, which were considered the first programmable computers, and in the 1940s, computers took up entire rooms, like the ENIAC, which was once called a mathematical robot. In the 1950s, computers were strictly used for scientific and

engineering research, like the JOHNNIAC, once described as a "helpful assistant" for mathematicians (Olito, 2019). In 1953 Grace Hopper developed the first computer language, known as COBOL (Common Business Oriented Language). Over the next decade, COBOL became the default choice for writing business applications (Zimmermann, 2017; Yegulalp, 2020). In the 1960s, everything changed when Programma 101 became the first desktop computer sold to the average consumer. Until 1965, computers were reserved for mathematicians and engineers in a lab setting. However, Programma 101 changed everything by offering the public a desktop computer that anyone could use. The 65-pound machine was the size of a typewriter and had 37 keys and a printer built-in (Olito, 2019).

Initially, the private sector started to employ computers to fast track their processes as computers were more efficient for some administrative tasks. Similarly, the government also started to use computer technology as there was a need to find a better way of providing public services. The United States Federal Government was one of the governments in the world to massively fund computer technology research. According to the Comptroller General of the United States, the US Federal Government increased its computers from only two in 1950 to 15 800 in 1980. The reason cited for the increased computer usage was that the government needed to be a large user of computers because of increased government services, population growth, and concern for efficiency and effectiveness. The interest in computers saw the federal government making significant contributions to the research base for computing technology (National Research Council, 1999:136).

Other governments worldwide followed suit and started to use computer technology in a wide range of government services, such as military, agriculture, academics, and others. Very soon, it became clear that through the usage of computer technology, it was possible to gain new knowledge and insight through the massive computation capacity of the computers. This era of computing innovation was just as important as other technologies that came from previous dominant innovations in the first to third industrial revolutions. As the US National Research Council (1999:17) mentioned, these earlier eras witnessed “transformations wrought by steam power, internal combustion engines, and electricity”

while the 1990s saw the development, elaboration, and diffusion of a general-purpose technology that transformed society.

Related industries and businesses were created using the information and knowledge from computers' computational abilities to create value and develop a knowledge-based economy. Chen and Dahlman (2005) in Barkhordari *et al*. (2019:1169), indicate that a knowledge-based economy is built upon four pillars: “it requires an economic and institutional framework that provides incentives for the efficient creation, the dissemination, and the use of knowledge to promote growth and increase welfare; it needs an educated and skilled population that can create knowledge and use it; innovation systems that can tap into the growing stock of global knowledge, adapt it to local needs, and transform it into products valued by markets as necessary; and a dynamic information infrastructure is required that can facilitate effective communication and processing of information". For this reason, private and public sector companies have invested in researching and processing data through computer technology to come up with ways of leveraging the knowledge that can be extracted from data. For this reason, governments have tried to regulate such industries by putting regulations and frameworks in place to regulate how interested parties can source and analyse data ethically.

There is a quest for high quality technology-enabled public services, and for this reason, it is generally accepted that ICT-enabled public services have the potential to increase productivity, good governance, and accountability. Bekkers and Zouridis (1999:185) indicate that ICTs have made it possible to process and retrieve more information in less time, increasing public service delivery quality and efficiency. Bekkers and Zouridis (1999:186) further argue that using ICTs can lead to “improved access to public services, facilitate remote communication and transaction, and provide linkages and communication across organisational boundaries, both within and between organisations as well as increasing transparency to stakeholders”. Zhan *et al.* (2011:220) concur and indicate that the rapid development of ICT improves productivity, even in the public sector sphere.

e-Government was introduced to guide the government using ICT technologies to improve public services. e-Government delivers government information and services

online through the internet or other digital means. The emergence of e-Government has improved how government delivers public services (Zomorrodian, 2012). Digital, electronic or e-Government applies IT to government processes to improve services to constituents (Chen *et al.*, 2008: XVII). Through e-Government, government departments and agencies can interact better amongst themselves and with citizens, businesses, and civil society in general. Through such interactions, the government is better informed about the public's public service requirements and provides information to these stakeholders. Gupta *et al.* (2008:140) point out that e-Government initiatives worldwide endeavour to integrate ICT to transform the delivery of government services to their stakeholders by improving the quality of services, accountability, and efficiency. Governments worldwide are turning to technology to transform the delivery of basic public services, driving innovations and productivity gains, and improving competitiveness (World Bank (2013). According to the Financial and Fiscal Commission (2016:91), the innovative use of technologies improves internal functioning and the rendering of public services to society.

Schwab (2016) maintains that just as other previous innovations in technology, such as the use of water and steam power to mechanise production in the first industrial revolution, and the use of electric power to create mass production in the second revolution, as well as the use of electronics and information technology to automate production in the third industrial revolution, ICT in the 4IR will lead to massive innovation on how it can be embraced to improve public service delivery and governance. Schwab (2016) further reiterates that the 4IR is building on the third, and it is a digital revolution that has been occurring since the middle of the last century. It is characterised by a fusion of technologies blurring the physical, digital, and biological spheres. In Industry 4.0, governments use IoT and big data technologies to source data from society used in smart city initiatives. Using these technologies, it is possible to predict behaviour, to budget even better for public policy initiatives. Resources can be used better than before, and monitoring and evaluation can happen in real-time and appropriate responses implemented to avoid wastage. Citizens' participation and engagement can be enhanced, and governance protocol better enforced.

2.6 THEORETICAL FRAMEWORKS FOR EMBRACING TECHNOLOGY IN PUBLIC ADMINISTRATION

There are various theories and approaches that are related to the adoption of ICT, of which the 4IR was founded upon. These theories explain why certain technological innovations are adopted and the adoption rate. It is important to examine some of these theories as they provide a basic meta-theoretical underpinning for analysing the adoption of smart city technologies and will provide a background in designing a suitable smart city model for Gauteng-based metropolitan municipalities. Below is a brief exposition of these theories and approaches related to technology adoption.

2.6.1 Critical Mass Theory

Critical Mass Theory refers to "when enough members of a society or community have adopted an interactive innovation so that the further rate of adoption becomes self-sustaining" (Gruenbaum, 2015:142). This term, which was advanced by scholars such as Pamela Oliver and Gerald Marwell, provided an idea that some threshold of participants must be reached before a social movement is accepted and society starts to use it (Oliver *et al.,*1985). After reaching the critical mass point or the tipping point, the speed of adoption of the idea then accelerates greatly.

Oliver and Marwell (2001:292) refer to Critical Mass Theory as a theory of public goods provision in groups. It means that when society starts to accelerate the adoption of a certain idea, such as the usage of ICT, society, in general, will benefit from the positive externalities of embracing an idea. As discussed earlier in the chapter, private sector entities saw and reaped the benefits of applying ICTs in their business processes. It then led to increased efficiency in the production process, which prompted even the public organisations to apply such technologies to provide public goods and services. Once it was evident that ICTs impact private organisations positively, and more and more private organisations were using the technology and society was also seeing a reduction in inefficiencies, the adoption rate of technology became self-sustaining. Hence public administration in the modern era has adopted these 4IR enhanced methods of doing things.

2.6.2 Knowledge Gap Theory

Knowledge Gap Theory occurs when the “infusion of mass media information into a social system increases”, and then “segments of the population with higher socio-economic status tend to acquire this information at a faster rate than the lower status segments, the gap in knowledge between these segments tends to increase rather than decrease” (Tichenor *et al.,* 1970:160). According to this theory, the more highly educated segments of society will have access to more knowledge than the lower poor population, and because knowledge can be used to acquire resources such as wealth, then the educated section of society will benefit more, and there will always be a gap between the two. As the mass media grows, the gap in knowledge between an educated segment of society and the less educated will increase. Tichenor *et al.* (1970:160) maintain that the knowledge gap is consistent with the cumulative change model and that the “acquisition of knowledge about science and other public affairs issues may be viewed as a component of social change". It is because "a given increment of change may lead to a chain reaction appearing as an increased rate of acceptance of a pattern of behaviour, a belief, a value, or an element of technology in a social system" (Loomis and Loomis, 1961; Moore, 1963). This theory, therefore, predicts that technological acceptance will start with the more educated segments of society because they have access to information about the technology and the benefits to be derived from the technology advancement. The more educated advance further than those with no access to information by utilising the technology.

Further down the line, as the technology becomes more accessible, society easily accepts the innovation because the more affluent are already using it, which becomes part of the new social practice. Cities in developing countries have recently started to use terms such as "smart" and "intelligent" cities when describing some of their public service offerings to be seen as following up and adopting technology already being implemented in developed countries.

2.6.3 Muted Group Theory

Muted Group Theory was developed by Edwin Ardener and Shirley Ardener in 1975. It was developed to explain the relationship between men and women and how men marginalised women. According to this theory, women are marginalised and cannot express their views openly because they must express their views in men's language. Over the years, the theory has been used to explain relationships generally between dominant and marginalised groups. According to Smith Barkman (2018:03), this theory is "a sociological tool that aids in the study of interactions between dominant and subdominant groups" and can be used as a framework for articulating such a relationship. The same can be said of the technology. Developed and advanced economies were the early adopters of technology and improved ICT innovations to match their needs. Less developed economies, characterised by poor availability of resources, particularly technological infrastructure, always find themselves at the mercy of developed economies. Their reliance can see it on developed and dominant countries for technological support. It then means they adopt technologies that are not appropriate for their local conditions and are muted, in that their ideas cannot be translated to a language that the dominant developed countries can understand.

2.6.4 Actor-Network Theory

According to Cowan and Carr (2008:149), the Actor-network theory (ANT) is a theory usually associated with studying science and technology and how technology can lead to the social construction of society. Detel (2001:14264) refers to an actor as everything that in some causal way affects the production of scientific statements and theories, while a network as a set of actors such that there are stable relations and translations between the actors, in this way determining the place and functions of the actors within the network. This theory arose from French sociologists' efforts to understand how scientific theories spread within scientific communities, become embedded in the community and are taken for granted as a basis for further scientific progress (McBride, 2003).

Callon (2001:62) contends that studying society is ongoing and that ANT is an attempt to provide analytical tools for explaining the very process by which society `is constantly

reconfigured. It, therefore, implies that technology influences society and its stakeholders, while at the same time, these stakeholders, in turn, influence the direction technology will follow. McBride (2003:266) agrees and states that ANT provides a framework of ideas for describing the process of technology adoption and developing stories that explain technology take-up. The theory suggests that technology is a product of social construction as technical innovation and advancement. Technological success and take-up within an organisation or group will depend on technical and social aspects. McBride (2003:266), in his study, also found that patterns of technology spreading and adoption is affected by geographical factors, both human and physical, government policy, current physical infrastructure, technology availability and ease of use, economic models and culture. Technology uptake within the modern era of public administration stems from how other private sector actors used technology to maximise profits for their shareholders. Soon enough, it was clear that similar technologies could be applied for the wider benefits to society within the public service space.

2.6.5 Socio-Technical Theory

The Socio-Technical Theory is yet another useful framework for understanding the general role of technology in society. Emery (1969) in Hesketh and Graco (2015:104) describes the socio-technical systems model as an organisation model where the technological, social, and managerial components interact. Elements within both the social and technical systems are interdependent and that “organisational system will maximise performance only if the interdependency of the subsystems is explicitly recognised” (Cartelli, 2007:437). This theory hypothesises the presence of two systems in every organisation; the technical and the social system (Cartelli, 2007:01). The theory assumes that these outputs result from mutual interactions between these two systems. Technological change has an obvious and direct impact on the technical system and the social/cultural and management systems, especially concerning modes of communicating and working, and how data is gathered, analysed, and used. The technological system includes all the equipment, infrastructure, and technology in the workplace, while the social system includes cultural and other diverse groups and individuals. The technical system is concerned with the processes, tasks, and technology needed to transform inputs into outputs, while the social system is concerned with the

attributes of people such as attitudes, skills, and values as well as the relationships among people, the reward systems, and authority structures (Bostrom and Heinen, 1977:217; Cartelli, 2007:1; Hesketh and Graco, 2015:104).

According to Manda and Dhaou (2019:245), in Industry 4.0, the human or social and technology or technical dimensions are brought together, which results in increased interaction and interconnectedness of man and machines. Bostrom and Heinen (1977:17) argue that adopting the socio-technical perspective in management information systems research was also because the failure of technology is because of overlooking the importance of the behavioural "and social elements in the design or implementation of new technologies". Therefore, the socio-technical theory suggests that successful technology implementation requires an understanding of social, technical and environmental systems in which they operate in a smart society. In designing a smart city and deciding on which 4IR technologies to employ, cities should properly understand social and technical systems prevalent in their unique local conditions.

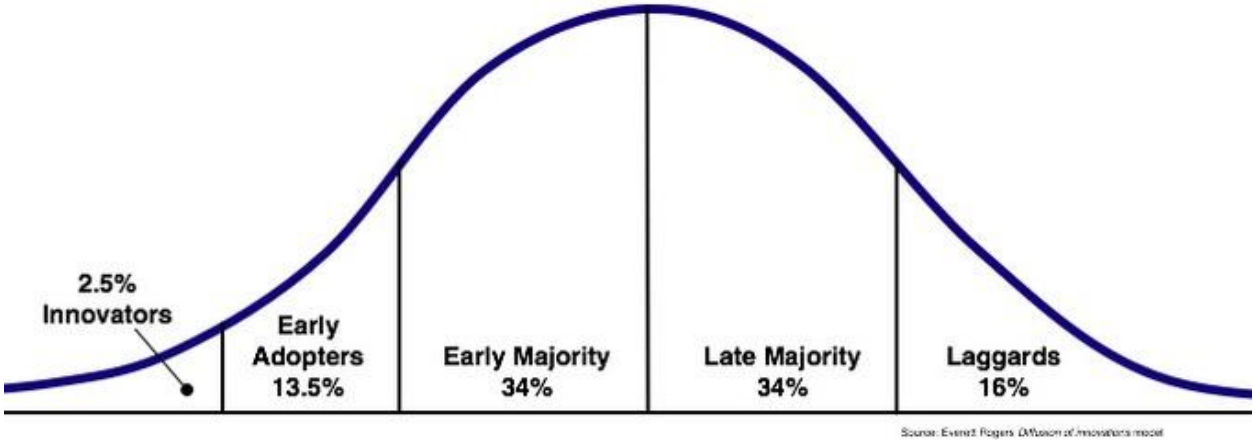
2.6.6 Diffusion of Innovation Theory

The idea of diffusion, or the spread of new ideas and products, has been studied since the beginning of the 20th century and popularised by Everette Rogers, a communication studies professor (Scott and McGuire, 2017). According to Rogers (1983:03), the diffusion of innovation (DOI) is "a process by which an innovation is communicated through certain channels over time among the members of a social system". Rogers (1983:24) refers to a social system as “a set of interrelated units that are engaged in joint problem solving to accomplish a common goal and that the members or units of a social system may be individuals, informal groups, organisations, or subsystems”.

Kaminski (2011) also explains that the DOI is a process that occurs as society adopts "a new idea, product, practice, philosophy, and so on and is often regarded as a valuable change model for guiding technological innovation where the innovation itself is modified and presented in ways that meet the needs across all levels of adopters". Furthermore, according to Rogers (1983:247), several adopter categories serve as a classification of units of a social system based on innovativeness. The categories include innovators,

early adopters, early majority, late majority, and laggards. Figure 5 provides a graphical presentation of the various categories of adopters.

Figure 5: Adopter categorisation based on innovativeness



Source: Rogers (1983:247)

Rogers characterised innovators as venturesome because they are the first to try out the innovation and adopt it. He viewed early adopters as respectable in that they have the highest degree of opinion leadership, a higher social status, more financial liquidity, and possess an advanced education. The early majority are deliberate because they are slower in the adoption process and need evidence to prove innovation works before they are willing to adopt it. Successful stories of innovation encourage them to adopt the technology. The late majority are sceptical in that they adopt an innovation after the average members of society have already done so. The final category is the laggards, which are traditional and are the last category to adopt an innovation because they are very conservative and believe in traditional tested ways of doing things, their point of reference in the past.

This section focused on theoretical frameworks predicting and explaining why society has embraced technology throughout civilisation. It was demonstrated that early adopters of technological innovation are mostly the educated and well-resourced part of society and that certain portions of society will always be left behind. They will depend on technological solutions to meet early adopters' tastes and preferences. Additionally, the theories discussed in this section show how technological innovation can also be influenced by society and that society's use of technology can lead to further technological

development and innovation in using the available technology. These elements are used in the development of a suitable smart city model for Gauteng-based metropolitan municipalities.

2.7 APPLICATION OF THE FOURTH INDUSTRIAL REVOLUTION TECHNIQUES WITHIN THE LOCAL GOVERNMENT SECTOR

As outlined above, the 4IR has to do with the convergence of digital, physical, and biological technologies, disrupting existing industries and producing and consuming goods and services (Department for Science and Technology, 2019. The convergence of these technologies is enabled by systems like IoT, AI, big data analysis, blockchain, robotics, and WiFi. These systems then connect with humans to create better ways of doing things and provide new insights to users that benefit society in general. That is why Industry 4.0 is fundamentally different from the other three revolutions that came before it. As Schwab (2016) puts it, the range of new technologies fusing the physical, digital, and biological worlds impacts all disciplines, economies and industries, even challenging ideas about what it means to be human. Manda and Dhaou (2019:244) emphasise this point and attest that the advent of the 4IR promises significant social and economic opportunities and challenges which demand that governments respond appropriately in supporting the transformation of the society. 4IR disrupts society, business, and government through its innovations.

2.7.1 Artificial Intelligence and Machine Learning

AI is a paradigm where computers or machines are designed to perform tasks requiring high-level cognition commonly associated with human beings. Computers or machines can learn from experience through AI, adjust to new inputs, and perform many human-like tasks (Marwala, 2015:1; Scotti, 2020:27). Computers and machines can, through a model, be programmed to learn and adapt. Alpaydin (2010:03) describes machine learning (ML) as programming computers to optimise a performance criterion using example data or experience. It would then allow a machine in a changing environment to have the ability to learn. The intelligence part stems from its ability to learn and to adapt. AI and ML can be used to describe or make predictions in the future by analysing and

learning from collected data and past learnings and knowledge gained from data. The World Economic Forum (WEF) upholds that AI is a software engine that drives 4IR and the rapid advances in ML as a tool that increases the scope and scale of AI's deployment across all aspects of daily life. Due to the ability of the technology to learn and change on its own, the WEF sees a need to have multi-stakeholder collaboration on how best to optimise accountability, transparency, privacy, and impartiality to create trust with regards to this kind of technology (WEF, 2018:11). Throughout the world, AI "is seen as a powerful concept still in its infancy that has a huge potential to provide a vehicle for positive change that could promote sustainable transitions to a more resource-efficient liveability paradigm. AI, with its deep learning functions and capabilities, can be employed as a tool which empowers machines to solve problems that could reform urban landscapes" and help with establishing a new era of smart cities (Nikitas *et al.,* 2020:1).

2.7.2 Internet of Things (IoT)

Atzori *et al.* (2010) in Zanella *et al.* (2014:22) describe the IoT as a recent communication paradigm that envisions a near future, in which the "objects of everyday life will be equipped with microcontrollers, transceivers for digital communication, and suitable protocol stacks that will make them able to communicate with one another and with the users, becoming an integral part of the internet". Consistent with this view is Kim *et al.* (2017:159), who attest that IoT is "about installing sensors for everything and connecting them to the internet through specific protocols for information exchange and communications, in order to achieve intelligent recognition, location, tracking, monitoring and management". In 2020, IoTs were already a reality in many parts of the world, and the interconnectedness of everyday objects allows such devices to send and receive data amongst themselves.

As claimed by the WEF (2018:18), there are now more connected devices in the world today than humans, and it is projected that the number of IoT devices exceed 20 billion fuelled by continued technological advances and the plummeting costs of computing, storage, and connectivity. Smart cities worldwide use IoT technologies to support city administrations to improve public service delivery. As the devices communicate with each other and learn and adapt to conditions, this is where the benefit accrues from IoTs, as it

provides a unified, simple, and economic access to a plethora of public services, thus unleashing potential synergies and increasing transparency to the citizens (Zanella *et al.*, 2014:23). Employing IoT can lead to better use of limited public resources and increase the quality of the services offered to the citizens while at the same time reducing the operational costs of the municipal administration.

2.7.3 Big data

Big data refers to the large volume of heterogeneous data, both structured and unstructured, that inundates an organisation on a day-to-day basis. The data is generated from independent sources with distributed and decentralised control and seeks to explore evolving relationships among the data (Wu *et al*., 2014; SAS Insights, 2020). The amount of structured and unstructured data is not important, but rather what organisations do with the data that matters. In the case of a smart city, the significant number of connected devices and machines in a metropolitan area has led to increased growth in the data collected. According to the WEF, data is the oxygen that fuels the fire of 4IR, and as more and more data is being generated than ever before due to the increased availability of everyday devices that interconnect with each another, data is in turn being leveraged through ML to make AI possible and to power advances in diagnostics and predictive analytics used across industries (WEF, 2018:18).

Cities can use IoT devices to collect data daily and store it in a cloud. Big data analysis offers cities opportunities to obtain valuable insights from the collected data. IoT devices offer capabilities to communicate amongst themselves in real-time and can share, collate and analyse the data into valuable information that the city administration can use in the decision-making process. Hashem *et al.* (2016:750) insist that the application of big data technologies for smart city initiatives enables efficient data storage and processing to produce information that can enhance different smart city services. In addition, big data helps decision-makers plan for any expansion in smart city services and resources.

2.7.4 Other 4IR applications

Many other various 4IR applications can be employed by organisations worldwide. These include advanced materials, quantum computing, 3D printing, robotics, autonomous vehicles, blockchain, 5G and many others. Robotics uses machines or automated mechanical devices to automate tasks, whether humans can perform the tasks or not. Asada (1995:139) argues that the goal of robotics and AI is to build “an autonomous agent that behaves adequately to accomplish a given task through interactions with its environment”. Autonomous vehicles (AV) are another form of an automated device that can sense its environment and move safely with little or no human input and can be more efficient and more economical than vehicles today due to its ability to analyse data and thus utilise the best options or routes to get from point A to point B.

These emerging technologies impact how cities of the future will use data to develop solutions to challenges faced by major metropolitan areas through technologies like 5G, which enables a network designed to connect virtually everyone and everything, including machines, objects, and devices. The WEF sees intelligent connectivity, enabled by 5G, as the catalyst for the socio-economic growth that the 4IR could bring to society (Mauro, 2019). This next-generation network is also conducive for blockchain technology, which is an early-stage technology that enables the decentralised and secure storage and transfer of information and has the potential to be a powerful tool for tracking and transactions that can minimise friction, reduce corruption, increase trust, and empower users (World Economic Forum, 2018).

2.7.5 Skilled personnel

Although there are many benefits to embracing 4IR technologies, there is still a need for human capacity to oversee 4IR processes. Even though technologies such as robotics, automation and big data analysis allows machines to do many tasks, there are many areas in which machines are not yet capable. Skilled personnel to develop software and programmes for these machines are necessary. The 4IR requires employees with various skills ranging from soft, technical, and entrepreneur capabilities. Personal attributes such as communication and interpersonal skills, the ability and knowledge to perform

specialised technical skills, and entrepreneurship and intrapreneurship skills, which create new 4IR business ventures and opportunities, are still necessary. However, cities and municipalities will need to compete with private sector organisations for this limited commodity due to the scarcity of some of these skills. Butler-Adam (2018:01) argues that as the global economy moves towards the widespread adoption of AI solutions, competition will grow for employees who have the scarce skills required to implement, manage, and work alongside the new technology. Furthermore, the demand for even more highly trained professionals will grow accordingly.

2.7.6 Drawbacks of 4IR on the local government sector

It was highlighted above how various 4IR technologies can be applied by cities worldwide to implement smart city initiatives. However, there are several challenges that municipalities would need to address to benefit from 4IR technologies fully. These challenges include, but are not limited to, the cost of the technology, skills, governance, ethical issues around privacy and the disruptive nature to current jobs and industries. Furthermore, for 4IR to be effective, huge investments in ICT hardware and software, IoT, big data analysis storage and server's facility, ICT security, and other technology are necessary. Smart cities require investments in infrastructure such as broadband, smart transport networks, smart health systems, smart energy, smart water and many more. It means that municipal governments, particularly in South Africa, will divert investment away from social development programmes towards ICT. It may prove problematic for politicians, whose main priority is pleasing the immediate needs of their constituencies.

Municipalities need to showcase how they will protect citizens' privacy rights and have e-Governance policies and frameworks to guard against the abuse of smart city systems. Systems need to be in place to ensure proper management of the smart system, and insight gained should be used for citizens and businesses based within the metropolitan area, not for politicians and associates.

Employee representative organisations may be against implementing 4IR enabled smart cities, as they fear job losses for their members. Industry 4.0 will lead to many jobs being made redundant and replaced by robotics, which can perform such tasks and activities

even better at a much lower cost over the longer term. City management will need to engage organised labour and agree to a process upfront to ensure uninterrupted implementation of smart city initiatives. Corfe (2019:31) also argues that the implications of 4IR for the wider economy are likely to impact local government tax collections. It is due to the changing nature of business in the 4IR era, in which they switch from brick-and-mortar businesses to online-based businesses, which could reduce rates and taxes collection of municipalities.

The 4IR will increasingly give citizens the ability to use technology to seek greater autonomy, which will challenge the power of government and institutions in disruptive ways (Lye, 2017). We have seen such cases in South Africa, where citizens and businesses adopted solar power due to the weakness of Eskom in guaranteeing power. However, this has led to less revenue for municipalities as more and more people and businesses move off the grid.

For 4IR techniques to be successful, Manda and Dhaou (2019:251) insist that leadership from all sectors of society needs to work together to leverage the opportunities and address the challenges of Industry 4.0. Romero *et al.* (2016:02) equally emphasise that sustainable implementation of 4IR requires technological transformation, which includes training and development programmes for employees in new tools and technologies needed in the era of 4IR.

2.8 CONCLUSION

Chapter 2 highlighted the meaning of concepts such as cities, metropolitan municipalities, smart cities, and the 4IR. It was done to illustrate these concepts and why cities worldwide have embraced them and are in the process or have already implemented them. The evolution of public administration from classical to modern new public service was highlighted, including the application of technology during the evolution stages. Various theories of technology adoption and application were discussed, and special attention was drawn to how such theoretical frameworks applied to the diffusion of a concept such as smart cities, which is the focus of this study. The discussion highlighted theoretical frameworks that attempt to explain how technology is adopted by society and justify

investment in technology for improved public service delivery. When designing a comprehensive smart city model for the local government environment, such aspects will be considered.

The key smart city dimensions of technology, people, and institutions, which cut across various approaches to what a smart city should be about, was also briefly analysed. It is evident that for a smart city to be effective, it must have the right skilled personnel, technology and right governance policies and frameworks to ensure success. Furthermore, the application of the 4IR technologies within the local government sector was explored. It was made evident that investment in infrastructure, particularly ICT infrastructure, personnel training and a functional governance system, is essential to implement these smart technologies successfully.

The next two chapters will focus on exploring smart city best practise approaches, models, and praxis from leading smart cities globally and the statutory and regulatory framework that governs the application of smart city initiatives, respectively.

CHAPTER 3: INTERNATIONAL SMART CITY MODELS AND BEST PRACTICE APPROACHES AND PRAXIS FROM LEADING SMART CITIES IN THE WORLD

3.1 INTRODUCTION

The previous chapter provided a literature review on the role of government in society, how technology advancement was applied to public administration over time, and the development of the smart cities concept. Books and research in journal articles and conference papers on smart cities and 4IR were reviewed, and background was set on the perceived benefits to society from such technologies. All these activities provided a basis for this study on a suitable model for implementing smart city technologies within the metros in Gauteng.

The current chapter evaluates international smart city models and best practice approaches and praxis from leading smart cities worldwide. Lessons from early adopters and challenges experienced in embracing smart city technologies were highlighted and used towards formulating a smart city model for South African metropolitan municipalities. The chapter explores international smart city frameworks, revealing some common characteristics found in smart cities worldwide. Further sections explore best practices and applications from leading smart cities globally, including BRIC countries and countries on the African continent. The latter is especially relevant to contextualise the South African developmental setting. The final section of the chapter summarises the learning that was applied in crafting a proposed smart city model for Gauteng-based metro municipalities as the main focus of this study.

3.2 INTERNATIONAL SMART CITY FRAMEWORKS

This section will investigate several smart city readiness models and frameworks to conduct a comparative analysis and extract best practices. Furthermore, the evolving nature of smart city concepts from mere technological points of view to a more comprehensive and integrated perspective will be explored. This integrated perspective

is in line with that advocated by Supangkat *et al.* (2018:169), who reason that a smart city has adequate capability and capacity to manage all resources effectively and efficiently to solve complex city problems. Smart cities also utilise innovative, integrated, and sustainable solutions for their citizens' general well-being and prosperity.

3.2.1 European Smart Cities Ranking Model

The European Smart Cities Ranking Model was published in 2007 by Giffinger *et al.* (2007) and explicitly dealt with medium-sized cities in Europe, taking into account their "perspectives for development" (Giffinger and Gudrun, 2010:13). Giffinger *et al.* (2007:10), in their study, focused on the ranking of European smart cities and found that there are several fields of activity in the literature that can be used to describe a smart city. The authors identified six common characteristics that are useful in assessing the overall performance of a smart city. The six characteristics are "smart economy, smart people, smart governance, smart mobility, smart environment, and smart living". Each part is further demarcated by several factors (33 in total), and each element is described by several indicators (Arduin *et al*., 2016:2). The indicators that delineate the characteristics of a smart city are derived from public and freely available data (Giffinger *et al.,* 2007:10).

Over time many other scholars such as Cohen (2012) and Lombardi *et al*. (2012:138) advanced the six characteristics by providing detailed perspectives and factors related to the smart city characteristics. Table 3 below summarises the key aspect of the Giffinger Smart City Model.

Table 3: Characteristics of a smart city and related aspects

Characteristic of a smart city	A related part of city life
Smart economy	Industry and competitiveness
Smart people	Education/ Human capital
Smart governance	e-Democracy/ Participation
Smart mobility	Logistics and infrastructures
Smart environment	Efficiency and sustainability/ Natural resources
Smart living	Security and quality of life

Source: Adapted from Giffinger *et al.* (2007), Cohen (2012) and Lombardi *et al*. (2012)

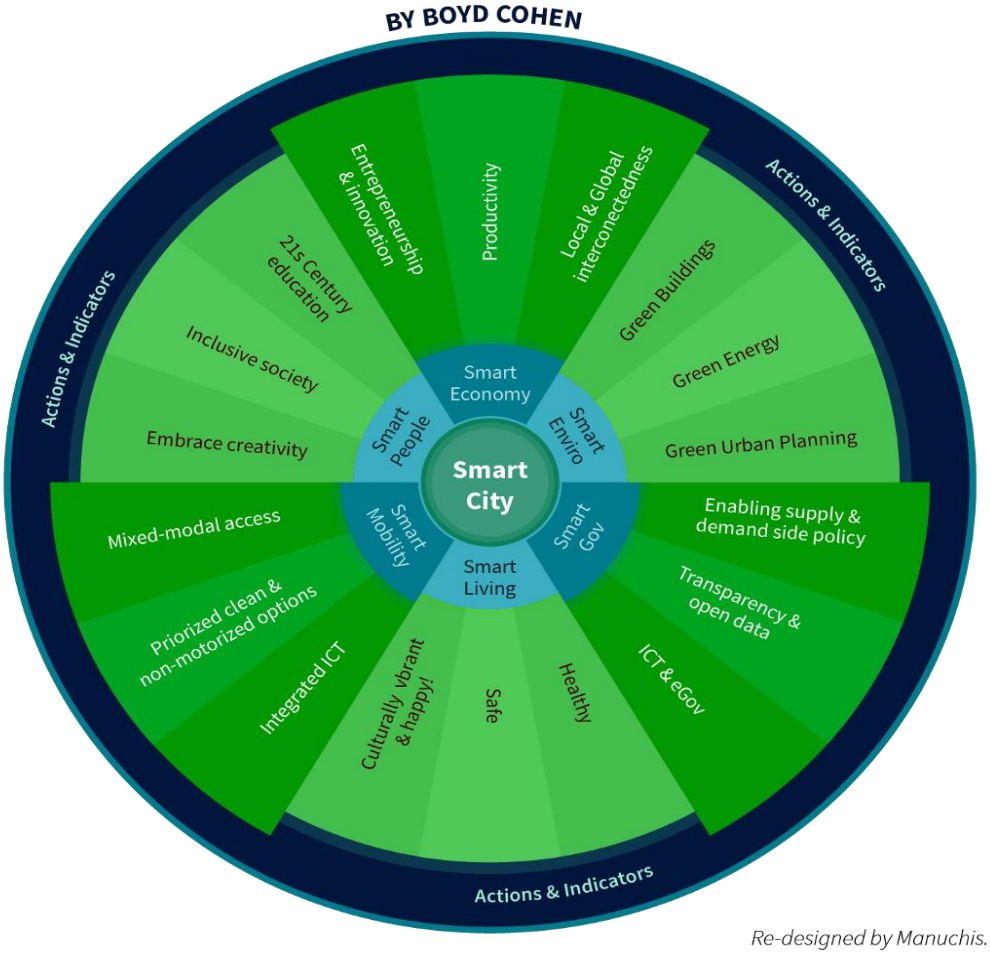
There is no universal agreement on defining a smart city (Caragliu *et al*., 2011; Lombardi *et al.*, 2012:137). However, Giffinger *et al*. (2007:11) describe it as "a city well performing in a forward-looking way in these six characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens". Lombardi *et al*. (2012:138) assert that the main focus of smart cities is "on the role of ICT infrastructure" but concede that the "role of human capital/education, social and relational capital, and environmental interests are important drivers of urban growth". That is why this model was adapted to elaborate on the importance of non-ICT factors on the success and performance of a smart city. The European Smart Cities Ranking Model can be criticised because it was designed for the European environment and takes the European developmental perspective, which may not apply to developing countries elsewhere.

