

UNIVERSITY OF PRETORIA

FACULTY OF ENGINEERING, BUILT ENVIRONMENT AND

INFORMATION TECHNOLOGY

DEPARTMENT OF TOWN AND REGIONAL PLANNING

The potential of 4th industrial revolution technology and smart city principles for South African planning and management

By Alessandro Ferro

Student Number: U17093458

Supervisor: Karina Landman

Date: September 2024

Acknowledgments

I would like to express my deepest gratitude to my supervisor, Karina Landman for their continuous guidance, support, and encouragement throughout the research and writing of this thesis. Their expertise and insights have been invaluable.

I also wish to thank my friends who provided advice, assistance, and feedback during this process, especially to Alessandro Patrizi, who ensured I mentally stayed on course through his selfless support. A special thanks to my family for their endless patience, support, and belief in me.

Lastly, I would like to acknowledge the institutions and organizations that provided the resources and materials necessary to complete this research.

Thank you all.

Abstract

In the modern age of rapidly evolving technology integration into the daily functions of nations, South Africa (SA) is at a crossroads where it must decide how best to integrate these advanced technologies into its urban planning efforts. This paper investigates the potential of Fourth Industrial Revolution (4IR) technologies and Smart City (SC) principles in the context of South African planning. The 4IR is characterized by the integration of digital technologies into various sectors and offers transformative opportunities for urban planning and development across the globe. This study combines a thorough analysis of existing literature with interviews conducted with planners from the country of SA to assess the specific challenges and opportunities faced by South African planners, to gauge the future potential.

The findings of this research highlight that while there is significant potential for 4IR technologies and smart city principles in SA planning, there are numerous limitations that need to be addressed. South Africa currently faces limited access to advanced infrastructure, a growing digital divide among citizens, and inadequate technical skills. These limitations hinder the effective implementation of 4IR technologies in urban planning.

Based on these findings, the study suggests that SA should focus on policy development and capacity building as a priority before fully embracing 4IR technologies. By establishing a more robust policy framework and investing in training and skill development programs, SA can create an enabling environment for the successful adoption of 4IR technologies and smart city principles. This approach ensures that technological advancements are effectively utilized to address urban challenges while ensuring equitable access and digital inclusion for all citizens.

In conclusion, this research exhibits the need for a balanced approach to SA planning, emphasizing the importance of policy development and capacity building of its planners alongside its planned implementation of 4IR technologies. By addressing the technological limitations and prioritizing policy frameworks, SA can leverage the opportunities and benefits fully from the transformative potential of 4IR technologies and SC principles to create sustainable and inclusive cities for its citizens.

Table of contents

ABSTRACT	III
LIST OF FIGURES	VI
LIST OF TABLES	VI
NOMENCLATURE.....	VII
CHAPTER ONE: INTRODUCTION	1
1.1 A WORLD IN MOTION	1
1.2 LOOKING BACK IN THE FUTURE	2
1.3 EXPLORING THE CHALLENGES.....	4
1.4 THE DIRECTION WE ARE HEADING	5
1.4.1 Aim and Objectives	6
1.4.2 Scope of the study.....	6
1.5 SUMMARY OF THESIS STRUCTURE.....	7
CHAPTER TWO: LITERATURE REVIEW	8
2.1 INTRODUCTION	8
2.2 THE FOURTH INDUSTRIAL REVOLUTION.....	9
2.2.1 Key issues	9
2.2.2 The correlation between 4IR Technology and Global Goals.....	10
2.2.3 Changes enabled by 4IR	12
2.2.4 Barriers to Widespread Implementation and the risks of getting it wrong	17
2.2.5 Risks of large-scale implementation of 4IR technology and principles	19
2.2.6 The impact of risks on the planning profession and cities	21
2.3 THE SMART CITY MOVEMENT	22
2.3.1 The importance of the marriage between the city and technology.....	22
2.3.2 Defining a Smart City	25
2.3.3 The Smart City Framework.....	25
2.3.3.1 Components of a Smart City	26
2.3.4 Benefits of a Smart City.....	32
2.3.5 Smart City Fundamentals.....	36
2.4 GLOBAL EXAMPLES OF 4IR AND SMART CITY IMPLEMENTATION	38
2.4.1 Smart cities around the world.....	38
2.4.2 Common trends of successful Smart Cities.....	48
2.4.3 Common Initiatives from Successful Smart Cities	50
2.5 South Africa's Smart Cities	53
2.6 South Africa's major challenges.....	61
2.6.2 The shortcomings created by the challenges of the country.....	65
2.6.3 The state of planning and the challenges hindering it	66
2.6 CONCLUSIONS	69
CHAPTER THREE: METHODOLOGY	71
3.1 INTRODUCTION	71
3.2 RESEARCH APPROACH	71
3.3 RESEARCH DESIGN	74
3.3 RESEARCH METHODS.....	78
3.3.2 Data analysis: Thematic analysis	81

3.4 LIMITATIONS OF STUDY.....	85
3.5 ETHICAL CONSIDERATIONS	85
3.6 CONCLUSION.....	86
CHAPTER FOUR: CONTEXT	87
4.1 INTRODUCTION	87
4.2 CONTEXT OF SOUTH AFRICA	88
4.2.1 <i>The South African Planning System</i>	89
4.2.2 <i>The spatial framework and three spheres of South African planning</i>	92
4.3 PROVINCIAL CONTEXT	95
4.4 METROPOLITAN CONTEXT	97
4.4.1 <i>City of Tshwane Metropolitan Municipality</i>	98
4.4.2 <i>City of Johannesburg Metropolitan Municipality</i>	101
4.5 CONCLUSION.....	103
CHAPTER FIVE: EXPLORING THE POTENTIAL OF 4IR AND SMART CITIES IN SOUTH AFRICA	106
5.1 INTRODUCTION	106
5.2. COMPLEX 4IR TECHNOLOGY AND THE SMART CITY NARRATIVE	106
5.2.1 <i>Benefits associated with the 4IR and SCs</i>	107
5.2.2 <i>Challenges associated with the 4IR and SCs</i>	110
5.2.3 <i>The difficulty of differentiating between the 4IR and SCs</i>	115
5.2.4 <i>The use of statistics to measure and indicate development</i>	118
5.3 THE TURBULENT CONTEXT OF SOUTH AFRICA	121
5.3.1 <i>Limited access to technology and skills</i>	122
5.3.2 <i>Inadequate infrastructure</i>	125
5.3.3 <i>Lack of resources</i>	129
5.3.4 <i>Lack of coordination between the different levels of government.</i>	130
5.4 THE GAPS WITHIN SA PLANNING	133
5.4.1 <i>Lack of awareness of 4IR technology and SC principles</i>	133
5.4.2 <i>The complex structure of the planning profession</i>	136
5.4.3 <i>The scarcity of 4IR and SCs plans in major documents</i>	139
5.4.4 <i>Uncertainty surrounding 4IR technology and SC principles</i>	141
5.5 CONCLUSION.....	144
CHAPTER SIX: PUTTING IT ALL TOGETHER	146
6.1 EMBRACING TOMORROW'S URBAN FRONTIERS.....	146
6.2 CLOSING THE LOOP.....	146
<i>The relationship between the 4IR and SC movements</i>	147
<i>The presence of the 4IR and SC in spatial development documents in South Africa</i>	148
<i>The awareness of planners related to the 4IR and SC movement to implement this in practice</i>	149
<i>The potential of 4IR technology and SC principles for the SA planning profession</i>	151
6.3 IMPLICATIONS FOR THEORY AND PRACTICE.....	153
6.4 FUTURE RESEARCH	155
6.5 CONCLUDING REMARKS	157
APPENDIX A: INTERVIEW QUESTIONS USED	158
APPENDIX B: EXAMPLE OF CONSENT FORM USED	159
CHAPTER 7 REFERENCES	160

List of Figures

- Figure 1: Innovation score capacity vs. Global Goal progress, shown by country
Figure 2: Graph showing the Impact of automation across industry sectors over time
Figure 3: Components of smart city Adapted.
Figure 4: Examples of Smart Mobility
Figure 5: SCSi distribution and statistical characteristics of SCs globally
Figure 6: City of Vienna Smart City framework pillars
Figure 7: City of London Smart City score
Figure 8: The Smart London Approach
Figure 9: City St. Albert Smart City Strategic Framework
Figure 10: St. Albert total rating sections.
Figure 11 Singapore's Smart Nation Pillars and Initiatives
Figure 12: Average scores across all fields of smart cities investigated
Figure 13: Framework for Smart Cities white Paper
Figure 14: Smart City Framework from the Smart Nation Singapore plan
Figure 15: A visual summary of common initiative areas of successful Smart Cities
Figure 16: The Durban Aerotropolis Master Plan map
Figure 17: Mooikloof Mega City Master Plan map
Figure 18: Modderfontein Smart City Master Plan map.
Figure 19: DCoG draft targets and indicators for the SCF Initiatives 2022
Figure 20: Africa's development indicators with ICT
Figure 21: Percentage of households with access to the Internet by province
Figure 22: Level of education of the unemployed in South Africa
Figure 23: Visual summary of Figure 24 layout
Figure 24: Visual representation of structure to answer the main research question
Figure 25: Visual representation of chapter structure
Figure 26: Diagram representing the history of the South African legal framework
Figure 27: Map of proposed NSDF 2050 outcomes
Figure 28: Visual representation of the spatial framework of South Africa
Figure 29 Locational context of the study areas
Figure 30: Region map of Tshwane metropolitan municipality
Figure 31: Map showing Sector Commitments in the City of Tshwane Metropolitan Space
Figure 32: Region map of Johannesburg metropolitan municipality
Figure 33: SDF 2040 principles are visually represented in a compact model

List of tables

- Table 1: Pros and cons of the qualitative method
Table 2: Contents for the aspects associated with Case Studies
Table 3: Pros and Cons of case studies.
Table 4: Advantages and disadvantages of thematic analysis.

Nomenclature

AI	Artificial intelligence
CIP	Consolidated Infrastructure Plan
CJMM	City of Johannesburg Metropolitan Municipality
COJ	City of Johannesburg
CTMM	City of Tshwane Metropolitan Municipality
DCoG	Department of Cooperative Governance
DDM	District Development Model
DFA	Development and Facilitation Act
DM	Developed Market
EAG	Education at a Glance
EM	Emerging Market
EV	Electric vehicle
GDP	Gross Domestic Product
GDS	Growth Development Strategy
GGT	Growing Gauteng Together
GSFD	Gauteng Spatial Development Framework
HDI	Human Development Index
ICT	Information and Communication Technologies
IDP	Integration development Plan
IT	Information Technology
LDC	Least Developed Countries
LED	Light Emitting Diode
MSA	Municipal Systems Act
MSDF	Metropolitan Spatial Development Framework
NDP	National Development Plan
OECD	Economic Co-operation and Development
PPI	Public Policy Implementation
RDP	Reconstruction and Development Program
SA	South Africa
SC	Smart City
SCF	Smart City Framework
SCSI	Smart City Strategy Index
SDF	Spatial Development Framework
SDG	Sustainable Development Goals
SONA	State of the Nation Address
SPLUMA	Spatial Land Use Management Act
TOD	Transport Orientated Development
UK	United Kingdom
UN	United Nations
UNDP	United Nations Development Programme
US	United States
WEF	World Economic Forum
4IR	4 th Industrial Revolution

Chapter One: Introduction

1.1 A world in motion

The relentless motion of human creativity and innovation has led to an overall improvement in the quality of life on the planet. The improvements brought about through advanced technology have quickly allowed the global population to exceed 8 billion. The rapid expansion of the global population places an overwhelming extra burden on numerous sectors across the world. This challenge has led nations to seek alternative methods to meet the increased consumption and resource demands that are associated with a rising population. Nations are becoming increasingly reliant on technology and machines to produce the sufficient outputs required to support the rising population base. This act of mechanization, coupled with the cultural, social, and economic trends of the modern day, has triggered a large wave of individuals who have sought better opportunities and has resulted in a surge of rural-urban migration (Srivatsa, 2015).

This migration trend consequently pushes urban areas to their limits in terms of spatial capacity, provisions, and services (Arroub & Zahi, 2016). These pressing issues encountered in urban areas have compelled governments to invest in finding optimal solutions. This consequently has led the spatial development planning systems of urban hubs to focus more on sustainability, efficiency, renewable energy, green space, and improved education for its citizens (Ferro, 2021). These focused investments into the urban context aim to utilize the maximum existing resources and extend the long-term viability of major cities. These improvements are made possible by the advancements in technology, where precise digital machinery enables effective monitoring and improvements from data collected across various aspects of the urban environment. This advancement in technology is the driving force for the digital revolution, the 4th Industrial Revolution (4IR).

Modern cities are increasingly depending on 4IR adaptive learning technologies to deal with the challenges that are associated with population growth and climate change (Woetzel, et al., 2018). This scenario has caused cities to undergo a transition towards more data-driven structures that incorporate advanced technologies to monitor and facilitate daily city functions. The integration of adaptive learning technologies, that utilize pattern recognition algorithms through machine learning to improve efficiency, is commonly referred to as “smart” technology. The word “smart” is an acronym for “Self-Monitoring, Analysis, and Reporting Technology,” which predominantly utilizes Artificial Intelligence (AI) to interpret and optimize data (Netlingo, 2022). This integration of smart technology into urban space has given rise to the popular term Smart City (SC) (Oztemel & Gursev, 2020).

SCs offer great potential for nations to address modern challenges, however, global progress is uneven, and some countries are better equipped to support urban upgrades and transformative change than others. Developing countries face unique spatial, economic, social, and political challenges in their approach to incorporating 4IR technology and SCs into their systems (Madangombe, 2019). This leaves Least Developed Countries (LDCs) vulnerable to being left behind on the global stage, as they cannot match the pace of the rapidly advancing world (Sello, 2019).

If conducted correctly, 4IR technology has the potential to be highly impactful. The world is in constant motion, and many nations have already begun benefiting from the use of smart 4IR technologies. To adapt to this change, planners and planning systems of countries would also need to evolve at the same pace. As an already struggling developing country, the integration of 4IR technologies and SC principles may be the solution to the challenges the country faces, or is it merely a “misplaced priority” (Balkaran, 2019)? Odendaal (2023) also concludes that SCs in Africa often lack a correctly engaging system for urban issues, which generates homogenous visions that fail to adhere to the important context of the nation implemented, and therefore are unable to address challenges correctly.

This chapter will provide the background rationale for the research, explore the challenges present, state the research questions, outline the scope and limitations of the study, state the research objectives, and lastly give a summary of the thesis structure.

1.2 Looking back in the future

The 4IR is characterized by the fusion of technologies that, “blur the boundaries between the physical, digital, and biological realms,” (Schwab, 2016). Within this revolution emerges the SC concept has been identified to be a highly impactful resource available to combat the world's challenges and meet future global goals (PwC, 2020). From the planning perspective, SC is viewed as an urban environment that utilizes digital technologies to enhance social inclusivity, efficiency, and environmental sustainability (Wade & Pfäffli, 2016).

In the present day, we currently reside in what has been dubbed “The Century of the City,” according to the World Urban Form 6 conference held by the United Nations (UN) (UN, 2010). This statement categorizes the current era to revolve around urban development and the pivotal role that cities will have in the quality of life. Projections indicate that the world is on track to reach a population of just under ten billion by the year 2050 and over eleven billion by the year 2100 (UN, 2017). Predictions also indicate that by the end of the century, 70% of the population will reside in urban environments, which further emphasizes the significant role that cities will have in addressing the challenges associated with population increases (UN, 2018). The challenge of providing sustenance and shelter for the increase in numbers will be most felt in major urban areas, due to the higher densities operate

present. This situation is unbiased, and both developing and developed nations are at risk of declines in the standard of living if nothing is done.

As the world embraces the digital revolution, the country of South Africa (SA) has recognized the need and urgency to participate in this global transformation.

“We have not built a new city in 25 years of democracy. I dream of a SA where the first entirely new city built in the democratic era rises, with skyscrapers, schools, universities, hospitals, and factories... Has the time not arrived to build a new Smart City founded on the technologies of the 4th Industrial Revolution?” (President C Ramaphosa, 2019, SONA)

An ambitious challenge that indicates to not only the country but to the rest of the world, that South Africa has the intention to participate in the 4th industrial revolution (4IR) and smart city (SC) movement. The future that was described by the president will require people in charge to be sufficiently equipped to effectively oversee operations. This places the planning profession of the country and its planners, in a critical position to map out this future. The announcement above has gathered both scrutiny and praise, with many people dismissing the idea as a mere “pipedream” and questioning the feasibility while we still have power outages (Anon, 2020). One reporter summarized the entire issue,” it is not that South Africans don’t support the president’s idea of a smart city of technological advancement in general; it’s simply that they’re wary of promises of a futuristic hi-tech utopia when we have bigger problems at home,” (Kathrada, 2019). This statement expresses the concerns that most of the country has with prioritizing futuristic ideals, as the country is still a developing nation and is still pressed by basic provision shortages (Erasmus, 2022).

SA is a developing country and forms part of the BRICS (Brazil, Russia, India, China, and South Africa) nations, due to it being identified as an emerging market with significant impact potential on global landscapes. SA is characterized as a 3rd world country with areas of 1st world infrastructure; However, the planning systems and government structure are characterized by a lack of clear strategic development goals and have an ongoing planning process that seldom sees the dawn of completion and implementation. This situation leads the country to struggle with expectations placed on it as the outcomes from varying time frames, inward-focused plans, plans that are not monitored correctly, plans that do not have any traction, and plans that seldom add value to the intergovernmental landscape of South Africa have caused the nation to be left behind (Lodi, 2006) (Creamer, 2018).

The decision to therefore embrace the revolution, coupled with the evident cracks of the country being a 3rd world developing nation, forms the backdrop to this research. Consequently, the identified research problem lies within the challenges associated with a struggling country that is confronted

with the developmental complexities associated with 4IR technology and SC integration. The next section will explore these challenges to elaborate on the research problem identified.

1.3 Exploring the Challenges

The SA government tends to create poetic documents that intend to create a prosperous position for the country however, they overlook the realistic capacity of what the country can provide (Ferro, 2021). This can be seen most evidently within the spatial documents of the country where “Spatial frameworks have been too broad and too utopian and have been contradicted by both national policy and trends in the property and housing markets,” (Todes, 2008). This trend of being overly ambitious with the resources available contributes to the worry identified previously where people question government intent on 4IR participation. The current state of the country can account for this mistrust of government promises. The country struggles with providing the basics and adding further expenditure into a revolution that has its challenges associated with it, is the main question being raised (Asmal, et al., 2019).