3.2.2 The Smart Cities Wheel Model

The Smart Wheel Model was adapted from the European Smart Cities Ranking Model and the ISO37120 (Sustainable cities and communities: Indicators for city services and quality of life) by Boyd Cohen in 2012. Similar to the European Smart Cities Ranking Model, the Boyd Cohen Smart Cities Wheel (BCSW) "identifies six key performance indicators (KPIs) for which a city can be identified or ranked" and then "establishes different levels of indicators for each KPI" (Ceballos and Larios, 2016:02). The BCSW is "a useful tool to measure the degree of smartness of a city". It is a frequently cited tool that helps cities, communities, and companies to become smart, innovative, and green

economy conscious (Shah *et al.*, 2017:124). As shown in figure 6 below, the BCSW is comprised of the six dimensions or KPIs drilled down into 18 working areas. The 18 working areas are factorised into 24 indicators, and 64 base level parameters are used to assess a city's smart readiness (Cohen, 2018).

Figure 6: Smart City Wheel



Source: Cohen (2018)

3.2.3 Smart Cities Framework

The Smart Cities Framework (SCF) was developed by the Smart Cities Council (SCC) and published in the Smart City Readiness Guide in 2015. The SSC is a network of leading ICT companies advised by top universities, laboratories and standards bodies on smart cities technologies and applications. The readiness guide was meant to be a roadmap to assist cities in transforming for the better by using available technologies.

The SCC described a smart city as “an ICT enabled city” that utilises ICTs to solve problems faced by modern cities by collecting data about the city environment, communicating, and analysing the data to influence decision-making to enhance a city’s liveability, workability and sustainability” (Smart Cities Council, 2015:06). The SCF is based on every city having responsibilities and enablers that allow a city to deliver public services. According to the SCF, a city’s obligations comprise of essential functions and services that must be provided every day, such as building environment services, energy, telecommunications, transportation, water and wastewater, health and human services, public safety, and finance. The SCF proposes that cities can radically improve all of their responsibilities through the power of ICT enablers. This is due to the ability of ICT-based solutions that can help a municipality provide its primary functions by applying 4IR techniques such as IoT and big data analysis. Such methods can make buildings more efficient, water more affordable, transportation quicker, and neighbourhoods safer. Table 4 below depicts the relationship between a city’s enablers and its responsibilities. The vertical city services represent essential responsibilities of a city, and the horizontal represents enablers which are technological abilities that increase the efficiency and economy of city services.

Table 4: Smart Cities Framework

		CITY RESPONSIBILITIES								
		Universal Aspects	Built Environment	Energy	Telecommunications	Transportation	Water and Wastewater	Health and Human Service	Public Safety	Payments and Finance
TECHNOLOGY ENABLERS	Instrumentation and Control									
	Connectivity									
	Interoperability									
	Security and Privacy									
	Data Management									
	Computing Resources									
	Analytics									

Source: Adopted from Smart Cities Council (2015:24)

The SCF measures smart city readiness from a technological point of view and values non-technological aspects, especially the human element effect, to make the smart city assessment more comprehensive (Achmad *et al*., 2018:278). The SCF also encourages citizen engagements by a city's administration and values transparency in setting targets and budget allocations.

3.2.4 Smart Cities Maturity Model and Self-Assessment Tool

The Smart Cities Maturity Model (SCMM) and self-assessment tool was commissioned by the Scottish government and conceptualised in conjunction with the Scottish Cities Alliance and a management consultancy firm, Urban Tide. The Scottish government refers to a smart city as "integrating data and digital technologies into a strategic approach to sustainability, citizen well-being and economic development" (Scottish Government, 2014:04). The model is based on the IDC model and the British Standards Institution Publicly Available Specification (BSI PAS181) 'Smart City Framework: Guide to Establishing Strategies for Smart Cities and Communities (Juniawan *et al*., 2017:99; Warnecke *et al*., 2019:658).

Table 5: Dimensions of the Scottish Government Smart Cities Maturity Model

Dimension	Explanation
Strategic Intent	"Successful smart cities have a strategy and roadmap setting out how investment in data" and digital technologies enables service reform and partner collaboration. An effective approach focuses on improving outcomes aligned to the city's strategic priorities.
Data	Successful smart cities effectively use "their data assets to secure better outcomes. They invest in system-wide data capture, integration and analytics capabilities. Open data underpins their commitment to transparency and innovation" (Urbantide, 2016).
Technology	"Successful smart cities invest in open, flexible, integrated, and scalable ICT architectures that enable accelerated service innovation", providing automated and real-time dynamic response capabilities (Urbantide, 2016).
Governance and Service Delivery Models	"Successful smart cities adapt traditional organisational models of delivery to realise the opportunities of data and digital technologies. They invest in system-wide partnership models focused on shared outcomes"(Urbantide, 2016).
Stakeholder engagement	Successful smart cities use data and digital technologies to invest in enhanced openness and transparency. Stakeholder engagement and stakeholder ownership of service reform are central within a smart city. Smart cities are proactive in improving the take-up of digital services while supporting the digitally excluded.

Source: Adapted from Scottish Government (2014)

The SCMM utilises assessment dimensions of strategic intent, data, technology, governance and service delivery models, and citizen and business engagement to determine maturity levels (table 5 above). The model and the self-assessment tool are based on a survey integrating these categories and differentiating between smart city initiatives currently running, planned, envisioned, and collaborations (Warnecke *et al*., 2019:658). The model "identifies and measures the existing conditions of a city to map the city's capabilities" (Juniawan *et al*., 2017:99). The SCMM tool is designed to walk cities through clearly identifying the next steps, investments, and resources required to realise smart city ambitions. It considers five maturity levels that lead to an optimised smart city approach based on the five key dimensions in table 3.3 above. Level 1 maturity

is the basic level where operations are digital and data-driven focused. At the same time, Level 5 represents an optimised city with a city-wide open system of systems approach, which drives innovation that enhances a city's competitiveness. A high-level summary of the maturity levels is presented in table 6 below.

Table 6: Scottish Government Smart Cities Maturity Model

	Level 1 Ad-Hoc	**Level 2 Opportunistic**	**Level 3 Purposeful & Repeatable**	**Level 4 Operationalised**	**Level 5 Optimised**
City Management Status	Siloed	System collaboration	System Integration	Managed System	Sustainable and 'Open System of Systems'
Smart City Status	The operation focused on digital and data-driven	Holistic system thinking and emergent sharing of data.	The strategy led and outcomes-driven. Enabled by system-wide technology investment.	Technology and data-enabled dynamic sense and response systems.	Continuously adaptive city-wide 'smart' deployment.
Effects on Outcomes	Capturing evidence and building business cases.	Cross-boundary partnerships are emerging to focus on shared outcomes.	Shared accountability for results and joint system-wide investment programme.	Improved prediction, prevention and real-time response deliver improved outcomes.	The city-wide Open 'System of Systems' approach drives innovation that enhances city competitiveness.

Source: Adapted from the Scottish Government (2014)

This model and the assessment tool allow cities to consider the extent to which the five key dimensions are maturing and can use that analysis as a reference point in determining the concept and direction of each smart city implementation effort. However, Warnecke *et al.* (2019:658) criticise the SCMM in that it does not enable "city authorities to assess their progress about their own earlier scores". Furthermore, the model does not

allow for comparison to other smart cities elsewhere, nor does it provide recommendations for the city administrators on achieving a better level of smart city maturity in the future. According to Prasad (2018:6), the SCMM may need to be adjusted when applied to developing countries. As such, governments will have different maturity levels compared to developed countries. Sharif (2020:4) also indicates that the SCMM is not necessarily research-based nor market-oriented, but its development relies on expert opinions.

3.2.5 Smart Cities Mission

The Smart Cities Mission (SCM) is an Indian government project initiated in 2015 aimed at driving economic growth and improving the quality of life in 100 Indian cities by "enabling local development and harnessing technology as a means to create smart solutions for citizens" (Praharaj *et al.,* 2018:172). In another study, Praharaj *et al.* (2018:35) describe the SCM as projects that "involve the provision of centrally devised guidelines for smart city development" throughout India. The SCM advocates utilising smart solutions in e-Governance and citizen services, waste management, energy management, and urban mobility. According to the Government of India (2015:05), the core infrastructure elements anticipated in SCM's smart city includes:

a) "adequate water supply
b) assured electricity supply
c) sanitation, including solid waste management
d) efficient urban mobility and public transport
e) affordable housing, especially for the poor
f) robust IT connectivity and digitalisation
g) good governance, especially e-Governance and citizen participation
h) sustainable environment
i) safety and security of citizens, particularly women, children and the elderly, and
j) health and education."

The features of a smart city as envisioned by the Government of India include: promoting mixed land use in area-based developments; expanding housing opportunities; creating

walkable localities by reducing congestion, air pollution and resource depletion; boosting the local economy, facilitating interactions and ensuring security; preserving and developing open spaces; promoting a variety of transport options; making governance citizen-friendly and cost-effective; and applying smart solutions to infrastructure and services in area-based development to make them better (Government of India, 2016:7). According to Bhattacharya and Rathi (2015:22), the SCM focuses on local level planning and empowers governance structures by building the adequate capacity of urban institutions and local governments in the 100 selected cities. The SCM utilises ICTs as an important enabler in attaining sustainability and good governance. However, Bhattacharya and Rathi (2015:37) see a need for an enabling policy environment to support technology interventions.

Praharaj *et al.* (2018:35) criticise the SCM as another Indian government's "stand-alone initiative". Praharaj *et al.* (2018:35) maintain that the SCM project is not long-term oriented and failed to fully take account of "a history and past of a highly bureaucratic and deeply-seated structural governance culture affecting most Indian cities". Additionally, the SCM was not customised to local institutional contexts and did not prioritise the democratic aspirations of its citizens. Inherent constraints in basic infrastructure, technology, and urban governance are things that urgently need attention if India is to achieve its SCM objectives (Praharaj *et al*., 2018:183). Also, Smith *et al.* (2019:518), in their study of attributes of participating cities in the SCM project, found that most cities "largely adopted projects that seek to provide basic urban infrastructure as opposed to truly embracing smart city ideas and concept".

Praharaj *et al.* (2017:1431), in their study on innovative civic engagement and digital urban infrastructure in 100 cities of the SCM project, found that "the disparity in digital infrastructure between different socio-economic demographics is a challenge for cities in emerging economies wishing to implement smart city policies" and "that engaging people in online platforms for civic deliberations is not simply a matter of digital infrastructure but is influenced by a complex set of socio-economic and political variables".

3.2.6 Smart City Readiness Model based on Technology-Organisation-Environment (TOE) Framework

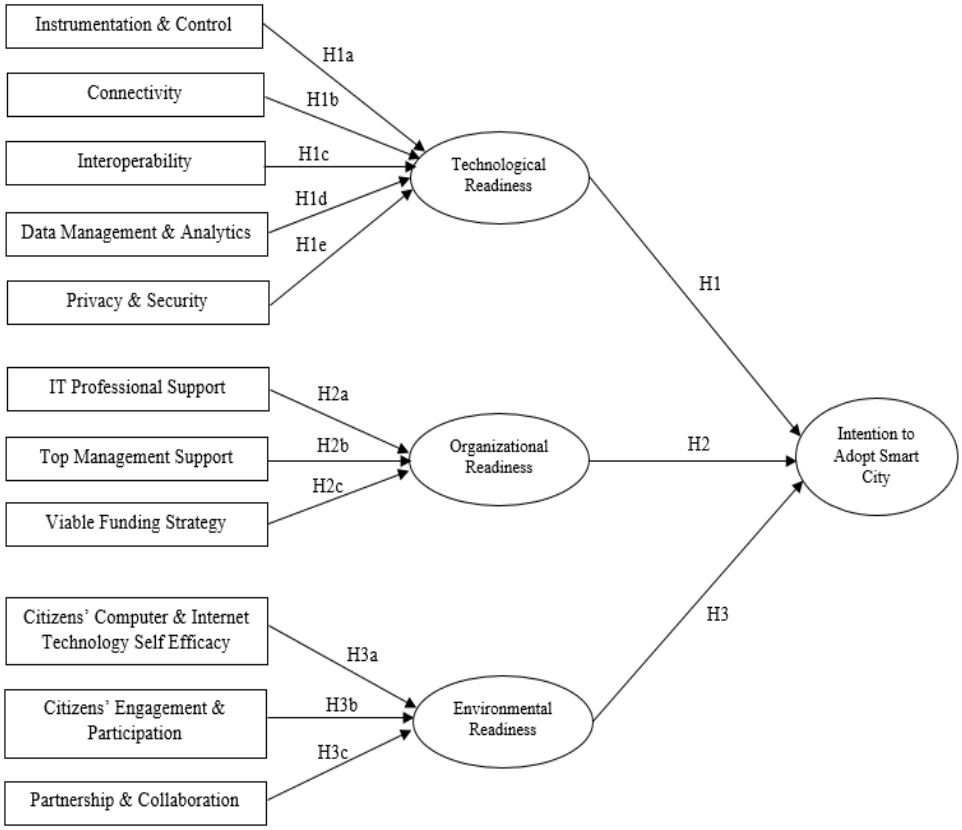
The Smart City Readiness Model (SCRM) based on Technology-Organisation-Environmental (TOE) Framework was proposed by Dewi *et al*. (2018) at the 22nd Pacific Asia Conference on Information Systems (PACIS 2018), which was held at Yokohama, Japan. The SCRM-TOE uses the TOE framework to assess smart city readiness. The TOE framework is described by Baker (2012:232) as an organisation level theory that explains how a firm's technological, organisational, and environmental context influences the technological innovation adoption decisions. Each of these elements is described in table 7 below.

Table 7: TOE Framework Elements

Elements	Definition
Technology	The technology dimension focuses on how technology's structure, quality, and characteristics influence innovation adoption.
Organisation	Organisational dimensions include several organisational attributes (such as structure, culture, objectives, size, quality of resources, and decision-making mechanisms) that can facilitate or hinder the adoption of an innovation.
Environment	The environmental dimension represents all external parties of an organisation, such as competitors, suppliers, customers, governments, communities, etc., that determine the needs of innovation, the ability to provide resources and facilitate the creation, and the ability to implement the invention.

Source: Adopted from Dewi *et al*. (2018:03)

Figure 7: Smart City Readiness Model (SCRM) based on Technology-Organisation-Environmental (TOE) Framework



Source: Dewi *et al*. (2018:3)

The TOE is a generic theory that is widely applicable to different disciplines and contexts depending on the objectives of the researchers. Dewi *et al*. (2018:03) apply the idea as an assessment tool for smart city adoption. In their opinion, smart city readiness can be seen as "the ability of the local government to prepare itself in adopting and implementing smart city optimally, so that the purpose of the smart city adoption can be achieved". Figure 7 above depicts the assessment framework proposed by Dewi *et al*. (2018).

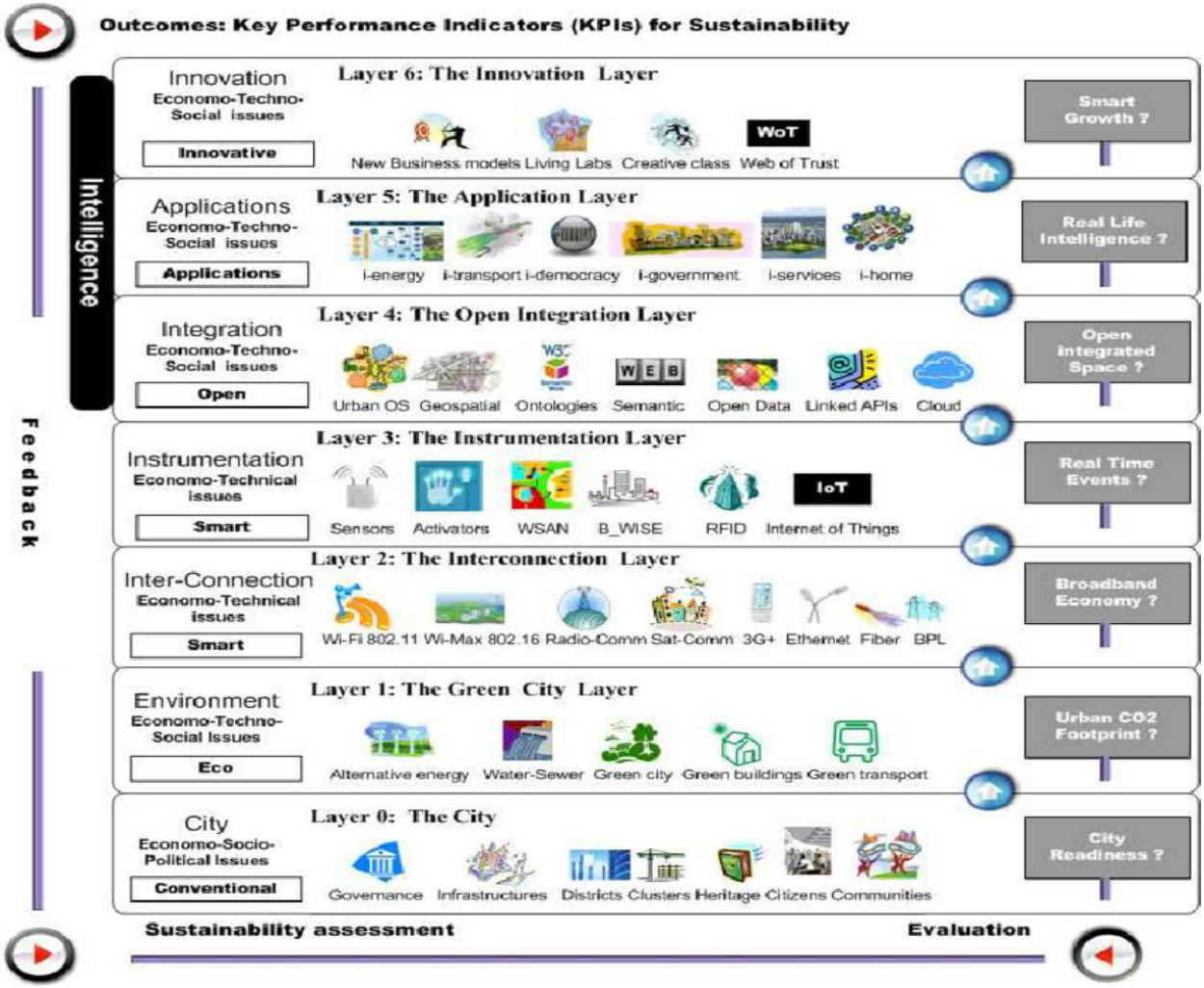
According to this assessment framework, adopting a smart city concept is based on a municipality's technological, organisational, and environmental readiness outcomes. Technological readiness looks at the technological enablers required to be in places, such as instrumentation and control, connectivity; interoperability; data management and analytics, and security and privacy. These technological capabilities enable a municipality to capture, store, process, use IoTs and analyse the data for better decision-making.

Organisational readiness, as reported by Yang *et al.* (2015) in Dewi *et al*. (2018:04), has to do with the preparedness of a municipality to “provide and manage all the resources needed to adopt a smart city concept”. Yang *et al.* (2015) added that organisational enablers include “the availability of IT professionals, top management support, and a viable funding strategy. The environmental readiness of a smart city adoption deals with issues such as citizens' computer self-efficacy, citizens’ engagement, and participation and collaboration amongst stakeholders. Environmental readiness is concerned with “how far the local government prepares all external parties, such as communities, private parties, business partners, etc., to support and help each other adopt a smart city approach” (Dewi *et al*., 2018:04). The SCRM-TOE framework thus uses technological, organisational, and environmental variables to assess the readiness of a fully functional smart city that improves its citizens' competitiveness and lives.

3.2.7 Smart City Reference Model

The smart city reference model (SCRM) is based on an idea of a smart city that is implemented through a layered approach “that elucidates the assembly of all smart city notions into green, interconnected, instrumented, open, integrated, intelligent, and innovating layers composing a planning framework” (Zygiaris, 2012:217). The model comprises of seven layers, 0 to 6, ranging from the basic city to the innovation. Figure 8 presents a summary description of the layers.

Figure 8: Smart city conceptual reference model



Source: Zygiaris (2012:217)

Layer 0, or the city layer, is about the standard components present in every city, which is considered an important denominator of cities' readiness in absorbing smart features (Belisent, 2010). These components comprise of governance, infrastructure, citizens, and communities. Layer 1 is concerned with green environmental issues that cities need to consider when providing services to communities. Applying green initiatives makes cities more sustainable and thus preserves the environment for future generations. Bell *et al.* (2009) in Zygiaris (2012:221) consider layer 2, the interconnection layer, as concerned with the innovation support capacity of the telecom infrastructure to interconnect people, smart nodes, workstations, and other embedded devices and provide high-speed network access to a city-wide area. Instrumentation uses 4IR technologies such as sensors and IoT to monitor real-time events using real-time connections outlets such as

radiofrequency transmitters, traffic signals, streets, smart meters, infrastructure sensors, and traffic and transit sensors (Greene, 2007).

Layer 3, the open integration layer, is concerned with a city's ability to "moderate, integrate, and make openly available smart digital resources" (Zygiaris, 2012:221). Layer 4, the application layer, involves the stage wherein a city starts to apply the available technology by using the interconnected and instrumented real-time operators that run on real-time and historical data and provide intelligence through several forms of ICT applications such as smart energy grids, intelligent transport, e-traffic, e-payment, and e-Government (Toppeta, 2010). Finally, the outermost layer is the innovation layer. At this level, the benefits of investing in a smart city start to come to the fore, as innovation and new businesses are being supported and created using the available 4IR technology and infrastructure. The technological innovation then makes a city more competitive and more able to attract further investment and skilled labour into the city region, enhancing the city's economic growth prospects. The SCRM is suitable to be adopted and utilised by cities of different shapes and sizes and could be applied "in a range of smart policy paradigms that embrace the green, broadband, and urban economies" (Zygiaris, 2012:217).

3.2.8 Integrated Framework to Measure Smart City Readiness

The Integrated Framework to Measure Smart City Readiness (IFMSCR) assesses the development of a smart city using "technological and non-technological aspects" such as political and societal support for smart city initiatives (Noori *et al.,* 2020:678). Hence, the IFMSCR values technological and non-technological aspects with similar strengths when assessing the readiness levels. Cities can then consider both elements when developing their respective smart city initiatives. This makes this framework more comprehensive and integrated, as the non-technological aspect is also considered a critical success factor for a smart city project. In their paper, Noori *et al.* (2020:681) base their IFMSCR on "qualitative data analysis of scientific papers and existing frameworks for smart cities readiness", such as the Input-Output (IO) model of the smart city development process, which characterises inputs (resources), throughputs, outputs (applications), and outcomes (externalities) of the smart city development process, and the smart city

readiness guide by the Smart City Council, amongst others. As shown in table 8 below, the IFMSCR is a framework for technological, socio-economic, and political readiness. It uses the theory of urban transitions to understand how technological, social, and political features influence the cities' willingness to become smart.

According to Noori *et al.* (2020:681), the technological readiness assessment looks at the current availability of ICTs and data management resources and the capabilities of a city to implement data collection, storage, analysis, and dissemination carried out by IoT, big data and AI technologies. At the same time, the social readiness assessment is concerned with the level of education, innovation, awareness, perceived usefulness, mentality, and values of a smart city system amongst the population. For a smart city initiative to succeed, they should be ICT skilled individuals and start-ups within the ICT arena who are innovative and capable of implementing such smart city initiatives. The public at large should perceive the initiatives as useful to society. Equally important is the assessment of political readiness to embrace smart city technologies through making a conducive environment in the form of political support.

Table 8: Integrated Framework to Measure Smart City Readiness

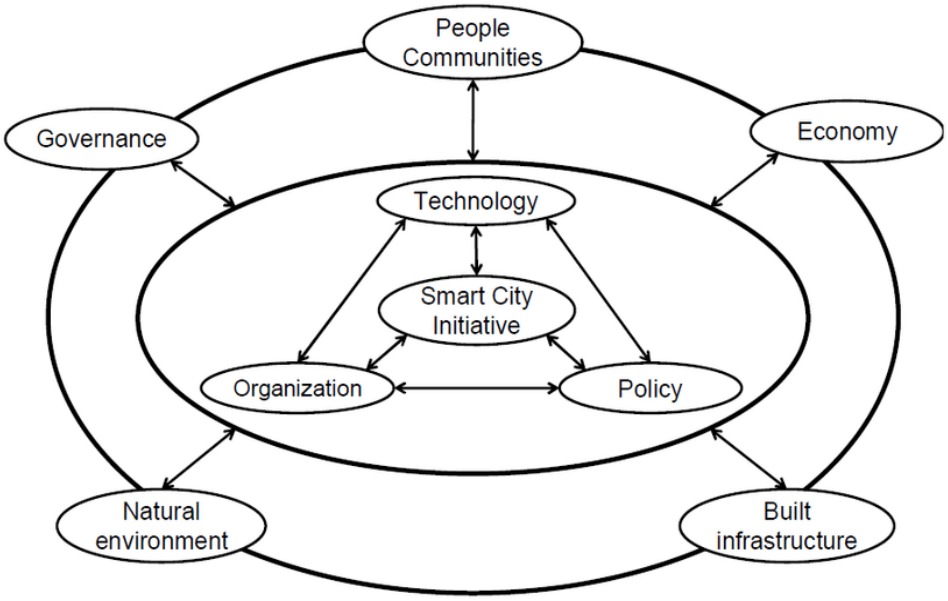
Integrated Framework to Measure Smart City Readiness Focus Areas	Operationalisation
Technological Readiness Assessment	• Big data establishment • Sensors and actuator equipped devices, CCTVs, and cameras • ICT Development Index (IDI) • Data science centres • Data visualisation platforms • Data Laws • Establishing a cyber-security framework
Social Readiness Assessment	• Number of universities and research centres (education) • Knowledge transfer and knowledge sharing programmes • Specific policy in place to promote smart city innovation • Supporting and encouraging programmes for innovative companies (Science and technology parks, free zones, etc.) • The level of citizens' awareness of the smart city programme in their city • The level of citizens' awareness of the smart city concept and technologies • The level of perceived usefulness of the smart solutions for the city's challenges by citizens • Citizens' opinion about a smart city • Citizens' image of their cities • Citizens' different ideas of quality of life
Political Readiness Assessment	• Leadership vision/support for a smart city program • Government structure, governance arrangements and policy networks • Rules, laws, legal and regulatory reforms • Policies, policy instruments • Legitimacy, transparency and trust • Partnerships with industry, academia, and citizens • Providing a platform for multi-stakeholder partnership

Source: Adopted from Noori *et al.* (2020:698)

3.2.9 Smart City Integrative Framework

Another integrative framework proposed to gain a holistic perspective of smart cities is the Smart City Integrative Framework (SCIF), designed by Chourabi *et al*. (2012). Chourabi *et al*. (2012:2289) examine a wide and extensive array of literature from various disciplinary areas to identify eight smart city initiative critical factors. The eight areas of the SCIF are "management and organisation; technology; governance; policy context; people and communities; economy; built infrastructure; and the natural environment". As can be seen in figure 9 below, Chourabi *et al*. (2012: 2289) suggest that these eight "factors form the basis of an integrative framework that can be used to examine how local governments are envisioning smart city initiatives".

Figure 9: Smart City Integrative Framework



Source: Chourabi *et al*. (2012: 2294)

The SCIF explains the relationships and influences between the eight factors and smart city initiatives undertaken by a municipality and can study and determine the success factors of such smart city initiatives or projects. The factors could be classified into two categories, internal and external elements. Internal elements comprise of the "policy environment where a smart initiative is deployed; the managerial and organisational resources employed to implement the initiative and the technology that is selected to address an urban problem". The external elements include factors that could influence

the direction of a specific smart city initiative such as “the reactions of people and communities who are positively or negatively affected by the initiative” (Gil-Garcia *et al*., 2013:296).

3.3 COMPARATIVE ANALYSIS OF SMART CITY FRAMEWORKS

Smart city literature is fairly recent, yet many frameworks have been developed worldwide, designed for cities of varying sizes and socio-economic backgrounds. Such frameworks attempt to assess, rank and provide guidelines towards achieving a truly integrated smart city. Several smart city readiness frameworks were reviewed in the previous section to assess cities' smart city readiness or maturity level. Table 9 below provides a summary of the comparative analysis of these frameworks.

Table 9: Comparative analysis of smart city frameworks

Framework	Key dimensions	Similarities
European Smart City Ranking Model	This was designed for medium-sized European cities using six smart characteristics, namely, the economy, people, living, government, environment, and mobility.	This model provided a foundation for most smart city approaches that followed.
Smart Cities Wheel Model	The European Smart City Model provides a detailed perspective and factors related to the six smart characteristics.	The six smart characteristics are used as KPIs. They are drilled into 18 working areas, factorised into 24 indicators, and 64 base level parameters assess smart readiness.
Smart Cities Framework	Based on basic service delivery responsibilities and related technology enablers in cities in their duties.	Values ICT enablers as a critical success factor for cities.

Framework	Key dimensions	Similarities
Smart Cities Maturity Model and Self-Assessment Tool	Strategic intent, data, technology, governance and service delivery models and stakeholder engagement.	Enables cities to measure smart city maturity level against predetermined objectives.
Smart Cities Mission	Centrally/ nationally devised smart cities guidelines	ICT is identified as an important enabler in attaining sustainability and good governance.
Smart City Readiness Model based on Technology-Organisation-Environment Framework	Technology, organisational and environmental dimensions.	Adopting the smart cities approach is based on technology, organisational and environmental readiness outcomes.
Smart City Reference Model	Conventional, environment, inter-connection, instrumentation, integration, application and innovation dimensions.	It uses a layered approach to measure the maturity level of a city from conventional to innovation.
Integrated Framework to Measure Smart City Readiness	Technological, social and political readiness assessment dimensions.	Uses urban transitions to understand how technological, social, and political features influence the smart readiness of a city. Technological and non-technological aspects are valued with similar strengths.
Smart City Integrative Framework	Management and organisation; technology; governance; policy context; people and communities; economy; built infrastructure and the natural environment dimensions.	It uses similar dimensions to the European Smart City Ranking Model. It categorises the dimensions into external and internal elements, without and with, respectively, some level of control by a city.

Source: Researcher's own

From the table above, it is clear that these frameworks and models have several similar dimensions and are built upon one another. Smart city readiness in all these models, frameworks, and guidelines is concerned with technological aspects and how citizens, city administrators, and politicians value the use of available technology to make informed decisions that lead to sustainable cities.

This study utilises the Scottish Government's Smart Cities Maturity Model (SCMM) to determine the respective levels of Gauteng-based metropolitan municipalities as well as to propose appropriate recommendations on how to take advantage of available technology to improve public service delivery. The SCMM was preferred for this study due to its ability to categorise the various maturity levels regarding implementing a smart city. The SCMM allows assessing a city's strategic intent, data usage, available technological infrastructure, governance and service delivery, and stakeholder engagement. Furthermore, the maturity model is suitable for cities with basic knowledge and the application of smart city technology to rate themselves and gauge how far they are, regarding embracing smart city technologies.