The challenge of implementation plagues SA as documents hardly ever meet their five-year intended deadlines and, in some cases, “are entirely replaced,” by additional documents to amend the previous documents comings (Creamer, 2018). The SA pattern of creating overly ambitious, well-worded, and sounding 1st world-level plans, is why even documents such as the National Development Plan for 2030 (NDP), fall short of their mid-term goals (Sibanyoni, 2021). The time frames set were not realistic, and this ambitious document became a part of the struggling narrative of SA planning. This issue perpetuates across all levels of planning as this problem occurs from the national, all the way to the municipal level. “Some municipalities are moving beyond these criticisms, towards better plans, more closely linked to both infrastructure and land use management, but in many cases, spatial plans remain concept-driven, and the older criticisms remain” (Todes, 2008). This is a clear sign that the Public Policy Implementation Program (PPI) within SA is nonfunctional. The PPI’s failures are accredited to the lack of knowledge, experience, skills, and expertise within the public sector, as well as the non-compliance to public policy by officials (Mahlako, 2016). These issues spill over into the many levels within the planning environment, which leads to a never-ending cycle of writing new documents to solve created problems that couldn’t be addressed by a previous failed document. This is most evident on the national and provincial levels, as their intended roles have fallen short in sustainability, implementation of government policies, and legislation (Lodi, 2006).

SA,” has all the legislative and constitutive provisions in place, but we are not seeing a truly bottom-up development” (Buccus, 2016). The challenge of undertaking SCs not only reinforces the statement that government documents are more utopian than practical but also further neglects the rural regions. Presently the urban regions of the country are underperforming as, “Although much progress was made on the policy level, not enough was done in practice to improve the developmental performance

of the urban regions,” (Coetzee, 2010). The situation before the inclusion of complicated 4IR technology and SC developments already has the country struggling in many sectors, specifically in the rural regions. The move towards the integration of smart technology would only benefit the urban environment and disregard the rural. The country being financially constrained post-COVID-19 adds to present challenges as “Public debt is now at almost 80 percent of GDP and under the current trajectory debt levels will not stabilize before 2026.” (Fengler, 2021). The digital revolution is not cheap and the financial debt that needs to be incurred in the preliminary stages will only be able to be paid back in the long term (Wray, 2018). For SA to justify large amounts of revenue to be diverted away from addressing basic service needs, will be a challenge, as currently the country suffers from an electrical supply shortage and a rising population of people living in poverty (Gumede, 2022).

The challenges present all revolve around a common theme where the base requirements needed to incorporate advanced technology, are not present and is a current struggle within the country. SA’s shortcomings extend far beyond its planning profession and the current state of the country firmly labels it a developing nation (Ferro, 2021). The country therefore consists of the typical attributes associated with a developing nation. The countries encountered difficulties with crumbling infrastructure, a widening inequality gap, and a poor service delivery sector (Kovachek, 2019), which are therefore not a surprise. The great threat to the current trajectory of the country would be to be labeled as a high-risk nation for investment. This would further weaken the economic strength of the country and lead to slower development (Peyper, 2021). The country is heavily reliant on foreign investments and export/import of goods, as the country is not self-sustainable. For example, a report stated that it is estimated that 90% of food ingredients must be imported, a statement that exposes the poorly developed secondary sector of the country (GAIN, 2023). This factor further increases the challenge of incorporating future 4IR technology and building smart cities when the country lacks the sectors or experience required to produce the materials needed. This fact simply means that the extra cost of importing materials will need to be factored in by the government.

The above-mentioned set the pretext for the research problem as the country’s intent to participate is marked by many challenges that would need to be addressed by the individuals/companies who are charged with narrating this change. The role of the planning profession is therefore critical in assisting in this transition and ensuring the maximum potential is procured from investing in 4IR technology and developing SCs.

1.4 The direction we are heading

This section intends to establish the directional road map of this research paper by elaborating on, the aim and objectives, scope, limitations, and objectives of the study.

1.4.1 Aim and Objectives

The following Objectives, seek to provide the necessary information that will assist in creating a surrounding structure of information, that is to effectively aid in answering the main research question - What is the potential of applying 4th industrial technology and smart city principles for South African planning and management?

1. To determine what is the relationship between the 4IR and SC movements.
2. To see if the country has sufficient plans in place for the 4IR and SC movement in its spatial development documents.
3. To know that planners within the country have sufficient awareness of the 4IR and SC movement to implement this in practice.

The following objectives are to ensure that the research follows and constructive roadmap which has the end goal of providing a structured course to answering all required questions. Achieving the answer to each will ensure a sufficient understanding of each section and this will establish and increase the overall accuracy of the conclusions found from this document.

Objective 1 will focus on defining the 4IR and smart city movements, the challenges associated with both, and understanding what both movements comprise. **Objective 2** will be to establish an understanding of the present spatial context of SA and what is its current stance both with the 4IR and SCs, as well as seeking to provide an in-depth analysis of SA spatial policies that govern the planning profession and the policies that guide planners within the metropolitan areas of Tshwane and Johannesburg. **Objective 3** focuses on establishing what the current understanding of planners within the chosen study areas is concerning the 4IR and SCs.

These objectives will form the direction of this research paper as each objective is strategically chosen to accurately provide the best possible information, to effectively be able to answer the research questions.

1.4.2 Scope of the study

The study will be focused on SA and its planning profession. More specifically the relevant documentation and planners present from the major metropolitan cities of Johannesburg, and Tshwane. The research was conducted through semi-structured interviews, readings of the present policies that affect the selected areas, and previous relevant studies that have been done on the topic, that are intended to guide towards what aspects need to be investigated to establish what the potential in the country is. The use of primary data through semi-structured interviews will provide qualitative data on the opportunities, challenges, and potential benefits associated with the incorporation of these

technologies and principles within SA planning. The use of secondary data through official policy documents is crucial to understanding the present functionality of the SA planning environment and the governing tools that dictate the planning direction.

1.5 Summary of Thesis Structure

Chapter Two Will contain the literature review. The review will cover the present research done on the areas concerning the 4IR, the SC movement, The present status of SA in terms of what has currently been research with regards to 4IR and SC integration, and lastly ended by an elaboration of what gap exists within the literature and what the paper intends to amend.

Chapter Three of the study will discuss the research mythology and research design which will guide the rest of the paper.

Chapter Four will cover the South African context and the two chosen study areas of Johannesburg and Tshwane metropolitan areas.

Chapter Five will explore the findings of the research conducted. This will combine and show the information gained from the interviews and policy documents. The information will be covered by the common themes discovered across all the various data inputs.

Chapter Six is the final chapter which covers the conclusion of the study. This will include the main findings and implications for planning practice.

This concludes the introduction chapter of this research paper. The next chapter to follow is the literature review component which seeks to elaborate the research gap through the established knowledge bases.

Chapter Two: Literature Review

2.1 Introduction

In recent decades, the world has seen the rapid emergence of 4IR digital technologies, physical systems, and biological advancements. This new era brought about by these transformations has ushered in a new wave of innovation and distribution opportunities, that are fundamentally reshaping industries, societies, and economics across the globe. Simultaneously, SCs have been undergoing major traction and profound evolution, driven by 4IR advancements in digital synchronization, versatile sensors, and AI integration within the city environment. The marriage between digital electronics and the city offers major potential for nations that see alternative options to address their present challenges. The combined opportunity and potential of the 4IR and SC movement for SA is unprecedented for its planning landscape and despite the possible obstacles that are associated with partaking, the country has indicated its intentions to participate, but it is unclear to what capacity.

The purpose of the literature review is to critically analyze the opportunities and challenges presented by 4IR technology and SC principles and how prepared SA and its planning domain are to undertake it. This will be done by exploring existing research, theoretical frameworks, and practical field applications. Through this, the aim is to shed light on the transformative power of these technologies, their potential, and how they could reshape planning practices across multiple sectors.

The literature review chapter will address issues related to 4IR, smart cities, the South African context, and the state of its planning profession. These areas are discussed to establish what has currently been researched to be able to effectively answer the research question. The sections that cover the 4IR and SC movement will focus on defining each, the components affected by each concept, placing each of them in the present-day context, the opportunities provided by each, and the barriers/risks present from each. This information will enable a detailed understanding of each concept to be reached, which will capture what a nation requires to implement each effectively. The next sections covered SA's present position and the current state of its planning profession. Establishing the present state and challenges facing the country will allow for a grounded backdrop of the country's present ability to adapt to change. This insight is important as when combined with the level of the awareness of planners and the state of the planning profession structure in SA, an idea of the country's ability will be understood.

The literature review sets out to explore the transformative potential of 4IR technology and SC principles for SA planning. By examining existing research, the review seeks to provide relevant insights into the challenges and benefits of 4IR and SC technologies and how they can contribute to a more prosperous and equitable future for any nation that partakes in their integration.

The chapter commences with a discussion of the 4IR. The goal is to define and understand what it is, where it is being used, what are the barriers to implementing it and establishing the risks involved when working on a large scale.

2.2 The Fourth Industrial Revolution

This interconnected nature of this topic means it has many avenues and relations across a wide array of sectors. For this research, only the aspects that are associated with the focus of the study will be covered. The focus will be on technologies and concepts that will have a potential impact and viability within the South African planning profession. The key issues that are covered have been used to narrow down and concisely target specific key areas of information. The insight gained has the intention to provide the necessary information required to understand the main impact points of the 4IR, which in turn assists in the focus of determining potential.

2.2.1 Key issues

There are different interpretations of the 4IR. In 2015 when notable authors, “Nicholas Davis and Klaus Schwab started talking about the increasing frenzy around technological disruption.” (Desk, 2019) This conversation led to a book being published and it forms the basis for this review of this section as it is constantly referenced by authors. This book, titled “The Fourth Industrial Revolution,” covers extensively “the beginning of a revolution that is fundamentally changing the way we live” (Schwab, 2016). This book contains a definition of the 4IR which is reiterated by McGinnis and gives insight into what key issues are associated with the 4IR. The 4IR is the “blurring of boundaries between the physical, digital, and biological worlds,” and how “the collective force behind many products and services is fast becoming indispensable to modern life.” (Schwab, 2016) (McGinnis, 2020). The dependency on technology leads the population to become more reliant on technology and creates a demand for these devices. This demand creates competition between suppliers who compete to sell their products to consumers. This creates an environment in which having the most up-to-date technology and production chains leads to increased margins for profits (Nyagadz, 2022). These key issues exhibit that the level of technology that a nation can manage to install, has a large impact on the society it influences due to the increasing dependency on digital electronics.

The next relevant key issues are the areas associated with the planning profession, and the effect of rapid technology development and increased digital dependency on it. The need for sustainable development is the most repetitive topic that is brought up, as the aging population puts a lot of strain on resources and requires innovation leaps to cope with the demands. The increased use of technology is therefore welcomed, however, the issues mentioned are brought about by advancing technologies, and the solution is rooted in using other technologies, creating a never-ending

“feedback loop,” where equilibrium is never met (Fischer, 2020). This key issue is therefore summarized as adopting new technologies to solve problems, which will equally come with challenges that are brought about due to its implementation.

The rise of the digital economy and a society where technology influences space, people, and daily functions is the key issue that follows from the previous. These issues specifically focus on the social impacts, as authors agree that the impact 4IR technology will have, will be felt hardest by the citizens it affects (Malomane, et al., 2022) (Perrin, 2021). The issues associated with this section all commonly stem from fairness and access to technology. This ties into the initial issue that digital dependency creates competition, except authors constantly refer to the “divided society” risks and the challenges of those who are “left out,” (Marsh, 2019) (Richards, 2022). Access to technology is a key issue that causes major concern from the literature since there is already an uneven society present across the world. The unequal distribution of resources and varying developmental states of countries is one of the major defining factors agreed upon, that determine a country's chance of success with 4IR adoption (Nath, 2018). These key issues therefore are associated with the social impacts caused by rapid technology adoption and the challenges that uneven access presents.

The issue of this rapid change is touched on by Schwab, who states that “changes are so profound that, from the perspective of human history, there has never been a time of greater promise or potential peril” (Schwab, 2016). This idea of the potential perils associated with the 4IR is never far from mentioned in the literature, as the transition is depicted above as being fraught with risk (Jendamark, 2022). The key issue that complicates the 4IR is the rapid rate at which it is occurring. New technologies are continuously being outdated by the next and the threat of being left behind on the global stage is highly prevalent (Marsh, 2019). This situation creates the necessity for nations to adapt rapidly but also to encounter the risks head-on, with the dangers of mismanaging them being highly detrimental. These risks underpin the common goals of 4IR adoption, of efficiency and further bettering the quality of life of people.

The key issues mentioned are the main areas that are relevant to the study and this section. These areas narrowed down the search for material and allowed irrelevant information to be excluded. The next part to be examined is the current state of 4IR technology and its global position. This establishes the worldview and is the first step in mapping the potential 4IR technology can have in the spaces it is applied to.

2.2.2 The correlation between 4IR Technology and Global Goals

“The technologies of the 4th Industrial Revolution (e.g., Artificial Intelligence, Blockchain, and the Internet of Things, among others) are rapidly becoming mainstreamed, enabling the transformation

of entire systems and networks,” (PwC, 2020). This in turn creates better access to advanced technologies for nations as these supplies are becoming more frequently used and demanded. These technologies have seen a positive change within companies, industries, and society. However, a report by PricewaterhouseCoopers states that “For all the potential that these technologies offer, they could also put greater stress on the Earth, its resources, and on our society” (PwC, 2020). Confirming that the technology does contain “potential peril,” as Schwab warned in his book (Schwab, 2016). A report compiled by the World Economic Forum (WEF) titled “The Global Risks Report 2022,” mentions the greatest threats to the globe. These threats include “societal and environmental risks” as the most concerning. “Extreme weather”, and “biodiversity loss,” in the five-year short run, while in the 10-year long run, “debt crises” and “gloeconomic confrontation.” “Technological risks such as “digital inequality” and “cybersecurity failure”—are other critical short- and medium-term threats” (McLennan, et al., 2022).

The margins set for 2030 are not on track despite the progress made with sustainable development goals (SDGs) that were set in 2015 (Menon, 2019). These progressing goals were shown by the United Nations Development Programme (UNDP), where countries with a lower human development index (HDI), are catching up in basic capabilities. Primary education was up by 5,3% and cellular phone subscriptions by 49.3%, between the years of 2007 and 2017. However, the inverse was true for low HDI countries, for the “most defining areas for an inclusive Fourth Industrial Revolution,” tertiary education and broadband access were both a 1,1% change, while in high HDI states there was a 7.1% and 28.3% increase (PwC, 2020) (Woetzel, et al., 2018).

The SDGs form the backdrop to the world’s Global Goals and try to address the most pressing challenges. This is the context where 4IR technology has been utilized to affect the state of play in the world. “We have found that Fourth Industrial Revolution technologies could have a “high” impact across more than half of the Goals” (PwC, 2020), was a statement from the WEF that showed the positive impact 4IR technology has on global goal progression. The research found a positive correlation between the countries’ ability to innovate new technology and global goal progression. This is illustrated in a table (Figure 1) which compares a nation’s innovation score against its progress (%) in SDGs.

The chart shows that the higher the innovation score of a country, the greater the progress toward SDGs. This comparison shows the impact technology can have as progress on SDGs is accelerated using more sophisticated technology. This graph also shows the countries that are falling behind in their SDGs, which is an indication that the innovation and implementation of newer technology are slower. The limited progress of 4IR technologies being utilized is down to a few notable barriers in these countries.” Most notably governance and policy, funding and resources for R&D and deployment, insufficient collaboration, as well as the maturity of data, technology, and infrastructure”

(PwC, 2020). This data points to the positive impact 4IR technology can have on a country and through innovation, a nation can prosper towards the future the UN mapped out with the 2030 agenda for sustainable development (UN, 2022). This graph also illustrates the importance and impact good policy by government can have, as nations of relatively equal or worse innovation score e.g., Argentina vs South Africa, can still progress with SDG goals. Innovation is a tool that is proven to show that if utilized, good SDG progress is possible, however, Chile, for example, has nearly an equal SDG progress as the highest-ranked innovation scorer of Switzerland. This reiterates the importance of management and policy by a national government.

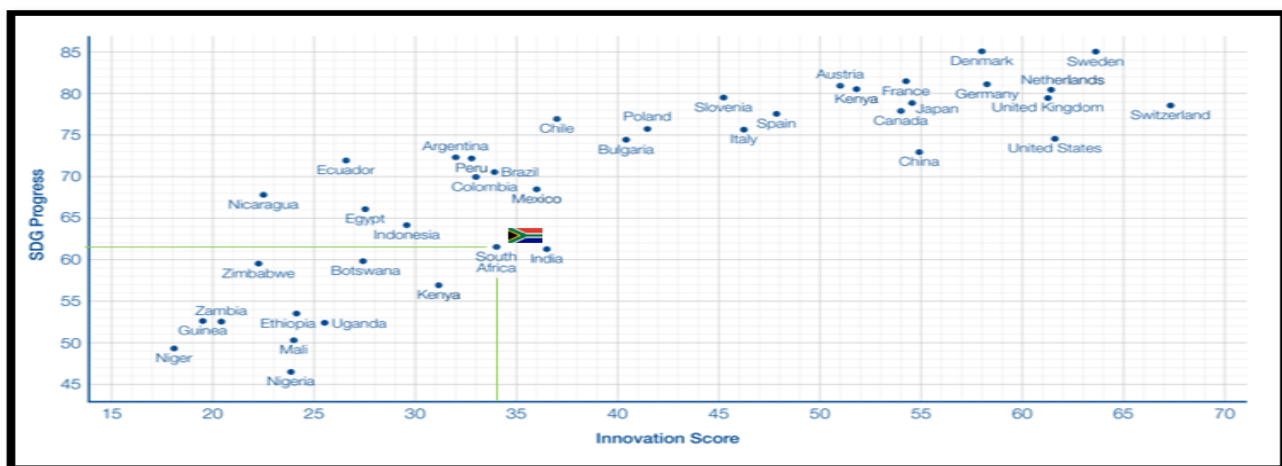


Figure 1: Innovation score capacity vs. Global Goal progress, shown by country
Source: Sustainable Development Report, 2019.

4IR technology has a high impact on ten out of the seventeen SDGs (PwC, 2020). The global goals that have the highest number of 4IR applications are the goals of good health and well-being, affordable and clean energy, industry, innovation, infrastructure, and sustainable cities and communities. These SDGs are all influenced by the emerging technology of 4IR and will continue to do so as industry 5.0 is making its way through the industry (Perrin, 2021). The potential of 4IR technology has been proven to benefit a country through the measure of SDG progress and innovation scores between high and low HDI countries. The next step is to establish what technologies, systems, and functions the 4IR consists of that enable these benefits in the first place. This information will be beneficial to the context of this study as measuring potential will first require an understanding of what is added that enables these benefits within a system.