The SCMM would be easily applied to Gauteng-based metropolitan municipalities, and these municipalities would also benefit and ascertain the necessary investments required to benefit from 4IR technologies fully. Some urban cities in South Africa claim to be 'smart' and are implementing smart city-related initiatives. However, there is no benchmark or guideline they are following, which would enable policy-makers and analysts to evaluate these municipalities' smart city progress and achievements.

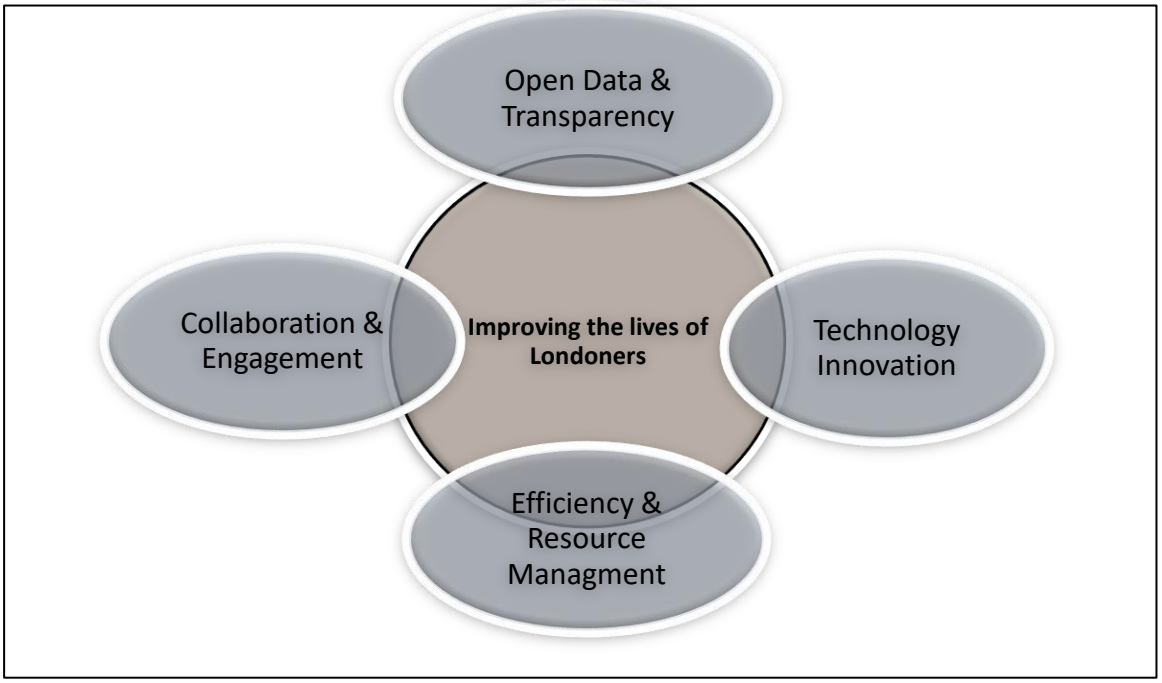
3.4 BEST PRACTISE AND APPLICATIONS FROM LEADING SMART CITIES IN THE WORLD

This section focuses on smart cities' best practices and applications from leading cities worldwide. Ten leading smart cities that are pre-eminently rated amongst the best in the world were analysed with a view of extracting lessons that can be applied to the proposed smart city model suitable for Gauteng-based metropolitan municipalities. These cities were chosen due to their appearance on many leading smart cities' indexes and are discussed here in no particular order.

3.4.1 London

London is England's capital, and the largest city in the United Kingdom, with about 9.3 million people. The Greater London Authority launched a "Smart London Plan (SLP)" in 2013 to deal with increasing pressure on the city to provide a conducive sustainable environment where people can safely live, work and play. As can be seen in figure 10 below, the SLP is about "using the creative power of new technologies to serve London and improve citizens' lives and revolves around seven key themes in the domains of services for citizens, citizen engagement, development of businesses, smart infrastructure, and networking among stakeholders" (Greater London Authority, 2013:13). Hosseinian-Far *et al.* (2018:54) maintain that the SLP relies on exploiting big data, IoT, cloud computing and digital technology to facilitate the achievement of the smart city strategy.

Figure 10: Smart London Approach



Source: Greater London Authority (2013:18)

Through the implementation of the vision of the SLP, the city is considered one of the leading smart cities in the world. London also houses more ICT start-ups and programmers than almost any other city in the world (Business Insider, 2017). This is due

to the commitment to the smart city vision by the Greater London Authority, supported by relevant stakeholders such as the public, private companies, universities and ICT research institutions. The city appointed a Smart London Board, comprising of a group of experts, including academics, business leaders and entrepreneurs, which provides oversight in shaping and implementing the smart city strategy to ensure that digital technology makes London one of the best cities to live in (Greater London Authority, 2013:17; IESE Business School, 2020:28; Willems *et al.,* 2017:251).

The City of London has many initiatives designed to support the development of the next generation of smart technologies and promote greater data sharing among the city's public services. There are smart city initiatives geared towards increasing public participation by citizens about the city's public policies. Access to open data is provided to citizens, universities, the private sector and research institutions to leverage the city's research, technology, and creative talent. London was ranked the smartest city in the world in the IESE Business School's Cities in Motion Index 2020. Traits such as capable human capital, ICT governance, urban planning, transportation and mobility, and technology propelled the city to the top of the index.

3.4.2 New York City

New York City is the largest city in the United States of America and is home to the United Nations. It is also the centre of global finance, communication and business (TheUSAonline.com, 2019). The city developed a digital city roadmap that outlines "New York City government's commitment to technology in the public service and presents a comprehensive plan to achieve New York City's digital potential"(New York, 2011). The city follows a well-articulated digital strategy shaped concerning local recourses, priorities, and needs (Angelidou, 2014:7). The roadmap's core focus areas include access to the internet and WiFi, an open government framework for easy access to data and information, a citizen-centric engagement platform, and industry support for the digital ICT media sector (City of New York, 2011:2).

According to the IESE Cities in Motion Index 2020, New York City is one of two highly developed smart cities globally. New York City's highly rated ranking is thanks to the city's

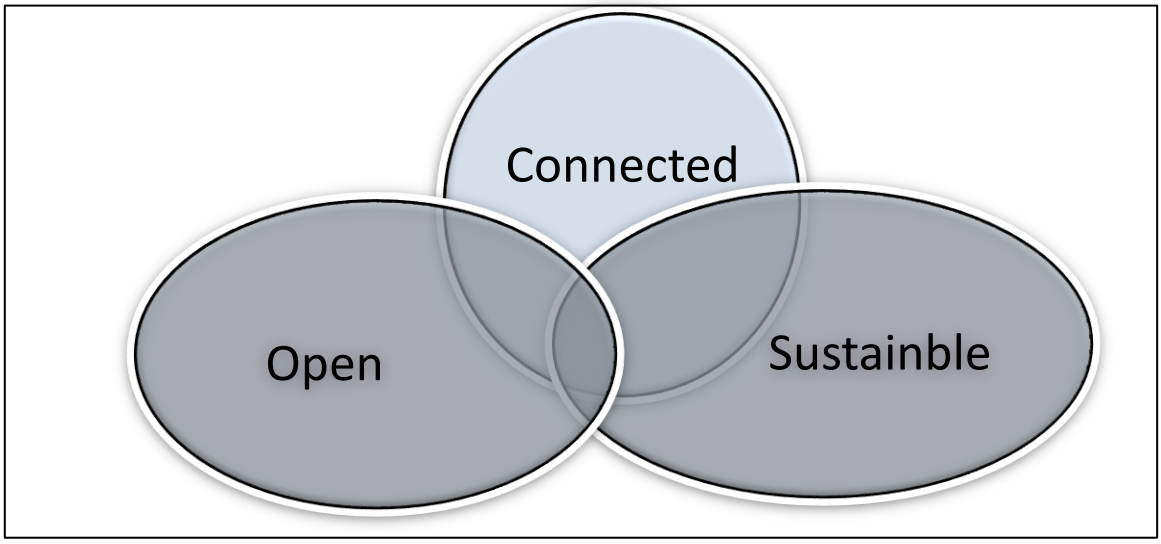
performance in the dimensions of the economy, urban planning, mobility and transportation, and human capital development and investment (IESE Business School, 2020:30). In 2016, New York City was also announced as the Best Smart City of 2016 at the Smart City Expo World Congress in Barcelona, as part of the World Smart City Awards (Michell, 2016). The city is partnering with private companies to develop smart city technology solutions to help solve issues such as water quality and conservation, public safety, and waste management. Smart city technologies are already in place in areas such as wireless water meters, smart indoor lighting, smart transport and mobility, smart waste management, water quality monitoring and 24/7 service requests through the city's 31, which supports access via phone, web, text, social, and mobile to submit service requests or obtain community information.

Through the smart public safety initiatives, New York City can feed real-time information to the fire and police departments so that they can respond rapidly to emergencies and threats and they have been able to reduce crime by 27% by gathering data in a central location and relaying real-time information to officers in an instant (Washburn and Sindhu, 2010:07). Other smart cities initiatives include a peer-to-peer energy sales network based on Blockchain technology. "Homes with solar panels on their roof can sell energy to neighbours on the same road devoid of solar systems" (Pieroni *et al.,* 2018:303).

3.4.3 Paris

Paris is the "capital and the most populous city of France", with an estimated population of over 2 million residents (Arduin *et al*., 2016:02). To overcome challenges faced by modern cities, the city launched the Paris Smart and Sustainable City strategy in 2015. The plan was meant to address challenges of urbanisation, resource scarcity and climate change, amongst others, through the digital transformation of the city and using smart city solutions based on three pillars of an open, connected, and sustainable city.

Figure 11: Three pillars of the Paris Smart and Sustainable City strategy



Source: Adapted from the City of Paris (2015:26)

The open dimension pillar focuses on open innovation, open data; open governance; citizen participation and an innovative ecosystem. Paris believes that the solutions of tomorrow will emerge through collective intelligence and the collaboration between public stakeholders, businesses, researchers and citizens. While the connected dimension is concerned with digital services, user relations; digital inclusion and new digital careers; platforms and applications; and the IoTs, which makes information instantly accessible and enables citizen initiatives to emerge, which alter their relationships with the city's governance. The sustainability dimensions look at town planning; energy and networks; mobility and logistics; circular economy, waste, recycling; greening; climate change adaptation plan and resilience (City of Paris, 2015:2). Through such a strategy, Paris "aspires to become a model of smart cities for other cities in Europe and has been a subject of many studies and articles on smart cities" (Mancebo, 2020:136). Many smart city projects are underway in Paris, such as using cameras to reduce traffic congestion and aid planning.

3.4.4 Tokyo

Tokyo is a global city and the capital city of Japan. The city is a strategic economic hub as it contributed 37% to Japan's National GDP between 2000 and 2014 (OECD, 2018:03).

Tokyo has approximately 38 million residents and is considered one of the most populated cities globally by the UN. It is obvious why there will be consequences and challenges for such a vast population size on the city resources and services (Kim *et al*., 2017:159). For this reason, Tokyo has invested in smart technologies to use scarce resources more efficiently for the benefit of citizens. Some of the existing smart city applications include the upgrading of energy efficiency in buildings via installations of Energy Management Systems, fostering take-up of renewable energy sources such as solar PV and hydrogen, and several other measures to ensure a stable energy supply and lower carbon dioxide emissions within the city (Clarisse, 2015:5). Furthermore, Tokyo has one of the highest Broadband Wireless Access (BWA) subscribers globally and offers several free WiFi hotspots in the city. Other smart infrastructure within Tokyo includes having the longest rail line, with many stations and the longest operating hours, and generally, the use of public transportation by the population is high. The city also invests in knowledge management and has several knowledge-intensive institutions, with the most scientific publications and patent applications coming from such institutions (Fietkiewicz and Stock, 2015:234).

3.4.5 Reykjavik

The City of Reykjavik is the capital and largest city in Iceland. Reykjavik strives to become a smart city by using ICTs to improve the quality of life sustainably. The city believes that it will do this by gathering and combining data from different databases related to the city's infrastructure and using it to improve services, quality of life and the environment. Reykjavik smart city initiatives focus on better efficient transport, improved operations, increased environmental awareness, and better energy use (Nordic Smart City Network, 2020).

The objective of the Reykjavik Smart City is innovation for the benefit of city residents in fields such as welfare, education, culture, and transportation. This city achieves this through platforms such as Better Reykjavík, an online consultation forum that allows citizens to present their ideas on service delivery and operations issues affecting the City of Reykjavík. Better Reykjavík is essentially an e-petition and open innovation website

that enables citizens to submit, debate, and prioritise policy proposals and ideas (Nordic Smart City Network, 2020).

Community ideas then go through the city's process in terms of feasibility and costs, and if successful, can be implemented as a crowdfunding idea. Other applications of smart city initiatives include public transportation apps for city buses, geographic information system (GIS) and an energy company that produces electricity through harnessing geothermal energy. Iceland is the most sustainable country on earth, with 100% renewable hydro and geothermal power sources. By 2025, the City of Reykjavík aims for 100% of vehicles to be powered by energies free of greenhouse gas emissions. Reykjavik's fibre network is one of the world's most advanced and true open access, offering 100% fibre to home connectivity in the city (Nordic Smart City Network, 2020).

3.4.6 Singapore

Singapore is a city-state that has transformed itself into a major global commerce, financial and transportation hub and has about 5.5 million people living on this city island nation (World Bank, 2015). According to Hoe (2016:327), Singapore has had a long history of being a major user of ICTs, and there have been several national ICT plans formulated to transform the government, industry, and society in general. Mahizhnan (1999:13) recognises that Singapore was perhaps one of the first developing countries to realise the tremendous advantages of ICTs and telecommunications in transforming a developing nation into a developed one.

In recent times, Singapore launched the Smart Nation initiative (SNI), which aims to apply technology and innovation initiatives across Singapore to enhance the quality of living. The SNI involves developing an entire ecosystem supported by infrastructure, technologies, policies, culture and capabilities (Smart Nation and Digital Government Office, 2020). Singapore identified several key enablers to the SNI aimed at adopting smart technologies. Key enablers include:

- the National Digital Identify, which allows for citizens and businesses to transact conveniently and securely online;

- the Smart Nation Sensor Platform, which uses sensors and data to run a smart, green and liveable city;
- Smart Urban Mobility, which leverages data and digital technologies, including AI and autonomous vehicles, to enhance public transport;
- e-payments, an open, accessible and interoperable national e-payments infrastructure that facilitates simple, seamless and secured digital transactions; and
- the Core Operations Development Environment and exchange (CODEX) is the digital platform that enables the city government to deliver better digital services to citizens faster and more cost-efficiently (Smart Nation and Digital Government Office, 2020).

All these initiatives are already live and operational within the city-state.

3.4.7 Seoul

Seoul is the largest metropolitan area and the capital city of South Korea. It is a city of over 10 million inhabitants that has become a global economic power in less than 50 years (Bernardi and Diamantini, 2018:34). South Korea is generally an early adopter of the smart city concept at the city and national levels (Kang, 2020). Stevens (2020) reports that Seoul has been named the best global e-Government globally by United Nations for seven consecutive years and is seen as a leading smart city based on its application of big data and 4IR technologies. The Seoul Metropolitan Government already produces, stores, processes, analyses, and utilises big data when providing city services. The city has one of the world's best ICT networks where people can access free high-speed WiFi, even in moving buses and subway trains (Stevens, 2020).

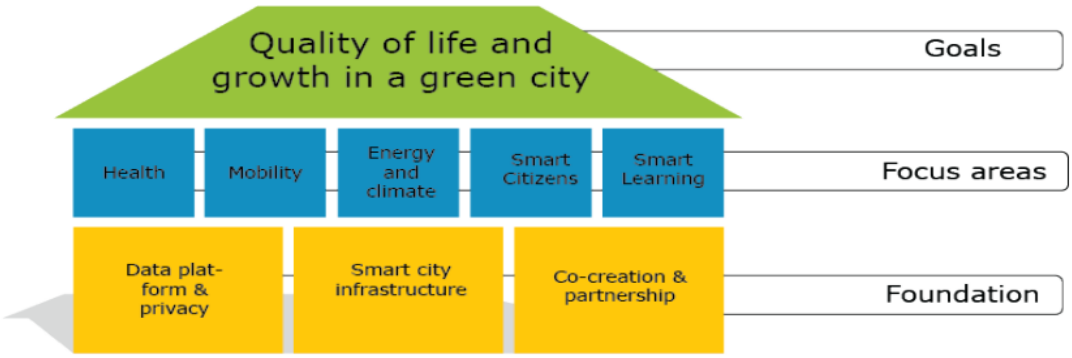
According to the Mayor of Seoul, Mr Park Won-Soon, three factors constitute the Seoul smart city: smart city infrastructure, innovative companies with cutting-edge technologies, and smart citizens (Bernardi and Diamantini 2018:35; Hwang and Choe, 2013:6; Stevens, 2020). Seoul supported investments and innovation and had a governance framework in place suitable for these conditions. There are many digital innovations in place in Seoul, in areas such as smart mobility, smart waste and energy, smart citizenry, smart public

space and through the “Digital Mayor’s Office”, a smart city digital platform where the Office of the Mayor can see the status of the entire city at a glance in real-time. The City of Seoul, through its Seoul Smart Mobility Reform, which was introduced in 2003, uses advanced ICTs such as intelligent transport system (ITS) technology, Bus Management System (BMS), and Global Positioning System (GPS) to manage public transport. The city managed to get the share of people using buses and the subway to almost 70% and car users at less than 30%, which reduced traffic congestion. Other smart city initiatives in Seoul include the Gangnam Resource Recovery Facility (RRF) and the 120 Dasan Call Centre. The RRF transforms waste into energy, which helps reduce landfill and power neighbourhood heating by reducing fossil fuel use and carbon emissions, thereby contributing to climate mitigation and sustainable urban growth. The 120 Dasan Call Centre is a telephone, SMS, social media, text and video chat complaints handling system that directs all inquiries and complaints towards a single integrated call centre, designed to process the daily grievances of citizens more quickly and conveniently on a one-to-one consultation (Kang, 2020).

3.4.8 Copenhagen

Copenhagen is Denmark’s capital and most populous city, with approximately 794 000 residents. The city launched the Copenhagen Connecting Strategy in 2013 to become a CO2 neutral capital by 2025 by employing smart city technologies to improve the city's competitiveness and living conditions for citizens (Fourtané, 2020). The focus areas of the strategy are on health, mobility, energy, and climate; smart citizens; and smart living (City of Copenhagen, 2016:06). Many smart city projects are ongoing within the city and have succeeded. Such projects include smart parking, smart waste, air quality and provision of free WiFi, amongst others. Figure 12 below shows the building blocks of Copenhagen’s smart city strategy, which is building a smart city infrastructure, mainly using ICTs to create data platforms and address privacy concerns as well as co-creation and partnerships with the private sector companies and start-ups, universities and research institutions, citizens and civil society organisations. The municipality has over the years allocated a huge amount of money to smart city projects and has leveraged private sector investments in the process.

Figure 12: Smart City Strategy Copenhagen



Source: City of Copenhagen (2016:6)

Over the years, Copenhagen has won many international titles, including being the number one smart city in Europe in 2012, a three-time winner of the most liveable city in the world award in 2014, the European Green Capital Award in 2014 (Cavada *et al*., 2016:248), and the World Smart Cities Award for having the world's best plan for the collection and use of big data to create a greener city and improve the quality of life for citizens. According to Lubanski (2012) in Cavada *et al*. (2016:248), Copenhagen's success can be attributed to green-technological companies based within the city and the financial support from the government that values employment growth and the overall desire to become smarter.

However, Ghasemi (2015:1) mentions that there has been criticism against some of Copenhagen's smart city projects. For example, Copenhagen's Intelligent Traffic System (ITS) collects "media access control (MAC) addresses from the smartphones of citizens moving through the project area with activated WiFi or Bluetooth" without the consent of citizens. Even though the project was deemed legal by the Danish Business Authority, it is, however, unethical. Ghasemi (2015:1), in his study, also found that the city of Copenhagen focuses more on climate change, private business partnerships, and the digital infrastructure and less on citizen participation and choice in the smart city transformation efforts.

3.4.9 Hong Kong

Hong Kong is a former British colony that became a special administrative region of China in 1997 when Britain's 99-year lease expired (BBC, 2018). It is a metropolitan area with over 7.5 million people (GovHK, 2020). Hong Kong's vision is to strive to become a world-class smart city through adopting innovation and technology measures set out in its Smart City Blueprint (SCB), which was launched in December 2017. Hong Kong's SCB focuses on short-, medium=, and long-term recommendations in six major areas, smart mobility, smart living, smart environment, smart people, smart government, and smart economy (HKSAR Government, 2019). According to Govada *et al.* (2017:199), the Hong Kong Government has encouraged and facilitated the city's transportation, telecommunications and technology sectors through effective public policy incentives and collaboration. In that way, Hong Kong has managed to do well with certain aspects of smart mobility, smart economy and smart infrastructure but has room for improvement with most parts of smart living, smart governance, and smart environment (Govada *et al.*, 2017:199).

Hong Kong's smart city initiatives include 5G infrastructure in 400 multi-functional Smart Lamppost. According to Jackson (2019), the lamppost is a 5G base station, a surveillance camera, a weather station, thermal traffic detector, and even a radio-frequency identification (RFID) cane navigation system, which also emanates free WiFi. Other initiatives include a smart lock for cargo, wearable tech for prisoners, an open data dashboard, mobile-enabled digital ID, digital departure kiosks at its airport, as well as a virtual Hong Kong platform. The analysis of Hong Kong's SCB indicates that it is based on BCSW towards its vision of becoming a truly smart city.

3.4.10 Amsterdam

Amsterdam is the Netherlands's capital city and is one of the early adopters of the smart city concept in Europe (Smith, 2017). The city launched the Amsterdam Smart City (ASC) programme in 2009, a collaboration between the municipality and the private sector organisations. The decision to transform Amsterdam into a smart city had a political commitment. There was a clear motivation and desire to "use ICTs to help the city solve environmental problems" and build an urban sustainable city environment (Mora and

Bolici, 2017:255). The ASC followed a holistic strategy to successfully integrate environmental and societal goals with economic and technological objectives. The city is considered a European smart city role model and was named the European Capital of Innovation by the European Commission in 2016 (Lisa, 2017; Yigitcanlar *et al.,* 2019:06). Amsterdam is one of the world's top smart cities, having implemented over 150 functioning projects in green energy, mobility, citizen engagement, and urban planning (Page and Miller, 2019).

Amsterdam relied on the cooperation between the government and key stakeholders within the ICT sector to achieve this feat, including the private sector, research institutions, universities, and citizens. The ASC's holistic strategy is based on the universal six smart cities dimensions of smartness of the economy, people, governance, mobility, environment, and way of living (Putra and Van Der Knaap, 2018:235). Through the ASC, the city and its stakeholders can share knowledge and collaborate to develop innovative solutions suitable for metropolitan issues of social, economic, and ecological. Yigitcanlar *et al.* (2019:06) indicate that the starting point of the ASC was not merely about providing ICT technical solutions, but rather the "collaboration, co-creation, and partnerships between the city and key stakeholders towards sustainable and smart city solutions".

Findings by Manville *et al.* (2014:75) on a report providing background information and advice on Smart Cities in the European Union (EU) commissioned by the European Parliament's Committee on Industry, Research and Energy, revealed that Amsterdam is one of a few cities in Europe, with a large number of smart city initiatives covering a variety of smart city characteristics. Smart city projects within the ASC are divided into seven areas, which cover infrastructure and technology; smart energy, water, and waste; smart mobility, governance, and education; citizen participation; smart city academy and circular city, which is aimed at reusing anything produced within the ASC to in turn create new products or services, reducing waste and the cost of raw materials (Yigitcanlar *et al.*, 2019:06). Furthermore, Yigitcanlar *et al.* (2019:06) add that Amsterdam has managed to embed all kinds of digital infrastructure and networks, devices, sensors, and actuators. As a result, the volume of data produced by this city has grown exponentially.

3.4.11 Best practices and principles emanating from leading smart cities in the world

This section focuses on the smart city experiences of some of the leading cities in the world. Some best practices and learning can serve as a crucial input in designing a smart city model suitable for Gauteng based metros. Table 10 below highlights some critical success factors from these leading smart cities and lessons from cities in a developing country like South Africa.

Table 10: Key features and lessons to be learned from leading smart cities worldwide

City	Key features and lessons to be learned
London	• Devised a Smart London Plan, which relies on the exploitation of big data, IoT, cloud computing and digital technology to facilitate the achievement of the smart city strategy. • Appointed the Smart London Board, comprising of experts from academia, business, and entrepreneurs, which provides oversight in shaping and implementing the smart city strategy.
New York City	• Developed a digital city roadmap that outlined the government's commitment to technology in the public service and presented a comprehensive plan to achieve the city's digital potential.
Paris	• Launched the Paris Smart and Sustainable City strategy to address challenges of urbanisation, resource scarcity, and climate change through the city's digital transformation.
Tokyo	• Tokyo has invested in smart technologies in smart transportation renewable energy to lower carbon dioxide emissions. • The city has a high penetration of broadband and WiFi access and has invested in knowledge management capabilities.
Reykjavik	• True open-access fibre network offering 100% home connectivity in the city. • E-petition and open innovation websites enable citizens to submit, debate, and prioritise policy proposals and ideas.
Singapore	• Developed an entire smart city ecosystem supported by infrastructure, technologies, policies, culture, and capabilities.

City	Key features and lessons to be learned
Seoul	• The focus of the strategy is on securing smart city infrastructure, innovative companies with cutting-edge technologies and smart citizens. • Ongoing projects in smart mobility, smart waste and energy, smart citizenry, and smart public space operating from the Office of the Mayor.
Copenhagen	• Adopted the Copenhagen Connecting Strategy, partly funded by the government and focuses on smartness in health, mobility, energy and climate, citizens, and quality living. • Smart city initiatives are rooted in 4IR infrastructure, co-creation and partnerships with the private sector companies and start-ups, universities and research institutions, citizens and civil society organisations.
Hong Kong	• The Hong Kong Government facilitates and encourages the city's transportation, telecommunications and technology sectors through effective public policy, incentives, and collaboration.
Amsterdam	• The ASC had political support and collaborated between the municipality and the key stakeholders such as the private sector, research institutions, universities, and citizens. • The ASC is a holistic strategy that integrates environmental and societal goals with economic and technological objectives.

Source: Researcher's own

Some of the features in the table above are good practices and guidelines for any city wishing to implement smart city initiatives. It can be deduced that one of the common trends in table 10 above is national or local government support for smart city projects. Most of the leading smart cities in the world have permission from the national government, and the smart city project is even, at times, developed or included as national policy. This then allows for a budget allocation to be set aside, especially towards smart infrastructure delivery and human capital development within the ICT space. The private enterprises are invited to collaborate with the cities to provide public service.

3.5 SMART CITY IMPLEMENTATION IN SOME BRICS COUNTRIES

This section considers key features and lessons from smart cities within the BRICS countries (Brazil, Russia, India, China, and South Africa), excluding South Africa. BRICS is a cooperation amongst these member states “aimed at complementing and strengthening existing bilateral and multilateral relations to increase the economic growth and competitiveness” of their respective economies globally. BRICS plays a vital role in the world economy “in terms of total production, receiving investment capital, and expanding potential consumer market” (BRICS, 2015:04). Thus, these countries' smart city experiences and lessons can be applied to the South African context when designing a suitable smart city model.

3.5.1 Búzios

Armação dos Búzios or Búzios is a municipality located in the Rio de Janeiro State in the Southeast Region, Brazil. The city developed *the Búzios Smart City* project with an Italian multinational energy company, the Brazilian Electricity Regulatory Agency, and a local energy company. The Búzios Smart City project “aims to build the first intelligent city in Latin America” and to be a prototype to be applied elsewhere within Brazil to expand the adoption of the smart city concept (Fortes *et al.*, 2014:01). One of the project’s major goals is centred around the Smart Grid. The smart grid combines initiatives such as smart energy management; energy storage systems; smart energy generation; smart vehicle; smart public lighting; smart buildings, telecommunications, control and internet, and conscious and informed citizens. Through such initiatives, the Búzios municipality can make “use of renewable energy sources, control individual energy consumption in real-time, construct a new electrical infrastructure to optimise energy resources, a system for the remote control of an energy network, the implementation of a more economical public lighting system, and the introduction of different cost rates for the supply of electricity” (Batista and Fariniuk, 2017:32). The smart energy management aims for “the implementation of smart meters which can remotely cut, read and reclose processes to energy supply, making it faster and more dynamic” (Fortes *et al.*, 2014:3).

However, Batista and Fariniuk (2017:38), in their case study, found that “there is an inherent difficulty in identifying examples of the real impact of the technological apparatus” in Búzios municipality. Batista and Fariniuk (2017:38) also indicate that integrating the public and private sector actors into these projects was a challenge they observed in their study. Another concern for this ongoing project is the changing political interests when a different municipal government was elected and came into power and jeopardised the project. The new administration did not see value in the project and started to disengage from the project (Brandão and Joia, 2018:1146).

3.5.2 Moscow

Moscow is the capital of Russia and the largest city in Europe, with over 12 million residents. Since 2011, Moscow has invested heavily in ICTs and developed a plan towards achieving a fully integrated smart city by 2030. Through the Smart Moscow 2030 strategy, Moscow “aims to provide digital solutions that advance urban development, in particular, to boost local living standards and ensure more cost-effective management and service-provision solutions” (OECD, 2019:01). The smart city strategy adopted by the city is geared towards ensuring Muscovites’ well-being and allowing its administration and businesses to work more efficiently. To this end, according to Artem Ermolaev, the CIO of Moscow between 2010-2018, in Smiciklas and Imran (2018: ii), the city of Moscow has an impressive digital infrastructure, “with disruptive technologies such as blockchain in an e-voting system, widespread WiFi network, public online schools, AI-based healthcare” and smart public transport and many more. The city has “reached nearly 100% 4G and high-speed internet coverage”, and it is the second-largest WiFi-covered city in the world”. As shown in figure 13 below, the Smart Moscow 2030 strategy is based on the expansion of Giffinger *et al.* (2007)’s European Smart Cities Ranking Model, which focuses on dimensions of the smart economy, people, governance, mobility, environment and living. Moscow is at an advanced state of smart city implementation compared to its BRICS counterparts.

Figure 13: Dimensions of the Smart Moscow 2030 strategy

Source: Smiciklas and Imran (2018:12)

A 2018 study by the International Telecommunication Union (ITU) evaluating Moscow's progress in meeting the objectives of its smart city strategies and the United Nations' Sustainable Development Goals (SDGs) established that Moscow's city government plays a crucial role in coordinating the implementation of a wide array of smart city projects in the city. It also illustrated that these projects have substantially improved the quality of life for city residents.

3.5.3 Bengaluru

Bengaluru, formerly Bangalore, is one of India's largest cities and the capital city of Karnataka State in Southern India. According to Graham (2002:37), Bengaluru is seen as India's own "Silicon Valley" due to its high-tech landscapes and efforts that the government is making towards configuring the city into industrial and technological parks and housing developments with the best possible infrastructural connections to distant places. Bengaluru is part of the Indian government's ambitious 100 Smart Cities Mission project, which aims to transform 100 Indian cities to improve the urban quality of life and the natural environment through smart cities technologies. As part of the migration towards smart, the Karnataka State entered into a memorandum of understanding (MoU) with the technology giant Cisco to develop a roadmap for using an ICT network for integrated city management for a better quality of life for citizens improved economic development. The pilot programme of the MoU was aimed at "developing replicable ICT solutions to help promote sustainable, intelligent urban development practices in the city" (Madakam and Ramaswamy, 2013:118). The partnership further developed proposed solutions, products and services to deal with urban issues such as public safety and security, transportation, buildings, energy, health care and education, amongst others. However, "no city in India fully qualifies to be called a smart city, mainly because many parameters do not match the prevailing standards, either European or American" (Shah *et al.,* 2017:111).

3.5.4 Shanghai

Shanghai is China's largest city with more than 26 million, as reported by United Nations Population Division (2019:1). Like many other cities worldwide, the Shanghai municipality also turned to ICTs to find solutions to address some of the urban challenges found within its jurisdiction through the launch of the Smart Shanghai 2011–2013 plan. The Shanghai smart city plan "inherits a process of transformation from the beginning of the 1990s in public policy areas of governance, technology, built-in infrastructure, and economy" within China (Gil and Zheng, 2017:128) and aims "to strengthen city management, to improve city services and ameliorate city functions" (Hao *et al.*, 2012:289). Smart cities in China are generally based on an investment-led model. Government funding allocations and

resources are made available for management and organisational capacitation, the economy, technology, especially IoTs and built infrastructure development (Gil, 2014:24). Gil (2014:24) maintains that Shanghai, over the years, has become a leader in most smart city projects and has "developed a vision of innovation-driven transformation to become an international economic, financial, trade, and shipping centre as well as a socialist modern international metropolis". Shanghai also partners with universities, firms, foreign firms, and banks" in its smart city initiatives. It has a wide governance structure to govern the smart plans, including an expert smart city advisory committee.

Shanghai faces severe environmental concerns (Gil, 2014:9). Furthermore, Gil and Zheng (2017:128), in their study on Shanghai, found that there was "a more limited scope for people, communities and the natural environment" for shaping change towards a fully integrated smart city. This is mainly due to the top-down policies implemented by the governing party, which may not be contested through elections. Gil and Zheng (2017:140) further attest that the natural environment is absent in the Smart Shanghai 2011–2013 plan, even though the city has challenges around traffic congestion and environmental pollution.

3.5.5 Best practice and principles emanating from BRICS countries

BRIC countries' smart city initiatives are also national government policies like the more traditional developed economies. All strategic efforts are coordinated from a national perceptive or local level city management. This allows smart initiatives to be prioritised in budget allocations towards human capacitation and smart infrastructure investments.

Table 11: Key Smart City features and lessons from BRICS countries

City	Key features and lessons to be learned
Búzios, Brazil	• The Búzios Smart City project created a Smart Grid that generates renewable energy.
Moscow, Russia	• Moscow's city government plays a coordinating role in implementing a wide array of smart city projects in the city.
Bengaluru, India	• Part of the National government's 100 Smart Cities Mission project towards configuring the cities into an industrial and technological park.
Shanghai, China	• Government makes funding and resources available for human capacitation, for technology, including the required smart city infrastructure.

Source: Researcher's own

3.6 SMART CITIES IMPLEMENTATION FROM AN AFRICAN PERCEPTIVE

Western and developed economies are early adopters of smart city initiatives. Some developing countries who form part of BRICS have also embraced such technologies, as seen in the previous sections. The current section explores the smart city phenomenon from an African perspective. Analysis from this section will form a critical role in developing a smart city model suitable for a South African metropolitan municipality, which is the focus of this chapter. Lessons learned from an African perspective are critical in applying similar approaches for the South African municipality.

3.6.1 Nairobi

Nairobi is the capital city and the commercial hub of Kenya. Since the late 2000s, the city has become a focal point of "largescale and ambitious technology-driven city-making processes and ambition" (Guma and Monstad, 2020:1). According to Mwaniki *et al.* (2017:749), the city has seen the rapid adoption of ICTs in various economic sectors, particularly "the growth of e-commerce, e-finance and e-Governance, coupled with friendly policies and a rapidly emerging middle class that is already causing an economic revolution". The diffusion in ICTs usage in Nairobi has resulted in an ICT-driven smart

economic growth revolution in both the formal and informal sectors of the economy and established massive opportunities for sustained growth.

Nairobi was awarded the title of the most intelligent city in Africa in 2015 and 2016, and the entire country is a world leader in the use of mobile phones for money transfers. The success of the money transfer service, known as M-Pesa, has inspired many entrepreneurs in Nairobi to focus on the tech industry and proactively launch start-ups. According to Vera (2017), in 2010, the city of Nairobi invested further into fostering innovation by creating the iHub. In this tech incubation centre, developers and entrepreneurs can connect and work side by side. By 2015, the incubation centre had spawned 150 start-ups and had created more than 1,300 jobs.

3.6.2 Kigali

Kigali, the capital city of Rwanda, has seen rapid and unpredicted growth of citizens moving into the city since the end of the genocide incidence that occurred in 1994 (Mhute, 2014). This influx of people into the city resulted in pressure on the infrastructure and services. According to Manirakiza *et al*. (2019:304), to mitigate the situation, the city of Kigali developed master plans and policies, which helped the city to manage urbanisation and the provision of health, education and other services to the city dwellers.

Kigali has been undergoing remarkable changes in modernisation by rejuvenating commercial areas, building new business offices and quality infrastructure, improving urban service delivery, tourism, and industrial development. Smart city initiatives are part and parcel of this modernisation agenda, and Rwanda has become one of the prominent pioneers of smart city development in Africa (Meyer, 2018:11). The country even developed a smart cities blueprint, which was designed as a reference tool to support African cities as they build their smart city initiatives.

Some of the smart city initiatives in Kigali included the Smart Kigali Initiative, which aimed to modernise citizenship through ICT for better service delivery. Through this initiative, which consists of a public-private partnership element, free broadband WiFi Internet access in public places including commercial buildings, bus stations, airports, and public

transport is provided, there is improved "internet connectivity and access in hotels and restaurants, automated ticketing, and taxi meters in public transport; and electronic payments systems to improve financial services", amongst other measures (BiztechAfrica, 2013). Kigali has also developed an extensive fibre optic infrastructure to deliver 4G LTE capability to more than 95% of citizens (Davis, 2017).

3.6.3 Lagos

Lagos is Nigeria's economic capital and is part of the Nigeria Smart City Initiative (NSCI), which is aimed at initiating sound and actionable strategies for transforming Nigerian major urban centres from traditional dysfunctional cities to modern, efficient, responsive ones capable of satisfying the needs of present and future generations of Nigerians. The City of Lagos's goal is to achieve the above by relying heavily on the application of ICT and other smart technologies in the operations and management of the city (Kabir, 2019:6). By utilising ICT solutions, it is believed that city management and administration, particularly of basic service delivery that citizens need, will improve.

The objective of employing smart city initiatives in Nigerian cities, according to Kabir (2019:6), is towards achieving better connectivity in the transport sector, a secured environment, decent, affordable housing, efficient sanitary and waste disposal system, and urban regeneration upgrade in the cities. However, Backhouse and Cohen (2014:133) disagree with this view and raise concerns that the Nigerian government does not have a particular standpoint on how they envision the smart cities in that country. Backhouse and Cohen (2014:133) believe that large multinational companies influence the government to implement smart city initiatives to benefit these companies. A case in point is the Eko Atlantic City on the outskirts of Lagos, which Backhouse and Cohen (2014:133) view as a modern space for business and leisure for the middle and upper classes and tourists. It is not necessarily tailored to solve SDG objectives for the poor and marginalised groups.

According to the IMD Smart City Index 2019, which "focuses on how citizens perceive the scope and impact of efforts to make their cities 'smart', balancing 'economic and technological aspects' with 'humane dimensions'", Lagos was ranked 102 out of 102 cities

surveyed. This is because Lagos is still in the early stages of 'smartness' due to challenges such as inadequate social and economic infrastructure, including ICT infrastructure, proper and functional ICT governance, and electricity power outages.

3.6.4 Casablanca

The City of Casablanca is one of the largest cities in Morocco and has a population of more than 3 million people within the urban area. The Moroccan government established the smart city e-Madina to improve the city's competitiveness. According to Abyre *et al.* (2019:74), the smart city e-Madina makes Casablanca more attractive, effective, and competitive for companies, citizens, and visitors. Casablanca believes in the potential of the smart and sustainable city approach. The mission of the e-Madina is to create a smart city ecosystem that brings about initiatives to transform the city using digital technologies and tangible and intangible resources available (e-Madina, 2016:3).

Current ongoing smart city projects within the City of Casablanca include the socially sustainable solar smart city project, the virtual museum of Casablanca project, the development of urban video surveillance project and the Casablanca digital project, amongst others (Benamrou *et al.,* 2016:879). These projects aim to use solar technology to complement energy generation, enabling visiting museums virtually and using video surveillance technology for automatic vehicle detection and tracking in clouds. Furthermore, according to Takouleu (2018), the City of Casablanca has invested more than 8 million euros in the Casablanca digital project, whose horizon is 2022. This investment is towards creating a tax information system, developing a GIS, dematerialisation of legalisation services, and acquiring a CRM (Citizenship Relation Management) tool.

3.6.5 Moka

Moka is a village in the Moka District of Mauritius. It is part of the Government of Mauritius's smart city scheme. According to the Mauritian Board of Investment, "the Smart City Scheme is an ambitious economic development programme aimed at consolidating the Mauritian international business and financial hub by creating ideal conditions for

working, living and spurring investment through the development of smart cities across the island". Moka smart city is one of eight smart cities developed to leverage the latest advances in urban planning and digitalised technologies to boost the economy and improve society's standard of living. According to Gobin-Rahimbux *et al.* (2020:342), some of the smart city initiatives in place include the use of GPS and GIS to monitor waste collection trucks, as well as using WhatsApp to send pictures to environmental inspectors while watching unoccupied lands and for solid waste management.

3.6.6 Best practice and principles from an African perceptive

Various cities in Africa have realised that ICTs have a role in their development and have started making plans and investing in 4IR technologies. However, issues such as inadequate infrastructure, electricity generation capacity and governance concerns, amongst others, continue to be a challenge. According to the Smart Kigali Initiative, the smartness of a city is not only about technical issues but also about using available resources effectively and involving society in the provision of solutions.

Table 12: Key Smart City features and lessons from an Africa perceptive

City	Key features and lessons to be learned
Nairobi, Kenya	• Invested in the iHub, a tech incubation centre where developers and entrepreneurs connect and work side by side. By 2015, the incubation centre had spawned 150 start-ups and had created more than 1,300 jobs.
Kigali, Rwanda	• Developed the Smart Kigali Initiative to modernise citizenship through ICT for better service delivery.
Lagos, Nigeria	• There is a national Nigeria Smart City Initiative (NSCI), which has managed to secure some investment from multinational ICT companies.
Casablanca, Morocco	• The City of Casablanca has invested more than 8 million euros in the Casablanca digital project.
Moka, Mauritius	• Moka is a relatively new city being built around smart city technologies as a means of boosting the economy and improving the standard of living of the society.

Source: Researcher's own

Overall, smart city implementation in Africa is still in the early stages, and huge investments in ICT infrastructure and human capital development are necessary. Like developed economies, African cities have also developed bold, smart city plans that are part of government policy towards improving the quality of life for citizens and better competitiveness.

3.7 CONCLUSION

This chapter focused on smart city approaches and best practices from leading smart cities in developed economies, BRIC countries, and from an African point of view. It was shown that many cities see smart city initiatives as a possible solution to some of the urban challenges encountered in the 21st century city living environment. Prioritising smart city initiatives as part of a country or a city's policy was a cross-cutting issue that prevailed in many smart cities examined in this chapter. This policy allowed fiscal budget allocations towards smart infrastructure needed to operate 4IR technologies such as broadband, WiFi, IoTs and many other technologies. It was evident that human aspects

were also critical to the success of a smart city, leading cities invested in knowledge management and creating a conducive environment for citizens, businesses, universities, and research institutions to collaborate with a city's government in the provision of solutions to public issues as well as creating new business ventures that benefit society.

The next chapter explores the chronicles of ICT applications in urban governance in South Africa. The exploration will also include statutory and regulatory frameworks governing the application of ICT in urban management, leading to smart city initiatives.

CHAPTER 4: THE STATUTORY AND REGULATORY FRAMEWORKS GOVERNING THE APPLICATION OF ICT IN URBAN GOVERNANCE LEADING TO SMART CITY INITIATIVES

4.1 INTRODUCTION

The South African Constitution (1996) created a government structure with three distinct but interdependent spheres of government, namely national, provincial, and local spheres. The national sphere of government is responsible for setting macroeconomic policies for the country as a whole; the provincial sphere of government has the primary responsibility to deliver on those policies from a provincial point of view. The third sphere, the local sphere of government, is the one that is closest to communities and is responsible for the delivery of basic services, including waste management, electricity, water, and sanitation services. Urban governance is thus practised within the local sphere of government, and it relates to how government and other stakeholders decide how to plan, finance, and manage urban areas. According to Edelenbos and Van Dijk (2017:1), urban governance involves a "continuous process of negotiation and contestation by different stakeholders from various backgrounds such as government actors, private actors, non-governmental organisations (NGOs), and citizens over the allocation of social and material resources as well as political power''. In this regard, a comprehensive statutory and regulatory framework, inclusive of departmental policies and operational guidelines, was developed to direct the affairs of urban government. This includes directives for the way cities should deal with urban challenges, including public service delivery requirements and growing demands of urban communities.

Chapter 2 reviewed the meta-theoretical underpinnings, principles, and dimensions of smart cities in the context of 4IR. In contrast, chapter 3 focused on exploring international smart city models, frameworks, best practice approaches, and praxis from leading smart cities worldwide. The current chapter builds upon the previous chapters and is concerned with the statutory and regulatory frameworks governing the application of ICTs in urban governance leading to smart city initiatives. In aligning to international best practice of accommodating the exponential growth of ICT in government operations, the South

African government established an extensive statutory and regulatory framework to direct the application of ICTs, including 4IR technologies, within the public sphere. This chapter serves as a further theoretical data set to inform the design of a smart city model suitable for application in South Africa by focusing on the statutory and regulatory frameworks governing the application of ICT in urban governance.

4.2 THE NATURE OF URBAN GOVERNANCE IN SOUTH AFRICA

The United Nations Development Programme (UNDP) regards governance as the “exercise of political, economic and administrative authority in the management of a country’s affairs at all levels” (UN-HABITAT, 2004:13). It comprises of mechanisms, processes and institutions through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations, and mediate their differences (UN-HABITAT, 2004:13). Urban governance can be regarded as “profoundly political, influenced by the creation and operation of political institutions, government capacity to make and implement decisions and the extent to which these decisions recognise and respond to the interests of the poor” (Avis, 2016:5). In the South African context, the Constitution of the Republic of South Africa, 1996, is the "supreme law of the land. It sets out how all the elements of government, including urban (local) government, are "organised and contains rules about what power is wielded, who wields it and over whom it is wielded in the governing of a country" (Republic of South Africa, 2020).

The Constitution, chapter 7, section 152(1), outlines the objects of local government as follows:

a) “To provide a democratic and accountable government for local communities.
b) To ensure the provision of services to communities in a sustainable manner.
c) To promote social and economic development.
d) To promote a safe and healthy environment.
e) To encourage the involvement of communities and community organisations in local government matters".

Furthermore, section 153 deals with the developmental duties of municipalities and stipulates the following:

“A municipality must –

a) structure and manage its administration and budgeting and planning processes to give priority to the basic needs of the community and to promote the social and economic development of the community; and
b) participate in national and provincial development programmes”.

In addition, section 155(1) of the Constitution makes provision for three categories of municipalities, namely:

(a) “Category A: A municipality with exclusive municipal executive and legislative authority in its area.
(b) Category B: A municipality that shares municipal executive and legislative authority in its area with a category C municipality within whose area it falls.
(c) Category C: A municipality with municipal executive and legislative authority in an area that includes more than one municipality”.

The focus of the current study is on Category A municipalities, which are urban metropolitan municipalities. According to the Local Government: Municipal Structures Act 117 of 1998, areas can be categorised as Category A municipalities if that area can reasonably be regarded as –

a) “a conurbation featuring-
   (i) areas of high population density.
   (ii) an intense movement of people, goods, and services.
   (iii) extensive development; and
   (iv) multiple business districts and industrial areas.
b) A centre of economic activity with a complex and diverse economy.
c) It is a single area for which integrated development planning is desirable,
d) with strong interdependent social and economic linkages between its constituent units".

The Constitution promotes the mechanism for urban governance and economic development by municipalities to improve society's welfare. South African metropolitan municipalities are urban areas consistent with the meta-theoretical underpinning. Information and insights gained from statutory and regulatory frameworks governing urban governance in South Africa should thus be used as a data set to inform the proposed smart city model as the focus of this study.

4.3 STATUTORY FRAMEWORK FOR URBAN GOVERNANCE IN SOUTH AFRICA

Since 1994, several government initiatives have been designed to improve service delivery by employing ICT technologies to create a digitally inclusive society geared for economic prosperity. The South African government advocates the usage of ICTs in providing government services. Over the years, many statutory mechanisms have been adopted towards this goal. Below is a discussion of some of these statutory frameworks related to e-Government and e-Governance, including smart cities initiatives at the local sphere of government.

4.3.1 Public Service Act 103 of 1994

According to this Act, electronic or e-Government means using ICTs in the public service to improve its internal functioning and render services to the public. Section 3 (1) of the Public Service Act of 1994, including all its amendments, "empowers the Minister of Public Services and Administration (MPSA) to develop and establish norms and standards related to", amongst others, information management and e-Government in the South African public service. The mandate of the MPSA empowers the Department of Public Service and Administration (DPSA) to provide direction on e-Government for the entire public service. Furthermore, the DPSA is mandated to foster good governance and sound administration in the public service. This includes transforming and modernising the public service through developing and implementing policies and frameworks (Republic of South Africa, 2017). The Public Service Act was designed to change the public sector and show the government's commitment and seriousness towards imploying ICT solutions to government processes.

The purpose of introducing this Act was to enable the public service in its quest for improved service delivery. The South African government believed in improving public services through ICT key focus areas. The Public Service Act assists all spheres of government by enabling the MPSA to develop norms and standards relating to information management in the public service and e-Government, amongst other areas, which is fundamental for ICT-enabled solutions, especially within the local government. This piece of legislation covers a broad range of issues and thus is not detailed in the ICT arena; however, it makes room for more focused legislation to be developed to address the public sector and regulatory provision to oversee the public ICT space.

4.3.2 State Information Technology Agency Act 88 of 1998

The State Information Technology Agency (SITA) Act, 88 of 1998, builds on other ICT-related statutory frameworks. It provides for establishing a company that will act as an agent of the South African Government and provide information technology, information systems and related services to the public sector. SITA (Pty) Ltd was thus established as a juristic person for this purpose. The SITA Act prescribes that SITA may assist municipalities and municipal entities in acquiring all IT-related goods and services.

Section 7(1) provides that for the agency to achieve its objectives, the agency may, amongst others:

a) Provide wide-area information technology networks (WAN); acquire, build, or maintain transversal information systems; and provide data-processing or associated services for transversal information systems.
b) Provide training in information technology or information systems; application software development; maintenance services for information technology software or infrastructure; data-processing or associated services for departmentally specific information technology applications or systems; technical, functional, or business advice or support, or research, regarding information technology; and management services for information technology or information systems.

According to Kekana (2011:38), in delivering its objectives, SITA assists the government in achieving goals such as getting value for money through ICT procurement, effective utilisation of expensive ICT resources such as consultants, integrated ICT solutions across government, and a rationalised IT infrastructure. Thus, for any organ of the state, including municipalities at a local sphere of government, to succeed in implementing ICT solutions, a good working relationship and cooperation with SITA is crucial, as SITA coordinates state-wide ICT interventions. This Act is both strategic and operational at the same time as it illustrates the government's big picture of ICTs and how to operationalise ICTs for the benefit of all organs of the state.

4.3.3 Electronic Communication and Transaction Act 25 of 2002

The Electronic Communication and Transaction (ECT) Act facilitates and regulates e-Government services and electronic communications and transactions with public and private bodies, institutions, and citizens. In addition, the ECT Act of 2002, including all its amendments, empowers the Minister of Communications and Digital Technologies to develop the National e-Strategy, which seeks to encourage access to electronic communication and transaction by all within the republic. The ECT also governs the high demand spectrum, which is necessary to access quality broadband for all South Africans. The ECT also provides how online transactions and contracts occur and the legal principles that govern such issues.

Smart cities are built on 4IR technologies that need a quality internet connection to collect, store, analyse and distribute data. For a smart city to be effective, ICTs need to have the ability to share available data and for transactions to occur electronically, as electronic communication and transaction is the backbone for the implementation of any smart city's technology. The ECT Act provides strategic and operational considerations that are critical to the success of any smart city initiates.

4.3.4 Protection of Personal Information Act 4 of 2013

The Protection of Personal Information Act 4 of 2013 (POPI Act) was introduced in 2013 to protect personal information. The POPI Act is more detailed than ECT on these issues. It is aimed to promote the security of personal data processed by both private and public sector bodies and introduce certain information to establish minimum requirements for processing such personal information (Republic of South Africa, 2013).

With regards to smart cities applications, much data is collected by such systems for processing to improve the decision-making processes of city administration and related stakeholders. Therefore, the POPI Act ensures that collected information is not used unlawfully and that privacy concerns of citizens are considered by municipalities when collecting and processing such data.

Table 13: Key statutory requirements towards a smart city plan

Statutory Framework	Key requirements to comply with by municipalities
Public Service Act	• Municipalities need to comply with e-Government norms and standards as issued from time to time by the Minister of Public Services and Administration.
State Information Technology Agency Act	• There are no legislated requirements for municipalities to utilise SITA services. However, the National Treasury recommends that municipalities consider utilising SITA to procure IT-related goods and services through a competitive bidding process.
Electronic Communication and Transaction Act	• Municipalities and other government institutions accept the filling of documents and payments electronically. Furthermore, public sector entities can issue permits, licences, or approval in the form of a data message.
Protection of Personal Information Act	• Municipalities and other government institutions must comply with conditions for lawful processing of personal information as per the Act. • Additionally, municipalities must abide by the Information Regulator's code of conduct.

Source: Researchers' own

This section focused on key statutory frameworks within urban governance in South Africa. Key pieces of legislation governing municipal ICT services were discussed. Table 13 above summarises the key requirements that municipalities need to comply with. The statutory frameworks governing ICT within South Africa are more general and do not specifically deal with smart cities. It is clear that there is a gap in legislation, and guidelines and policies need to be developed to address such shortcomings. This will go a long way in providing certainty to stakeholders and, hence, improve South African municipalities' attractiveness and competitiveness.

4.4 REGULATORY FRAMEWORKS FOR URBAN GOVERNANCE IN SOUTH AFRICA

The South African government has issued several regulatory frameworks such as white papers, strategies, standards, and other official documents to transform the public service

and private sector using ICTs solutions. Such regulatory frameworks also impact urban governance, as they provide direction and support towards implementing ICT technologies, including smart cities, within the local sphere of government.

4.4.1 White Paper on Transforming Public Service Delivery, 1997

The White Paper on Transforming Public Service Delivery, *Batho Pele*, 1997, aims to provide a policy framework and a practical implementation strategy for transforming public service delivery. *Batho Pele* is primarily about how public services are provided and specifically about improving the efficiency and effectiveness of how services are delivered. It looks at principles that put people first in public service delivery. The white paper advocates nine principles to guide public servants; consultation with citizens, setting service standards, increasing access to information, ensuring courtesy, providing information, openness and transparency, redress, and value for money (Visser and Twinomurinzi, 2009:36). ICT can thus be used to put people first, through its ability to improve consultations with the public through online and mobile ICT solutions; through its ability to provide tools for monitoring, reporting and evaluation; through ICT's ability to easily provide access to a wide range of audiences and many other applications that can assist the government in meeting the obligations of the *Batho Pele* principles. Similarly, municipalities wishing to advance public service delivery through employing *Batho Pele* principles would be in an even better position by doing so using ICT powered smart city technologies.

4.4.2 Public Service Regulations, 2001

The Public Service Regulations of 2001, including all its amendments, sets out regulations for e-Government. These regulations address key areas of e-Government and require all departments to manage IT effectively and efficiently, considering that IT must improve the delivery of public services and the productivity and cost-efficiency of government departments and entities. This regulation required the MPSA to issue the Minimum Information Security Standards (MISS) handbook. The MISS is a standard for the minimum information security measures that any institution must have for sensitive or

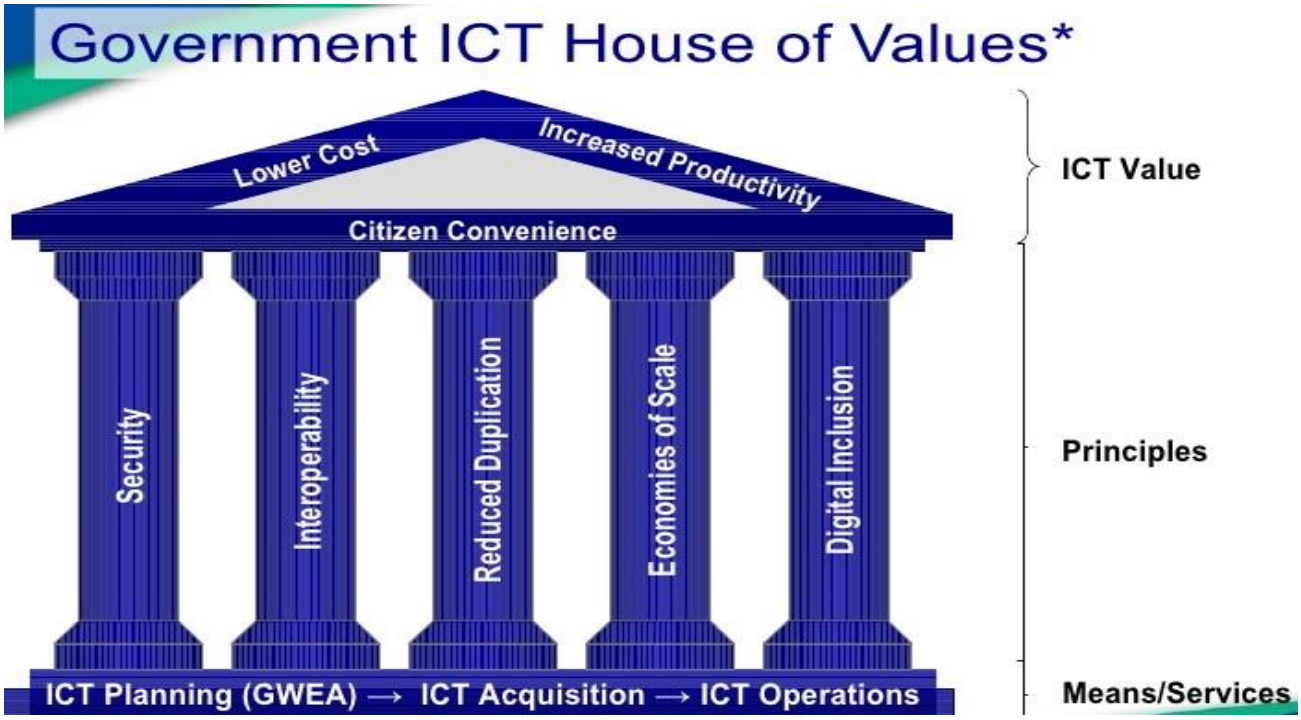
classified information to protect national security. Additionally, all persons working with public service information resources must comply with the MISS.

According to the regulation, the MPSA should also issue a handbook on Minimum Interoperability Standards (MIOS). The purpose of the MIOS is to prescribe open system standards that will ensure minimum interoperability within and between IS/ICT systems utilised in government, industry, citizens, and the international community in support of the e-Government objectives. All departments must comply with MIOS, which is essential for seamless and integrated service delivery. Thus, the Public Service Regulations of 2001, including all its amendments, provide for minimum security measures and minimum level of interoperability when designing and operating ICTs, which is an important element of any smart city technology since smart cities collect and use publicly obtained data that may pose security risks to the public. Furthermore, smart city technologies, such as IoTs, should have the ability to easily exchange, share, and use public obtained data amongst themselves and other government ICT systems.

4.4.3 Government-Wide Enterprise Architecture (GWEA) Framework Implementation Guide, 2010

The South African Government Wide Enterprise Architecture (GWEA) Framework implementation guide provides a minimum ICT standard to be used across all government departments and agencies. The framework is intended to supersede all prevailing Enterprise Architecture and ICT planning frameworks and methods used by the government. The GWEA Framework is generic and can be applied in all spheres and levels of government and is valuable to produce a department/agency ICT Plan or Roadmap that is fully aligned with the department/agency business plan whilst observing the objectives and principles of the South African e-Government as defined in the ICT House of Values.

Figure 14: Government ICT House of Values



Source: GITOC (2010:06)

As shown in figure 14 above, the ICT House of Values depicts the values and key focus areas of ICT service delivery. These are strategic outcomes, principles, ideals, and key focus areas that inform ICT acquisition, management, and use in the public sector. According to the DPSA (2001:08), the "success of the e-Government initiatives is underpinned by primary focus areas" of interoperability, IT security, economies of scale, reduced or elimination of duplication and digital inclusion of all South Africans. It is evident that the government sees the value of ICTs in public services and is putting measures in place to achieve the desired objectives. Smart cities success will also depend largely on government policies and frameworks', such as the GWEA, investment in 4IR technologies.

4.4.4 Municipal ICT Governance Guidelines, 2012

The Municipal ICT Governance Guidelines or Roadmap was issued by the South African Local Government Association (SALGA) in 2012. SALGA is an independent association comprised of all South African municipalities representing the local sphere of government.

One of the roles of SALGA is to define, promote, and protect local governments' interests and raise the profile of local government, amongst other objectives. These guidelines were issued to provide suggestions to municipalities on improving the status of ICT governance within their operations. According to SALGA (2012:10), ICTs are integral to a functioning, well-run city and can be leveraged for effective administration, service delivery and socio-economic development for local government. The objectives of the guidelines include:

a) “Raising the profile of ICT within municipalities
b) Raising the ICT profile as a strategic enabler for effective administration and service delivery
c) Bringing good international practices into the municipal arena
d) Further strengthening corporate governance of ICT as well as ensuring the CIO (head of ICT) is an integral part of the executive management of a municipality
e) Institutionalising IT governance as an integral part of municipal corporate governance
f) Creating a process whereby IT governance standards across and within the local government sector can be introduced
g) Improving the IT governance literacy and lingo within municipalities” (SALGA, 2012:10).

Furthermore, according to this document, a municipality’s ICT governance is the responsibility of the political and executive management. For this reason, it is recommended that the Executive Authority or political principals provide the political ICT leadership. In contrast, the Accounting Officer or City Manager provides the strategic leadership and ensures that ICT governance is implemented and managed. This roadmap further recommends elevating the ICT function to be part of the executive management of the municipality. Through this document, SALGA showed its intention of embracing technological innovation to raise public service delivery, early on. Smart city technologies are yet another development in this sphere that can greatly advance the pace of transformation, economic competitiveness, and growth of municipalities.

4.4.5 National Broadband Policy: SA Connect, 2013

South Africa Connect is the country's broadband policy to create opportunities and inclusive economic growth by ensuring affordable broadband reaches many South Africans. The purpose of the policy is to provide a broadband vision and a roadmap to achieve the vision in ways that enable economic enterprise and innovation; ensure social and financial inclusion; and identify policy choices and strategies that will deliver a robust and cost-effective solution to universal, affordable broadband access (Department of Communications and Digital Technologies, 2013). Furthermore, one of the objectives of the policy is ensuring an efficient public sector delivery, including e-Government services, underpinned by the aggregation of broadband needs, so that all public institutions at the national, provincial, and municipal level should benefit from broadband connectivity and this should be extended to the communities they serve. The Smart Cities Council (2015:143) upholds that "ubiquitous broadband telecommunication is a prerequisite for a smart city". Broadband availability everywhere within a smart city enables 4IR technologies to connect, process, exchange, and act upon the collected data to improve public services.

4.4.6 Gauteng City-Region (GCR) e-Government Strategy 2015-2020

The Gauteng Provincial Government (GPG) developed a Gauteng City Region (GCR) e-Government Strategy aimed at public modernisation service by utilising ICT solutions, through the deployment of the broadband network; the transformation of the back office functions within the GCR; increasing access channels for public services; eliminating duplication, and ensuring interoperability between systems. The GPG believes that through building an enabling ICT infrastructure; developing an enabling platform and support services for designing and developing e-Government services; establishing an e-Governance structure; promoting the use of e-Government services by citizens; and the stimulation of the ICT economy, this would lead to connectedness among government entities, citizens and businesses, which will increase collaboration and make it easier and more efficient to interact with government.

According to the Gauteng Estimates of Provincial Revenue and Expenditure (2019:512), the GCR e-Government Strategy was adopted to achieve the following:

a) “Build an enabling broadband infrastructure for a connected government.
b) Create an enabling platform to deliver e-Government services.
c) Establish a GCR structure to coordinate, standardise, regulate, and prioritise our e-Government initiatives.
d) Promote the use of e-Government services across the board by government, citizens, and the private sector.
e) Stimulate the ICT economy by encouraging public, private partnerships for the development and roll-out of e-Government services.”