2.2.3 Changes enabled by 4IR

The literature with regards to 4IR utilization indicated that the present-day implementation of 4IR technology varies between maturity levels, “from country to country, and even within borders” (PwC, 2020). This deviation in maturity and technology solutions is important to note as it indicates that solutions are unique and “the 4IR is not a one-size-fits-all solution” (Jendamark, 2022). The deviation

occurs for several reasons, these reasons include “different levels of investment in R&D and research infrastructure across countries, digital-infrastructure readiness, the commerciality of the solution concerned, government incentives, and the maturity of the underlying core technologies” (PwC, 2020). This fact leads unsurprisingly to countries that have higher levels of wealth and innovation to use higher maturity technology compared to those with lower scores. This fact is made clearer when 80% of innovations require internet access and 90% require electricity (PwC, 2020). Factors that not all countries can provide evenly across their nation (McLennan, et al., 2022).

In the background, 4IR technology will therefore differ in complexity, method, and solution to progress global goals but the outcomes that are enabled by it are still constant (McLennan, et al., 2022). The outcomes and changes enabled by the 4IR are available in any country, however, the potential of each differs due to the reasons mentioned above. The advantages and disadvantages of each will come down to the context of the country (Nath, 2018). The enabled outcomes by the 4IR are as follows:

A. New Discoveries and the inclusion of new materials

The technology in use from 4IR is increasing the use of Artificial Intelligence (AI) systems. This unsupervised learning technique, combined with the autonomous nature of newer technologies, leads to more transformation in existing systems (Vyas, 2019) (Perrin, 2021). This happens because the nature of AI technologies speeds up the processes of discoveries and machines can process more data than intelligent humans ever could. This rate of discoveries could enable better solutions to be found and provide further progress toward global goals (PwC, 2020). These new solutions can provide cleaner fuel solutions, more sustainable methods, and breakthroughs in water use and management. The use of AI algorithms (e.g., Alpha zero) to fast-track solutions is one of the areas in that 4IR technology that will enable changes to the present systems (Vyas, 2019).

The most well-known example of discoveries is the agricultural sector and its synthetic proteins. Alternative organic sources do not exist naturally in the world and are created artificially by humans. These advancements alone include, “advanced biofuels, renewable chemicals, and synthetic meat” (PwC, 2020). These processes of selective interbreeding and cell manipulation have been around since the 1800s however, the processes have become more accurate and reliable through the use of machine learning from 4IR technology (J.F.Burton, 2019). These advancements already show promising potential for other systems within a nation since the agricultural sector has been able to improve its yields to cope with human demand due to the 4IR intervention. This puts AI systems as a core piece of the 4IR and its implementation is fixed to many if not all 4IR technologies (Schwab, 2016).

B. New and better access to financial models

4IR technology pioneers quantum computing and cloud storage, that it enables industries to operate more effectively on an analytical and data basis (Clothier, 2022). AI can facilitate complex data models and provide crucial information to businesses on patterns within the market. 4IR technology allows for a stronger market to be created as financial predictions can be automated, risks can be evaluated more accurately, digital transactions become easier, and the overall user experience is more accommodating in terms of being easier to use (Clothier, 2022). 4IR technologies are also enabling investments that “democratize,” “by enabling crowdsourcing and new investors in projects that address environmental and development challenges – from retail level investment in green infrastructure projects through to charitable donations for developing countries,” (PwC, 2020). In short, people who want to invest are connected to people who want access. An example of this is the Sun Exchanged blockchain platform that connects investors to people who want solar in sub-Saharan Africa (Cambridge, 2022). These programs indicate the place 4IR technology has and the impact it can have on a system on a digital scale.

Technology gives companies the ability to be inclusive and from a social standpoint is a rolling theme of the 4IR. Banking apps are one of the many technologies that when integrated with 4IR AI software, become a useful tool for accurate profiling and credit score tracking. This has the potential to also solve problems related to the financial exclusion of individuals as well as less traditional tracking methods such as mobile phone activity and virtual interviews. These measures create a personalized credit score for individuals and allow them to partake in the market where these scores are needed (Clothier, 2022) (PwC, 2020). This research also indicated that 4IR technology generates and requires a mass amount of data. Technology is more accurate and efficient when it has a large quantity of data at its disposal. A requirement that underpins the 4IR (Schwab, 2016).

C. Progression through decentralization

The decentralization of systems to distribute resources and authority provides a platform for progressing toward global goals (PwC, 2020). This is made possible by the 4IR AI combined with sensors to make smart monitors which allow for entire systems to be maintained digitally and unsupervised (Apata, et al., 2021). The environmental and social benefits of facilitating more decentralized systems will require a systematic shift. This shift will be in the form of a less physical exchange between systems but instead a digital one. The areas which benefit from decentralization in terms of 4IR intervention include,” physical resources such as energy and water, financial resources, and data (e.g., health information)” (PwC, 2020). Another advantage is that it enables peer-to-peer sharing, which benefits trading and resource distribution chains (Karjalainen, 2021).

Central utility systems struggle to match the demand that is required from them and suffer from “single points” failure, leaks, and losses from distribution. This is the same for energy as a central system lacks a diverse amount of energy sources and suffers from high losses due to the system not being resilient to failures and large-scale maintenance (PwC, 2020). The combination of AI and new technologies could set the world on a mass transition to decentralized systems. Platforms can collaborate through data transfers and resource sharing. This system, which can be combined with adaptive sensors that monitor nearly all sectors in an area, can produce a highly efficient system that is dynamic, cost-effective, and resilient (Ferro, 2021). These systems can extend as far as being more socially inclusive, prone to less failure, and decreased mismanagement. 4IR technology can provide systems with effective monitoring systems and could revolutionize the utility network of a country. This does come with its own set of challenges, but the benefits are outweighed by the challenges that will be encountered (Schwab, 2016).

D. Accountability through traceability

The modern world is becoming self-aware of the impact it has on the environment and the need to become more sustainable in our living is on the rise. This has led to many regulations which address, “environmental and social risks and/ or impact, including corruption, human rights violations, modern slavery, gender-based violence, water security, GHG emissions, and nature loss” (PwC, 2020). These regulations do exist in some sort of capacity in nearly all countries however the impact they have is not equal as enforcing, monitoring, and punishing offenders is difficult (Apata, et al., 2021). 4IR technology enables transparency through real-time monitoring with drones, satellites, and sensors. The access to data creates an environment where production chains, businesses, and entire cities can assess their environmental and social impacts (Njontini, 2021). Such accountability and tracking will in the long run discourage shortcuts when it comes to regulations. The theme of the 4IR is its ability to track real-time events and send the data to a central system for evaluation. The results can be interpreted, and changes can be made unsupervised. These systems will soon be essential for a country to operate effectively without incurring fines due to infringements of regulations that are becoming stricter each passing year (Marwala, 2020).

E. Improved production chains

The last change that the 4IR will enable is to improve upon the “ability to optimize systems through automating, assisting, augmenting and ultimately creating autonomous systems to execute decision making without human intervention” (PwC, 2020). Production can be optimized as resource distribution, wait times and procession can all be improved with 4IR technology. Using software to boost productivity creates the potential for cost reductions in a supply chain, which in turn can lower the cost of the final product sold. Limiting the loss within a system through AI integration builds a

strong case for the sustainable long-term benefits of the 4IR (Perrin, 2021). The latest example of the integration of 4IR technology into the production chain is the increased use of Autonomous vehicles (AVs). This form of movement in urban space can optimize transport networks and can be set to prioritize eco-driving to reduce the number of resources used on routes (Nath, 2018). These AVs are also implemented in shorter delivery rolls and turn reduce the amount of time it takes to distribute resources within a working environment.

The above information discovered that the potential the 4IR has is limited only to the resources that it has at its disposal. The more data that is accessible by the system is the differentiating factor that determines the effectiveness of the installed sensors, machines, and software. The wider the network and reach, the greater the impact 4IR interventions are enabled to have on an area. This fact about the 4IR shows that its potential is linked to the willingness of a system to accept its technology and sensors (PwC, 2020) (Schwab, 2016).

2.2.3.1 The potential for planning and city management

The potential for planners and city management that are enabled by the above mentioned, offer alternative solutions that ultimately benefit the profession. AI systems enable unsupervised learning techniques and speed up discovery processes, through processing large amounts of data. The benefits to planning and city management in the long term include finding better sustainable methods, such as cleaner fuel sources and breakthroughs in water and waste management (Buonocore, 2022). The inclusion of AI's processing large amounts of data extends to processing the information sent by sensors within an urban environment. The use of AI and sensors allows for the creation of a decentralized system, which has the potential to enable better monitoring, resource distribution, and management. The planning profession can implement these 4IR innovations to revolutionize the utility network, enhance efficiency, and create more dynamic systems within cities (Nyagadz, 2022).

The integration of 4IR technologies in conjunction with AI automation provides higher optimizations for resource distribution and reduced wait times, especially within supply chains of production. The planning profession can leverage these advancements to enhance the sustainability and efficiency of distribution and production processes within cities. The benefits associated with real-time monitoring contribute to supply chain optimizations but inherently also enable greater transparency and accountability, using the various sensors, drones, and even satellites, across a cityscape (Buonocore, 2022). The use of all these advancements in sensors by planners allows for a tighter enhancement of the social, environmental, and governance structures. Planners will be able to monitor urban environments and make them adhere to stricter regulations to comply with, which serves the purpose of meeting targeted long-term goals (Oztemel & Gursev, 2020).

These tools available for planners and city management, enabled by 4IR technology, highlight the value and potential impact of their widespread utilization. These tools include faster discoveries in a decentralized system, optimized production chains, and enhanced accountability within social and environmental aspects. Widespread implementation of 4IR technology has the potential to open new doors for planners, however, cities are not linear,” they are open, complex, bottom-up and are often chaotic,” (Portugali, 2013). Every action of change will have its drawbacks, and these are essential for a planner to consider.

This leads to the next area of the 4IR, and this is its drawbacks and potential problems that are associated with its widespread implementation. Understanding the flaws of the 4IR will assist the research in determining its potential when applied to a context, as the challenges found in this section can be compared to the ability of the country’s context in that specific area.

2.2.4 Barriers to Widespread Implementation and the risks of getting it wrong

The full potential that 4IR technology brings to a country can only be achieved if the barriers and risks that come with it are acknowledged and planned for. An Analysis conducted by PwC of over 300 emerging and existing 4IR devices uncovered various barriers and risks. These obstacles, once overcome, would unlock the promised potential of the 4IR (PwC, 2020). The barriers are associated with the implementation of technology and policy difficulties, while the risks involved are what happens when these innovations are implemented on a large scale. The 4IR has many sectors that it can influence and change, which for this reason is why the complexity of the challenges and risks involved are difficult to address individually. The entire network of a country is affected, and the social landscape of a nation can influence the outcome of 4IR-related projects (Malomane, et al., 2022)

The findings from the readings indicate that four major areas create barriers that prevent countries from maximizing the potential of 4IR technology. These areas involved are as follows: the **people**, the **processes** involved, the **data**, and the **technology** used (Richards, 2022) (PwC, 2020) (Malomane, et al., 2022) (Zervoudi, 2020).

A) The skill of the people

“Skills has always been a challenge,” (Richards, 2022) as it is difficult to have access to highly skilled labor.” The rapid advances in technology development and adoption,” requires highly skilled and experienced individuals to operate within this environment, however “the current pool of individuals with this expertise is too small and unequal,” to be able to effectively function at a large scale (PwC, 2020). This barrier exists due to several factors that stem from the lack of access to education, poor

funding for advanced re-training programs, and a lack of higher education courses that have an updated curriculum (Zervoudi, 2020).

B) Rigid regulatory processes

“Rapid technological advancements are regularly, and increasingly, outpacing governance and regulation” (PwC, 2020). The largest hindrance to new technology and principal adoption is the government frameworks that dictate a country. Traditional systems struggle to adapt to the complex nature associated with 4IR technology and principles (Zervoudi, 2020). Present systems would require several changes due to the integrated nature of the 4IR. The blurring of lines created by a decentralized digital network causes operational changes in the manufacturing, social, and economic sectors (Malomane, et al., 2022) (Richards, 2022). An example of this can be given on a legal scale, where legal liability is now difficult to establish due to decentralized systems making it difficult to ascertain who is responsible in a blockchain system (PwC, 2020). This barrier exists due to the lack of “the speed of change,” within governments, a lack of clear incentives for businesses to partake, the technology is high risk as it can get outdated quickly and widespread scaling of new technologies creates societal and system challenges that are not yet addressed by governments frameworks, which can create an unregulated environment of integrated technologies (Malomane, et al., 2022) (Zervoudi, 2020) (PwC, 2020).

C) Data access

The quality, quantity, and level of interpretation of data are essential parts of unlocking the potential that 4IR technology offers. Access to data is a global challenge in the present day and this is more prevalent in less developed economies (PwC, 2020). The AI systems that run within smart technology are only as effective as the data that they are given. Obtaining and storing data from many sources and sensors requires a high level of infrastructure to support these complex integrated systems (Smith, 2018). The level of infrastructure and the number of sensors required is not set value as the more data acquired, the more efficient and productive the system can be made (Richards, 2022). Data forms the core of 4IR innovations as improvements can only be made when the data of the issue is identified. Sufficient data being given to 4IR technology gives it the ability to communicate, predict, and solve real-time problems (PwC, 2020).

This barrier is present because of the high costs associated with data storage, collection, and upgrading infrastructure. The systems required would require a large initial investment and would be a barrier for less developed nations more so than developed ones (Zervoudi, 2020). The complexity of the installation of systems would also drive up the cost and require skilled labor to monitor and maintain (Smith, 2018). The last reason is the integration and communication of data between

platforms, are not mainstream, which leads to more independent systems in the initial stages (Zervoudi, 2020). This does not provide the maximum benefits for the system. This factor, along with a little incentive to join the integrated network, creates a barrier for a new country that wants to adopt new systems technologies (Malomane, et al., 2022).

D) Difficult transition to newer technologies

Support for digital upgrades and “other Fourth Industrial Revolution technologies is either underdeveloped or non-existent.” The basis for 4IR technology is centered around internet, cloud, and electricity access. Over 90% of new technology applications require electricity access and more than 80% rely on having an internet connection (PwC, 2020). This presents a challenge to all nations as the output of their energy grid will be put under greater pressure (Malomane, et al., 2022). The added strain on the grid can only be solved in the long term with renewable energy measures that less developed countries may not be equipped to implement. The barrier present is more prevalent for less developed countries since they lack the basic needs of the country. Developed nations can provide the services needed but the difficult nature of implementing technological upgrades remains. Slow government response programs and small incentives delay projects (Zervoudi, 2020) (PwC, 2020) The lack of skilled labor, infrastructure, and data collection also adds to a nation’s difficulties. This barrier exists due to the previous barriers having an integral part in the management of new technologies.

A common theme across the barriers to the 4IR for nations is the high financial costs and the integrated nature of the 4IR, which requires cohesion between policy, people, and technology. Progress in overcoming one barrier is meaningless without attention to the others. Cohesion when overcoming barriers is essential if meaningful progress is wanted.

2.2.5 Risks of large-scale implementation of 4IR technology and principles

The technologies of the 4IR and the principles which are associated with it have risks considering when it is implemented on a large scale. These risks can be categorized into three main groups, which are **environmental**, **security**, and **socioeconomic** (PwC, 2020) (Malomane, et al., 2022)(Zervoudi, 2020). These risks are what a country would need to consider in the long term as there is no progress without danger. The benefits have been established about the 4IR however these risks, if left unaddressed, can lead to the potential of the 4IR not being realized fully (Zervoudi, 2020). The opposite may be true, and a country would run the risk of wasting resources or causing more harm than benefits to itself and its people (Marsh, 2019).

A) Environmental risks

Large-scale mechanization and the implantation of complex technology run the risk of increased urbanization, population growth, food/water insecurity, pollution from electronic waste, and an increase in power consumption (Marsh, 2019). These risks left unattended can cause large-scale biodiversity loss and human harm (Zervoudi, 2020). Nations that cannot adjust to cleaner alternatives for energy, waste disposal, and resource management, will find themselves in a dangerous position in terms of health, security, economic strength, and resource availability (Oláh, et al., 2020).

B) Security risks

Digitization of many services and having personal data all online has the risk of large-scale cyber security risks. Cyber-attacks and hacking create high-level security risks to businesses, individuals, cities, and even resources (PwC, 2020). The more operations that are linked to a digital framework through technology and controlled through AI software, the higher the risk of these services being disrupted (Zervoudi, 2020) (Malomane, et al., 2022). Data leaks create privacy concerns since an entire profile of a person can be sold for advertisement or impersonation (Marsh, 2019). This risk requires the greatest amount of care when considering the long-term impacts of the 4IR. Cyber security and policies which ensure its regulation should be a top priority (Oláh, et al., 2020). Data is the greatest asset to unlocking the potential of the 4IR, but it can also be its downfall if not properly managed and guarded (PwC, 2020).

C) Socioeconomic risks

The social and economic risks that are present when considering the 4IR on a large scale are numerous. The alteration to the social context is largely driven by the mechanization of businesses and factories. “It is estimated that the US will have to invest \$19.9 billion to reskill 77% of its workforce that will be displaced by technology” (PwC, 2020). This automation is reflected in **Figure 2**, where the percentage of risk in an industry sector is reflected over time.

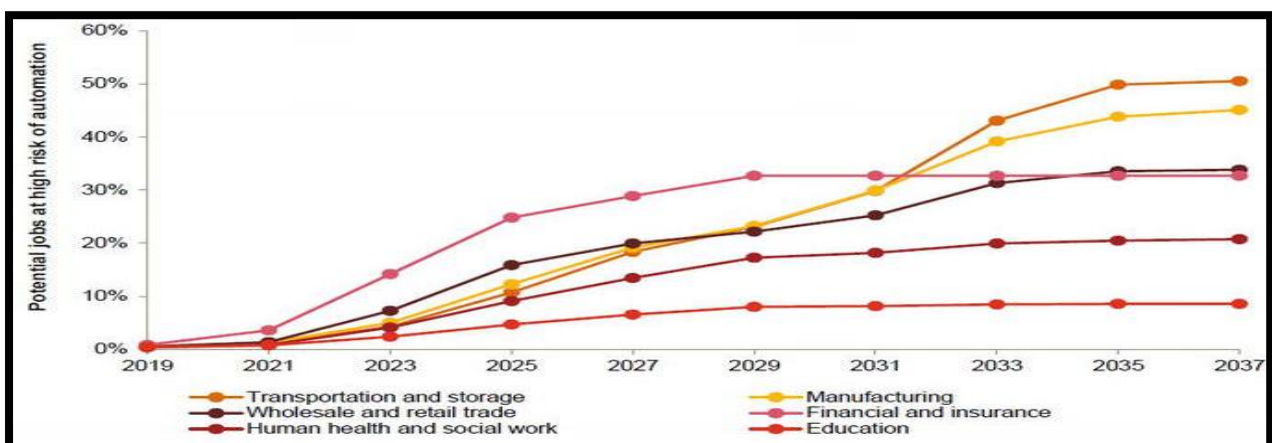


Figure 2: Graph showing the Impact of automation across industry sectors over time
Source: PLAAC data Figure 3, (Zervoudi, 2020).