Furthermore, the GPG established a department of e-Government, which is tasked to coordinate the implementation of GPG ICT strategy and generally improve and expand access to e-Government services within the Gauteng City-Region (GCR) (Makhura, 2015). Three metropolitan municipalities are part of the GCR, which are the focus of this study. These urban municipalities take their cue to implement ICT solutions from this strategy, supported by the Gauteng Department of e-Government. According to the strategic plan 2020-2025 of the Gauteng Department of e-Government, the focus of the department over the medium term is to move the province from e-Government to e-Governance where the connectedness of government to citizens is universal, and the public service is modernised through enabling citizens to interact and receive government services easily. This illustrates the commitment of the GPG to ICT solutions such as those provided by smart city technologies.

4.4.7 National Integrated ICT Policy White Paper, 2016

The South African government believes that ICTs can play a critical role in facilitating developmental objectives outlined in the National Development Plan (NDP). According to the NDP objectives, by 2030, ICT will underpin the development of a dynamic and connected information society and a vibrant knowledge economy that is more inclusive and prosperous. In light of these NDP 2030 objectives, the National Integrated ICT Policy White Paper (NIIPWP) was developed. The white paper introduces a range of

interventions to ensure that "everyone in South Africa, regardless of who they are, where they live, or their socio-economic status can improve the quality of their lives through participating in the digital society" (Republic of South Africa, 2016:01).

Section 4 of the white paper provides the objectives of the policy as to facilitate:

a) “A decisive and visionary leadership of the digital transformation project in South Africa.
b) A whole government approach to digital transformation and coordination between government departments and entities and across all relevant spheres of government.
c) Effective monitoring of the implementation of strategies adopted and the impact on the vision of the inclusive digital transformation of government, the economy and society”.

To this end, an Inter-Ministerial Committee, called the Digital Transformation Committee, which is answerable to the executive, was formed (Republic of South Africa, 2016:02). The committee is responsible for driving the change programme across the public service, and it facilitates coordination of activities across government to ensure that a whole-of-government approach is applied. Furthermore, the DCDT envisages that several Bills required to implement this white paper will be developed and submitted to Parliament over the medium-term (2020/21FY-2022/23FY). The Bills allow for, among other things, the rationalisation of state-owned ICT companies for greater efficiency and ensure that communities and individuals have access to ICT services and skills for the digital economy. The South African government has been weighing the decision to establish two companies, an IT company, and an ICT Infrastructure Company, through the merger of the different functions of the State IT Agency (SITA), Sentech and Broadband Infraco (Mzekandaba, 2020). This white paper provides the benefits that the government anticipates from using ICTs in public service delivery and aiding the private sector to create opportunities and improve business processes for improved and better economic performance for the benefit of society. The smart cities approach is an element and extension of e-Government and directly creates value for the government and society as resources are used more efficiently and public service delivery time is shortened.

4.4.8 The National e-Strategy (Digital Society SA), 2017

The Digital Society SA is South Africa's National e-Strategy, which aims to transform South Africa into a fully digital society marked by a widespread diffusion, uptake, and usage of ICTs in the whole of society. The National e-Strategy emanates from Chapter 10 of the NIIPWP. Its purpose is to articulate the vision for developing an inclusive information society and knowledge economy for South Africa based on the citizens' business and public sector (SAnews.gov.za, 2017). The government has identified the ICT sector as having a significant role in driving and enabling the new growth and developmental trajectory. The National e-Strategy also articulates the part of the government in the use of ICTs to improve service delivery, the involvement of all South Africans in growing the economy, the use of e-commerce, ensuring that the population possesses the necessary skills and abilities to use ICTs, as well as developing comprehensive programmes to counter cybersecurity threats.

The National e-Strategy (2017:03) consists of three pillars, which are:

a) "interventions focused on the ICT sector as a standalone growth area;
b) sectorial plans focused on the uptake and usage of ICTs in all sectors of society and the economy, and
c) developing a roadmap and action plan to transition the South African economy to the Digital Industrial Revolution".

Each of these pillars is mutually reinforces and complements each other. Furthermore, each post has different considerations and activities designed to achieve defined policy ends (Republic of South Africa, 2017). Regarding municipal and urban governance environment, this strategy supports the idea of creating low power consuming wireless technologies that respond to changes in demand for IoTs connectivity to support the building of smart communities, both in large cities and rural municipalities. The National e-Strategy thus encourages smart city interventions and employing technological solutions towards improved basic public service delivery.

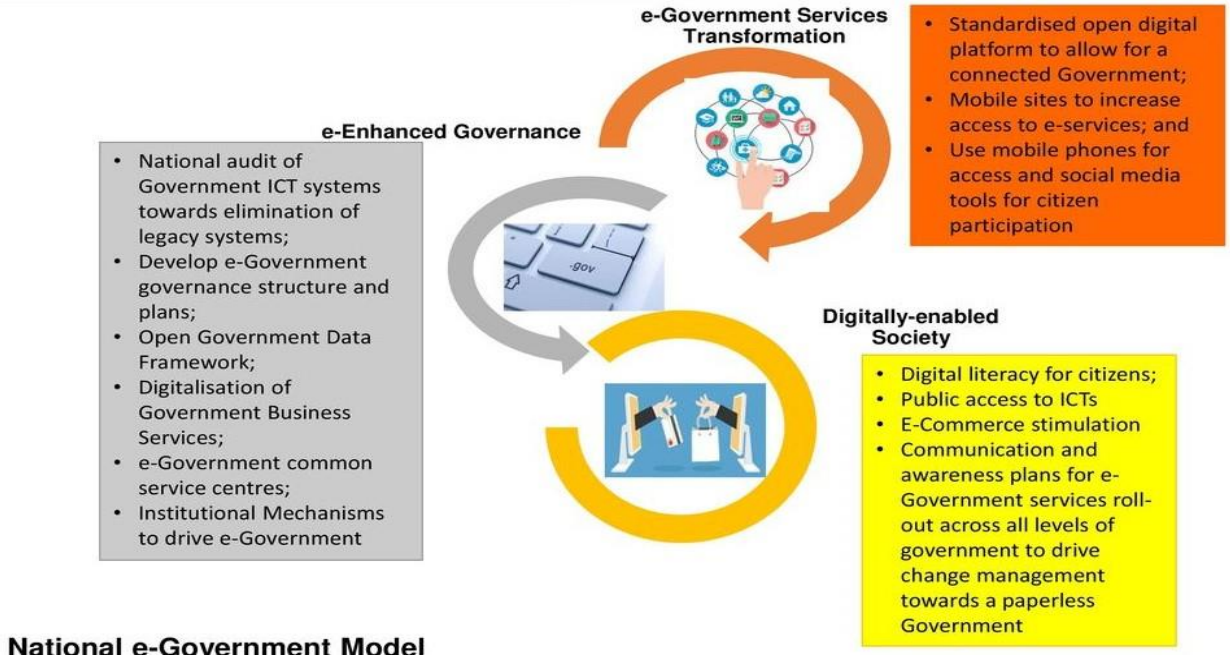
4.4.9 King IV Corporate Governance Code on Municipalities, 2016

The King IV Report on Corporate Governance comprises of a set of corporate governance “voluntary principles and leading practices drafted to apply to all organisations, regardless of their form of incorporation” (PwC South Africa, 2017). The code refers to corporate governance as the “exercise of ethical and effective leadership by the governing body towards achieving governance outcomes such as ethical culture, good performance, effective control and legitimacy” (Institute of Directors in Southern Africa, 2016:11). Although the King Code is not legislated, it is applied in the public sector, and the King Committee has also issued a municipality supplement of the King Code. Principle 12 of the supplement states that the governing body or “council should govern technology and information in a way that supports the municipality setting and achieving its strategic objectives" (Institute of Directors in Southern Africa, 2016:85). King IV takes cognisance of advances in 4IR technologies that revolutionise businesses and society and transform products, services, and business models. The impact of such technologies is to cause possible disruptions, opportunities, and risks for both the public and private sectors of society (Institute of Directors in Southern Africa, 2016:30). In applying and explaining Principle 12, municipalities must put measures in place to deal with 4IR technological innovation to increase their sustainability by improving their processes so that cities can be competitive, economical, and effective in public service delivery.

4.4.10 The National e-Government Strategy and Roadmap, 2017

The National e-Government Strategy and Roadmap is also derived from Chapter 10 of the NIIPWP, which emphasises the need to realise the digital transformation of public services. The purpose of this strategy is to guide the digital transformation of public service into an inclusive digital society where all citizens can benefit from the opportunities offered by digital technologies to improve their quality of life. Figure 15 below depicts this strategy's purpose, objectives, and proposed strategic outcomes in summary form.

Figure 15: National e-Government Model



Source: Republic of South Africa (2017:25)

The National e-Government Strategy and Roadmap aims to:

a) "ensure that all South Africans can access quality public service and government information from anywhere, any time.
b) Reduce the cost of public administration in South Africa.
c) Harmonise the policy environment and legislative framework to enable digital transformation.
d) Establish institutional mechanisms that will advance the coordination and facilitation of e-Government services.
e) Create and manage reliable, accessible, and cost-effective common central services centres.
f) Manage the development of frameworks addressing skills development.
g) Deliver integrated electronic services, which will ensure a one-stop service portal.
h) Develop capacity and skills programmes that will ensure good service delivery.
i) Develop monitoring and evaluation frameworks for e-Government services.
j) Make government more accountable by making its operations more transparent, thus reducing corruption opportunities.
k) Transform the way government interacts with citizens.

l) Provide socio-economic development opportunities by empowering rural and traditional under-served communities using ICTs.
m) Leverage on advances brought upon by technological innovations (such as cloud computing, internet of things (IoT), big data, mobile innovations, etc.) to drive the success of digitising government.
n) Expand the technological capabilities of citizens and businesses for participation in the government decision-making process; and
o) Provide administration by internationally acceptable standards and best practices".

The mandate derived from this strategy covers all major aspects of e-Government, which is the use of ICT to facilitate communication for government to government (G2G), government to citizens (G2C), government to employee (G2E) and government to businesses (G2B), in all three spheres of government. The National e-Government Strategy and Roadmap also provides guiding principles, similar to the Government ICT House of Value, to implement e-Government initiatives successfully. According to these principles, government ICT systems should connect, communicate, exchange, and use the information amongst each other (interoperability). Furthermore, ICT security issues, economies of scale, elimination of duplication and digital inclusion should be at the forefront of all government ICT decisions. The success of smart cities depends on the quality of data collected and analysed. If society has access to ICT devices and technology suitable for 4IR, this will greatly increase the quality of data collected. The government will be better positioned to provide practical solutions required by society.

4.4.11 The Presidential Commission on the Fourth Industrial Revolution (PC4IR), 2018

The South African President, Mr Cyril Ramaphosa, during the 2018 State of the Nation Address, indicated that the prosperity of South Africa depends on the country's ability to take full advantage of rapid technological change by developing South Africa's capabilities in the areas of science, technology, and innovation (Ramaphosa, 2018). To this end, the establishment of the Presidential Commission on the Fourth Industrial Revolution (PC4IR) was gazetted and is chaired by the President of South Africa and

comprises of individuals from the public and private sector, including civil society. The PC4IR has been tasked with a comprehensive set of responsibilities under its Terms of Reference (ToRs). These include proposing the country's overarching strategy for 4IR and making recommendations regarding the institutional frameworks and roles of various sectors of society within the comprehensive plan. The commission was established to ensure that South Africa is better positioned to seize the opportunities and manage the challenges of rapid advances in ICT. The mandate of the commission is to:

a) “develop an integrated national strategy and plan to respond to the 4IR
b) advise on strategies to enhance South Africa's global competitiveness
c) advise on a research programmes to advance 4IR
d) advise on the skills development and future of work
e) make recommendations on enabling relevant infrastructure for South Africa to participate in the digital economy
f) make recommendations on an institutional framework and mechanism to coordinate 4IR programmes
g) make recommendations on approaches to address inclusivity and the digital divide
h) make recommendations on interventions to enable entrepreneurship and SMMEs to take advantage of the 4IR
i) mobilise resources to support the 4IR interventions and make recommendations on mechanisms to measure the impact of interventions of 4IR” (Department of Telecommunications & Postal Services, 2018:6).

The concept document for the establishment of the PC4IR (2018:5) outlines the following as key enablers:

a) “investment in critical, enabling ICT infrastructure to develop a digital economy.
b) innovation, research and development.
c) skills development.
d) SMME, entrepreneurship and localisation; and
e) labour market restructuring”.

According to the Department of Telecommunications & Postal Services (2018:15), smart cities are seen as another platform to expedite the diffusion of technologies at the municipal level by applying 4IR principles, thereby enabling cities to make more efficient use of resources in their operations. The commission regards 4IR technologies to be tools to assist municipalities with issues such as shortages of housing, waste management and big data analytics, which affords cities the possibility of managing traffic, scheduling transportation services, and responding to emergencies in a more efficient way (Republic of South Africa, 2018).

4.4.12 White Paper on Science Technology and Innovation, 2019

The 2019 White Paper on Science, Technology and Innovation sets the long-term policy direction for the South African government to ensure a growing role for science, technology, and innovation (STI) in a more prosperous and inclusive society. In particular, the White Paper engages with the significant changes that are associated with 4IR and are based on extensive reviews of various aspects of the National System of Innovation (NSI), as well as consultation with a wide range of role-players such as relevant government departments, civil society, business, and academia. Furthermore, this paper has a much stronger focus on partnerships with such stakeholders. According to this paper, integrating digital technologies into the provision of government services (e-Government) and the management of cities (smart cities) has the potential to transform the scope and efficiency of public services (Republic of South Africa, 2019:17).

This section provided several regulatory documents (Table 14) such as white papers, official guidelines, strategies, and standards that the South African Government has issued to transform the public service by employing ICTs solutions. This regulatory framework provides direction and support towards implementing ICT technologies, including smart cities, within the local sphere of government.

Table 14: Key regulatory requirements towards a smart city plan

Regulatory Framework	Key requirements to comply with by municipalities
White Paper on Transforming Public Service Delivery	• *Batho Pele* advocates the following nine principles to guide public servants in improving the efficiency and effectiveness of services delivered: consultation with citizens, setting service standards, increasing access to information, ensuring courtesy, providing information, openness and transparency, redress, and value for money. • Use ICTs to put people first through its ability to improve consultations with the public through online and mobile ICT solutions; through its ability to provide tools for monitoring, reporting and evaluation; through ICT's ability to easily provide access to a wide range of audiences and many other applications.
Public Service Regulations	• Sets out regulations that address key areas of e-Government and requires public sector entities to manage IT effectively and efficiently to improve productivity, cost efficiency, and public service delivery. • Municipalities need to comply with the Minimum Information Security Standards (MISS), a standard for the minimum information security measures that municipalities must put in place for sensitive or classified information to protect national security.
Government-Wide Enterprise Architecture Framework implementation guide	• GWEA provides a minimum ICT standard, including the enterprise architecture and ICT planning frameworks and methods to be used across all government departments and agencies. • Municipalities to apply the GWEA Framework implementation guide to produce a municipal ICT Plan or Roadmap fully aligned with a municipal business plan whilst observing the objectives and principles defined in the ICT House of Values.

Regulatory Framework	Key requirements to comply with by municipalities
SALGA's Municipal ICT Governance Guidelines	• Requires the chief information officer (CIO) or Head of ICT to be an integral part of the executive management of a municipality. • Provides that an Executive Authority or political principals provide the political ICT leadership. In contrast, the Accounting Officer or City Manager provides the strategic leadership and ensures that ICT governance is implemented and managed effectively.
National Broadband Policy: SA Connect	• It aims to create opportunities and inclusive economic growth by ensuring that affordable broadband reaches a critical mass of South Africans. • A municipality should benefit from broadband connectivity, which should be extended to the communities they serve.
GCR e-Government Strategy	• Provides establishing a GCR structure to coordinate, standardise, regulate, and prioritise e-Government initiatives. • It stimulates the ICT economy by encouraging public and private partnerships to develop and roll out e-Government services.
National Integrated ICT Policy White Paper	• Provides a whole government approach to digital transformation and coordination between government departments and entities and across all relevant spheres of government.
National e-Strategy	• It aims to transform South Africa into a fully digital society marked by a widespread diffusion, uptake, and usage of ICTs in the community. • Municipalities should ensure that citizens possess the necessary skills and abilities to use ICTs and develop comprehensive programmes to counter cybersecurity threats.

Regulatory Framework	Key requirements to comply with by municipalities
King IV Corporate Governance Code on Municipalities	• Municipal Council should govern technology and information to support the municipality setting and achieve its strategic objectives. • Municipalities must address the advances in 4IR technologies that are revolutionising businesses and society and transforming products, services, and business models. The impact of such technologies can cause disruptions, opportunities, and risks for both the public and private sectors of society.
National e-Government Strategy and Roadmap	• It is aimed at reducing the cost of public administration in South Africa. • It leverages advances brought upon technological innovations (such as cloud computing, the IoT, big data, mobile innovations, etc.) to drive the success of digitising government.
Presidential Commission on the 4IR	• The mandate of developing an integrated national strategy and plan to respond to the 4IR. • Mobilise resources to support the 4IR interventions and make recommendations on mechanisms to measure the impact of interventions of 4IR.
White Paper on Science Technology and Innovation	• It focuses on 4IR partnerships with relevant government departments, civil society, business, and academia.

Source: Researcher's own

4.5 CONCLUSION

The objective of this chapter was centred on the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives. The discussions provided a background to legislation and regulations that govern ICT initiatives within the South African public sector. It was illustrated that the South African government's intention to utilise ICT to improve society stems from the republic's

Constitution and other key pieces of legislation such as the Public Service Act, Public Service Regulations, and the National Integrated ICT Policy White Paper.

It was further shown that several frameworks, guidelines, and strategies had been developed to further support the implementation of ICTs by the public sector, including the local sphere of government, comprised of municipalities. It was made clear that smart city initiatives to improve public service delivery is yet another element of e-Government offering by the public sector. However, despite the relative comprehensive statutory and regulatory framework presented, there is evidently a gap as far as smart cities, in particular, are concerned. There is a need to provide specific regulations or guidelines on how municipalities could generally become smart cities. In the next chapter, the e-readiness of Gauteng based metropolitan municipalities towards becoming smart cities will be determined by obtaining opinions and perspectives of key stakeholders and role-players within the ICT and city governance domain.

CHAPTER 5: E-READINESS OF GAUTENG-BASED METROPOLITAN MUNICIPALITIES: EMPIRICAL FINDINGS

5.1 INTRODUCTION

This study aims to develop a smart city model suitable for metropolitan municipalities with specific reference to those situated in the Gauteng Province. To this end, Chapter 1 introduced and outlined the orientation of this study and highlighted the problem statement, aim, research objectives and research methodology. Following that, Chapter 2 established a theoretical and conceptual framework for cities, urban governance, local states and municipalities in the context of ICT and 4IR as part of the evolution of public administration. Chapter 3 explored international best practice regarding smart cities, inclusive of cases from BRICS and the Africa continent. Chapter 4 ascertained the statutory and regulatory frameworks governing the application of ICT in urban governance leading to the establishment of smart cities. These chapters provided different data sets and perspectives enabling the assessment of the e-readiness of Gauteng-based metropolitan municipalities against the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain.

This chapter aims to present, interpret, and discuss the findings of a survey aimed at assessing the smart city e-readiness of Gauteng-based metropolitan municipalities by gaining the opinions and perspectives of key stakeholders and role-players in the smart city arena. The findings of the e-readiness assessment were used to design and populate a smart city model for Gauteng-based metropolitan municipalities, as the locus of this study. The results of the survey, comprising of purposively sampled participants (n=30), were used to verify, refine and validate the content of the proposed smart city model.

5.2 RESEARCH METHODOLOGY

As was detailed in Chapter 1, an exploratory qualitative research design was used with the purpose of ascertaining the context, dimensions and strategic aspects of smart city maturity (i.e. e-readiness) amongst Gauteng-based metropolitan municipalities. Data was

collected by means of semi-structured interviews. Based on the theoretical, policy and international orientation, an interview schedule was designed with the intention of asking critical questions to key stakeholders (external) and role-players (internal) in the ICT and city governance domain.

During mid-November 2020, the researcher began to send emails to the three Gauteng-based metropolitan municipalities asking them for permission to conduct the study and to provide contact details regarding the sampled participants for the study. The purpose of the study and what was expected from participants was explained in detail to the gatekeepers at the three metros. This process also involved obtaining informed consent from participants before any data was collected.

5.2.1 Sampling

Participants were selected based on the positions they occupy in metros, their role in the smart city programmes, oversight responsibilities and previous research work within the local government ICT arena, amongst others. Participants outside of the metros were selected based on the role they play within the ICT and city governance domain, including providing oversight, advice and guidelines on how municipalities can benefit from ICT technology. Individuals with no dealings within the local government and ICT arena were excluded from the study.

A judgemental or purposive sampling method was selected for this study. According to Kumar (2014:234), this type of sampling method is primarily focused on using the researcher's judgement in choosing people who, in the researcher's opinion, are likely to have the required information and be willing to share it with the researcher. A total sample of 30 participants (n=30) across key stakeholders' entities and role-players in the ICT and city governance domains were secured.

5.2.2 Data collection method

Semi-structured interviews were conducted with participants using an interview schedule as a data collection instrument (see Chapter 1, section 1.2.3). Fylan (2005:65) defines

semi-structured interviews as simply a conversation that is free to vary in which a researcher knows what he or she wants to find out about and has prepared a set of questions to ask on the topic of interest. Open-ended questions were mainly used to allow participants enough opportunity to broadly respond to questions. The interview questions were categorised into the following main sections:

a) Biographical profile of participants
b) e-Readiness of Gauteng-based metros
c) Input into the draft smart city model

A pilot study was conducted with four participants from CoJ's Smart City Office and ICT department, a senior researcher at the Council for Scientific and Industrial Research (CSIR) with urban planning responsibilities, as well as a Digital Specialist from the South African Local Government Association (SALGA). This pilot study was aimed at testing the validity of the interview schedule and to ensure that participants comprehend the nature of the questions posed.

The interviews for this study were conducted during the period 1-31 June 2021. The purpose of the interview was explained to each of the participants. Furthermore, before the interviews, all participants signed consent forms and provided verbal consent. All COVID-19 protocols were also closely adhered to.

The biographical details of all participants are depicted in table 15 To ensure confidentiality and anonymity of the participants a code and number were assigned to each (i.e. PS1-30).

Table 15: Participants' biographical profile

Participants (PS)	Biographical details
Participant 1 (PS1)	Head of Smart City Office. Master of Science in Development Planning, Built Environment and Master of Business Leadership. 3 years in the position.

Participants (PS)	Biographical details
Participant 2 (PS2)	Information Communication Technology Project Manager. Diploma in Financial Information System. Over 2 years in the position.
Participant 3 (PS3)	Assistant Director: Information Management. 8 years in the position and BA holder.
Participant 4 (PS4)	Administrative Assistant: ICT Management. Diploma in Risk Management. Nine years in the position.
Participant 5 (PS5)	Assistant Director: ICT Support. Five years in the position. 10 years local government experience.
Participant 6 (PS6)	Director: Office of the COO. Five years' experience and MBA holder.
Participant 7 (PS7)	Deputy Director: CT. Thirteen years' experience and National Diploma in IT holder.
Participant 8 (PS8)	Assistant Director: Planning. A Town and Regional Planning degree.
Participant 9 (PS9)	Deputy Director: ICT Systems. Holder of BCom IT with over 4 years' experience in the position.
Participant 10 (PS10)	Director with 5 years in the position. Diploma in IT.
Participant 11 (PS11)	Chief Digital Officer: South African Local Government Association. Ten months in the position with over 20 years in ICT. MBA, Hons BCom and BCom Informatics
Participant 12 (PS12)	Director: Smart City Office at CoJ. Four years in the position, with over 20-year experience in government. Postgraduate in Development Studies. Hons BA Arts.
Participant 13 (PS13)	Senior Researcher at the Council for Scientific and Industrial Research (CSIR), with over 20 years of experience and specialises in integrated development and spatial planning, urban futures and smart cities. Town and Regional Planning degree

Participants (PS)	Biographical details
Participant 14 (PS14)	Group Head: Information and Network Technology Operations Head, with over 20-years of public and private sector ICT experience.
Participant 15 (PS15)	Deputy Director: Smart City Office, over 4 years in the position. MBA and PhD.
Participant 16 (PS16)	Director of Operations with over 4 years in position. BCom Marketing and Business Management and Postgraduate Diploma in Business Management.
Participant 17 (PS17)	Specialist with 2 years in the position. BSc Computer Science.
Participant 18 (PS18)	Assistant Director: Information Management. 8 years in the position and BA holder.
Participant 19 (PS19)	Administrative Assistant: ICT Management. Diploma in Risk Management. Nine years in the position.
Participant 20 (PS20)	Assistant Director: ICT Support. Five years in the position. 10 years local government experience.
Participant 21 (PS21)	Specialist: ICT System Support. BCom IT and 6 years' experience.
Participant 22 (PS22)	Deputy Director: ICT Applications Management. Two years in the position and 10 years ICT experience.
Participant 23 (PS23)	Director: Data Centre Support. Three years in the position and BSc Computer Science holder.
Participant 24 (PS24)	Deputy Director: Network Management. Honours Degree in IT Management. 6 years in the position.
Participant 25 (PS25)	Deputy Director: ICT Infrastructure Management
Participant 26 (PS26)	Deputy Director: ICT Service Delivery Support. Five years in the position and holder of Computer Science degree.
Participant 27 (PS27)	Director: Management Support. Two years in the position and a Postgraduate Diploma in Management holder.

Participants (PS)	Biographical details
Participant 28 (PS28)	Deputy Director: Security Operations. Degree in Computer Science and 9 years' experience working local government ICT.
Participant 29 (PS29)	Deputy Director: Application Development & System Support. IT Degree and 7 years' experience.
Participant 30 (PS30)	Administrative Assistant: ICT Management. Diploma in Risk Management. Nine years in the position.

Table 5.1 above depicts the total number of participants that were involved in this study, the positions they hold and their areas of responsibility for the smart cities approach. Participants are public sector employees employed at the CoE, CoJ and CoT. The profile also highlights the academic background of participants as a rationale for skills and competencies necessary within the ICT and city governance arena. The high profile (i.e. seniority) of participants as well as their levels of experience in local government in general, and ICT applications in particular, ensured that rich data was obtained.

5.3 RESEARCH FINDINGS: E-READINESS OF GAUTENG-BASED METROPOLITAN MUNICIPALITIES

The cases selected for the purposes of designing an e-readiness model were the City of Ekurhuleni (CoE), City of Johannesburg (CoJ) and the City of Tshwane (CoT). This section provides background information on the three metros as well as e-readiness assessments using the Scottish Government's Smart Cities Maturity Model (SCMM) and Self-Assessment Tool as outlined in Chapter 3 (Sections 3.2.4 and 3.3). A brief overview of the metros and the results of the e-readiness assessment are reported using input obtained from the participants.

5.3.1 Case Study 1: City of Ekurhuleni

The City of Ekurhuleni (CoE), earmarked as an aerotropolis, is an important domain within the GCR's economic hub. CoE's economy accounts for "nearly a quarter of Gauteng's economy and contributes to over a third of the national GDP" (Republic of South Africa, 2021:08). The city's "economy is dominated by manufacturing, finance and business services, community and government services,' and hospitality" (Republic of South Africa, 2021:21). Globally integrated industries in Ekurhuleni largely serve as pull factors to attract labour from across South Africa, leading to a high proportion of informal settlements which need to be serviced in terms of infrastructure and household services (Abrahams and Newton-Reid, 2008:17). The region has a population of 3.3 million people within a land size area of 1975 km^2. It is South Africa's fourth-largest metropolitan area, behind Cape Town, Johannesburg, and eThekwini (PR Newswire, 2018). Ekurhuleni is "highly urbanised, with 99,4% of the population living in urban settlements ranging from informal settlements to elite urban residential suburbs" (Republic of South Africa, 2021:06).

5.3.1.1 Profile of CoE participants

Responses of the CoE participants indicate that 80% of those interviewed are males. Furthermore, the findings show that only 40% of participants hold IT and 4IR related qualifications. The majority of participants, 60% hold non-IT qualifications. The results revealed that 70% of participants have more than 5 years' experience within their current position and have also worked for more than 8 years within a local government environment.

5.3.1.2 Discussion of findings: Current smart city operations

The responses of the 10 participants from the CoE are summarised in table 5.2 below. As stated, the questions were designed to ascertain the current smart city operations within the CoE. The participants views (PV) were calculated using the following formula:

$$\frac{\text{Particpants View}}{\text{Total Number of participants (10)}} \text{X} \frac{100}{1}$$

Table 16: Current smart city operations

Questions on current smart city operations	Summary: Participants views (PV)
Q9. What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?	**PV.** All participants (10/10) view a smart city as a city that uses ICT to improve service delivery. However, only 80**%** of participants understand which smart city approach CoE is pursuing. CoE is pursuing an incremental approach strategy to building a smart city.
Q10. What is your opinion regarding smart city e-readiness of this municipality?	**PV.** All participants indicated the CoE is at an early stage of e-readiness and that more still needs to be done for CoE to be more competitive in this space.
Q11. What are some of this municipality's smart city success stories?	**PV.** All participants cited the *My CoE* app. as one on the municipality's milestones. One participant (PS14) summarised this as follows: "The app enables an accessible, sustainable, convenient, responsive and cost-effective channel for the integrated delivery of services to our employees, residents, businesses and communities".
Q12. What are some of this municipality's smart city challenges?	**PV.** All participants cited the lack of adequate funding towards smart city initiatives as the most significant stumble block.
Q13. What do you think should be done to address these challenges and improve smart city e-readiness?	**PV.** All participants indicated that more funding should be made available to digitalise the municipality and its services.
Q14. Is there any collaboration in terms of smart city funding, projects, infrastructure or any related items	**PV.** All participant indicated that currently there is no formal relationship between CoE and the other Gauteng metros**.**

Questions on current smart city operations	Summary: Participants views (PV)
between this metropolitan municipality and the other two adjoining metropolitan municipalities?	
Q15. Is there a smart city strategy included in this municipality's IDP?	**PV.** All participants agreed that a smart or digital strategy is part of the IDP
Q16. What is the annual budget allocation towards smart city adoption?	**PV.** Fifty percent (5/10) of participants stated that the budget is not centralised and the remaining group (50%) indicated that they do not know.
Q17. Is the budget allocation adequate to move the municipality to smart city e-readiness?	**PV.** All participants indicated "No". However, they believed that allocated funding can be utilised more effectively to build cases for additional funding in future.
Q18. Is there a dedicated team responsible for smart city implementation at this municipality?	**PV.** All participants agreed**.**
Q19. What is the seniority level of the Head of the Smart City team?	**PV.** All participants stated that the head of the digital team is a Senior Manager.
Q20. Is there a dedicated oversight body overseeing smart city implementation at this municipality? Yes or No? Describe the smart city oversight process at the municipality	**PV.** All participant agreed that there is dedicated oversight body, Section 79 Committee, which undertakes this role at the CoE.
Q21. In your opinion, are there any statutory, regulatory and legislative prescripts that act as obstacles towards effective implementation/ adoption of smart city technologies and processes?	**PV.** Seventy percent (7/10) of participants cited that MFMA Supply Chain Regulations impede quick implementation of the digital city strategy as all procurement has to meet these regulations, which is not conducive for a competitive international ICT environment. While 30% of participant believed that

Questions on current smart city operations	Summary: Participants views (PV)
	statutory, regulatory and legislative prescripts in place within the municipal environment are conducive for smart city adoption.
Q22. Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?	**PV.** All participants agreed that there is a need to elevate ICT to Executive Management within the municipality and that funding should be ring-fenced for the ICT related investments.