Figure 2 visually shows how specific industries will be at risk of automation, the most notable being transport, manufacturing, and wholesale trade. This data exhibits the challenge of what to do with the newly unemployed workforce who are being replaced by machinery. The risk of job displacement may not just affect the current workforce but also the upcoming one (Oláh, et al., 2020). The demand for skilled labor will rise as employment will be created through new positions because of 4IR interventions, however, these jobs would require either a reskill or upskill of the present systems (Malomane, et al., 2022) (Mhene, 2019). This issue will accelerate the social risk of widening the inequality gap as, “People whose income, skills, and wealth are already high will be further favored by the significant increase of their assets’ value because of the technological progress,” while lower-skilled workers, “will experience unemployment are the ones who are in competition with robots and can also be replaced by AI software (Zervoudi, 2020). These risks will all contribute to increasing the percentage of people in poverty as lower-class citizens will lack the skills to partake in skilled roles. The socioeconomic risks would require careful monitoring and input by government policy as unregulated scaling of 4IR interventions will lead to more misfortune than benefit (Oláh, et al., 2020).

The general agreement from the literature is that the 4IR will not come without its risks and the risk of getting it wrong can cause long-lasting consequences (Zervoudi, 2020). This section exhibits the risks when scaling to larger forms of implementation and that even if these are done successfully, social impacts may only be felt in the years to come (Mhene, 2019). The areas that will be at the largest risk will be the areas that will be upgraded and changed the most. The increasing rate of urbanization and the prediction that “almost 60% of the world’s population will be concentrated in urban areas,” by 2030 (PwC, 2020) , means that the focal point of change will be in cities.

2.2.6 The impact of risks on the planning profession and cities

The above-mentioned risks affect planning and city management in the following areas the environment, security, and socioeconomic stability. Increased urbanization means that planners would need to accommodate for the excess growth and effectively manage urban sprawl. This growth adds pressure onto food and water security, and urban planning would need strategies for solutions to sustainable food production, water management, and ensuring effective access to the growing population. This increase in population also adds additional strain on waste management for planners, as electronic waste generated by technological advancements must be correctly disposed of and pollution associated with extra citizens must be accounted for. All this additional technology, people, and services will also consume more energy from the power grid. Urban planning would need to focus on energy-efficient infrastructure and promote renewable energy sources, to minimize the environmental impacts accredited to higher power consumption and demands (Khanna, 2021) (Mirembe, 2017).

The security risks associated with digital integration for planners and city management center around cybersecurity and privacy concerns. Urban planners need to consider data protection and secure infrastructure when implementing these digital services and SC technologies. Data leaks and privacy are both at risk within a digitally dependent system (Malik, 2017). Planners and city management would need to consider incorporating policies and regulations to safeguard these areas as the personal data of residents and infrastructure is highly sensitive. Planners also need to consider the ramifications of what plans are in place for when systems face inevitable breakdowns, require maintenance, or go offline for extended periods, as the dependency poses a huge risk when faults occur (Lebeck, 2014).

The socioeconomic risks for planning and cities primarily are focused on the people, with regards to job displacement, reskilling, and equality, both for income and technology access. Urban planners would need to anticipate the impact of automation and develop strategies to reskill or upskill the labor force (Richards, 2022). A planner would need to ensure job opportunities in the new emerging sectors of smart development, as the necessary skills required by the labor force need to be able to operate effectively for projects to be utilized and sustainable. To plan for inclusive growth and equitable access to opportunities, therefore becomes important to not only ensure sufficient skilled labor but also to prevent the exacerbation of income inequality and lower the risks of poverty, due to people not possessing the correct skills.

In summary, these points highlight the risks and considerations that both planners and city authorities need to discuss and address when implementing 4IR technologies and principles within a system. These essential aspects are the relation of the risks mentioned to planning and balancing the challenges and opportunities presented by the revolution will determine how effective implemented measures are. This instillation and implementation extend into the creation of SCs, as planners are pivotal in their development.

The next section of the literature review will examine the Smart City (SC) movement and establish what an SC is, what components make up a successful SC, the benefits and challenges of an SC, and the difference between developing and developed countries' SC.

2.3 The Smart City Movement

2.3.1 The importance of the marriage between the city and technology

“To cope with the increasing population, hyper-urbanization, globalization as well as to ensure economic and environmental stability, cities are now focusing on becoming smart cities” (Patel, 2019). This “marriage” between technology and the city is the direct result of the pressures facing the urban environment. Cities are the drivers of opportunity and human development and therefore are seen as

crucial areas for a country's well-being. The inclusion of advanced technology is simply the next step to further optimizing the city system and further raising the standard of living (Farjood, 2021). This is important as the slow introduction of 'smart' 4IR technology over the years into the city narrative, has led to the widespread use of the term Smart City across the world.

The future estimates indicate that two-thirds of the world will be living in an urban environment by 2050 (Ritchie & Roser, 2018). This indicates how influential cities will be and why investment into optimized 4IR-related systems is on the rise. The modern world has been slowly steering towards a more people-driven mindset where cities are built with the occupant's well-being in mind, rather than the previous mobility-driven mindset, which has dominated since the invention of the automobile. This statement is supported by the latest Human Development Report, which states that "the world is currently progressing through the age of the 'Anthropocene', (Shanmugaratnam, et al., 2022). This is an unofficial term that is used to denote the period of Earth's history where humans have started to have a significant impact and dominance on the planet (Pavid, 2022). This is significant as it reinforces the importance of the people-driven mindset as now this commodity, paired with technology, has both a positive and negative impact on space (Farjood, 2021).

While the adoption of AI technology within the urban environment offers the promise of improved sustainability, efficiency, and quality of life, there are clear concerns regarding its potential negative impacts. In the age of 'The Anthropocene,' the statement that humans have dominance and control over the world, does have merit to an extent, however with the state of climate change we are not perfect (Marsh, 2019). The actions taken to amend challenges with advanced technology are not without their faults, as "every action within nature, has an opposite and equal reaction." -Isaac Newton. The one major critique of 4IR technology adoption is its potential to exacerbate existing social inequalities (Arroub & Zahi, 2016). The introduction of AI-driven technologies can inadvertently perpetuate present biases and discrimination patterns (Marr, 2022), especially in areas of predictive policing, resource allocation, and hiring practices. Additionally, the overreliance on AI thinking technology, may disproportionately benefit more affluent communities and leave the marginalized groups to be even further displaced (Jansen, 2021). This is partly due to the data being provided already inherently being biased.

This issue forms the base of the next critique which revolves around ethical considerations within urban contexts. This vast amount of data being collected and utilized, which is needed for AI algorithms to function, raises many concerns related to data security, surveillance, and privacy. The vulnerability of the personal information of citizens has the potential to be misused or be at risk of unauthorized access, which compromises their rights and autonomy (Dagada, 2021). Moreover, this issue is made more complicated by the lack of transparency of AI systems, which makes it harder to

hold them accountable for their actions due to it being a self-thinking autonomous entity, rather than a person (Jha, 2020). The marriage between city and technology does have its drawbacks, however, the promotion of a new mindset when it comes to alternative methods when tackling challenges has shown to come with its merits.

The change in mindset has created the popularization of the sustainable paradigm within cities and the planning mentality. Optimizing resource usage and raising the efficiency of city functions promotes longevity and stability in the long run for a city (Ritchie & Roser, 2018). An overall increase in output production is the byproduct of creating sustainable and people-driven environments, therefore, this has incentivized this type of development for major cities. A Forbes article found that the social relationship between people and the spatial environment they operate is directly related to the output potential of labor within a city (Preston, 2017). A person who operates in a pleasant environment that promotes their mood and can easily travel to and from work will generate higher levels of output compared to the opposite type of city environment. This relationship understanding means that an optimized and 'smart thinking' city, generates higher outputs with essentially the same amount of human/resource input (Mustafa, et al., 2017).

The concept of a SC has faced criticism despite the potential benefits it offers. Some argue that the increased emphasis on technological and data-driven solutions overlooks the complexity and unique needs of urban communities (Arroub & Zahi, 2016). The literature argues that solely taking the technology-centric approach, neglects the importance of human-centered design, preservation of local cultural identities, and community engagement (Karjalainen, 2021). For planners, this final critique calls for a balanced approach that considers the socio-cultural impacts alongside the technological advancements being made. This is a crucial understanding required to ensure that SCs are both sustainable but also inclusive (Oláh, et al., 2020).

In summary, while the integration of 4IR AI technology in urban environments holds great potential, nations and planners must address the critiques associated with them beforehand. The combination of the influx of people to urban areas, the scarcity of resources due to global challenges, the rise of advanced smart technologies, the change in mindset to people-driven environments, and the popularization of green and sustainable developments, have all led to the increased demand of SC interventions, therefore the critiques associated with them are unavoidable and will need to be accounted for.

2.3.2 Defining a Smart City

There are many different interpretations of how a smart city is defined as it is not clear when a city crosses over to becoming “smart.” It is therefore easier to describe an SC as a city that adopts a smart framework and makes use of smart technologies (Wade & Pfäffli, 2016). There are many definitions for a SC, which indicates just how broad and complex this topic is and how interpretation, even between experts, can lead to discrepancies in definitions. Despite the multiple different definitions, many areas overlap and are widely agreed upon amongst the authors. These areas will be the focus to ensure greater accuracy. An SC can therefore be defined as a framework, that is predominantly composed of self-monitoring, analysis, and reporting technology (smart), and information and communication technologies (ICT), that merge the physical and digital world, to develop, promote, and sustain practices that address the growing challenges associated with rapid urbanization (Editorial, 2021) (Facilitator, 2021) (Netlingo, 2022) (Patel, 2019) (Schwab, 2016) (Thales, 2022) (Wade & Pfäffli, 2016). This definition is the culmination of overlapping areas that authors refer to frequently. In short, cities are turning to smart technology to manage the challenges of the approaching urbanized future (Ferro, 2021). With a clearer definition established, the next section to look at is what components make up a smart city.

2.3.3 The Smart City Framework

The complexity of a normal city means that it can be broken down into many different components. These components, when functioning in unison, create a successful SC framework. Backhouse puts forward six components for a smart city framework that act as a general encapsulation of the various fields that an SC works with (Backhouse, 2020). These six components are smart – Economy, Living, Mobility, People, Governance, and lastly Smart Environment. There are many different functions in a city that fall under these main components as visually shown in **Figure 3**, however, these components do not add quality and cover all the aspects that would create a successful SC framework (Ferro, 2021). Through in-depth research I believe that there can be additional components added, to better improve the scope and accuracy of the necessary features to further improve the potential of an SC.

These additional components are Smart Infrastructure and Smart Planning. Many more components could be added to improve the clarity and map the potential of an SC framework, however, for this study, only two will be explored as they are the most relevant. In the literature by Perez (2017), the idea of smart infrastructure will be explored, while the reading by Dignum and Ogie (2017) discusses future construction and the important role that infrastructure has in it. The concept of Smart Planning is explored in the literature of Exner and Mirembé, where they discuss the need for smart-orientated spatial planning that makes more use of technology (Exner, 2014) (Mirembé, 2017). These two added components will be discussed later after the core components by Backhouse are explored

2.3.3.1 Components of a Smart City

The following figure shows the different components by backhouse and the two additional ones. These eight components all contribute to the SC framework and in turn, contribute to the potential impact the city can have. For each area to be investigated in a country, it would reveal the impact the component will have on the SC framework. The overview of all the components would then reveal the potential that the SC framework has. Next will be to look at each component to define and establish its place in the SC framework.

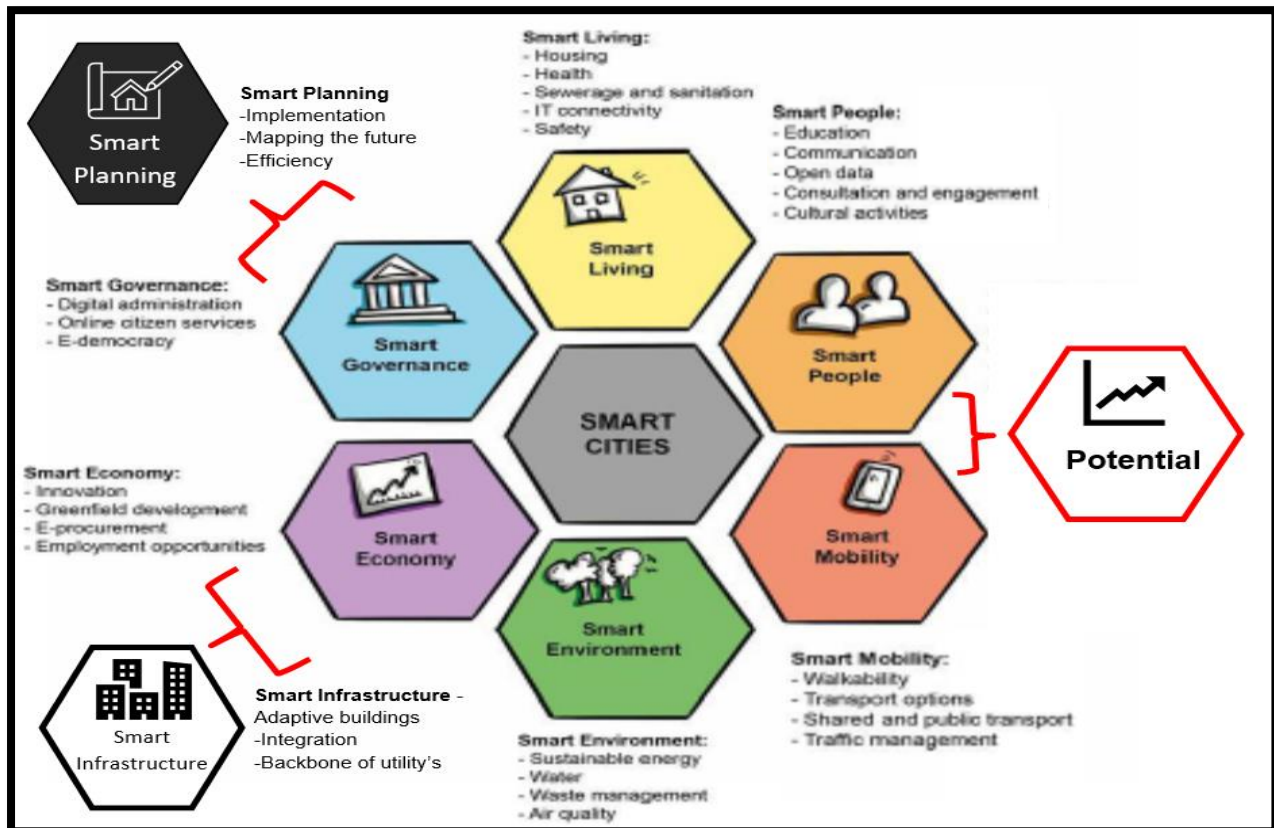


Figure 3: Components of smart city Adapted

Source: (Backhouse, 2020) adapted by (Author)

A. Smart Economy

A smart economy is a market that exhibits the following characteristics: Promotion of entrepreneurship and vertical thinking-focused programs for youth employment, a flexible and productive labor market that focuses on new technology implementation, an adaptable market that is resilient to shocks due to strong fiscal policies by government and lastly, a market which incentivizes companies to follow green standards and emission regulations (Fischer, 2020) (Bruneckienė, 2014) (Mustafa, et al., 2017).

All these characteristics have the intention to project a strong global image of the country's economy. In summary, a smart economy is the use of adaptive digital technology to streamline financial processes within an SC framework (Bruneckienė, 2014). This component offers benefits to the labor, social, and output sectors of a city, by creating an environment that is accessible, stable, and optimized. Strong economic backing is essential for smart initiatives as implementing new technology does incur an extra burden on the financial logistics of a city. This point means that less financially stable countries, the majority being a part of the developing world, are ill-equipped to follow the frameworks that developed nations use. Alternative frameworks would need to be created that account for a country's financial situation as the research shows that "one shoe size, does not fit all," when it comes to SCs.

B. Smart living

"Smart living is where technology is being installed into households, to increase the quality of life, while still sustaining the environment for the future" (Lee, et al., 2011). The integration of digital monitoring and pattern recognition software is how living can be made Smart. This component focuses on the technologies that promote a higher quality of life standard within an SC framework. These technologies allow for real-time data on household resource consumption to be made available, create a network that focuses on efficiency through optimization of resource distribution, and construct buildings that have longevity in mind by making use of alternative energy sources. One of the largest challenges in many countries is affordable housing that is optimally positioned for the occupants.

This component would require more than just the technology to be installed as the literature warns of the risk of "underutilization". A house can be made Smart, but if the occupants themselves are not educated on using the technology (Smart people), the position of the properties is not optimal (Smart planning) and there is no viable transport system to commute to work with (Smart mobility), the house will not be utilized to its optimal potential. To live smart can be optimized through technology for electricity usage, recycling, water consumption, reduced carbon footprint, and general health/well-being, however, the limiting factor of this potential benefit is the people who utilize it.

C. Smart people

"Smart cities won't truly be smart until we get smarter" (Khanna, 2021). This statement is supported by Dameri as he remarks that if upgrade a city into a smart one, without informing or educating the occupants on how to operate the technology, it is pointless to upgrade in the first place (Dameri, 2016). This component closely resembles the smart living component however, it focuses on the ability of the individual and not on the quality-of-life products that are installed. This component is

measured by the education level of the general population, the Human Development Index (HDI), the number of graduates in the population, and the qualifications of employed individuals (Roser, 2014) (Mustafa, et al., 2017). These areas are where a planner can focus to determine the shortcomings within this SC component. Education determines how able the population will be to operate digital technology, graduate percentages determine how much-skilled labor is being produced, the qualifications of individuals who are employed determine what areas would require more focus to produce people who are qualified in a specific profession and the HDI determines the speed the development of people, as well as the overall quality of life present in the city (Dameri, 2016) (Roser, 2014) (Mustafa, et al., 2017) (Schwab, 2016). All these measures can determine the potential of how an individual can operate within a smart environment and how they can live smart (Khanna, 2021). This component encourages open-minded thinking and promotes creativity, adaptability, and communication in the public realm (Schwab, 2016). A population who is made aware and educated about their surroundings, can live more sustainably, and support a healthy environment (Mustafa, et al., 2017).

D. Smart mobility

Smart mobility is the improvement of transportation from point A to point B, using integrated digital technology, renewable fuel sources, and AI software (Mustafa, et al., 2017). This component is responsible for all the movement that occurs within a smart city framework. This could either be for commuters moving around or for goods and services that need to be transported. Smart mobility simply takes the present movement methods within a city, integrates them with smart technologies, and optimizes them to meet their full potential. These sensors are linked to a central database that optimizes traffic flow, and route usage and reduces delays caused by congestion. A system operating to its full potential allows a consumer to make use of many alternative transport methods, such as nonmotorized transport or public transport. Multi-model transport allows for fewer private vehicles to be present and in turn, the movement system of an SC will be free-flowing and efficient.