From the summarised findings presented in the table, the participants' views are elaborated on below.

a) **Q9**. *What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?* In answering this question, 100% (10) of participants viewed a smart city as a city that uses ICT to improve service delivery. Participants agreed that the use of ICT is an integral part of a smart city. Participants' responses are aligned to the meta-theoretical principles and dimensions of smart cites as explored in Chapter 2 and 3. However, only 80% of participant understand which smart city approach CoE is pursuing. CoE is pursuing the incremental approach to smart city and is using case studies to showcase the full potential of a smart city.

b) **Q10**. *What is your opinion regarding smart city e-readiness of this municipality?* All of the participants (100%) indicated the CoE is at the early stages of e-readiness and that more still needs to be done for CoE to be more competitive in this space. Participants indicated that resources in the form of investment in infrastructure, tools of trade and training of staff are necessary, if e-readiness of the city is to be improved. Again, participants responses are aligned to the theoretical underpinnings as outlined

in Chapter 3 on international smart city models and best practise approaches and praxis from leading smart cities in the world.

c) **Q11**. *What are some of this municipality's smart city success stories?* All of the participants (100%) cited the *My CoE* App as one on the municipality's milestones. The "app enables an accessible, sustainable, convenient, responsive and cost-effective channel for the integrated delivery of services to our employees, residents, businesses and communities" (Ekurhuleni, 2022).

d) **Q12**. *What are some of this municipality's smart city challenges?* All of the participants (100%) cited lack of adequate funding towards smart city initiatives. Participant indicated that lack of political support was one of the reasons why inadequate funding is made available for 4IR initiatives. As was established in Chapter 2, investments towards human, technological and institutional capabilities of a municipality is one way of advancing the smart city agenda.

e) **Q13**. *What do you think should be done to address these challenges and improve smart city e-readiness?* All interviewed participants (100%) indicated that more funding should be made available to digitalise the municipality.

f) **Q14**. *Is there any collaboration in terms of smart city funding, projects, infrastructure or any related items between this metropolitan municipality and the other 2 adjoining metropolitan municipalities?* All participants indicated that currently there is no formal relationship between CoE and the other two Gauteng metros.

g) **Q15**. *Is there a smart city strategy included in this municipality's IDP?* All of the participants agreed that a smart or digital city strategy is part and parcel of the CoE's IDP.

h) **Q16**. *What is the annual budget allocation towards smart city adoption?* 50% (5/10) of participants stated that the budget is not centralised and the rest of the participants (50%) indicated that they do not know. Upon further interrogation, participants indicated that the city does not have a separate budget for the digital city strategy,

however, funding for such projects is allocated directly to the department involved in designing and running the project. The Digital City Teams simply provide support to such projects.

i) **Q17**. *Is the budget allocation adequate to move the municipality to smart city e-readiness?* 100% of participants indicated that the budget allocated to e-readiness is not adequate. Participants believed that the currently allocated funding can be used to build cases for more funding in the future.

j) **Q18**. *Is there a dedicated team responsible for smart city implementation at this municipality?* All of the participants (100%) confirmed that the CoE has a Smart City Office, which is responsible for reviewing the strategies of the municipality to ensure alignment with the smart city's strategy. Participants' responses are aligned to smart cities best practise approaches explored in Chapter 3.

k) **Q19**. *What is the seniority level of the Head of the Smart City team?* All the participants stated that the head of the Smart City Office is a Senior Manager.

l) **Q20**. *Is there a dedicated oversight body overseeing smart city implementation at this municipality? Yes or No? Describe the smart city oversight process at the municipality*. All the participants agreed that there is dedicated oversight body, which is a Section 79 Committee, which provides oversight on all municipal projects. Participants, however, believed that there is a need for an ICT specific committee to closely monitor and oversee smart city initiatives within the municipality. Participants' responses are aligned to smart cities best practise approaches from leading smart cites in the world, explored in Chapter 3.

m) **Q21**. *In your opinion, are there any statutory, regulatory and legislative prescripts that act as obstacles towards effective implementation/ adoption of smart city technologies and processes?* Seventy percent (7/10) of participants cited that MFMA Supply Chain Regulations impede quick implementation of the digital city strategy as all procurement has to meet these regulations, which is not conducive for competitive international ICT environment. Thirty percent of participants believed that statutory,

regulatory and legislative prescripts that are in place within the municipality are conducive for smart city adoption and applications.

n) **Q22**. *Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?* All of the participants (100%) agreed that there is a need to elevate ICT to Executive Management within the municipality and that funding should be ring-fenced for the ICT-related investments. According to participants, introducing regulations to this effect will contribute to better e-readiness for the CoE.

5.3.1.3 Discussion of findings: Smart City Maturity Assessment of the City of Ekurhuleni

In this section, an analysis of the maturity levels of the City of Ekurhuleni Municipality (CoE) is undertaken using dimensions of the Scottish Government's Smart Cities Maturity Model. The analysis uses qualitative data gathered from the study, which had 10 participants. These included officials from CoE's Smart City Office and ICT department).

Based on the opinions of the interviewed participants, the maturity level of the CoE is on average 2, which according to the SCMM indicates that the CoE is moving from Ad-Hoc smart city processes towards a more systems collaboration approach and that smart city business cases are being built to showcase potential (see table 17 below).

Table 17: City of Ekurhuleni Smart City e-Readiness

Dimension Maturity Levels	PS 1	PS 2	PS 3	PS 4	PS 5	PS 6	PS 7	PS 8	PS 9	PS10	Average Score
Strategic Intent	3	1	3	3	2	2	3	2	4	2	**2.5**
Data	1	1	2	1	2	2	1	2	1	3	**1.6**
Technology	2	1	3	2	2	2	2	2	2	2	**2**
Governance and Service Delivery Models	3	2	2	3	2	2	3	2	4	3	**2.6**

Stakeholder Engagement	2	2	2	2	2	2	2	2	2	2	**2**
Average Score	**2.2**	**1.4**	**2.4**	**2.2**	**2**	**2**	**2.2**	**2**	**2.6**	**2.4**	**2.14**

Source: Researcher's own

Strategic Intent

The CoE scored a maturity level of 3 (average of 2.5) with regards to the assessment of the strategic intent dimension. A level 3 or "Purposeful and Repeatable level", indicates that a municipality has "a shared vision, strategy and roadmap for the smart city with multiple partners across multiple domains". Additionally, level 3 shows that a business case has been established and shared investments are in place to secure scalable improvements to agreed outcomes (Scottish Government, 2014:12).

Data

With regards to the data dimension, the CoE scored an average of 1.6. This means that CoE is at "Ad Hoc Level 1" maturity. According to Scottish Government (2014:12), at this level, a municipality's "data re-use and integration is limited by the range of disparate systems in use for different operations". Furthermore, such a municipality is facing "issues with data integrity, quality, privacy and security and data is used primarily for the delivery of a particular service" (Scottish Government, 2014:12).

Technology

CoE scored an average maturity level of 2 for the technology dimension. Level 2 or the opportunist level implies that such a municipality has “some shared or integrated architectures existing but deployed on a limited set of services. Furthermore, technology barriers are understood and are being addressed between partners. There is also some shared use of sensor networks by the municipality” (Scottish Government, 2014:12).

Governance and Service Delivery Models

The average maturity level of the governance and service delivery models dimension is 2.6. Level 3 or “Purposeful and Repeatable Level” means that a municipality’s leadership and governance models are evolving to share accountability for delivering system-wide outcomes. Furthermore, there is “greater input to problem solving and service design from providers, suppliers and users”, and there are “organisational budgets and structures, adapted to ensure effective and transparent delivery of system-wide approach” (Scottish Government, 2014:12).

Stakeholder engagement

Based on the responses from research participants, the average maturity level of the stakeholder engagement dimension is 2. Level 2 or “Opportunist maturity level” indicates a municipality with departmental level only “commitment to investing in digital channels to enhance citizen engagement”. Furthermore, the approach of such a municipality “predominantly focuses on using digital means to provide improved information and transparency to stimulate engagement”. A level 2 municipality has plans in place “to address digital exclusion in specific service areas” (Scottish Government, 2014:12).

Overall Maturity Level of the CoE

The overall maturity level of CoE based on the results of SCMM dimensions is level 2 (average score of 2.14). Opportunistic or level 2 maturity implies that the CoE has introduced some level of system collaboration for manging the municipality and that there

are cross boundary partnerships emerging to focus on shared ICT outcomes. Overall, the smart city status of the CoE can be said to at a holistic system thinking and emergent sharing of data.

5.3.2 Case Study 2: City of Johannesburg

The City of Johannesburg (CoJ) is the “most advanced commercial city in Africa and the engine room of the South African and regional economy” (Republic of South Africa, 2021:5). CoJ is also South Africa’s largest metropolitan municipality in terms of population size and economy. The region has a population of 5.4 million people within a land size area of 1645 km2 and contributed around 14.9% of the national Gross Domestic Product (GDP) in 2018 (Republic of South Africa, 2021:05). CoJ’s economy is mainly dominated by finance, community services, trade, manufacturing and transport sectors, amongst others. The findings of the CoJ case study are outlined below.

5.3.2.1 Profile of CoJ participants

Responses of the CoJ participants indicate that 90% of those interviewed are males. Furthermore, the findings show that only 30% of participants hold IT and 4IR related qualifications. The majority of participants, 70% hold non-IT qualifications. The results revealed that 100% of participants have more than 5 years’ experience within their current position and have also worked for an average of more than 10 years within a local government environment.

5.3.2.2 Discussion of findings: Current smart city operations

The responses of the 10 participants from the CoJ can be summarised in table 5.4 below. An interview schedule was used as a data collection tool. The questions were designed to ascertain the current smart city operations within the CoJ. This is related to Research Question 4, which is concerned with the opinions and perspectives of key stakeholders and role-players in ICT and city governance domain with regards to the e-readiness assessment of the CoJ.

Table 18: Current smart city operations

Questions on current smart city operations	Summary: Participants views (PV)
Q9. What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?	**PV.** All participants (10/10) view a smart city as a city that uses digital technology solutions to help citizens stay connected and allow businesses, citizens and the public administration to find ways to respond better in delivering public services. All respondents indicated that CoJ's smart city approach is focused on accelerating service delivery by improving operational efficiencies.
Q10. What is your opinion regarding smart city e-readiness of this municipality?	**PV.** All participants indicated that the CoJ is at an early stage of e-readiness and the city has a long way to go in order to realise comprehensive benefits of being a smart city.
Q11. What are some of this municipality's smart city success stories?	**PV.** All participants cited the successful rollout of free public WiFi to many sites within the municipality.
Q12. What are some of this municipality's smart city challenges?	**PV.** Seventy percent (7/10) of participants cited lack of adequate broadband infrastructure within the municipality, which limited access to digital services for communities. Thirty percent (3/10) of respondents cited a shortage of 4IR talent workforce to advance implementation of the smart city approach within the municipality.
Q13. What do you think should be done to address these challenges and improve smart city e-readiness?	**PV.** All participants indicated that more funding should be made available to fund investment into broadband connectivity and

Questions on current smart city operations	Summary: Participants views (PV)
	access by communities as well as 4IR skills development initiatives.
Q14. Is there any collaboration in terms of smart city funding, projects, infrastructure or any related items between this metropolitan municipality and the other two adjoining metropolitan municipalities?	**PV.** All participant indicated that currently there is no formal relationship between CoJ and the other 2 Gauteng metros**.**
Q15. Is there a smart city strategy included in this municipality's IDP?	**PV.** All participants confirmed that a smart or digital strategy is part of the IDP.
Q16. What is the annual budget allocation towards smart city adoption?	**PV.** All participants stated that the budget for smart city projects is not centralised. According to participants, a budget is allocated to departments and municipal owned entities and thus it is difficult to say what the annual budget is.
Q17. Is the budget allocation adequate to move the municipality to smart city e-readiness?	**PV.** All participants said that the current allocation is not adequate and that massive investments running into billions of Rands are needed to advance CoJ's smart city ambitions.
Q18. Is there a dedicated team responsible for smart city implementation at this municipality?	**PV.** All participants agreed the Smart City Office is responsible for the implementation of the city's smart city strategy.
Q19. What is the seniority level of the Head of the Smart City team?	**PV.** All participants stated that the Unit Head: Smart City Office is the senior member responsible for smart city implementation city-wide.
Q20. Is there a dedicated oversight body overseeing smart city	**PV.** All participants agreed that there is a dedicated oversight body, Section 79

Questions on current smart city operations	Summary: Participants views (PV)
implementation at this municipality? Yes or No? Describe the smart city oversight process at the municipality	Committee, which undertakes this role at the CoJ. Participants also stated that the CoJ's Group Performance Audit Committee also provides oversight in performance of the Smart City Office.
Q21. In your opinion, are there any statutory, regulatory and legislative prescripts that act as obstacles towards effective implementation/ adoption of smart city technologies and processes?	**PV.** All participants indicated that MFMA Supply Chain Regulations impede quick implementation of the digital city strategy as all procurement has to meet these regulations, which is not always conducive for the fast-evolving ICT environment.
Q22. Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?	**PV.** All participants agreed that there is a need to elevate ICT to Executive Management within the municipality and that funding should be ringfenced for the ICT related investments.

From the above summary of responses, the participants' views are elaborated on below.

a) **Q9**. *What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?* In answering this question, 100% of participants view a smart city as a city that uses digital technology solutions to helps citizens stay connected and allow businesses, citizens and the public administration to find ways to respond better in delivering public services. All respondents indicated that CoJ's smart city approach is focused on accelerating service delivery by improving operational efficiencies. Participants' responses are similar to those in the CoE case study, and furthermore, the responses are aligned with theoretical underpinnings of smart cities as discussed in Chapters 2 and 3.

b) **Q10**. *What is your opinion regarding smart city e-readiness of this municipality?* All of the participants (100%) indicated the CoJ is at early stage of e-readiness and that the city has a long way to go in order to realise comprehensive benefits of being a smart city. Again, participants' responses are aligned to theoretical underpinnings discussed in Chapter 3 on international smart city models and best practise approaches and praxis from leading smart cities in the world.

c) **Q11**. *What are some of this municipality's smart city success stories?* All of the participants (100%) cited the successful rollout of free public WiFi to various areas within the municipality as one of its major success stories.

d) **Q12**. *What are some of this municipality's smart city challenges?* Seventy percent of participants cited a lack of adequate broadband infrastructure within the municipality, which limits access to digital services for communities. Thirty percent (3/10) of respondents cited a shortage of 4IR talent workforce to advance implementation of the smart city approach within the municipality. The responses are in alignment with the theory outlined in Chapter 2, which states that investment towards human, technological and institutional capabilities of a municipality is one way of advancing the smart city agenda.

e) **Q13**. *What do you think should be done to address these challenges and improve smart city e-readiness?* All interviewed participants (100%) indicated that more funding should be made available to fund investment into broadband connectivity and access by communities as well as 4IR skills development initiatives.

f) **Q14**. *Is there any collaboration in terms of smart city funding, projects, infrastructure or any related items between this metropolitan municipality and the other two adjoining metropolitan municipalities?* All interviewed participant (100%) indicated that currently there is no formal relationship between CoJ and the other two Gauteng metros.

g) **Q15**. *Is there a smart city strategy included in this municipality's IDP?* All of the participants (100%) agreed that a smart city strategy is part and parcel of the CoJ's IDP.

h) **Q16**. *What is the annual budget allocation towards smart city adoption?* All participants stated that the budget for smart city projects is not centralised. According to participants' responses, 4IR budgets are allocated to departments and municipal owned entities and thus it is difficult to say what the annual budget is.

i) **Q17**. *Is the budget allocation adequate to move the municipality to smart city e-readiness?* All participants indicated that the current allocation is not adequate and that massive investments running into billions of Rands is needed to advance CoJ's smart city ambitions.

j) **Q18**. *Is there a dedicated team responsible for smart city implementation at this municipality?* All of participants (100%) agreed that the Smart City Office is responsible for the implementation of the city's smart city strategy. Participants' responses are closely aligned to smart cities best practise approaches explored in Chapter 3.

k) **Q19**. *What is the seniority level of the Head of the Smart City team?* Again, all participants indicated that the Unit Head: Smart City Office is the senior member responsible for smart city implementation city-wide.

l) **Q20**. *Is there a dedicated oversight body overseeing smart city implementation at this municipality? Yes or No? Describe the smart city oversight process at the municipality*. All participants agreed that there is a dedicated oversight body, Section 79 Committee, which undertakes this role at the CoJ. Participants also stated the CoJ's Group Performance Audit Committee also provides oversight in performance of the Smart City Office. Participants' responses are aligned to smart cities best practise approaches from leading smart cites in the world, explored in Chapter 3.

m) **Q21**. *In your opinion, are there any statutory, regulatory and legislative prescripts that act as obstacles towards effective implementation/ adoption of smart city technologies and processes?* All participants cited that MFMA Supply Chain Regulations impede quick implementation of the digital city strategy as all procurement has to meet these

regulations, which is not always conducive for the fast-evolving ICT environment. This view is similar to that of the CoE case study.

n) **Q22**. *Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?* All of the participants (100%) agreed that there is a need to elevate ICT to Executive Management within the municipality and that funding should be ring-fenced for the ICT related investments. This view is similar to that for the CoE case study.

5.3.2.3 Discussion of findings: Smart City Maturity Assessment of the City of Johannesburg

In this section, an analysis of the maturity levels of the City of Johannesburg Metropolitan Municipality (CoJ) is undertaken using dimensions of the Scottish Government's Smart Cities Maturity Model. The analysis uses qualitative data gathered from the study, which had 10 participants, including officials from CoJ's Smart City Office and ICT department.

Based on the opinions of the interviewees, the maturity level of the CoE is on average 2, which according to the SCMM indicates that the CoJ is moving from "Ad-Hoc smart city processes" towards a more "systems collaboration approach" and that smart city business cases are being built to showcase potential (see table 19 below).

Table 19: City of Johannesburg Smart City e-Readiness

Dimension Maturity Levels	PS 11	PS 12	PS 13	PS 14	PS 15	PS 16	PS 17	PS 18	PS 19	PS 20	Average Score
Strategic Intent	3	3	3	3	3	2	3	2	4	2	**2.8**
Data	3	3	2	3	2	2	3	2	3	3	**2.6**
Technology	2	3	3	2	3	3	2	2	2	2	**2.4**
Governance and Service Delivery Models	3	2	2	3	2	2	3	2	4	3	**2.6**
Stakeholder Engagement	2	2	2	2	2	2	2	2	2	2	**2**
Average Score	**2.6**	**2.6**	**2.4**	**2.6**	**2.4**	**2.2**	**2.6**	**2**	**3**	**2.4**	**2.48**

Source: Researcher's own

Strategic Intent

The CoJ scored a maturity level of 3 with regards to the analysis of the strategic intent dimension (average of 2.8). Similar to the CoE, a CoJ level 3 or "Purposeful and Repeatable" level, indicates that a municipality has "a shared vision, strategy and roadmap for the smart city with multiple partners across multiple domains" (Scottish Government, 2014:12). Additionally, level 3 shows that "a business case has been established and shared investments are in place to secure scalable improvements to agreed outcomes" (Scottish Government, 2014:12).

Data

With regards to the data dimension, the CoJ scored an average of 2.6, meaning a maturity level of 3. This means that there is a "data management and optimisation strategy agreed between partners and there is investing in advanced data management, capturing, analytics and big data applications" (Scottish Government, 2014:12). At this maturity level, there is an extensive range of open data published with strategic intent to leverage innovation and citizens are also sharing data in key areas with the municipality.

Technology

CoJ scored an average maturity level of 2.4 for the technology dimension. Level 2 or "Opportunist" level implies that such a municipality has "some shared or integrated architectures existing but deployed on a limited set of services. Furthermore, technology barriers are understood and are being addressed between partners. There is also some shared use of sensor networks by the municipality" (Scottish Government, 2014:12).

Governance and Service Delivery Models

The average maturity level of the governance and service delivery model dimension is 2.6. Level 3 or "Purposeful and Repeatable Level" means that a municipality's leadership and governance models are evolving to share accountability for delivering system-wide outcomes. Furthermore, there is "greater input to problem solving and service design from providers, suppliers and users", and "organisational budgets and structures adapt to ensure effective and transparent delivery of a system-wide approach" (Scottish Government, 2014:12).

Stakeholder engagement

Based on the responses from research participants, the average maturity level of the stakeholder engagement dimension is also 2. Level 2 or "Opportunist Maturity" level indicates a municipality with departmental level only "commitment to investing in digital channels to enhance citizen engagement". Furthermore, the approach of such a municipality "predominantly focuses on using digital means to provide improved information and transparency to stimulate engagement". A Level 2 municipality has plans in place "to address digital exclusion in specific service areas" (Scottish Government, 2014:12).

Overall Maturity Level of the CoJ

The overall maturity level of CoJ, based on the results of SCMM dimensions, is level 2 (average score of 2.48). "Opportunistic" or level 2 maturity implies that the CoJ has

introduced some level of system collaboration for manging the municipality and that there are cross boundary partnerships emerging to focus on shared ICT outcomes. Overall, the smart city status of the CoJ can be summarised as a holistic system characterised by strategic thinking and emergent sharing of data.

5.3.3 Case Study 3: City of Tshwane

The City of Tshwane (CoT) is located in the northern part of Gauteng and is the largest metropolitan municipality in size when compared to the City of Johannesburg and the City of Ekurhuleni. CoT covers 6 345 km^2 in land area and is headquarters to national government departments and home to 135 embassies. This municipality hosts the administrative capital of South Africa, where the Union Buildings are located. The key economic drivers in CoT include community services, finance, trade, manufacturing and transport. In 2017, the municipality contributed 10% to South Africa's GDP. Below, the smart e-readiness of CoT, is probed.

5.3.3.1 Profile of CoT participants

The responses of the CoT participants indicate that 100% of those interviewed are males. Furthermore, the findings show that only half of participants (50%) hold IT and 4IR related qualifications. The other 50% hold non-IT qualifications. The results revealed that 100% of participants have more than 5 years' experience within their current position and have also worked for more than 8 years within a local government environment.

5.3.3.2 Discussion of findings: Current smart city operations

The responses of the 10 participants from the CoT are summarised in table 5.6 below. An interview schedule was used as a data collection tool. The questions were designed to ascertain the current smart city operations within the CoT. This related to Research Question 4, which is concerned with the opinions and perspectives of key stakeholders and role-players in ICT and the city governance domain with regards to the e-readiness assessment of the CoT. The participants' views (PV) were calculated using the following formula:

$$\frac{\text{Particpants View}}{\text{Total Number of participants (10)}} \text{X} \frac{100}{1}$$

Table 20: Current smart city operations

Questions on current smart city operations	Summary: Participants views (PV)
Q9. What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?	**PV.** All participants (10/10) view a smart city as a city that interacts better with its customers/citizens and a city that enables innovative technology driven initiatives to drive local economic development, skills development and to bridge the digital divide between the rich and poor.
Q10. What is your opinion regarding smart city e-readiness of this municipality?	**PV.** All participants agreed that the CoT has some elements of a smart city. However, it is still in an early stage of development and implementation.
Q11. What are some of this municipality's smart city success stories?	**PV.** All participants cited the finalisation of the CoT Smart City Master Plan and the e-Tshwane online portal, which allows residents to communicate with the city electronically from anywhere in the world.
Q12. What are some of this municipality's smart city challenges?	**PV.** All participants confirmed that the lack of an adequate fibreoptic network infrastructure for the purposes of rolling out broadband to government facilities, businesses and citizens seriously hampers progress.
Q13. What do you think should be done to address these challenges and improve smart city e-readiness?	**PV.** All participants indicated that more funding is necessary to enable the municipality to rollout fibreoptic network

Questions on current smart city operations	Summary: Participants views (PV)
	infrastructure to all the strategic areas within the city.
Q14. Is there any collaboration in terms of smart city funding, projects, infrastructure or any related items between this metropolitan municipality and the other two adjoining metropolitan municipalities?	**PV.** All participant indicated that currently there is no formal relationship between CoT and the other two Gauteng metros**.**
Q15. Is there a smart city strategy included in this municipality's IDP?	**PV.** All participants agreed that a smart or digital strategy is part of the IDP
Q16. What is the annual budget allocation towards smart city adoption?	**PV.** All participants stated that there is no separate budget to implement the Smart City Master Plan. However, departments use their allocations to undertake smart city projects within their areas of specialisation.
Q17. Is the budget allocation adequate to move the municipality to smart city e-readiness?	**PV.** All participants responded negatively. However, they believed that allocated funding can be used to build cases for more funding in the future.
Q18. Is there a dedicated team responsible for smart city implementation at this municipality?	**PV.** All participants agreed and that stated that the programme falls under the Group Information & Communication Technology and Management (GICT) department within the municipality.
Q19. What is the seniority level of the Head of the Smart City team?	**PV**. Participants (10/10) stated that the Group Chief Information Officer oversees the smart city programme.
Q20. Is there a dedicated oversight body overseeing smart city implementation at this municipality?	**PV.** Participants (10/10) agreed that there is a dedicated oversight body, Section 79

Questions on current smart city operations	Summary: Participants views (PV)
Yes or No? Describe the smart city oversight process at the municipality	Committee, which undertakes this role at the CoT.
Q21. In your opinion, are there any statutory, regulatory and legislative prescripts that act as obstacles towards effective implementation/ adoption of smart city technologies and processes?	**PV.** All participants cited that MFMA Supply Chain Regulations impede quick implementation of the digital city strategy as all procurement has to meet these regulations, which is not conducive for competitive international ICT environment.
Q22. Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?	**PV.** All participants agreed that there is a need to develop Supply Chain Regulations, specifically for the ICT environment within the Local Governments System in South Africa.

From the above table, the participants' views are elaborated below.

a) **Q9**. *What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?* In answering this question, 100% (10/10) of participants viewed a smart city as a city that interacts better with its customers/citizens and a city that enables innovative technology driven initiatives to drive local economic development, skills development and to bridge the digital divide between the rich and poor. Participants' responses are similar to those in the CoE and CoJ case studies and furthermore, the responses are aligned with theoretical underpinnings of smart cities as discussed in Chapters 2 and 3.

b) **Q10**. *What is your opinion regarding smart city e-readiness of this municipality?* All of the participants (100%) agreed that the CoT has some elements of a smart city, however, it is still in an early stage of development and implementation. Again, participants' responses are aligned to the theoretical underpinnings discussed in

Chapter 3 on international smart city models and best practise approaches and praxis from leading smart cities in the world.

c) **Q11**. *What are some of this municipality's smart city success stories?* All of the participants (100%) cited the finalisation of the CoT Smart City Master Plan and the e-Tshwane online portal, which allow residents to communicate with the city electronically from anywhere in the world.

d) **Q12**. *What are some of this municipality's smart city challenges?* All of the participants (100%) cited lack of an adequate fibreoptic network infrastructure for the purposes of rolling out broadband to government facilities, businesses and citizens. As explored in Chapters 2 and 3, availability of a broadband fibreoptic network is the backbone of a smart city.

e) **Q13**. *What do you think should be done to address these challenges and improve smart city e-readiness?* All interviewed participants (100%) indicated that more funding is necessary to enable the municipality to rollout fibreoptic network infrastructure to all the strategic areas within the city.

f) **Q14**. *Is there any collaboration in terms of smart city funding, projects, infrastructure or any related items between this metropolitan municipality and the other 2 adjoining metropolitan municipalities?* All interviewed participants (100%) indicated that currently there is no formal relationship between CoT and the other two Gauteng metros.

g) **Q15.** *Is there a smart city strategy included in this municipality's IDP? All* of the participants (100%) agreed that a smart or digital city strategy is part and parcel of the CoT's IDP.

h) **Q16**. *What is the annual budget allocation towards smart city adoption?* 100% (10/10) of participants stated that there is no separate budget to implement the Smart City Master Plan, however, departments use their allocations to undertake smart city projects within their areas of specialisation.

i) **Q17**. *Is the budget allocation adequate to move the municipality to smart city e-readiness?* All participants said no, however, they believed that allocated funding can be used to build cases for more funding in the future

j) **Q18**. *Is there a dedicated team responsible for smart city implementation at this municipality?* All of participants (100%) agreed and stated that the programme falls under the Group Information & Communication Technology and Management (GICT) department within the municipality.

k) **Q19**. *What is the seniority level of the Head of the Smart City team?* One hundred percent of participants stated that the Group Chief Information Officer oversees the smart city programme.

l) **Q20**. *Is there a dedicated oversight body overseeing smart city implementation at this municipality? Yes or No? Describe the smart city oversight process at the municipality*. All participants agreed that there is dedicated oversight body, Section 79 Committee, which undertakes this role at the CoT.

m) **Q21**. *In your opinion, are there any statutory, regulatory and legislative prescripts that act as obstacles towards effective implementation/ adoption of smart city technologies and processes?* All participants cited that MFMA Supply Chain Regulations impede quick implementation of the digital city strategy as all procurement has to meet these regulations, which is not conducive for competitive international ICT environment.

n) **Q22**. *Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?* All of the participants (100%) agreed that there is a need to develop Supply Chain Regulations specifically for the ICT environment within the Local Governments System in South Africa.

5.3.3.3 Discussion of findings: Smart City Maturity Assessment of the City of Tshwane

In this section, an analysis of the maturity levels of the City of Tshwane (CoT) is undertaken using dimensions of the Scottish Government's Smart Cities Maturity Model. The analysis uses qualitative data gathered from the study, which had 10 participants. It included officials from CoT's Smart City Office and ICT department.

Based on the opinions of the interviewed participants, the maturity level of the CoT is on average 2, which according to the SCMM indicates that the CoT is moving from Ad-Hoc smart city processes towards a more systems collaboration approach and that smart city business cases are being built to showcase potential (see table 21 below).

Table 21: City of Tshwane Smart City e-Readiness

Dimension Maturity Levels	**PS 21**	**PS 22**	**PS 23**	**PS 24**	**PS 25**	**PS 26**	**PS 27**	**PS 28**	**PS 29**	**PS 30**	**Average Score**
Strategic Intent	3	2	3	3	3	3	3	2	4	2	**2.8**
Data	2	2	2	2	2	2	3	2	2	3	**2.2**
Technology	2	2	3	2	2	3	2	2	3	2	**2.3**
Governance and Service Delivery Models	3	2	2	3	3	2	3	2	4	3	**2.7**
Stakeholder Engagement	3	2	2	2	2	2	2	2	2	2	**2.1**
Average Score	**2.6**	**2**	**2.4**	**2.4**	**2.4**	**2.4**	**2.6**	**2**	**3**	**2.4**	**2.42**

Source: Researcher's own

Strategic Intent

Similar to CoE and CoJ, the CoT scored an average maturity level of 3 with regards to the analysis of the strategic intent dimension (2.8). A level 3 or “Purposeful and Repeatable level”, indicates that a municipality has “a shared vision, strategy and roadmap for the smart city with multiple partners across multiple domains Additionally, level 3 shows that a business case has been established and shared investments are in place to secure scalable improvements to agreed outcomes” (Scottish Government, 2014:12).

Data

With regards to the data dimension, the CoT scored an average of 2.2. Level 2 maturity implies that there are “barriers to optimising data assets being discussed between partners and a solution is emerging. Additionally, there is some advanced data sharing and analytics applications in place, with some data sets opened to the public” (Scottish Government, 2014:12).

Technology

CoT scored an average maturity level of 2.3 for the technology dimension. Level 2 or “Opportunist Level” implies that such a municipality has “some shared or integrated architectures existing but deployed on a limited set of services. Furthermore, technology barriers are understood and are being addressed between partners. There is also some shared use of sensor networks by the municipality” (Scottish Government, 2014:12).

Governance and Service Delivery Models

The average maturity level of the governance and service delivery model dimension is 2.7. Level 3 or “Purposeful and Repeatable Level” means that a municipality’s leadership and governance models are evolving to share accountability for delivering system-wide outcomes. Furthermore, there is a “greater input to problem solving and service design from providers, suppliers and users”, and there are “organisational budgets and structures

adapt to ensure effective and transparent delivery of system-wide approach" (Scottish Government, 2014:12).

Stakeholder engagement

Based on the responses from research participants, the average maturity level of the stakeholder engagement dimension is also 2.1. Level 2 or "Opportunist Maturity Level" indicates a municipality with departmental level only "commitment to investing in digital channels to enhance citizen engagement". Furthermore, the approach of such a municipality "predominantly focuses on using digital means to provide improved information and transparency to stimulate engagement". A level 2 municipality has plans in place "to address digital exclusion in specific service areas" (Scottish Government, 2014:12).

Overall Maturity Level of the CoT

Similar to the CoE and CoJ, the overall maturity level of CoT, based on the results of SCMM dimensions, is level 2 (average score of 2.42). Opportunistic or level 2 maturity implies that the CoT has introduced some level of system collaboration for manging the municipality and that there are cross boundary partnerships emerging to focus on shared ICT outcomes. The overall smart city status of the CoT can be characterised as an emergent integrated system.