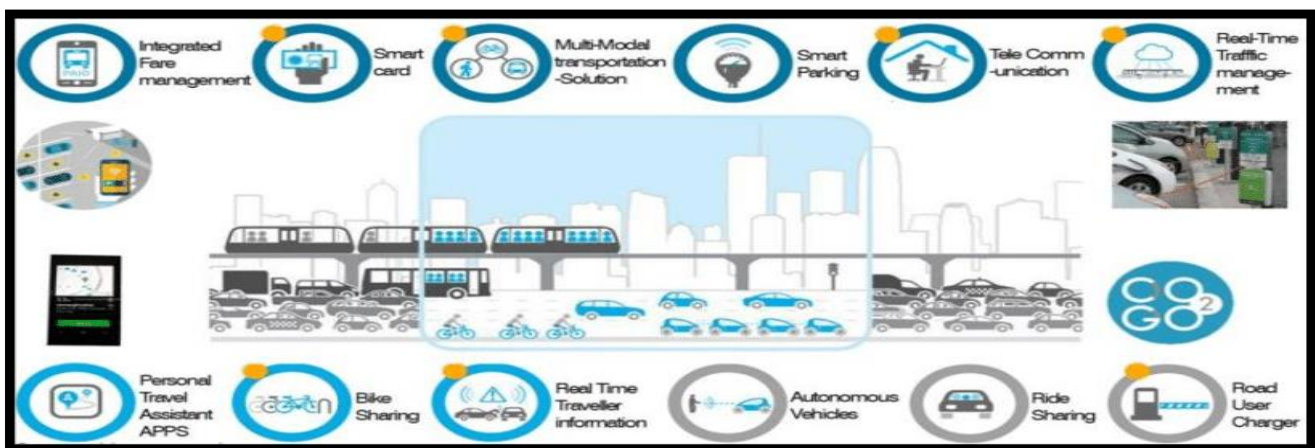


Figure 4: Examples of Smart Mobility

Source: (Brcic, 2018).

This is illustrated by Figure 4, which visually depicts the components associated with Smart mobility within an SC. The diagram shows the different areas that digital integration will influence. The main areas a planner can measure the potential within this component are the ease of use of services, the fuel efficiency of vehicles, public access to services, the number of alternative transports, the amount of technology integrated into each system, and the safety scores of drivers and pedestrians. These measures determine how effective the mobility is in an SC framework. If these areas are operating to their maximum potential, they can improve the output of a city by lowering the time lost due to traffic and in turn a workforce that operates more efficiently. An environment that is less car-driven can be created using Smart mobility and promotes a more walkable environment that modern planners envision.

These innovations are, however, limited by their access to a reliable electricity source and Wi-Fi connection. Smart technologies are interlinked using network connections and rely heavily on an electrical source to operate. These facts are particularly a concern to developing nations as the required services are normally not at a level to support these additions (Nyagadz, 2022). SC components and sensors add additional strain to a country's energy grid and infrastructure, due to digital product's dependency on electricity and smart technologies requiring connections to an array of sensors and data. This places energy and network connections as a must for a country if the maximum potential is desired by the integration of smart technologies.

E. Smart Governance

Smart governance is the “technology-enabled collaboration between local governments and citizens” (Tomor, et al., 2019). Smart governance focuses on democratic decision-making to enhance the impact that smart planning initiatives have. This is necessary for sustainable development as projects that are approved and wanted by the people are made use of and taken care of (Hassan, 2021). This component is broken up into three areas that planners can use to measure the potential and status within an SC framework. These areas are Citizen Participation, Governmental Organization, and Technology use. These sub-components are the areas that can determine the relationship between a government and sustainable outcomes (Dameri, 2016).

Citizen participation in government projects is when the people who are affected by a project are included or invited to give input. This feedback allows for better implementation of projects as if done correctly, the project will be utilized and not neglected. This is relevant as SC initiatives will require the support of the people. Governmental organization pertains to the structure and coordination by officials. This is related to all government matters such as paperwork, documentation, and the legal system. Having an organized system that focuses on a common goal is beneficial when considering

what SC technologies to implement first. Clear organization and plans will ensure the correct steps are taken to the common goal agreed upon.

Digital technology not only enables organization but also allows for systematic open communication with the people. Streamline communication between the government and its people enables the assessment of needs to be easier and admin, such as document requests and renewing licenses, to be less tedious using online systems (Gawel & Herweijer, 2020). Communicational avenues to government using official online websites, community phone groups, social media pages, etc. all enable better interconnections through all levels of government and the local population. These measures have been noted to be necessary because if governments are too slow to adapt, the desired efficiency from public services will not be met and people will lose faith in the governing system (Mubangizi, 2019).

The last measure is the amount of technology used in the governance system. The amount of technology in use is a good indication of how accessible the governance system is. A Smart governance system is optimized using smart technologies, data, and communication. A smart government is approachable, communicative, and present in communities, through various means of digital information and devices. This component is important as it acts as the backbone for all the other functions within an SC framework. Smart components cannot operate to their potential without the correct backing within policy and the government (Przebylowski, et al., 2017).

F. Smart infrastructure

The marriage between digital technology and urban infrastructure is the simple definition of how engineers describe the concept of smart infrastructure (Perez, et al., 2017). This additional component is largely looked over in literature due to the assumption that the infrastructure is already included within the components of an SC framework (Ferro, 2021). This assumption leads to this component being overlooked, however for a developing country to access the potential of an SC, it is a requirement. This component ensures that buildings are adaptable and in turn, improves their sustainability by becoming a multipurpose smart object. The literature denotes that an object which is “none-smart,” is dumb, and the opposite is “intelligent,” which is used to describe “smart” objects (Perez, et al., 2017). In terms of describing infrastructure, intelligent (smart) can communicate with its surrounding area, respond to demanding situations, and improve the overall performance of the structure. Dumb is the opposite, where the infrastructure does not adapt or communicate to the wider network and can be considered a standard building (Weiss, 2009).

When old infrastructure systems meet newer ideologies/technologies, it becomes obvious that the trusted traditional systems will not be able to cope with the demands of modern technology (Artman, 2000). The strategic value of smart infrastructure within an SC framework cannot be overlooked. This

is reiterated by Perez as he states that present cities cannot simply adopt new technologies without the correct infrastructural system first (Perez, et al., 2017). Implementing smart technology onto a structure that is not compatible, such as lacking an internet connection or sufficient energy supply, the device would not be able to operate or function to its full potential. Not having smart infrastructure means smart initiatives run the risk of being a burden to the system it is implemented with. This means that this component acts as the backbone of an SC framework and is linked to all the components

F. Smart Environment

A smart environment consists of the previously mentioned components when they are operating to their intended potential. In short, the culmination of technology within the open space of a city/area merges to create an environment that is beneficial for the occupants that roam in it (Postolache, 2019). Three subcomponents can be measured to determine the overall potential impact the system is having. These sub-components are the physical, communication, and analysis functions within a smart environment. Physical measurement is the number of sensors and technology that are physically present in an environment. SCs operate more effectively, the more sensors that they possess. The communication aspect is the way that these physical devices communicate with one another. The relationship between sensors can determine the amount of data that is being transmitted and made use of. The lower the variation, the fewer connections between devices and in turn fewer data to be used to operate a system to its optimal level. The final measure is how data received is interpreted and analyzed. The data communicated by physical sensors require a central hub that interprets and acts upon the data collected. These three subcomponents determine the overall impact a smart environment has.

This component, when operating in unison with the other ones, creates favorable private spaces that promote hazard-free, healthier, and resource-efficient living. The data provided by the sensors can also be used to monitor water systems, power usage patterns, waste management, and air quality within an SC. Breakages, leaks, and faults may quickly be found and addressed. The carbon impact of the city can be monitored and assured to be up to environmental standards. Overall, when these sensors are enabled by the infrastructure, promoted by the government, and grouped with smart-thinking people, a sustainable and cleaner living pattern will be created, the only limit to this, is the three subcomponents mentioned previously (Schwab, 2016). Installing the sensors and using them correctly is how the potential of this component can be utilized.

G. Smart Planning

The increased amount of “spatial information,” digital incorporation, and societal change occurring within the city environment, leads to challenges and risks that would need to be addressed by the planning profession (Exner, 2014). This additional component to the Backhouses framework I argue

is necessary as the SC movement is complex and the risks of getting it wrong can be catastrophic (Arroub & Zahi, 2016). Smart planning will play a critical role in the fostering and maintaining of new/present SCs. The planner's role and position in the framework is to be the bridge/intersection for the interests of companies, authorities, and citizens (Exner, 2014). The role of smart planning is to create an efficient spatial system that is sustainable, efficient, resilient, and accommodating to new technology, using updated techniques that make use of the technology present (Mirembe, 2017). Traditional planning techniques are required to "keep up with the times," as the literature indicates that all professions would be required to branch out and change with the times, to remain relevant and have an impact (Exner, 2014). For this reason, planning professionals in developed nations are taking more command over initiatives, rather than just being in dialog over them (Sassen, 2011).

Implementing complicated SC initiatives with traditional planning systems can lead to situations where there is a communication breakdown. For example, a situation where illiterate communities are approached and offered to partake in a participation program since it is required by law in the SC framework, are unable to engage effectively with the projects due to the people being unable to understand any of the terminologies discussed (Mirembe, 2017). Outdated techniques cannot be used when implementing smart initiatives. This is especially prevalent for developing nations as they are all at different stages of developing their components. For the case above, a smart planner would understand the situation and would first send in people to educate the citizens before coming in, and later include them in public participation practices.

Smart planning is required as a balance between the social, environmental, political, and economic frameworks is required within a functional SC framework. SCs are being viewed as "laboratories of invitation," in the developed world because what is produced in an SC will have a knock-on effect on the rest of the country. Smart planning is a beneficial tool when optimizing and perfecting the harmony within an SC framework. This component does not necessarily need to be isolated from just SCs as the practices can also be applied to the rest of the country. The rapid increase in urban culture and SC development across countries in recent years, it is safe to say that the profession is relevant if it can adapt and branch out to become smarter.

2.3.4 Benefits of a Smart City

The SC framework is considered a guide and is not a fixed plan in which if the boxes are checked, the framework would be successful. The complexity of a city and the different mechanisms that operate inside it is the reason the framework is broken down into smaller components. They all operate within the same sphere which is the SC and can be considered to each be equal in value. The research indicates that due to these components being a part of the same system, each one has

a direct effect on the other. The integrated nature of a city means that if one component is underdeveloped, there will be consequences and shortcomings across the entire system. This means an SC framework is required to be developed with this fact in mind, where components are linked and cannot be more favored than others. To mismanage this will create a recipe for wasted resources and time. It can be summarized as “setting yourself up for failure,” if careful attention is not taken.

This research is assisting the creation or maintenance of SCs because it shows that if a framework is not operating to its predicted potential in a specific component, the problem may lie outside of the component entirely. The integration between components extends to their operation and implementation effectiveness. The table below contains the eight mentioned components and is a summary of the physical benefits and challenges that can be associated with each. This table indicates the topics that each component addresses and the intended benefits that each one can produce in the framework as well as the challenges within each component.

Summary of benefits and challenges for SC framework components

<u>Smart</u>	<u>Benefits</u>	<u>Challenges</u>
People	- Adaptable Workforce - Multi-skilled labor - Higher educated population - Equal access to opportunity - Better communication within communities - Improved quality of life - Better problem-solving abilities for issues - Operate and make use of SC technology - Knowledgeable about sustainable living patterns (Oláh, et al., 2020) (Mustafa, et al., 2017) (Khanna, 2021)(Schwab, 2016).	- Many jobs lost to automation - Divide between upper- and lower-class citizens. - Not all people will feel the benefits of SC initiatives in the initial stages. - To educate the population on smart living techniques - Making technology available to everyone (Khanna, 2021) (Perrin, 2021)
Economy	- Incentives ensure continued investment - Economic growth - Job creation for the new skilled areas - Creating a stable economy resistant to shocks - Increased wages - Encouragement of entrepreneurship - Improvements to the quality of life	- The division in skilled labor will widen the wage gap. - Unskilled labor will need to be repurposed and trained - SC initiatives are expensive and will require a large investment of wealth to begin.

	Increased efficiency through optimal resource allocations and equity investments (Oláh, et al., 2020) (Fischer, 2020) (Bruneckienė, 2014) (Mustafa, et al., 2017) .	Requires large amounts of skilled labor to be produced. (Bruneckienė, 2014) (Mustafa, et al., 2017) (Patel, 2019) (Fischer, 2020)
Mobility	- Improved safety for commuters - Accurate operation schedule - Multimodal transport options - Reduced traffic congestion - Easy access to public transport - Faster transit speeds - Alternative and efficient fuel usage - Lowered travel costs for commuters - Less private mobility present - Promotion of non-motorized transport (Fischer, 2020) (Brcic, 2018) (Oláh, et al., 2020).	- The road systems present must be able to incorporate the services required - Upgrades require sufficient power and internet access - High initial costs incurred from upgrades to public transport - Dependent on components (people, infrastructure) to operate effectively. (Patel, 2019) (Woetzel, et al., 2018)
Living	- Sustainable living practices - Improved living costs - Optimal resource utilization and distribution - Better control and monitoring of the residential sector - Lowered costs of household provisions - Interconnected communities (Lee, et al., 2011) (Dameri, 2016) (Oláh, et al., 2020) (Apata, et al., 2021).	- Equal distribution and social inclusivity of smart housing initiatives - Basic services to all housing are required first - Installing new sensors and connecting every house to the central database - Depends on more than one SC component to operate to its potential (Owusu, 2016) (Schwab, 2016)
Governance	- Strong and easily accessible network of communication between the government and the community - Mandatory public participation - Accountable and just government - Improved implementation and speed for SC policies and initiatives - Goal-oriented development, Bottom-up/top-down systems	- Political differences within a city system - Lack of information for SC initiatives - New data privacy laws - Coordination of the private, public, and governance sectors

	Targeted incentives that support and promote other components (Kakderi, 2013) (Tomor, et al., 2019) (Oláh, et al., 2020) (Marwala, 2020) .	Instilling the same SC mindset between all government entities (Janowski, 2015) (Backhouse, 2020) (Marwala, 2020)
Infrastructure	- Seamless integration of sensors and 4IR applications. - Structures all have an ethernet connection. - Buildings form part of a network and communicate and exchange data to optimize themselves. - Efficient data analysis and storage - Is scalable - Utilizes renewable energy sources (solar) and green spaces (roof gardens). - Reduced impact on the environment e.g., urban heat island effect. (Perez, et al., 2017). (Ferro, 2021). (Perez, et al., 2017) (Weiss, 2009) (Oláh, et al., 2020)	- Must be a foundational element for a framework - Updates to present systems will require a large wealth investment therefore a lack of budget can be a serious issue. - Must be able to be scaled up when the increased data is produced. An SC is useless otherwise and can't evolve. - Upgrades raise the land value within the city and drive up living costs in the short term. (Beevor, 2018) (Petrillo, et al., 2018)
Environment	- Optimized storage and delivery systems within the energy sector - Improved use and management of resources (waste/water/power) - Increased use of green energy and renewable energy sources - Reduced carbon emissions within the industry - Effective recycling programs to maximize resources - System maintenance is more effective as broken hardware i.e., leaks in underground pipes, are easier to locate - Green, safe, pleasant open spaces - Integrated space which enables the full potential of SC components (Owusu, 2016) (Oláh, et al., 2020) (Madangombe, 2019) (Schwab, 2016) (Postolache, 2019).	- Requires all components to be in operation to be effective - Short-run implementation costs are high due to renewable energy sources being costly. - Privacy issues of data collection within public space - The interdependency of technology in space requires backups for when the system is down, hacked, or crashes. - For everyone to participate in the environment created (Owusu, 2016) (Patel, 2019) (Schwab, 2016) (Apata, et al., 2021).

Planning

- The intersection between citizens, companies, and urban authorities.
- Finds a balance between bottom-up and top-down SC approaches by the government.
- Promotes a people-driven environment
- Updated planning strategies that incorporate technology use.
- Ensures that initiatives are resilient and implemented in the necessary areas
- Optimizes the use of sensor placements to ensure that not too many are used.
- Keeps projects within budget and maximizes the revenue spent.
- Encourage beneficial public participation in urban SC projects.
- Acts as the mediator within the SC framework (Exner, 2014) (Ferro, 2021)
- Ensuring that the people in the profession are sufficiently educated and aware of the topic and SC framework.
- To instill creative and updated thinking that utilizes new technologies
- To be fair and balanced in decision-making
- To have enough skilled planners within the labor force (Coetzee, 2010) (Exner, 2014) (Ferro, 2021)

The takeaways from the above table are that for every benefit, there is a counterchallenge that can be associated with it. Although not normally a direct correlation between benefit and challenge, the table illustrates that there is no net gain without incurring a challenge to some capacity. These challenges mentioned are associated with installing and maintaining the smart systems to achieve the benefits. The pretext is that a nation can provide the necessary basics beforehand, and the table is solely focused on targeted benefits and challenges with each component. This holds for a large percentage of the literature which also normally omits a nation's stance and focuses on the benefits and associated challenges that would occur for the country (Keeton, 2019).

2.3.5 Smart City Fundamentals

“The more the city turns into a computer, “the more it will be associated with the advantages and disadvantages of a computer (Exner, 2014). The research done for the table above highlights several key areas and facts that are unavoidable for SCs. These fundamentals are what need to be planned for and overcome, to operate an SC to its intended potential.

1. An SC is a complex undertaking, and one strategy does not necessarily work for all cases. The unique context of each country and the intended city to upgrade to cannot be overlooked. This

understanding of “one shoe size does not fit all,” is an essential mindset that is required to be adopted, since what works for one context will not work for another (Beevor, 2018) (Marsh, 2019) (Jendamark, 2022).

2. The economic impact of SC interventions requires a well-planned budget. New technology across all components is expensive and will require a large investment of funds in the preliminary stages of development. This ties into the context of a country as revenue is a major part of how effective SC development can be (Fischer, 2020) (Bruneckienė, 2014) (Mustafa, et al., 2017) .
3. The integrated nature of SC principles means that shortcuts on the road map to success, cannot be taken. The research of an SC framework has shown interdependent components that work off each other. There is a knock-on effect that if one component is neglected, it affects the entire system's potential (Beevor, 2018) (Backhouse, 2020).
4. There are little to no immediate returns on investments made toward SC initiatives. Research indicates that projects and initiatives require a large investment, and the returns and benefits are only noted in the long run. This is a fundamental part of SC development, where programs and initiatives all have their potential for benefits and returns, however, this is for the long term and the initial setbacks are unavoidable (Perrin, 2021) (Tomor, et al., 2019).
5. Upgrades to any area within an SC, most notably in real estate, will increase the price through the land value. This means that building in the long run, housing especially will be more difficult to execute at lower budgets (Beevor, 2018) (Perez, et al., 2017)
6. There will be gaps between the “smart” and “non-smart” sectors. This may occur even between cities that are not smart and people who can afford to live in them. The divisions that occur on a social basis and the inevitable “favoritism” between cities being focused is a fundamental challenge that is a part of SC development (Richards, 2022)
7. No matter the context of the country, a level of pre-training will be required to occur. The complex technology systems, whether it is in daily life use or industry, will require individuals to be reskilled/ trained on how to operate them effectively. The research shows that this fundamental, if ignored, will mean that the implemented technology will be irrelevant and difficult to utilize to its full potential for users (Smith, 2018) (Woetzel, et al., 2018).
8. The dependency on technology will rise drastically and key fundamental systems will become more digitally dependent. The population and industry sector will become accustomed to being more reliant on technology. This will range from basic to sophisticated needs and the result is complete technology dependency. This is an unavoidable outcome of SC implementation and the risks associated with this are critical to preparing for. If a system goes offline due to unforeseen circumstances, the risk of entire sectors being delayed and non-operational is a real threat (Zervoudi, 2020) (McGinnis, 2020).