The smart city e-readiness assessments of the three metros revealed that Gauteng-based metropolitan municipalities are at a level of 2 smartness. This shows that there is still significant work to be done and a huge amount of investment needed (e.g. technology, human capital, and ICT infrastructure) to enable the Gauteng Province and its citizens to truly leverage and benefit from advancement in smart city and 4IR technology. Given the level of smart city readiness in Gauteng, the next section focuses on drafting a smart city model to help Gauteng metros and other South African municipalities, in general, to move towards smart city readiness.

5.4 TOWARDS A DRAFT SMART CITY MODEL FOR SOUTH AFRICAN METROPOLITAN MUNICIPALITIES

In previous chapters, it was illustrated how a municipality can accrue benefits to its stakeholders by embracing smart city technologies. In this section, a draft smart city model for South African metros is proposed. The model content was verified and refined by using the input obtained from participants. The final detailed model will be presented in the last chapter. The proposed model was designed by using data triangulation from the content emanating from Chapters 2, 3, and 4. The draft model is a synthesis or fusion of the following key aspects:

a) theory and principles of local government (Sections 4.2, 4.3 and 4.4 in Chapter 4);
b) principles and dimensions of a smart city (Sections 2.3 and 2.4 in Chapter 2);
c) principles and elements of ICT governance (Sections 4.3 Chapter 4);
d) principles and elements abstracted from an analysis of international smart city models and frameworks (Sections 3.2-3.6 in Chapter 3);
e) case study analysis focusing on the Cities of Ekurhuleni, Johannesburg and Tshwane (Sections 5.3.1 -5.3.3 in Chapter 5); and
f) input obtained from key stakeholders and role-players in the ICT and city governance domain. (Section 5.3.1 -5.3.3 in Chapter 5).

To improve triangulation in the development of the model, information sourced from the above-mentioned sources were analysed and key aspects that need to form part of the smart city model were identified. The draft smart city model is structured on macro, tactical and operational layers. The three government spheres of the drafted model are briefly expounded below.

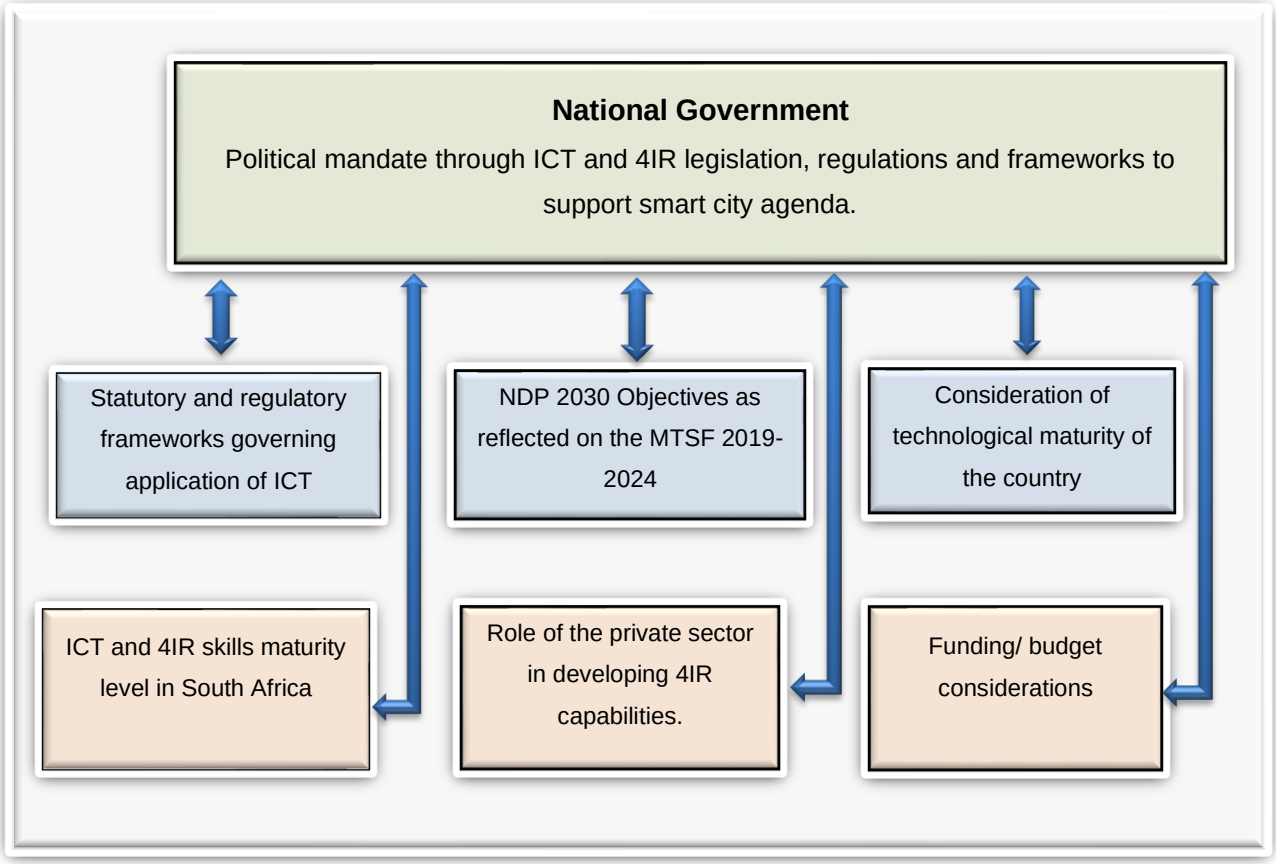
5.4.1 National government sphere

The national government sphere represents the macro, policy and strategic layers of the model and is mainly concerned with the overall structure that effectively supports municipalities. The national sphere or the macro-level dimension of the model is formulated based on the structural-functionalism and public institution theories as

discussed in section 2.2 above. Structural-functionalism theory views society as composed of a complex system of interrelated parts, which are interdependent to work together in the interest of meeting societal needs, while Public Institutional Theory states that modern societies are shaped by the state and professional bodies. In the external macro-environment, the national government is a key driver of the country's ICT and 4IR strategy. This is because national government determines the policy, mandate and frameworks stemming from legislations on ICT and 4IR implementation within the country, for both the private and public sectors.

The national policy on 4IR infrastructure, hardware and software including ICT governance is determined in the external environment by the central government. As discussed in Chapter 3, national policy influences the ICT relationship between government, the private sector and civil society. It was shown that many developing and developed countries initiated national ICT strategies to support policy proposals for smart cities. Smart cities in such cases were developed as part of a national strategy to digitalise and transform society. Indeed, a municipality needs support from the national government for it to become a smart city and has to work with such stakeholders to achieve the desired smart city objectives. The support is in the form of enabling legislation and regulations, as well as policies and frameworks, that allow municipalities to venture into the smart city arena.

Figure 16: Draft SMART City (macro) model for metropolitan municipalities



Source: Researcher's own

As illustrated in figure 16, national government is responsible for establishing the broad 4IR and ICT agenda for the country, stemming from the political mandate influenced by the governing party. Legislation is passed by parliament to enable the government to prioritise the political mandate. Through policies and regulations, the national government devises a plan to implement the ICT objectives as outlined in the NDP 2030 strategic document. Then the Medium-Term Strategic Framework (MTSF) 2019–2024 with detailed outcomes, interventions, outputs, inputs and activities, is drafted. The strategic government planning documents contain details on the role of the private sector, the 4IR skills gap in the country, the funding limitations of government for ICTs and the e-readiness maturity levels in South Africa, amongst other factors. All these are parameters that need to be considered in the external environment of a potential smart city, as they

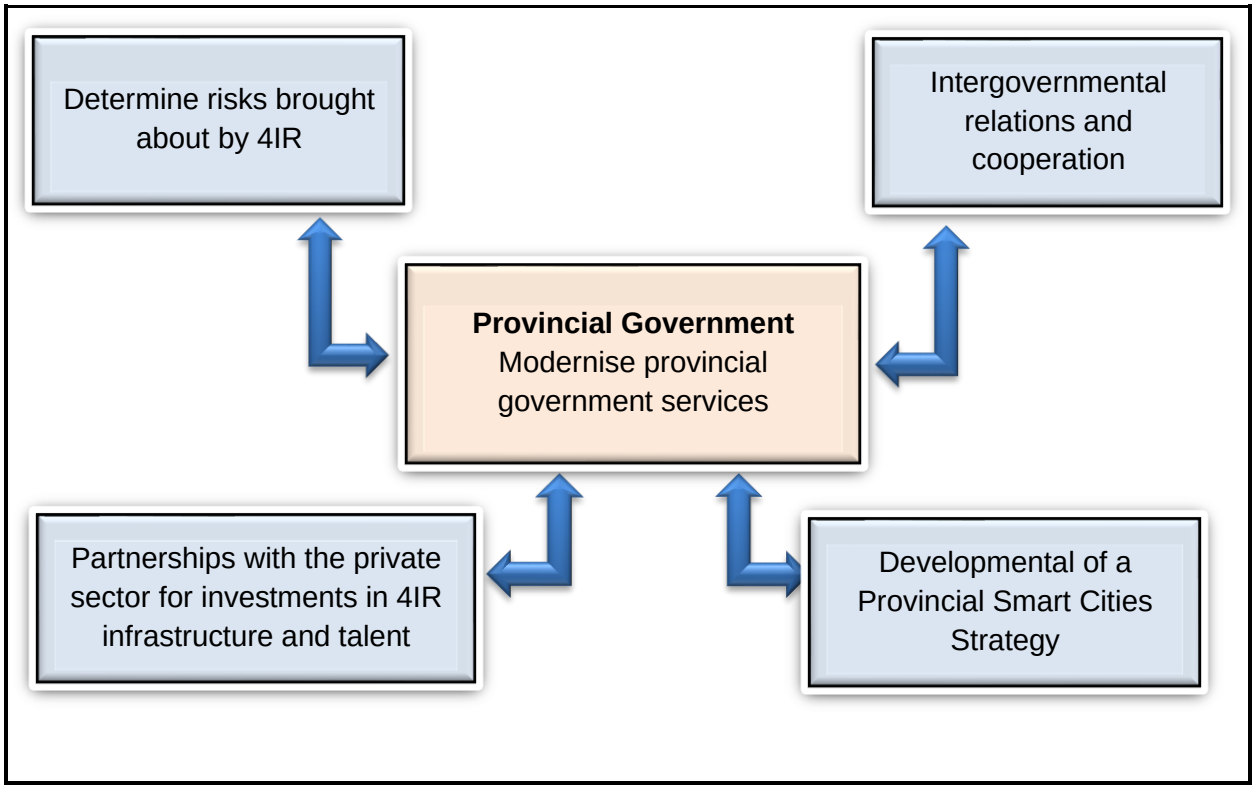
exhibit a two-way relationship with the national government and the municipalities, also influencing the planning arrangement of the national government.

5.4.2 Provincial government sphere

Once the macro strategy is established and the parameters for overall ICT and 4IR implementation, including the governance thereof, are in place, the next layer of the model represents the provincial sphere of government. This sphere represents the meso or tactical layer of the model.

The provincial government sphere links the macro and micro-environments and provides a framework for issues such as “policies standard operating procedures, rules and guidelines” (Shaw, 2011). In this setting, the meso-environment is composed of the Provincial Government administration. The Gauteng Provincial Government (GPG), specifically, has a mission to “modernise government services and foster the implementation of a citizen-centric innovation ecosystem that stimulates sustainable economic growth through transformative 4IR technologies” (Republic of South Africa, 2020:16).

Figure 17: Draft Smart City (meso) model for metropolitan municipalities



Source: Researcher's own

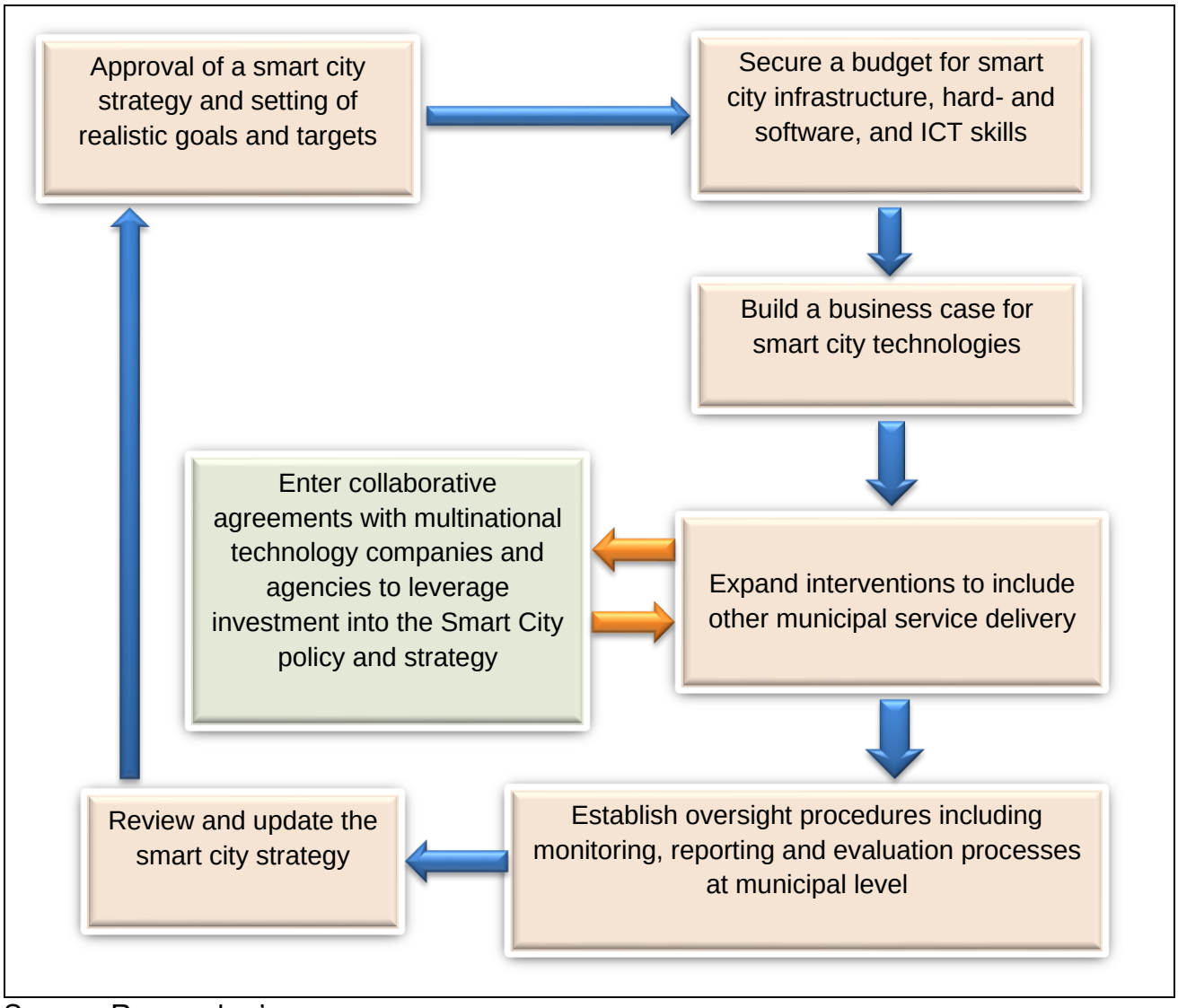
The examination of smart city implementation in developing and developed countries indicated that some countries also have a regional strategy for smart city implementation. Countries such as India, Rwanda, China and Singapore follow similar strategies. This implies that resources have to be shared amongst several cities in such countries and thus a regional strategy is necessary. In the case of Gauteng-based metros, a provincial strategy will allow municipalities to plan their smart cities' endeavours within the broader strategy approved at a provincial level. Such a provincial strategy should ascertain the risks and opportunities brought about by 4IR, an inter-governmental relationship both with municipalities and national government, and partnerships with the private sector to leverage the positive benefits of 4IR, among other priorities.

5.4.3 Local government sphere

In the sections above, the macro layer of the smart city model, which comprises of the political-administrative environment, was examined. The meso level for a smart city model outlines the key issues that the provincial department must incorporate into their

provincial smart city strategy. This section outlines the micro or operational level of the model, which is concerned with the local government sphere of government, which is the focus area of this study. The operational level is concerned with how an individual municipality operationalises the smart city agenda in day-to-day municipal activities.

Figure 18: Draft Smart City (meso) model



Source: Researcher's own

At this layer, a municipality should develop a smart city strategy that should be incorporated into the IDP of the municipality and approved by the Council. Management should then develop operational guidelines, processes and steps to implement smart city projects and activities. Operational plans should also include how oversight will be exercised over the municipality's smart city activities. Constant periodic monitoring and

evaluation of smart city initiatives should be done and, where necessary, the smart city strategy of the municipality should be reviewed and adjusted accordingly, with Council's approval.

The micro-level smart city model is based on the outcomes of Chapters 2 and 3, where the application of 4IR techniques within the local government environment and international smart city models, best practice approaches and praxis from leading smart cities in the world, were examined. A big part of best practices for smart cities in the world includes partnering with the private sector to accelerate 4IR developments while improving the competitiveness of cities. Chapter 4 on the statutory and regulatory frameworks governing the application of ICT in urban governance, also influenced the draft micro-level smart city model, where issues of funding smart city-related initiatives in the ICT and 4IR arena by the government came to the fore.

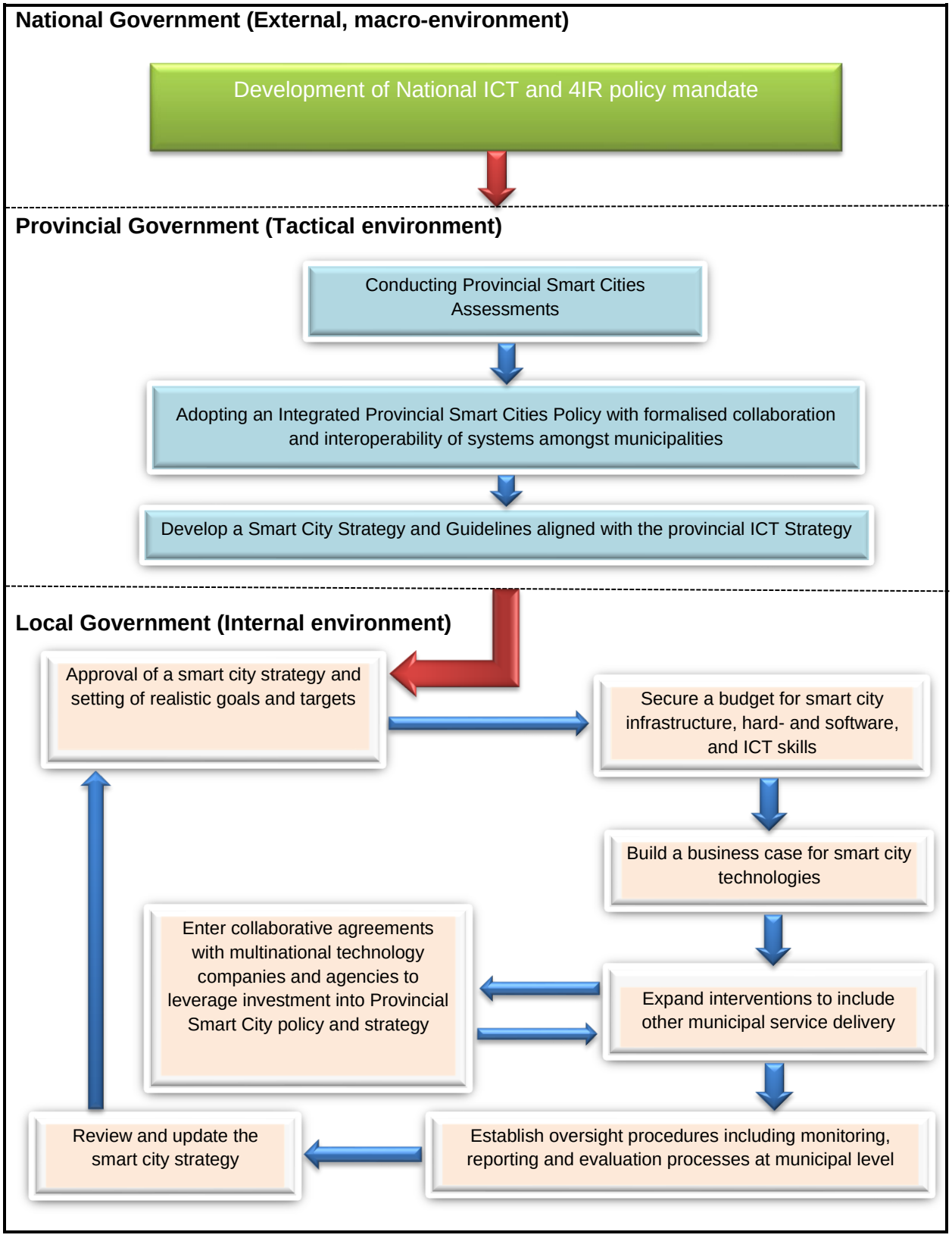
5.4.4 A draft comprehensive model

The discussions above focused on developing the draft smart city model within the macro, meso and micro layer environments. All three of draft models were influenced by discussions in Chapters 2, 3 and 4, as well as the interviews with participants during the pilot data collection stage of this study. The discussions above highlighted the issues that need to be addressed if any municipality wishes to become a smart municipality. The proposed draft smart city model is composed of a three-stage model integrating the macro-, meso- and micro-level environments. All these environments impact and influence each other:

a) Macro-environment representing the national government's influence on the ICT and 4IR within the private and public sectors;
b) Meso-environment representing the impact of the provincial governments on smart city implementation by municipalities; and
c) Micro-environment illustrating the impact of an individual municipality's initiatives on the smart city agenda.

The proposed smart city model and its integration of the above-mentioned three environments are depicted in figure 19 below:

Figure 19: Draft Comprehensive Smart City Model



Source: Researcher's own

In figure 19 above, the red arrows represent the interrelationships between the macro-, meso- and micro-environments in smart city implementation. The macro or external environment has a significant influence on the direction of ICT and 4IR developments in South Africa. This is because a national policy is devised at this level to influence the direction of South Africa within the ICT sector. The influence of the government is not only limited to the public sector but also extends and affects private sector entities and civil society at large.

The tactical environment is concerned with the provincial government's responsibility in directing and facilitating the implementation of smart cities within the province. The tactical environment is about conducting a preliminary smart city readiness assessment throughout the province, adopting a formal smart city policy and strategy that aligns the province's municipalities to national objectives as depicted in the NDP 2030. While undertaking these activities, the province should also consider possible risks of adopting 4IR technologies, intergovernmental relations with other government organisations, collaborations and areas of cooperation with the private sector and civil society in general.

The municipality level is the innermost part of the proposed smart city model and represents the micro-environment. This is where the actual smart city implementation takes place. The Municipal Council considers the municipality's smart city strategy, which is aligned with the provincial and national smart city priorities. Once approved by Council, Management has to work on securing a budget for delivering on the objectives of the approved smart city strategy. The budget allocation is used for delivering 4IR infrastructure and capacitating the municipality with qualified and competent human capital with 4IR skills and capabilities.

Key smart city projects and activities are produced using smart city applications to build a business case for an acceleration of the smart city agenda. While building the case for increased smartness in municipal service delivery functions, formal collaborations with the private sector, particularly multinational technology companies at the forefront of smart city technologies, leverage the benefit of these 4IR technologies. Smart city projects and activities can be reviewed regularly, and necessary adjustments made to tailor-make solutions for the local South African conditions. This draft smart city model

would be refined and modified based on inputs through online interviews with the identified research participants in the local government and 4IR arena. The input from these key stakeholders would determine the final model, which is presented in Chapter 6.

5.5 INPUT TO THE DRAFT SMART CITY MODEL FOR SOUTH AFRICAN METROPOLITAN MUNICIPALITIES

This section presents inputs and suggestions from the 30 participants across the three metros. All participants were requested to critique the draft model and to provide input for its refinement. The inputs were obtained to validate the content of the drafted smart city model. It should be noted that the inputs obtained are related to research participants' specific metro municipalities. The input will be presented as per the three case studies of the CoE, CoJ and CoT.

5.5.1.1 City of Ekurhuleni

The 10 participants from the CoE were asked questions during the interviews on the draft smart city model proposed by the current study. A summary of their responses is provided in table 22 below.

Table 22: Participants' input

Questions on the Draft Smart City Model	Participants' input
Q28. Does this model make provision for all the processes and steps associated with implementing a smart city?	**PI.** All participants agreed that the model seems to capture municipal processes towards implementing a strategy. Participants, therefore believed that if such processes are followed, it could lead to a successful implementation of a smart city strategy that is adequately funded.
Q29. What do you think should be added or adjusted to make the model more suitable for South African circumstances?	**PI.** Eighty percent (8/10) of participant recommended that there is a need to have a standard smart city framework that can be adopted at a national level, for all South African municipalities to adopt for their local conditions. **PI**. Twenty percent 2/10) of participants believed that the model is adequate.
Q30. Please make suggestions on how Government in general and this municipality in particular can strengthen its support towards smart city initiatives.	**PI.** All participants believed that investing in ICT infrastructure and human capital is the way to go, if South African cities are to compete internationally.

Source: Researcher's own

The researcher's response to inputs from participants can be summarised as follows:

a) *With the issue of having a standard smart city framework that can be implemented at all municipalities in South Africa*: The main objective of the current study is indeed towards the development of a smart city model suitable for South African conditions.

b) *With issues of a need to invest more into ICT infrastructure and skills development by Government*: This view is indeed aligned with theoretical underpinning of a smart city

as explored in Chapters 2 and 3 of the current study. The drafted smart city model has an action plan centred on securing a budget for infrastructure, hardware and software, and ICT skills.

5.5.1.2 City of Johannesburg

The 10 participants from the CoJ were asked questions during the interviews on the draft smart city model proposed by the current study. A summary of their responses is provided in table 23 below.

Table 23: Draft smart city model

Questions on the Draft Smart City Model	Participants' input
Q28. Does this model make provision for all the processes and steps associated with implementing a smart city?	**PI.** All participants agreed that the model captures the legislated municipal processes. However, in reality, the processes are not as smooth as they appear in the model.
Q29. What do you think should be added or adjusted to make the model more suitable for South African circumstances?	**PI.** Eighty percent (8/10) of participants recommended that responsibility for actions required as per model should be allocated a position within the municipality. **PI**. Twenty percent 2/10) of participants believed that there is a need for an Intergovernmental Committee to deal with issues around smart city adoption and implementation.
Q30. Please make suggestions on how Government in general and this municipality in particular can strengthen its support towards smart city initiates.	**PI.** All participants believed that there should be an Intergovernmental Committee to deal with issues around smart city adoption and implementation, including issues of funding for infrastructure and human capital development.

Source: Researcher's own

The responses to inputs from participants can be summarised as follows:

a) *With the issue of assigning responsibility to a person for steps or actions suggested by the model*: The model assumes that all actions required by a municipality will be the responsibility of the City or Municipal Manager. Municipal legislation and regulation allow the Municipal Manager to delegate and assign such responsibilities to any of the Municipal Manager's executives.

b) *With issues of an Intergovernmental Committee on Smart Cities*: The President of the Republic has already appointed a Presidential Commission on the Fourth Industrial Revolution (4IR), which amongst its tasks, is to oversee and ensure the implementation 4IR initiatives, including smart cities adoption across the country. It is thus the responsibility of this Commission to make recommendations of budget allocations to smart cities adoption priorities to relevant authorities such as National Treasury and COGTA.

5.5.1.3 City of Tshwane

The 10 participants from the CoT were asked questions during the interviews on the draft smart city model proposed by the current study. A summary of their responses is provided in table 24 below.

Table 24: Draft smart city model

Questions on the Draft Smart City Model	Participants' input
Q28. Does this model make provision for all the processes and steps associated with implementing a smart city?	**PI.** All participants agreed that the model captures the essence of how to implement a smart city plan within the South African context.
Q29. What do you think should be added or adjusted to make the model more suitable for South African circumstances?	**PI.** All participants recommended that it would have been better if there is a national policy on smart city implementation.
Q30. Please make suggestions on how Government in general and this municipality in particular can strengthen its support towards smart city initiates.	**PI.** All participants believed that a national policy on smart city implementation with applicable guidelines would assist municipalities in implementing smart city related initiates.

Source: Researcher's own

The response to inputs from participants can be summarised as follows:

a) *With the issue of a national smart city policy and applicable guidelines:* At the time of undertaking this study, the Department of Cooperative Governance (DCoG) in collaboration with the Council for Scientific and Industrial Research (CSIR), developed a document called "A South African Smart Cities Framework: A decision-making framework to guide the development of smart cities in South Africa" to address similar issues.

Overall, the 30 participants' input into the drafted smart city model and fulfilled objective 5 of the study, *Which smart city dimensions and elements should be incorporated in a smart city model that can be adopted and implemented by South African metropolitan municipalities to improve e-readiness?*

5.6 REFINING THE DRAFTED SMART CITY MODEL FOR SOUTH AFRICAN METROPOLITAN MUNICIPALITIES

Some of the comments and suggestions of the 30 research participants were used in refining the smart city model. The following alterations and adjustment were made to the drafted model:

a) The model was adjusted to make it easier to differentiate between the national, provincial and local government sphere sections of the model.
b) Responsibility areas were clearly marked for each sphere of government.
c) The visual and professional appearance of the model was improved.

Participants' inputs helped to refine and validate the suitability of this smart city models for South African conditions. The adjusted model will be presented in the next chapter (Chapter 6) as the major contribution to the research question and problem statement of the study (refer to Chapter 1).

5.7 CONCLUSION

This chapter assessed the smart city e-readiness of the Gauteng-based metropolitan municipalities. The results of the assessment indicated that the average smart city readiness maturity level for the CoE, CoJ and COT is level 2 (average score of 1.9). This indicates that these municipalities are still in the early stages of implementing a fully comprehensive open system of system ICT technology solutions, which is based on 4IR technologies, such as the IoT, AI, augmented reality, robotics, blockchains, drones, data analysis and visualisation, amongst other technologies. The result of the smart city readiness assessment was used as input into the draft smart city model, which was presented in this chapter.

This chapter also incorporated Chapters 2, 3 and 4 as well as input from research participants in the refinement of a draft smart city model for a South African municipality. The literature review chapter provided a philosophical background to a city and eventually a smart city. Best practice approaches and praxis from leading smart cities in the world provided a benchmark against which to develop the current smart city model. The chapter

on statutory and regulatory frameworks provided a South African policy perspective on the implementation of 4IR technologies including smart cities. Integrating key elements from these chapters and the input of the interviewed research participants provided a solid basis for developing the current smart city model, which is the aim of this study. All these elements were incorporated into the macro, meso and micro-levels of this model. The next chapter, (Chapter 6) will present the final refined comprehensive smart city model suitable for South African metropolitan municipalities.

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS: A SMART CITY MODEL FOR SOUTH AFRICAN METROPOLITAN MUNICIPALITIES

6.1 INTRODUCTION

The previous chapter presented findings from an empirical investigation regarding smart city e-readiness of Gauteng-based metropolitan municipalities. The main purpose of Chapter 5 was to solicit opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain on e-readiness maturity levels of Gauteng metros, with a view of developing a suitable smart city model for South African metropolitan municipalities. Participants also had an opportunity to provide input on the draft smart city model. Chapter 5 furthermore provided an overview of the research methodology followed, and highlighted the skills, experience and academic profile of sampled participants. The participants provided useful inputs on their respective knowledge and experience with smart city applications within the metros, the smart city governance regime and the interoperability of ICT systems between the metros. The empirical investigation revealed that there is no formal agreement between the three metros on the use of ICTs or the interoperability thereof of such systems. All this insight contributed to the finalisation of the refined smart city model for a South African metropolitan municipality.

This chapter focuses on drawing conclusions and providing recommendations from this study. Insights gained from the literature review, international smart cities best practices, South African ICT statutory and regulatory frameworks and the views of key stakeholders regarding the e-readiness of Gauteng-based metros, will be central to drawing such conclusions and recommendations from this study. Reflections from this study will be provided by explaining the extent to which research findings generated answers to research questions and operationalised the research objectives as well as the extent to which the problem statement was addressed. Furthermore, the smart city model will be presented after taking into account input from participants and suggestions for application of the model presented. Suggestions for further research and a conclusion will follow.

6.2 STUDY REFLECTIONS: RESEARCH OBJECTIVES AND QUESTIONS

The primary objective of this study was to develop a suitable smart city model for a South African metropolitan municipality to ensure that municipalities are informed and guided by such a model in their endeavours to implement smart city initiatives (see Chapter 1 section 1.3). The research objectives of the study have been devised in such a way as to describe what the study aims to achieve. Some of the secondary objectives of this study were highlighted as follows (see Chapter 1, section 1.3):

a) *To evaluate international smart city models and best practice approaches and praxis from leading smart cities in the world.*
b) *To analyse the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives.*
c) *To determine the e-readiness of Gauteng-based Metropolitan Municipalities by obtaining the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain.*
d) *To design a smart city model that can be adopted and implemented by South African metropolitan municipalities to improve their overall e-readiness.*

To operationalise these objectives into measurable observations, the researcher designed an all-inclusive interview schedule. Elements, as contained in the research objectives, were integrated into research questions as included in the designed interview schedule. Data was collected using interviews as the preferred data collection method.

As indicated in section 1.3 of Chapter 1, the primary objective of this study has been to develop a smart city model for South African metropolitan municipalities, with the aim of ensuring that metros are informed and guided by a model in their endeavours to implement smart city initiatives. For this purpose, the following research objectives (RO) were formulated and operationalised in this study:

a) **RO1:** To explore the meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of the 4IR

b) **RO2:** To evaluate international smart city models and best practice approaches and praxis from leading smart cities in the world.
c) **RO3:** To analyse the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives.
d) **RO4:** To determine the e-readiness of Gauteng-based Metropolitan Municipalities by obtaining the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain.
e) **RO5:** To design a smart city model that can be adopted and implemented by South African metropolitan municipalities to improve their overall e-readiness.

As can be seen in Chapter 1 (section 1.4), the key research questions came from the research objectives that were operationalised in this study. The primary research objective of the study was to develop a smart city model for South African metropolitan municipalities. From this primary research objective, the following secondary research questions (RQs) were developed and answered:

a) **RQ1:** What are the meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of the Fourth Industrial Revolution?
b) **RQ2:** What lessons can be learned from international smart city models and best practice approaches and praxis from leading smart cities in the world?
c) **RQ3:** What are the nature and content of the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives?
d) **RQ4:** What are the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain with regards to the e-readiness of Gauteng-based Metropolitan Municipalities?
e) **RQ5:** Which smart city dimensions and elements should be incorporated in a smart city model that can be adopted and implemented by South African metropolitan municipalities to improve their overall e-readiness?

The alignment of research objectives and question is summarised and presented in table 25 below.

Table 25: An alignment of research objectives and questions to the chapters of the study

Research objectives	Research questions (RQ)	Chapter(s)
RO1: To explore the meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of the 4IR	**RQ1**: What are the meta-theoretical and theoretical underpinnings as well as principles and dimensions of smart cities within the context of the 4IR?	Chapter 2
RO2: To evaluate international smart city models and best practice approaches and praxis from leading smart cities in the world**.**	**RQ2:** What lessons can be learned from international smart city models and best practice approaches and praxis from leading smart cities in the world?	Chapter 3
RO3: To analyse the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives.	**RQ3:** What are the nature and content of the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives?	Chapter 4
RO4: To determine the e-readiness of Gauteng-based Metropolitan Municipalities by obtaining the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain.	**RQ4:** What are the opinions and perspectives of key stakeholders and role-players in the ICT and city governance domain with regards to the e-readiness of Gauteng-based Metropolitan Municipalities?	Chapter 5
RO5: To design a smart city model that can be adopted and implemented by South African	**RQ5:** Which smart city dimensions and elements should be incorporated in a smart city model that can be	Chapters 3, 5 and 6

Research objectives	Research questions (RQ)	Chapter(s)
metropolitan municipalities to improve their overall e-readiness.	adopted and implemented by South African metropolitan municipalities to improve their overall e-readiness?	

Source: Researcher's own

6.3 SUMMARY OF CHAPTER CONTENT

This section summarises the contents of each chapter and its main points, with the aim of providing a concise summary of essential points, statements and facts that emerged from the research. The main issues are summarised with reference made to the relevant sections in the chapters, to avoid unnecessary repetition.

Chapter 1 introduced and outlined the orientation of this study. The problem statement, the research aims and objectives, as well as the methodology to be followed in the study were presented by the researcher. NPM concepts, such as smart cities, 4IR and ICT were briefly outlined with their importance towards addressing the problem statement of the study. Section 1.5 clarified the central theoretical statement as a starting point of the need for such a study. Ethical considerations and the significance of this study were also outlined in Chapter 1.

In **Chapter 2** a theoretical backbone of the study was presented. This included a conceptual clarification of what cities, municipalities and local government is, in general. A number of local government theories, such as the local state theory, general state theory, dual state theory, public institutional theory and principal agency theory amongst others, were presented to provide a theoretical background of the emergence of local government, of which smart cities are part and parcel of. These theories provide insight into how cities transact and function towards attaining societal needs.

The smart city concept and its key universal elements and dimensions as an emerging viable instrument with potential to improve local government services was contextualised within the scope of public administration. Philosophical perspectives of the role of

government in society, application of 4IR techniques within local government and theoretical frameworks for embracing ICT in public administration was provided. It was illustrated that ICT, smart cities and 4IR are elements employed within the NPM school of thought. Chapter 2 thus fulfilled RO1 and answered RQ1 by illustrating the theoretical underpinning, principles and dimensions of smart cities within the 4IR context.

In **Chapter 3** the focus was on international smart city models and best practice approaches from leading smart cities in the world. The researcher analysed nine leading smart city models and frameworks in an effort to identify appropriate elements and dimensions for inclusion when designing a suitable smart city model for South African metropolitan municipalities, which is the objective of this study. This included undertaking a comparative analysis of such smart city models and frameworks in order to ascertain similarities in content, elements, dimensions, approach and application so as to include applicable and implementable features in a smart city model suitable for thelocal South African context. The Smart Cities Maturity Model and its self-assessment tool, commissioned and conceptualised by the Scottish Government, was the preferred model used to determine e-readiness maturity levels of Gauteng-based metropolitan municipalities. This model was favoured due to its ability to clearly categorise levels of maturity of municipalities.

Chapter 3 also focused on analysing best practise and application of smart cities concepts in advanced and developing economies. Smart cities implementation in BRICS countries and from an African perspective was also analysed. Key features, challenges and lessons from the analysis of smart cities in advanced and developing economies was incorporated to shape the drafted smart city model produced by this study. In Chapter 3, the researcher operationalised RO2 by determining the lessons that can be learned from international application and best practice of smart cities.

In **Chapter 4**, the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives was analysed and addressed RO3. The researcher focused on the Public Service Act, SITA Act and ECT Act as these are critical in providing a statutory base and support for municipalities to embrace ICT in providing public goods and services to society. Regulatory frameworks such as the

WPTPSD, GWEA, the National Integrated ICT Policy White Paper and the National e-Strategy, amongst others, were also analysed to determine how matured, detailed and strategic they are in supporting municipalities towards being smart. The statutory and regulatory frameworks also highlighted the key requirements and expectations that municipalities must comply with to pursue a smart city agenda.

In **Chapter 5** of the study, an empirical study which addresses RO4 was undertaken which involved interviews with key stakeholders and role-players in the ICT and city governance domain. The study followed an exploratory qualitative research design using a purposive sampling technique. Data collected using an interview schedule, was analysed and presented using content and thematic analysis approaches. The findings of the study confirmed the problem statement detailed in Chapter 1, that there is a lack of integration and uniform application of smart citys technologies by Gauteng-based metros due to a lack of a suitable model to address such challenges. The findings from this chapter were used to inform, validate and refine a smart city model presented in Chapter 6.

In this concluding chapter of the study, **Chapter 6**, a synopsis of the whole study was presented. The chapter provided a summary of the study through a reflection of what was covered in all chapters. The chapter went further to recommend a smart city model for South African metropolitan municipalities as part of its contribution to new knowledge. This was to address the main aim of the study outlined in Chapter 1, which has been to develop a smart city model for local South African conditions. This chapter also proposed recommendations for further research areas.

6.4 RESEARCH CHALLENGES

This study encountered a number of challenges, especially during the data collection phase. The challenges that were encountered and the way they were resolved, are briefly expounded below:

a) *Unwillingness to participate in the study by a municipality.* Initially one of the three metros could not provide approval to the researcher to undertake the study. This was

due to the research limit that was reached by the municipality. However, in 2022, the metro in question eventually gave permission and the study was then undertaken at the municipality.

b) *Covid-19 Pandemic*. This study started in 2020 and during that time the Covid-19 pandemic was causing havoc all over the world. Covid-19 delayed interviews with participants, as some were not willing to do in-person interviews. This led to some initial interviews being conducted online using Microsoft Teams software.

c) Unavailability of some participants. Due to the nature of the positions some participants held, it was initially difficult to set-up an appointment to undertake interviews. However, persistency on the part of the researcher enabled the researcher to eventually secure time with the targeted participants, and the data was collected.

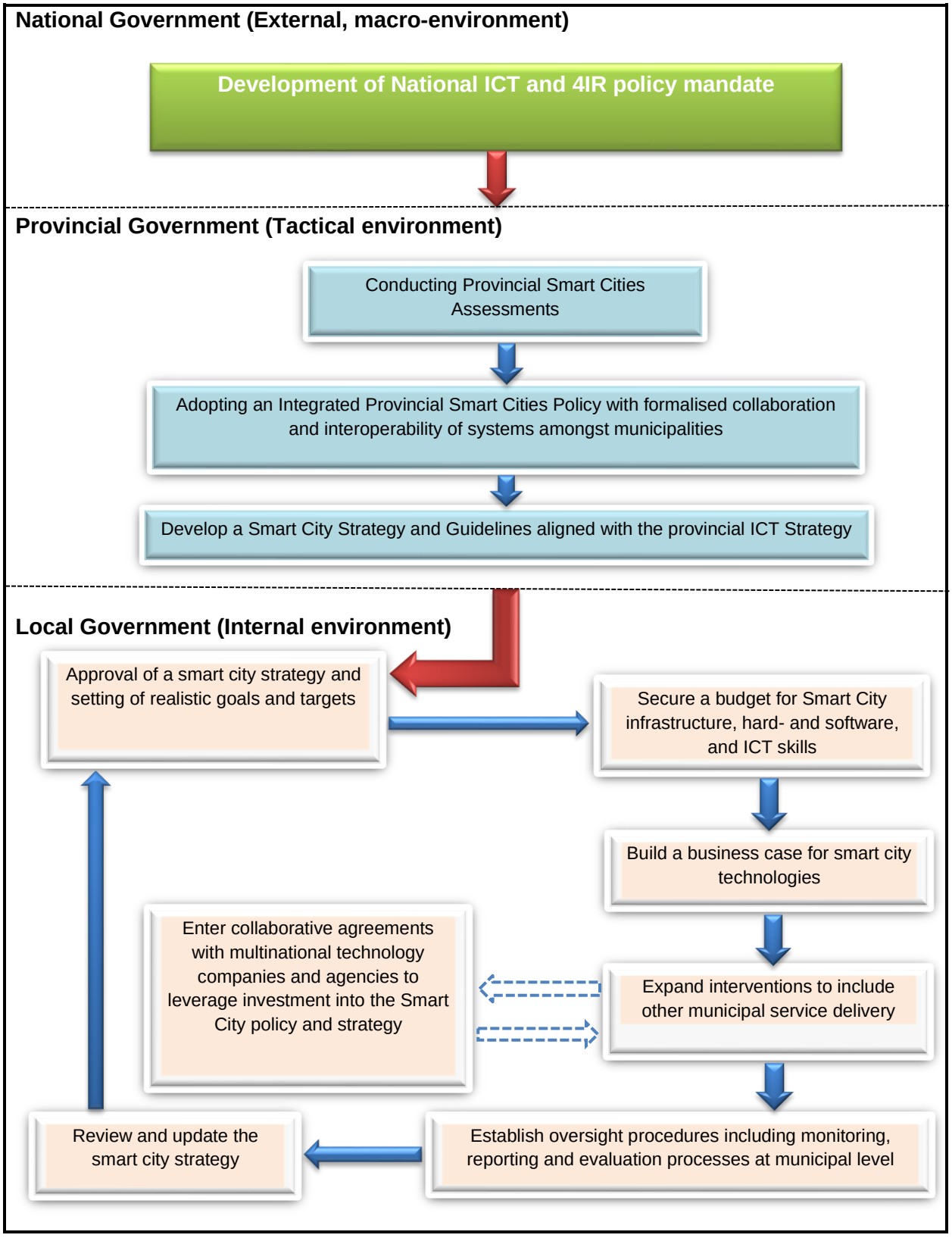
The researcher was fortunate that not a single challenge or problem compromised the original research design and the integrity of the research findings. In the next section, the final smart city model proposed by this study is presented.

6.5 PRESENTING THE FINAL SMART CITY MODEL FOR SOUTH AFRICAN MUNICIPALITIES

In the previous chapter, Chapter 5, the national, provincial and local government spheres of the proposed smart city model was presented. The model presented these spheres in layered phases, from strategic (macro), to tactical (meso) and operational (micro). An integration of these government spheres was then presented in a draft model, which the research participants refined through their comments and input.

Figure 20 below presents this refined and validated final smart city model, which is the contribution from this study as outlined in section 1.3 *Research objectives,* of this study. The final model takes account of participants' input which recommended that entering into a collaboration agreement with a technology company should not be compulsory for a smart city. This study recommends that the three spheres of government need to be aligned, if the smart city agenda of the Republic of South Africa is to be achieved.

Figure 20: The Smart City Model for South African Metropolitan Municipalities



Source: Researcher's own

6.6 SUGGESTIONS FOR THE APPLICATION OF THE MODEL

Based on the literature review, case study analysis and empirical validation, the following suggestions can be made regarding the process that should be followed when applying the smart city model in municipalities:

a) The national government, through national departments should develop a clear national smart city policy that is aligned with the existing national ICT and 4IR policy mandate. This is the case with similar countries to South Africa, those in BRICS and other developing economies.

b) Provincial government, such as the Gauteng Provincial Government, should formally adopt an integrated Provincial Smart Cities Policy, which has formalised collaboration and interoperability of systems amongst municipalities.

c) In local government, municipal councils should consider the following when implementing the smart city model:

i. Approval of a smart city strategy

Before any work is undertaken, the Municipal Manager must develop a smart city strategy for a municipality. The strategy should be aligned to the country's macro-ICT mandate as contained in the NDP2030 and related national policies and regulations. The smart city goals and objectives of the strategy should be realistic, taking into account the current smart city readiness of the municipality. Municipalities should ensure that their smart city strategy is also aligned with the provincial ICT priorities. Collaboration and interoperability of ICT systems with other municipalities within the province should be prioritised when the smart city strategy is being developed.

Before tabling the smart city strategy at the Municipal Council for approval, the Municipal Manager, should ensure that consultations with relevant national and provincial government departments on the strategy has been undertaken. The strategy should also be consulted on with all relevant internal stakeholders within the municipality, including

citizens. The Municipal Council should then consider the strategy for approval and adoption.

ii. Secure a budget

Once a municipality's smart city strategy has been approved by Council, the next phase is to secure a budget to enable the municipality to implement the strategy. Smart city projects can either be classified as capital or operational and as such, municipalities are able to raise funding, not only from internally generated sources, but from external sources. At an external macro-environment, it is possible for municipalities, specifically, the metros to raise smart city funding from external loans, other government grants, donations and public contributions, amongst others. Similarly, in the tactical environment, provincial grants and loans can be secured by metros to fund their smart city strategy. Internally, municipalities could utilise equitable share funding from national government and internally generated income to fund its smart city programmes and projects.

iii. Build a business case for smart city technologies

Once a budget is secured for the smart city strategy, municipalities need to implement smart city programmes and projects to continue building a business case for the smart city approach. At a macro-environment, this would involve municipalities in collaboration with national government departments, showcasing successful smart city projects that have improved service delivery provision to the public. At a tactical level, there is a need to build a case for interoperability of smart city systems between the metros, showcasing how smart technologies can make life easier for Gauteng residents. Internally within the micro-environment, smart city projects that enable municipal staff members to better provide municipal services to citizens would be ideal to build a business for the expansion of the use of smart technologies to other areas of the municipality.

iv. Enter into a collaborative agreement with technology companies (Optional)

To fast-track smart city implementation, municipalities have the option of entering into collaborative service level agreements with multinational technology companies and agencies, in order to leverage investments into their smart city strategy. As explored in section 3.5, municipalities from BRICS countries, such as Búzios in Brazil and Bengaluru in India, entered into agreements with multinational technology companies in order to leverage investments and fast track smart city implementation. In this type of public private partnerships, huge capital investments into smart cities can be possible, however, such collaboration needs to comply with national, provincial and local government procurement regulations.

v. Expand smart city interventions to other municipal service delivery domains

Once a business case for smart city technology has been implemented successfully, municipalities should then expand digitalisation to other service areas within the municipal administration.

vi. Establish oversight process

There is a need to have governance structures to oversee smart city implementation. The international smart city frameworks explored in section 3.2 provided a need for smart governance to ensure data privacy and security. London, for example, has a Smart London Board (section3.4.1).

Municipalities should have oversight procedures in place. This would include establishing regular monitoring, reporting and evaluation of smart city programmes and projects. Quarterly progress reports should be produced for all stakeholders at the external, tactical and internal environments, which include national and provincial departments, Section 79 Committees, Mayoral Committee and Municipal Councils.

vii. Review and update the smart city strategy

The smart city strategy needs to be regularly reviewed and updated to ensure that it is still fulfilling its mandate. Inputs and comments from stakeholders, including the private sector, need to be taken into account by a municipality when reviewing and updating the smart city strategy.

6.7 SUGGESTIONS FOR FURTHER RESEARCH

The current study focused on Gauteng-based metropolitan municipalities and as such findings may not be generalised for the entire country. Thus, the following issues require further scholarly inquiry:

- *Smart city readiness of the other six metros in South Africa:* It is recommended that further research be carried out on a wider scale to ascertain the smart city readiness of the other six metros in South Africa (Buffalo City, City of Cape Town, City of eThekwini, Mangaung Municipality and Nelson Mandela Metropolitan Municipality).

- *A South Africa Smart Cities Policy framework:* Chapter 4 illustrated that there is no compressive smart city policy framework in South Africa. Such a framework would guide provinces and municipalities on how to approach smart cities implementation and encourage interoperability of ICT systems between the metros. The design of such a comprehensive policy deserves further investigation.

6.8 CONCLUSION

The primary objective of the current study was to develop a smart city model for a South African metropolitan municipalities. Chapter 1 outlined the problem statement, the research aims and objectives, and the methodology to be followed in the study. The second chapter provided a theoretical backbone of the study and focused on conceptual clarification of cities, municipalities and local government. Elements and core dimensions of a smart city, philosophical perspective on the role of government in society, theoretical

frameworks for embracing ICT in public administration and the application of 4IR techniques within local government were explored.

In Chapter 3 the focus was on international smart city models and best practice approaches from leading smart cities in the world. Subsequently, Chapter 4 discussed the statutory and regulatory frameworks governing the application of ICT in urban governance leading to smart city initiatives. Chapter 5 presented the empirical findings of the smart city readiness assessment of Gauteng-based metropolitan municipalities and a smart city model was drafted using inputs from Chapter 2, 3 and 4, as well as inputs from research participants.

All this culminated in the presentation of the final smart city model for a South African metropolitan municipality in this final chapter. Suggestions for applying the smart city model were provided to ensure that the smart city model achieves the purpose for which it was designed. Suggestions for further research on smart city readiness of metros and on a smart cities policy framework were provided.

Even though the study focused on Gauteng-based metros, the smart city model has value for the entire South African local government sector. The value is based on the fact that any of the 257 local, district and metropolitan municipalities in South Africa can utilise the model in their smart city adoption and implementation agenda. Successful application of this smart city model can result in smart municipalities in South Africa, which would go a long way in addressing service delivery challenges facing the country.

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ANNEXURE A

INTERVIEW SCHEDULE

TOWARDS A SMART CITY MODEL FOR SOUTH AFRICAN METROPOLITAN MUNICIPALITIES: THE CASE OF GAUTENG-BASED METROPOLITAN MUNICIPALITIES

BACKGROUND INFORMATION OF THE PARTICIPANT

OFFICIALS

Current position

Municipality	F	M	Position
Ekurhuleni/Johannesburg/Tshwane			

Years of experience in this position

Municipality	F	M	1-5	6-10	11-15	16-20	21-25
City of Johannesburg							

Years of experience in local government

Municipality	F	M	1-5	6-10	11-15	16-20	21-25
City of Johannesburg							

Your IT and 4IR Qualifications

- ☐ Short-term Course/Workshop
- ☐ Certificate
- ☐ Diploma
- ☐ Degree
- ☐ Honours Degree/Post Graduate Certificate
- ☐ Master's degree/ MBA
- ☐ PhD/DBA
- ☐ Other

Other Non-IT Qualifications

- ☐ Short-term Course/Workshop
- ☐ Certificate
- ☐ Diploma

- ☐ Degree
- ☐ Honours Degree/Post Graduate Certificate
- ☐ Master's degree/ MBA
- ☐ PhD/DBA
- ☐ Other

CURRENT SMART CITY OPERATIONS

1 **Question 1:** What do you understand by a smart city? Which smart city approach/model/framework is being pursued by this municipality?

2 **Question 2:** What is your opinion regarding the smart city e-readiness of this municipality?

3 **Question 3:** What are some of this municipality's smart city success stories?

4 **Question 4:** What are some of this municipality's smart city challenges?

5 **Question 5:** What do you think should be done to address these challenges and improve smart city e-readiness?

6 **Question 6:** Is there any collaboration in terms of smart city funding/projects/infrastructure or any related items between this metropolitan municipality and the other 2 adjoining metropolitan municipalities?

7 **Question 7:** Is there a smart city strategy included in this municipality's IDP?

8 **Question 8:** What is the annual budget allocation towards smart city adoption? Is the budget allocation adequate to move the municipality to smart city e-readiness?

9 **Question 9:** Is there a dedicated team responsible for smart city implementation at this municipality? If yes, what is the seniority level of the Head of the smart city team?

10 **Question 10:** Is there a dedicated oversight body overseeing smart city implementation at this municipality? Yes or No? Describe the smart city oversight process at the municipality?

11 **Question 11:** In your opinion, are there any statutory, regulatory and legislative prescripts that can act as obstacles towards effective implementation/adoption of smart city technologies and processes?

12 **Question 12:** Are there any statutory, regulatory and legislative prescripts that can be introduced to aid effective implementation/ adoption of smart city technologies and processes by South African municipalities?

SMART CITY MATURITY ASSESSMENT TOOL

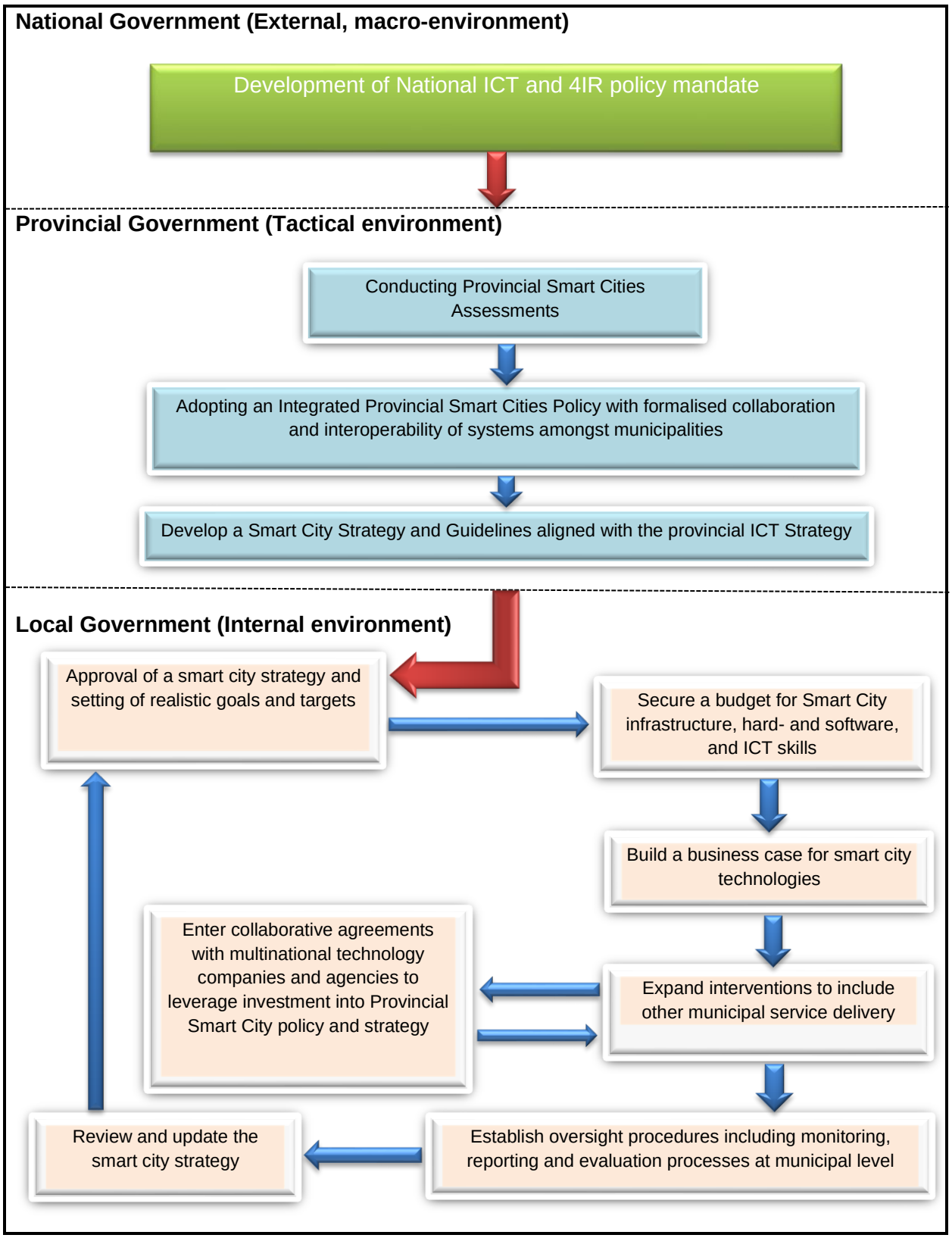
Dimension	Assessment indicator (Maturity Level)				
	Ad-Hoc (1)	Opportunistic (2)	Purposeful & Repeatable (3)	Operationalised (4)	Optimised (5)
Strategic Intent	No overall roadmap for digital transformation exists yet.	Strategy and investment largely at departmental level	A shared vision, strategy and roadmap for the 'smart' city in place with multiple partners across multiple domains	Vision, strategy and roadmap established at city-wide level.	Strategy is optimised and evolves based on clear evidence of impact on city competitiveness
Data	Issues with data integrity, quality, privacy and security	Some preliminary data sharing and analytics applications in place	Investing in advanced data management, capture, analytics and big data applications	Established open data community is building new services valued by users	Open data community generating new market opportunities and building alternatives to public service provision
Technology	ICT architectures are predominantly designed to support each line of business application	Some shared or integrated architectures exist but deployed on a limited set of services.	Joint investment plans in city-wide deployment of connected assets.	City-wide deployment of connected assets	A networked built environment across the city
Governance and Service delivery Models	Traditional client-provider-supplier-user relationships exist and are often managed separately	Shared budget accountability for some discrete initiatives.	Greater input to problem solving and service design from providers/suppliers and users	Traditional supplier/contractor relationships evolve to include gain sharing, co-development and performance contracting.	Leadership and governance model stimulates an innovation system that promotes new combinations of service delivery
Stakeholder engagement	Opportunities to enhance participation using web-based platforms is recognised and discrete initiatives are underway	Departmental-level commitment to investing in digital channels to enhance citizen engagement.	The engagement tools and approaches adopted enhance the voice of stakeholders and citizens across a range of city services	City uses multiple channels to engage with citizens tailored to their needs.	City has embedded inclusive and personalised engagement models that stimulate innovation and collaborative approaches across all sectors.

Please assess the smart city readiness of this municipality. Rate between 1 and 5 in the table below:

	Ad-Hoc (1)	Opportunistic (2)	Purposeful & Repeatable (3)	Operationalised (4)	Optimised (5)
Strategic Intent					
Data					
Technology					
Governance and Service Delivery Models					
Stakeholder Engagement					

VALIDATE THE DRAFT SMART CITY MODEL

Input, review and validate the proposed Smart City Model



13 **Question 13:** Does this model make provision for all the processes and steps associated with implementing a smart city?

14 **Question 14:** What do you think should be added or adjusted to make the model more suitable for South African circumstances?

15 **Question 15:** Please make suggestions on how Government in general, and this municipality in particular, can strengthen its support towards smart city initiates.

ANNEXURE B

Dr Imogen Mashazi
City of Ekurhuleni Metropolitan Municipality
Private Bag X1069
GERMISTON,
1400

RE: Permission to Conduct Research Study

Dear Mashazi

I am writing to request permission to conduct a research study at the City of Ekurhuleni Metropolitan Municipality. I am currently enrolled for a **PhD in Public Management and Governance** at the North-West University (Potchefstroom Campus) and I am working for the City of Johannesburg Metropolitan Municipality. I am in the process of writing my thesis with the topic "***Towards a Smart City Model for South African Metropolitan Municipalities: The Case of Gauteng-based Metropolitan Municipalities"***. As such, I request to undertake interviews with some officials from the following departments/sections:

- Office of the City Manager
- Office of the Chief Operating Officer
- Institutional Strategy, Monitoring & Evaluation
- Office of the Chief Information Officer
- Governance and Compliance and
- Projects, Architecture, Governance and Support Services

The information to be gathered will be used for academic purposes only. Upon completion of the study, I undertake to provide the City with a copy of the full research report. If you require any further information, please do not hesitate to contact me on the details provided below.

Thank you for your time and consideration in this matter.

Yours sincerely,

Mr. Mukundi Maphangwa
Email address: 36667528@student.g.nwu.ac.za
Cell Number: 061 436 1649

ANNEXURE C

Dr Ndivhoniswani Lukhwareni
City of Johannesburg Metropolitan Municipality
Metropolitan Centre
1st Floor Council Chamber Wing
158 Civic Boulevard
Braamfontein, Johannesburg, 2001

RE: Permission to Conduct Research Study

Dear Dr Lukhwareni

I am writing to request permission to conduct a research study at the City of Johannesburg Metropolitan Municipality. I am currently enrolled for a **PhD in Public Management and Governance** at the North-West University (Potchefstroom Campus). I am in the process of writing my thesis with the topic "***Towards a Smart City Model for South African Metropolitan Municipalities: The Case of Gauteng-based Metropolitan Municipalities".***

As such, I request to undertake interviews with some officials from the following departments/sections:

- Office of the City Manager
- Office of the Chief Operating Officer
- Group Information Communication Technology and Information Management (GICT&IM)
- Group Strategy Policy Coordination and Relations (GSPCR) – Smart City Office, and the
- Metropolitan Trading Company (MTC)

The information to be gathered will be used for academic purposes only. Upon completion of the study, I undertake to provide the City with a copy of the full research report. If you require any further information, please do not hesitate to contact me on the details provided below.

Thank you for your time and consideration in this matter.

Yours sincerely,

Mr. Mukundi Maphangwa
Email address: 36667528@student.g.nwu.ac.za
Cell Number: 061 436 1649

ANNEXURE D

Ms Mmaseabata Mutlaneng
City of Tshwane Metropolitan Municipality
PO Box 440
PRETORIA
0001.

RE: Permission to Conduct Research Study

Dear Acting City Manager

I am writing to request permission to conduct a research study at the City of Tshwane Metropolitan Municipality. I am currently enrolled for a **PhD in Public Management and Governance** at the North-West University (Potchefstroom Campus) and I am working for the City of Johannesburg Metropolitan Municipality. I am in the process of writing my thesis with the topic "***Towards a Smart City Model for South African Metropolitan Municipalities: The Case of Gauteng-based Metropolitan Municipalities"***.

As such, I request to undertake interviews with some officials from the following departments/sections:

- Office of the City Manager
- Group Information & Communication Technology and Management and
- Others related to the Smart and Innovative City Programme

The information to be gathered will be used for academic purposes only. Upon completion of the study, I undertake to provide the City with a copy of the full research report. If you require any further information, please do not hesitate to contact me on the details provided below.

Thank you for your time and consideration in this matter.

Yours sincerely,

Mr. Mukundi Maphangwa
Email address: 36667528@student.g.nwu.ac.za
Cell Number: 061 436 1649