These are the main fundamentals when considering SC development. There are many aspects and other fundamental acceptances that can be associated with SC development, however, for this research, the above points address the necessary understanding needed. The most important area to address before any SC development can occur is to establish a clear context of the host country (Editorial, 2021). Establishing the context of the country is a clear road map to figuring out what potential a country has when considering SC development. The research gathered on SC frameworks, the context of SA, and the level of awareness of its planners will determine the level of success and potential of SC interventions. The context encapsulates all the present components mentioned and determines the environment that the planner operates in, therefore, the level of experience and awareness the planner has is essential when considering the orchestrated development of SCs.

2.4 Global Examples of 4IR and Smart City Implementation

For this study, understanding the inner workings and common trends of the modern applications of 4IR technology within an SC environment is beneficial in establishing the potential of the available resources for the SA planning environment. Establishing the global practical applications of the present technologies being utilized in functional SCs will enable a basic understanding of the common approaches, challenges, and what works best for implementing and maintaining SCs. This section intends to highlight how cities worldwide are leveraging the technology at their disposal to enhance urban living, improve services, and importantly address the challenges encountered.

2.4.1 Smart cities around the world

Although there are no fixed criteria when it comes to defining when a city becomes smart, there is a general agreement that there are currently more than 140 smart cities across the world (Walbank, 2023). This figure is constantly changing due to the rapid evolution of technology and the rate of adoption across the world. The Smart City Strategy Index (SCSI) conducted by Roland Berger, investigated 153 cities that were identified to have official SC strategies in place. The report utilized its own set of criteria which supports the recent claims by Walbank of there being no set official criteria (Berger, 2019).

A document that investigated the top six leading SC frameworks confirms this further by elaborating how even the general definition of an SC is constantly evolving (Quélin & Smadja, 2021). SCs are now no longer driven by technology alone and are prioritizing sustainability more, and despite attempts to normalize an SC framework design, there are clear differences between all the leading SC approaches (Quélin & Smadja, 2021) (Henzelmann, 2019). The basic understanding from the literature is that there is currently no official established norm that any nation can copy and guarantee fixed results.

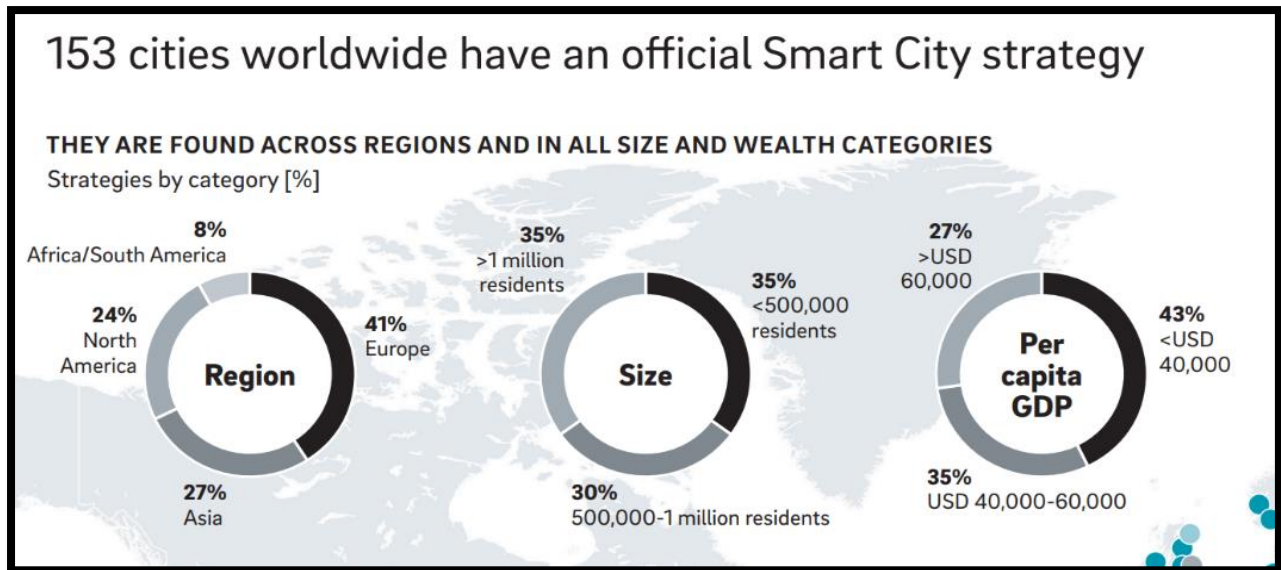


Figure 5: SCS distribution and statistical characteristics of SCs globally

Source: Roland Berger, SCS 2019, (Berger, 2019)- page 4

Figure 5 shows the distribution in the percentage of the 153 SCs across the globe within the categories of the region of the world, the population size of the city, and the Gross Domestic Product (GDP) per capita of the country the city resides in. Figure 5 indicates that the majority of Smart undertakings are in Europe and the least in Africa/South America. The size of the city being evenly distributed shows that regardless of scale cities are being planned for smart upgrades. Lastly, a vast majority of cities were less economically strong in terms of per capita GDP ratings, and only a small percentage ranked in the higher ends of economic output. This disparity in GDP can be accounted for by the average city being considered to contain weak strategies, while only the top 10% of cities are considered to have a comprehensive strategy (Berger, 2019).

Out of the 153 cities investigated by Roland Berger, only 15 of them demonstrated adequate comprehensive strategies in place. These main cities are the leaders in exhibiting what a smart city can look and operate like. From these cities, the leaders of Singapore, London, Paris, Copenhagen, Amsterdam, and Oslo are the indisputable frontrunners for setting and establishing new trends (Dong, 2023). This comes down to several factors why these nations are the leaders of innovation, mainly economic strength, government policy, technological ability, and dedication to field implementation schemes (Quélin & Smadja, 2021).

The following figure indicates the top 15 smartest cities, where the blue dots indicate an entirely new strategy was deployed by the city and the yellow indicates the cities that updated and improved their strategies with known methods. It is worth noting that the years of the smart city framework being installed are roughly the same (between 2015-2018), which indicates that serious functional SCs are still in their adolescence despite the high ratings of technology adoption and functional policy (Berger,

2019). Each of these above cities is unique in their approach and operation of how they manage and become a top-ranking SC. The figure also shows the distribution of the smartest cities to the east side of the Asia continent and central Europe. To briefly look into the top 4 cities would allow for an overview of the technologies being used, challenges being addressed, and overall, practical insight into high-level function SCs. The cities have been ordered and numbered according to the numerical ranking they have been given in Figure 6.

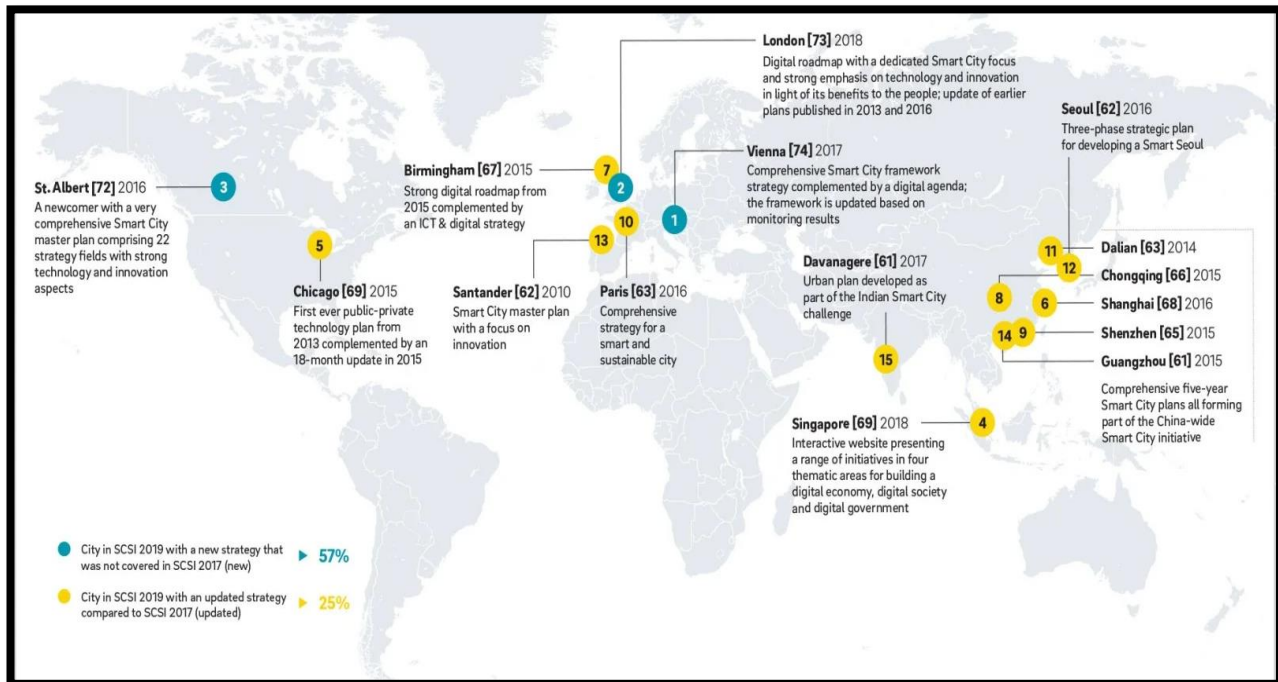


Figure 6: Locational context of the 15 smartest cities around the world

Source: (Henzelmann, 2019)- diagram 3

1. Vienna

“Vienna’s three-pronged plan sets specific targets for improving education, fostering innovation, and reducing resource use and greenhouse gas emissions. The city strives to offer the best quality of life of all cities in Europe by 2050“, was a summary of the SC framework said by Thomas Müller, who is the Co-Founder of *Bee Smart City* which is the world’s largest smart city knowledge center (Smith, 2018). The Austrian capital updated its framework strategy in 2015 with a new digital agenda that is a new robust system of performance-centered monitoring. This change has enabled improved coordination and better

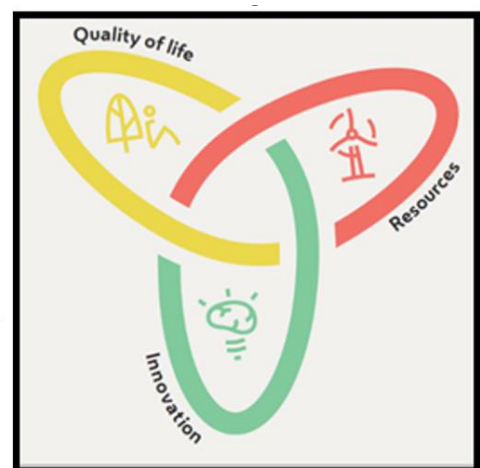


Figure 6: City of Vienna Smart City framework pillars
Source: Smart city Strategy document Vienna pg. 23.

synergy between actives and individual key players (Berger, 2019) (Smith, 2018) This sharpening of the smart objectives is evident in the visual depiction of the capitals SC framework (figure 7), the simplicity of its three pillars forms the basis for its entire framework.

The city encompasses a wide range of projects that all focus on excelling the framework pillars. The primary focus areas of the capital city are mobility, sustainability, social initiatives, and health care (Smith, 2018). Freight traffic optimization, specifically the two projects of 'Optihubs' and 'IMPALA' both aim to optimize the administrative and operational procedures of freight, rail, and car traffic along and around the Danube River. This is done using smart traffic light systems that monitor the movement lanes and ensure the maximum operational flow of traffic (Berger, 2019). The city removed all intersection buttons since 2018 for pedestrians, due to the lowered wait times created by the system's "Green waves". These waves focus on smooth-flowing traffic and can potentially allow for 3 or more consecutive green intersections for road users (Quélin & Smadja, 2021). The public transport system also utilizes a break energy recovery system which converts the energy from breaking into power for the grid to power facilities such as elevators or escalators of subway stations (Berger, 2019) (Smith, 2018). Although these projects are still in the testing phase, the reduction in energy consumption and wait times has been showing promising indicators in terms of reducing the carbon footprint of these facilities.

The city utilizes more LED light usage, renewable energy sources, and electric vehicles, to lower its emissions impact. The postal service alone has reduced its CO2 emissions by 30% since starting in 2011 (Smith, 2018). The city also encourages alternative transport by introducing a model car-free housing project, which saw the zoning of housing complexes be built with the goal of the tenets not being allowed a car, and instead construct adequate bike and public transport facilities that have 39% of all journeys in the city be by alternative means (Ornetzeder, 2008) (O'Sullivan, 2020). This reduction of cars is paired with many greening projects that intend to preserve the biodiversity of the city and protect the lake's water integrity. The social initiatives of the Wasserweg app, the Gardening Together project, and the project Pocket Mannerhatten, all promote educating the public, promoting sustainable living, and encouraging joint efforts to create green spaces. This has been supported by the council through large rezoning of areas to make more green spaces, promoting neighborhood gardens, and linking communal spaces through shared utilization of resources e.g., combining ownership of bicycles, garages, and shared energy systems between building units. All measure is accounted for and considers the impacts on owners and residents (Smith, 2018) (Heschl, 2020).

All in all, the city of Vienna is a top-rate smart city due to its comprehensive Smart City framework strategy, which is complemented by a central digital agenda that has the framework updated based on monitored results. The city focuses on the integration and cooperation of systems and its people to more effectively achieve its implementation and smart objectives set (Berger, 2019).

2. London

The city of London is constantly voted to be the smartest city in Europe and a recent study by ProptechOS confirms this, where London achieved a score of 73 out of a possible 100 in the categories depicted in figure 7. The diagram shows the high achieving scores by the city of London, with the dotted line indicating the world average (Berger, 2019). The city ranks higher than the next closest European SCs such as Amsterdam, Berlin, Paris, and Lisbon, by exhibiting good access to outdoor green space, dedicated green-certified buildings, and publicly accessible EV charging points (Puttkamer, 2023). London in the present day has more 5G towers, EV charging stations, and green infrastructure than any of the other European competitor cities mentioned. This is due to the city's well-constructed and newly updated Smart Framework, which focuses on building a people-centered environment, with a strong focus on the application of smart technology and innovation across various action fields (Puttkamer, 2023).

The Smart London approach shown in figure 8, gives a visual representation of London's pillars of focus in terms of achieving their smart goals. These focus areas intend to address all the present challenges facing the city, the most critical being the predicted population expected to reach 10 million by 2030, with only an urban area of 1,500 km², the challenge to provide enough public services for everyone is a major concern, specifically in the areas of health and transport (Henzelmann, 2019). The key to the city of London's smart framework and what makes it stand out from the other European SCs, is its large acquisition of data and how it effectively utilizes it. The London Datastore offers every Londoner free access to all information and statistics that relate to the city, this is handy for software developers and start-up companies especially. Programs such as High Streets for All rely heavily on this city data as it is used to model new school sites, identify brownfield lands, or measure air quality (Puttkamer, 2023). A similar program called Energy for Londoner enables better decision-making for when to identify where and how to prioritize funds and investment in green infrastructure, in optimal locations within the British capital (London, 2023).

In summary, the city of London has established a strong base in terms of its policy and legal positions, infrastructure provisions, coordination, and smart framework plan, to be able to secure its future. The

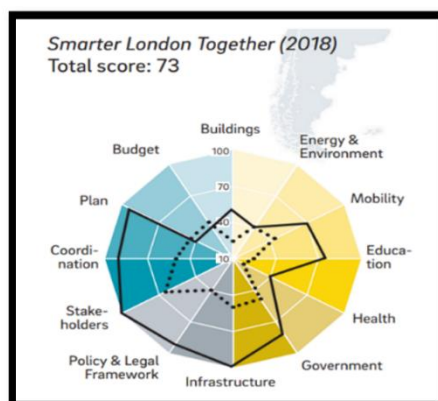


Figure 7: City of London Smart City score
Source: (Berger, 2019), Pg. 10.

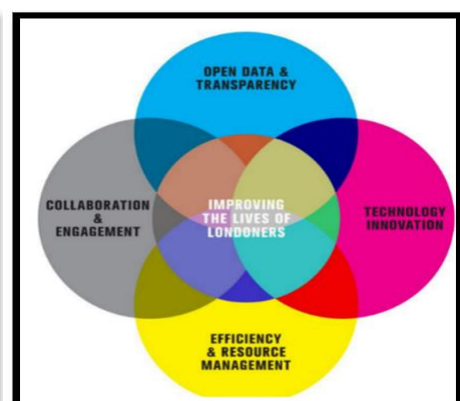


Figure 8: The Smart London Approach
Source: Smart London Plan 2018, Pg. 18.

city scores low in activity-based initiatives, however, plans that look as far as 2050 do include developments in those areas. The data-driven focus of the city is the main enabler for allowing the city to excel in its key sectors and exhibits the importance and effectiveness of large data collection (Puttkamer, 2023) (Henzelmann, 2019).

3. St. Albert

The Canadian city of St Alberts Smart City Plan 2.0 was updated in 2017 after the previous 1.0 plan achieved all its preliminary baseline goals (Albert, 2019). The update was, however, driven more by the need to align with new strategic plans to incorporate modern technology advancements and address present challenges the city was facing. Plan 2.0 focuses on the efficient delivery of municipal services, further economic development, regional partnerships, and inclusion of the wider community (Albert, 2019) (Brooks, 2014). The aim of incorporating digital technology is to use it as a catalyst for the positive change of the residents within the city. The strength of plan 2.0 lies within its design as it was made to be easily understood by non-technical readers and avoids complicated jargon that can be outdated (Berger, 2019).

The plan identifies key SC opportunities that will generate the highest impact without being prescriptive. The most notable approach taken by the city is its use of competition to denote funding for projects. Projects are measured on their impacts on service delivery and return on investment opportunities that they provide before funding is allocated to them (Nelson, 2023). This measure creates an environment for high-quality projects to be produced, due to the competition created through funding incentives. The long-term goal of Plan 2.0 is to integrate digital technology into everyday city practices to better service the citizens that reside in it (Berger, 2019) (Brooks, 2014).

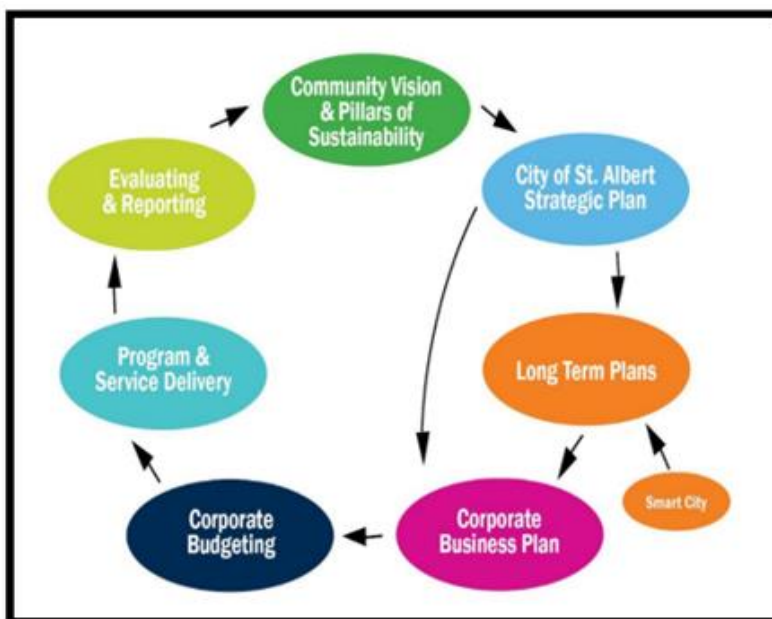


Figure 9: City of St. Alberts Smart City Strategic Framework
Source: (Albert, 2019)

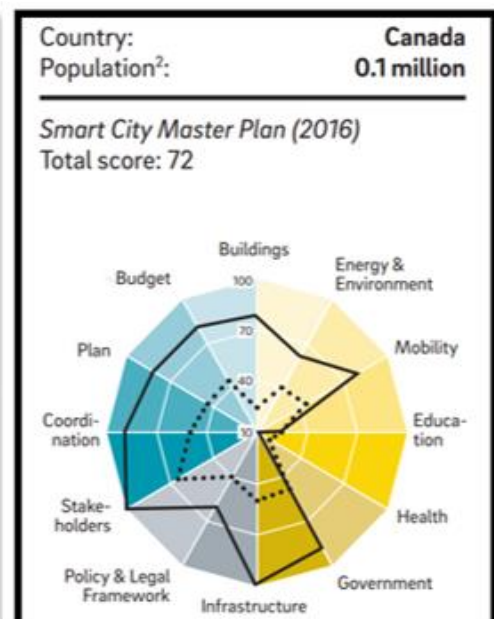


Figure 10: St. Alberts city total rating sections
Source: (Berger, 2019)

It is noted that the city of St. Alberts SC plan is only included in the long-term plans of the city, as visualized within the Strategic framework of the city in Figure 9. The strategic plan primarily focuses on the initial stages and a strong grounding of city functions rather than immediately incorporating smart digital technology (Albert, 2019) (Nelson, 2023). The plan holds the long-term goal of moving towards a functional SC and therefore the initial plans implemented are in line with producing an SC (Berger, 2019). This approach has been proven to be highly effective as is evident from the scoring of the city, Figure 10. The score given by Berger demonstrates the outcomes of the city's strategic approach as many fields examined are of a high level (Albert, 2019). It is noted within the city of St. Albert 2.0 overview pg. 12, that the Berger report critiqued the 1.0 plan by stating that the city did not address the areas of education and health. This is evident in Figure 10 where these columns are indicated to contain a zero score (Berger, 2019) (Albert, 2019).

The city-states that despite these two categories not being municipal responsibilities in Canada, the actions of cities and the urban environment have a large influence on their outcomes as well and need to be considered (Albert, 2019). This means that the Roland Berger report is slightly inaccurate in portraying this city however this seems to be a recurring theme across all 153 cities as the average dotted line is also just above zero (Berger, 2019). The reasoning is the same one city does not have control of these two variables and the cities that do, e.g., London Figure 7, have a limited impact and are usually the programs to educate the public on SC technology or measures that improve health care delivery, but in general cities do not have sole jurisdiction of those categories.

The further critiques of the city can be accounted for by the small size of the city. The '15-minute model' idea is centered around all services being available to its citizens within a 15-minute walk. The idea centers around cutting down the commute times of individuals which lowers the resources required to travel from point A to B daily (Albert, 2019). The problem cited by Nelson is that employment opportunities are diverse, and citizens would need to travel further than the designed distance, which in turn makes the model pointless (Nelson, 2023). This challenge mainly occurs in smaller communities as the density is just not there for all services of employment to be available. The model is still in its adolescence as people-driven environments within cities are slowly gaining traction. St. Albert is being built towards a 15-minute model; however, the cities understand density would need to be prioritized first (Albert, 2019). The movement within the city is however highly efficient and the present community is making use of alternative and sustainable transport. The proof will be shown in the practical application Nelson ends off with (Nelson, 2023).

In Summary, the Smart City of St. Albert demonstrates that it's not always about implementing technology and innovation to be smart. The social outcomes and health of residents need to be considered first as well as the structural backing by policy needs to be established (Berger, 2019). The important end goal should be which innovations applied will have the strongest impact on the

well-being of citizens. Practicality and return on investment are what St. Alberts uses to ensure that its implementation of projects is effective and sustainable (Albert, 2019).

4. Singapore

Singapore, lacking basic natural resources, has always relied on its intelligence and wit to prosper. The shift from an industrial economy to an information one emphasized the need for the nation to embrace and adapt the new information and technology trends (Mahizhnan, 1999). In 2014 Singapore launched its Smart Nation initiatives to leverage 4IR technology across the entire country. These initiatives are based on a system of three main pillars, Digital: Economy, Government, and Society, as shown in Figure 11 (SCS, 2020). These pillars are aimed specifically at increasing the productivity of the nation, improving the lives of its citizens, and attracting talent from outside the borders of the country (Thales, 2023) (SCS, 2020).

These three pillars support the main initiatives of the Smart Nation framework of Singapore, as seen to the right of Figure 11. These 5 main domains are urban living, transport, education, finance, and health. These core initiatives are the main areas in which technology is invested and are the categories that projects receive the most attention (Lee, et al., 2016). The purpose of this structure exhibited in Figure 10, is for the entire nation to benefit from the implemented technology and not just isolated pockets. The identified areas are noted to be the highest-impact domains in which technology usage and automation provide the largest impact (SCS, 2020).

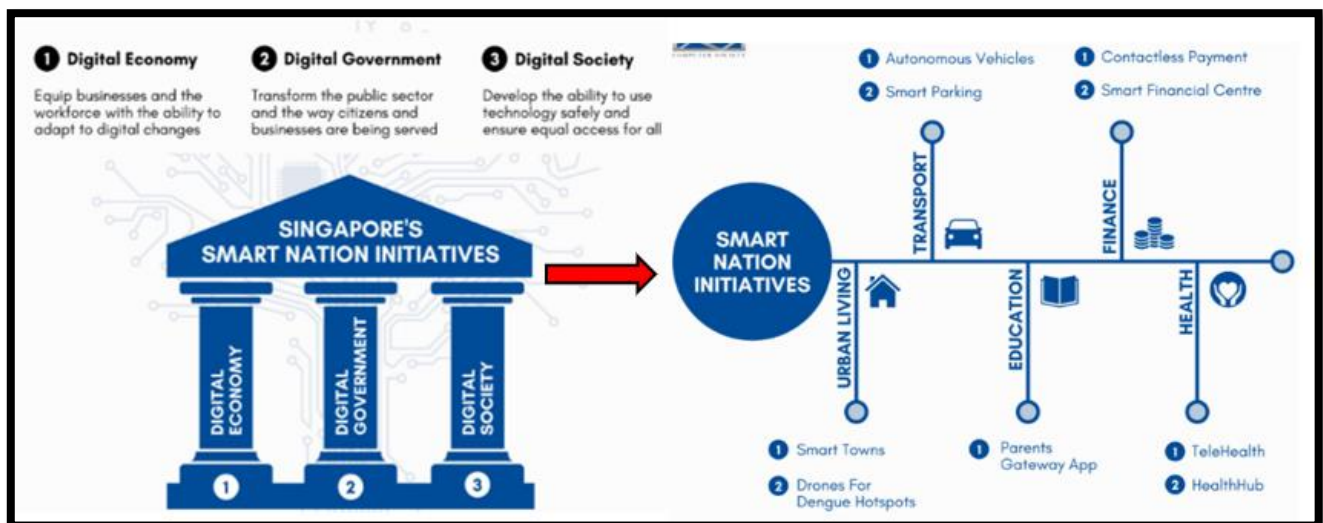


Figure 11: Singapore's Smart Nation Pillars and Initiatives

Source: (SCS, 2020), Fig 1,2 combined (Author).

Figure 11 represents the framework for the Smart Nation plan of Singapore. As the smartest ranked city in Asia, the city's blueprint can be that of a successful smart city (Thales, 2023). Understating the components would allow for a better understanding of what the Smart Nation approach is and what areas of technology have the highest success rates.

Digital Economy: The changes within the global sphere are undergoing rapid changes due to the increased integration of digitization technology (SCS, 2020). It has therefore been indicated to be a critical focus point as operations and the workforce would need to be adequately equipped to adapt to the changes that are ahead (Lee, et al., 2016).

Digital Government: This has been identified as a key driving force for the Smart Nation initiative. The backing of a strong policy that is uniform is an essential requirement when it comes to implementing smart initiatives. To achieve this, Singapore has cited the need for transformation of the public sector and the way the citizens are served by corporations (SCS, 2020). The increased emphasis on the use of more data-focused logging, computer usage, and connectivity across diverse platforms, is the focus of the government. The communication between the people and government forms the core of this pillar, as the people are the focus in terms of better attending to their service needs.

Digital Society: The implementation of advanced technologies would be useless if the people it was intended for were unable to effectively use them, due to a lack of knowledge (SCS, 2020). This last pillar of Singapore's Smart Nation plan is focused on the people who will operate in the smart environment that is being created (Lee, et al., 2016). Digital inclusion and education are the keys to building an effective digital society. Thus, Singapore has set a focus on equal access for all its citizens to technology, to promote the use of the, as well as increase the number of individuals who are adept and confident in utilizing technology in day-to-day life (SCS, 2020). This ensures that future implemented technology can be used and optimized by every citizen and not just a select few.

Smart Nation initiatives:

Urban Living: The main projects within the urban living initiatives are the development of smart towns, and the use of drone technology to optimize surveillance and monitoring (SCS, 2020). Smart towns are created by utilizing smart technology in 5 key areas, these areas are the environment, planning profession, real-estate data, living and lastly the community. These technology-driven sustainability initiatives focus on efficiency and overall quality of life changes, such as smart lighting and pneumatic waste conveyance systems (Lee, et al., 2016). The utilization of drones is further combined with this to monitor, survey, and evaluate areas. For example, Singapore is using drones to limit the spread of the Dengue plague by using drones to reach remote places to dispense larvicide to limit the breeding grounds of the disease.

Transport: The main projects within the transport realm of initiatives are the use of autonomous vehicles and the integrational use of mobile apps to further optimize parking around majorly congested areas. Singapore has over the years taken significant steps and investment into self-driving technology. The trials if proven successful could in the long run potentially help address the

manpower constraints present in Singapore, reduce the number of road accidents, and overall improve the traffic conditions of the road network (Thales, 2023). Additionally, the parking challenges of the country have seen the implementation of a smart parking app that can easily locate a nearby parking spot, make payments for parking, receive refunds if necessary, and be sent parking notifications remotely via the application (UNDP, 2023). This system has seen great success around major areas such as Funan Mall, where users can reserve parking and unauthorized parking can be tracked and removed. Overall, the application improves space efficiency and reduces road congestion for cars looking for a place to park (SCS, 2020).

Education: The main project that falls under the educational initiative is the use of online services to promote communication between parents and the school. This increases efficiency and organization as school announcements can be communicated directly to parents which overall, allows for teachers to better focus on educating, rather than being consumed with extra administrative tasks (SCS, 2020).

Finance: The main projects within the financial initiatives are centered around contactless payment methods and a Smart dedicated financial center. Contactless payment has become a staple in the present day and Singapore has extended this across all systems and is especially beneficial with the public transport services as payment and wait times are significantly reduced (SCS, 2020). This is all a part of the Smart Financial Center project which has the goal to increase efficiency, by creating a platform that can make use of the opportunities presented by technology (UNDP, 2023). Technology inclusion has been shown to open doors and improve risk management in Singapore due to the innovations implemented.

Health: The main projects within the health realm of initiatives are primarily focused on data collection and utilization. The projects of wearable bands for patients and a central health app that streamlines the entire healthcare operations center (SCS, 2020). The leader of this innovation within the health sector is the Telehealth app, which allows healthcare professionals the ability to work and treat clients remotely if needed. The latest innovations are the wearable sensor bands which can monitor patients and their rehabilitation can be more accurately tracked. The app also extends to all citizens as they can easily book appointments, access their medical records, and can easily get into various health branches all from the single app (Thales, 2023)

Singapore is a strong candidate for what an ideal SC blueprint can look like, however, it is one of the wealthiest countries in the world. The economic strength of the nation does contribute to its success and the initiatives and projects utilized, are at the forefront of innovation (UNDP, 2023). The way the city has targeted its projects is insightful as the simplicity and strength of a Smart Nation approach, is evident as the nation commits to moving forward together, instead of a sectoral approach.

The above cities are the highest ranked and serve as a base blueprint for what a successful SC can comprise. The top SCs narrowed down from the Berger ranking create a detailed scoring of each SC. The notable patterns and challenges encountered by top SCs are therefore a necessary insight into further understanding how comparable SC adoption in SA is progressing (Mzekandaba, 2023).

2.4.2 Common trends of successful Smart Cities

The common denominators of successful smart cities are primarily centered around enablers and action field criteria (Berger, 2019). Enablers are the systematic frameworks and variables that are responsible for allowing projects to function effectively on an administrative level, and action fields are the physical projects and fields that influence people or space within a city. The top cities were noted for having a smaller gap between action and enabler fields, with the latter scoring higher in terms of its implantation. This fact means that top SCs empathized with enablers as well as more ambitious activities and targets for solution areas (Berger, 2019). The cited issue from all SCs was that very few had comprehensive approaches to action fields, with the necessary enablers. For example, less than 10% of the 153 cities were able to reach a 60-point threshold for their enabling activities of the environment, for the action fields of health, education, and buildings, while no more than 20% reached the figure for the other three action fields of government, mobility and “energy & environment.” These scores are detailed in Figure 12 as seen below.

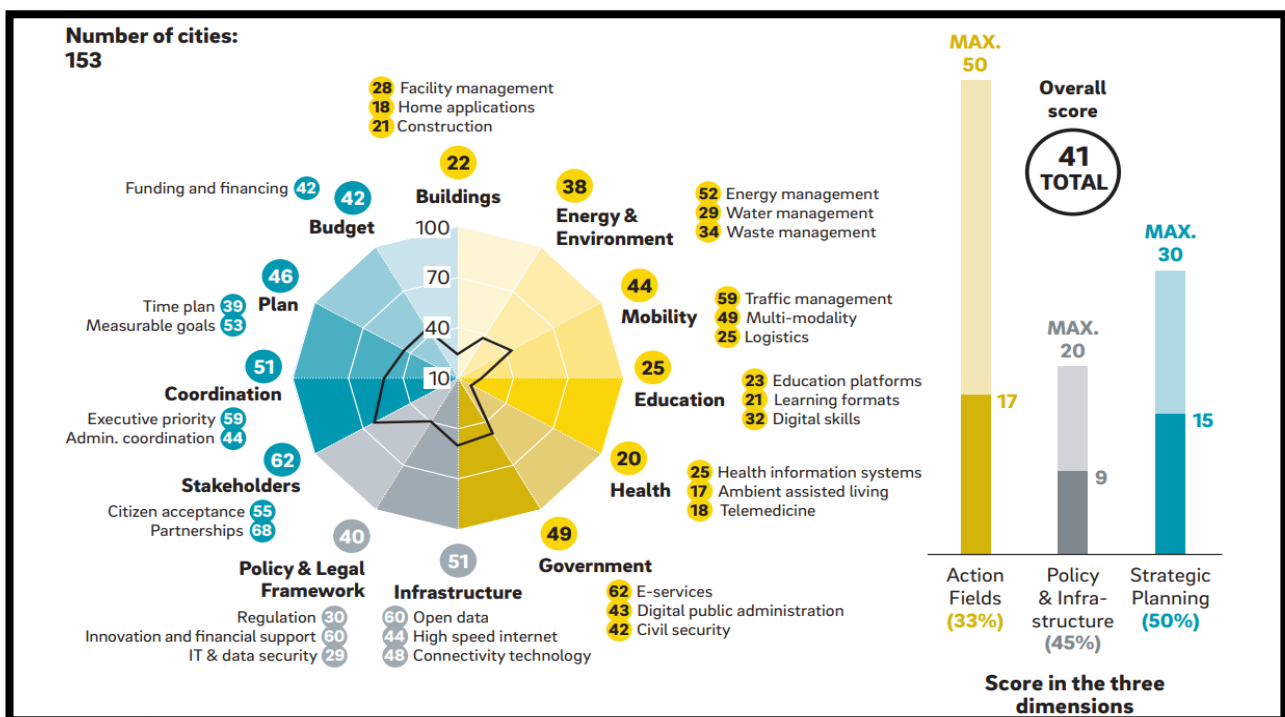


Figure 12: Average scores across all fields of smart cities investigated
Source: (Berger, 2019)

The above diagram indicates that world averages within the three dimensions, show a clear lower score from the action fields when compared to the other two dimensions. This common trend is accounted for by some SCs not having control of these fields, e.g., St Alberts SC case, or that only

the top 15 cities have completed or piloting flagship projects (Albert, 2019) (Berger, 2019). The success of higher-functioning smart cities is therefore closely tied to the city's ability to enable its projects. The ability to implement piloting projects is a combination of sufficient policy, infrastructural, and strategic planning frameworks (PwC, 2020).

Another trend that stands out across all the major successful SCs, is the similar structure of the frameworks that each implements. This similarity between frameworks stems from the White Paper Model that Denmark's State of Green proposed (UNDP, 2023). The leading SCs do not explicitly use the White Paper model, but they are aligned with its principles since they prioritize environmentally friendly practices and sustainability within their SC initiatives (Kim, 2022). The White paper document overall is a comprehensive literature that provides an overview of the main concepts of SCs. It is a document that highlights key considerations for successful implantation and serves as an intended guide for policymakers, stakeholders, and urban planners, who are interested in harnessing technology to create cities that are more livable, efficient, and sustainable (Green, 2023). The White Paper was not made for any specific nation or region and therefore its principles have been adopted by many nations (Hexia, 2018). The base of its proposed framework is shown in Figure 13, which is the original model utilized by Denmark's SC framework.

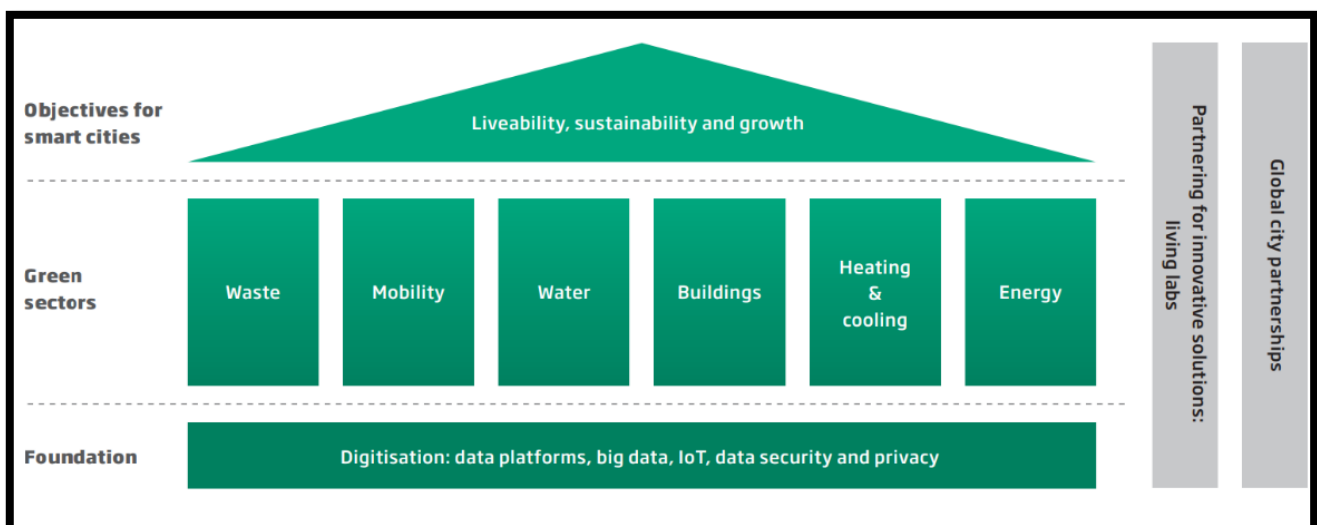


Figure 13: Framework for Smart Cities White Paper

Source: (Green, 2019).

The above figure is the white paper SC framework, which is structured like a house and the headings represent the role each sector plays in the framework. The foundation comprising elements associated with digitization forms the base of the 'house' as they are the core structuring elements that support the above initiatives. The green sectors act as the 'pillars' that support the above 'roof' that are the objectives of the SC (Green, 2019). The diagram resides at the start of the white paper

document and each label is elaborated on in-depth, however, the core principles of the model and its house reference are what successful SCs take away from the figure (Green, 2023).

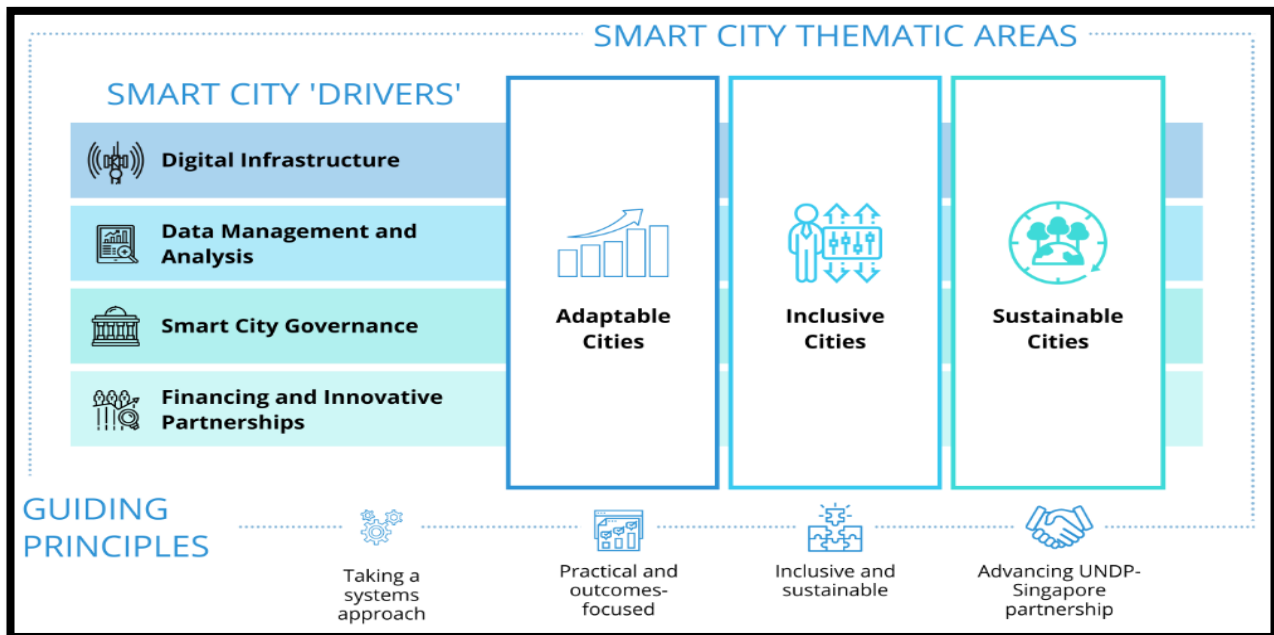


Figure 14: Smart City Framework from the Smart Nation Singapore plan
Source: (UNDP, 2023).

A good example of this can be seen in Figures 11 and 14, which are both from the highly functional SC of Singapore. In both diagrams, the core principles of digitization supporting smart initiatives are evident, as well as targeted objectives from the key pillars, which seek to obtain objectives that are geared toward sustainability, livability, and growth. This example is a common occurrence among the top SCs, as they adhere to the guide and adapt according to their situation. This type of adaption from a guide is what makes these top cities stand out from the rest, as they take an active stance to peruse models that are beneficial to them (Nyagadz, 2022).

The common trends extend beyond just the similarities between the frameworks of these successful cities. The top cities also incorporate similar technologies that are currently available to them, as the advantages they provide are approaching a level where the outcomes of installation are fixed rather than unpredictable as they were in the initial stages of implementation (Dong, 2023).

2.4.3 Common Initiatives from Successful Smart Cities

Searching across the top SCs around the world reveals common trends in the initiatives that these cities utilize. The information from the literature covers hundreds of different technologies, however, these can all be grouped into common areas of interest that make it easier to understand (Berger, 2019). The grouped areas resemble that of the components of a smart city and the focus areas of frameworks. A trend can be attributed to cities understanding what is necessary for progress in terms

of creating a functional SC (PwC, 2020). The following areas are the most common initiatives that were noted in the literature of highly functional SCs.

The underlying base of initiatives is the **Internet of Things (IoT)** sensors and devices, that collect and share data across and on various aspects of the city. These digital sensors are an essential part of a 4IR SC and are present across all cities (Facilitator, 2021). This information is processed as **Big Data Analytics**, which has large amounts of data collected by these IoT devices to gain insights and make informed data-driven decisions. These two areas work in harmony and are synonymous with all initiatives (PwC, 2020). These functions are what drive SC creations and are adapted into components of a city to optimize them (Farjood, 2021). Surrounding these main initiatives is the understanding of their point of vulnerability to a system in terms of security. **Data Security and Privacy** is the next area, which is common across successful SCs, as the presence of robust measures to protect citizen data and ensure cybersecurity within a city's infrastructure, is essential (Facilitator, 2021). Data-driven and dependent systems are vulnerable to attacks or tampering, therefore, to ensure smooth operations and a risk-free environment, measures to counter threats are present in top-ranking cities (PwC, 2020).

On top of these initiatives are the common technologies within the infrastructure of successful smart cities, one city does not necessarily possess all of these initiatives but on average these are the most reoccurring utilized ones. **Smart Grids** are associated with efficient energy management systems that integrate renewable sources and optimize distribution within a city (Madangombe, 2019). This is normally paired with the latest technology being commonly used called **Intelligent Street Lighting**. These adaptive lighting systems adjust based on real-time conditions to save energy and enhance safety at night (PwC, 2020). This Smart grid system being paired with intelligent streetlights caters to a variety of additional services, such as supplying power to electric cars, recording traffic flow, providing public Wi-Fi, collecting environmental data, and even as far as measuring how full a bin is, which is being utilized in Zurich, Switzerland (Halliwell, 2021). This technology is further utilized to give rise to **Intelligent Transportation Systems**, which make use of a variety of sensor technologies for managing traffic flow, monitoring and reducing congestion as well as improving safety through faster response times to incidents (Vyas, 2019) (Ornetzeder, 2008).

This instillation of technology within the infrastructure is commonly then attached to **Smart Buildings** that are equally equipped with energy-efficient systems and smart access controls for optimized energy consumption (PwC, 2020). These buildings are also commonly surrounded by **Smart Waste Management** monitoring, which are IoT-enabled systems for optimizing waste collection and disposal in and around the cities' alleys and movement paths (Green, 2019) (Perrin, 2021). Then internally of buildings and along major pipe arteries are **Smart Water Management** technologies, for efficient

SC projects are case-to-case projects and even between the most successful SCs, the commonalities between them are only on core principles and focus areas. The physical technology utilized may be similar in principle, but cities optimize what they are challenged by and do not install technologies where they are not needed (Patel, 2019). Cities are different from one another due to many factors such as geography, political environment, resource availability, etc. therefore the operational SC model that is tailored for the city will be different as well (Ferro, 2021). There is “no one size fits all approach,” available and all cities need their cases assessed if they want to have a successful SC transition (Halliwell, 2021).

With these trends and information from successful smart cities being covered, this gives a good indication of what to search for when covering the SA position with its SC programs. This insight allows for a narrowed search for what is important for an SC to be functional and what common challenge areas are being combated by the implemented initiatives. Understanding these areas will better assist in focusing the research of SA planning and its SCs.

2.5 South Africa's Smart Cities

When the country is compared to the context of other African countries, SA has a unique set of spatial challenges that are usually separate from the conventional African ones (Kotze, 2014). The apartheid past still taints the country even after 27 years of democracy and to right the wrongs of the past, is the focus of many spatial projects in the country. These challenges can be attributed to the rapid rate at which SA has grown which is one of the reasons the country is facing poor sustainability (Kotze, 2014). The dominant factor presented in the context of the country, however, is its widening inequality gap. The poverty present in the country, above all the other issues and statistics, is the main hurdle to overcome as the top 10% of SA holds roughly 60% of the country's wealth (Seery, et al., 2019).

The current state of the country leaves many to question the country's position and the value of investing in 4IR and SC frameworks (Gumede, 2022). These costly initiatives will divert the limited funds of the country to wishful ideas that could be spent getting the basics right first (Balkaran, 2019). This creates an issue where there is a divide in opinion for what direction the country should go. The hesitation to fully commit, whether by the government, stakeholders, or the people, means the country is lacking full cohesion and slow meaningful progress will be the outcome (Ferro, 2021).

2.5.1 The South African Smart City Blueprint

Between the different sectors of government, the consensus on the SC topic is that the country should build new ‘smart’ cities. “Has the time not arrived to build a new smart city founded on the technologies of the Fourth Industrial Revolution?” (Mzekandaba, 2019), a question by President Cyril Ramaphosa in his State of the Nation address to the country in 2019. This indicates that the direction set by the government is towards the country's participation with 4IR technology and SC frameworks, however, the Covid-19 pandemic delayed plans, as mentioned previously the country was set back due to the

slow recovery of its economic model (Sekyere, et al., 2020). The country therefore in 2022 has a divided mindset post-Covid as now the need for such an investment is being called into question. With the basics such as sanitation, electricity supply, employment, and adequate education struggling to be provided, the investment into the 4IR runs the risk of being a waste of time (Olaitan, et al., 2021). Balkaran states that “there is a considerable distance between the vision and the reality on the ground,” which shows the disconnect between the government's vision and what is occurring on the ground (Balkaran, 2019).

These thoughts are circulated in the media with the general thought being that “Taking on such a large public debt burden when the GDP-to-debt ratio is already strained, does not seem advisable,” (Philipas, 2020). The result is the country is not fully committed to the adoption of the 4IR, which adds to the challenge as the Smart Governance component requires a uniform commitment from both the people and the ruling powers (Backhouse, 2020).

Since February 2021, the country has conceptualized three smart cities that are labeled as “new post-apartheid cities, “ (Ragoasha, 2021). These smart cities are the Lanseria master plan, the Durban Aerotropolis, the Modderfontein Smart City project- proposed but never commenced, and the Mooikloof mega-city project. The country also recently published a guide titled “A South African smart cities framework,” which serves to function as a decision-making aid on smart cities for planners and government. This document and the three smart city projects will briefly be covered to form the country's context with smart cities.

The Lanseria master plan

This SC focuses on the use of Transit Oriented Development (TOD) and Sustainable Urbanism for the greater Lanseria area, located northwest of Johannesburg. This SC plan is in the preliminary stages and has only recently had the plan approved by the council (Parker, 2022). This 182-page document consists of a detailed plan which makes use of the SC components discussed previously, that a successful SC city would need to have. The goal of the master plan is to make a “Transformative city structure for true social and economic inclusion; Re-industrialization of the city economy; Adaptive and resilient to change and Modernizing to be more internationally competitive,” (GAPP, 2022). This SC plan is on schedule however, securing a loan is its latest obstacle, and “To get the project off the ground, innovative financing solutions would be needed,” as “It's not within the domain of the fiscus to be able to support the R15-billion needed,” (Parker, 2022). This means the current development of the SC is still on a document and principles-based level.

Durban Aerotropolis

This SC was conceived as early as 2015, adopted by the provincial cabinet in 2017, and launched in February 2018 (EDTEA, et al., 2018). This 50-year master plan is built around the newly built airport of King-Shaka International. This project seeks to drive transformation through the aerotropolis model.

The master plan creates a “favorable physical environment for investment through integrated and coordinated spatial planning,” and includes,” integrated multimodal transport networks, place marketing, infrastructure, and engineering services, “that intend to create, “environmental sustainability,” (EDTEA, et al., 2018). The detailed 300-page document uses graphics to its advantage and is up to the standards of similar 1st world documents (Ngwenya, et al., 2022). This project did suffer from the setbacks of the Covid-19 pandemic, however there “is evidence of early positive socio-economic impacts including employment creation, growth in imports and exports and the creation of a competitive environment,” (Ngwenya, et al., 2022). Figure 10 demonstrates the attention to detail of the master plan as SC projects evidently from the literature, rarely have detailed site maps to accompany them.

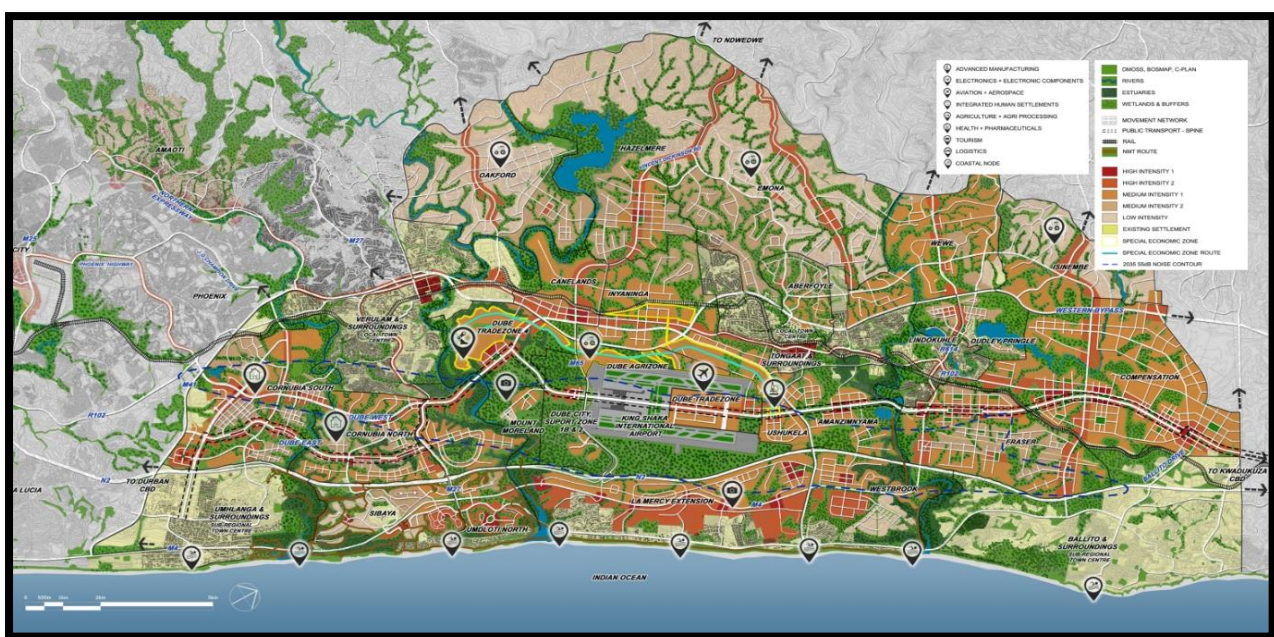


Figure 16: The Durban Aerotropolis Master Plan map

Source: Durban Aerotropolis Master Plan Report - July 2018- page 5- (EDTEA, et al., 2018)

The SC plan for Durban makes use of the SC components mentioned previously and covers an in-depth context of the area. The shortcomings in the literature, however, did limit and expose noteworthy issues. The data information used by authors was mostly based on 1st-world country data as SA lacks long-term data statistics regarding the economic impacts of SC initiatives, data collected that is presently available for the country are pre-Covid pandemic and are inaccurate and lastly there are few individuals presently who have worked with the metropolis, which means the sample size of information is small as well as a sign that the project is largely inactive currently (Ngwenya, et al., 2022) (EDTEA, et al., 2018) (Mzekandaba, 2019).

Mooikloof mega-city

A recent plan which has been classified as “the largest housing project in the country to date,” is a wide-scale mega-city project that seeks to supply affordable housing to the middle class of the economy (eNCA, 2020). The R84 billion smart city project has a projected completion date of 2030, with phase one including “50,000 sectional units,” since housing is the focus of the project. The plan also includes projects for schools, shops, and offices, intending to make the city as green as possible. “Buildings are fully green-classified, and we are managing to get solar in there, water, black-water harvesting among other green features,” is a statement made by one of the managers overseeing the project (Naidoo, 2023). This city project does not fall under a conventional SC framework as there is no main document as far as the literature is considered and the project is not technology-focused. The city plan can be considered smart due to its green and sustainable approach (Balwin, 2020).

To date, the project is set to be completed by 2030 however the managing business of the residential housing is still in talks with the government to secure sufficient water and power for the project (Mahlangu, 2021).

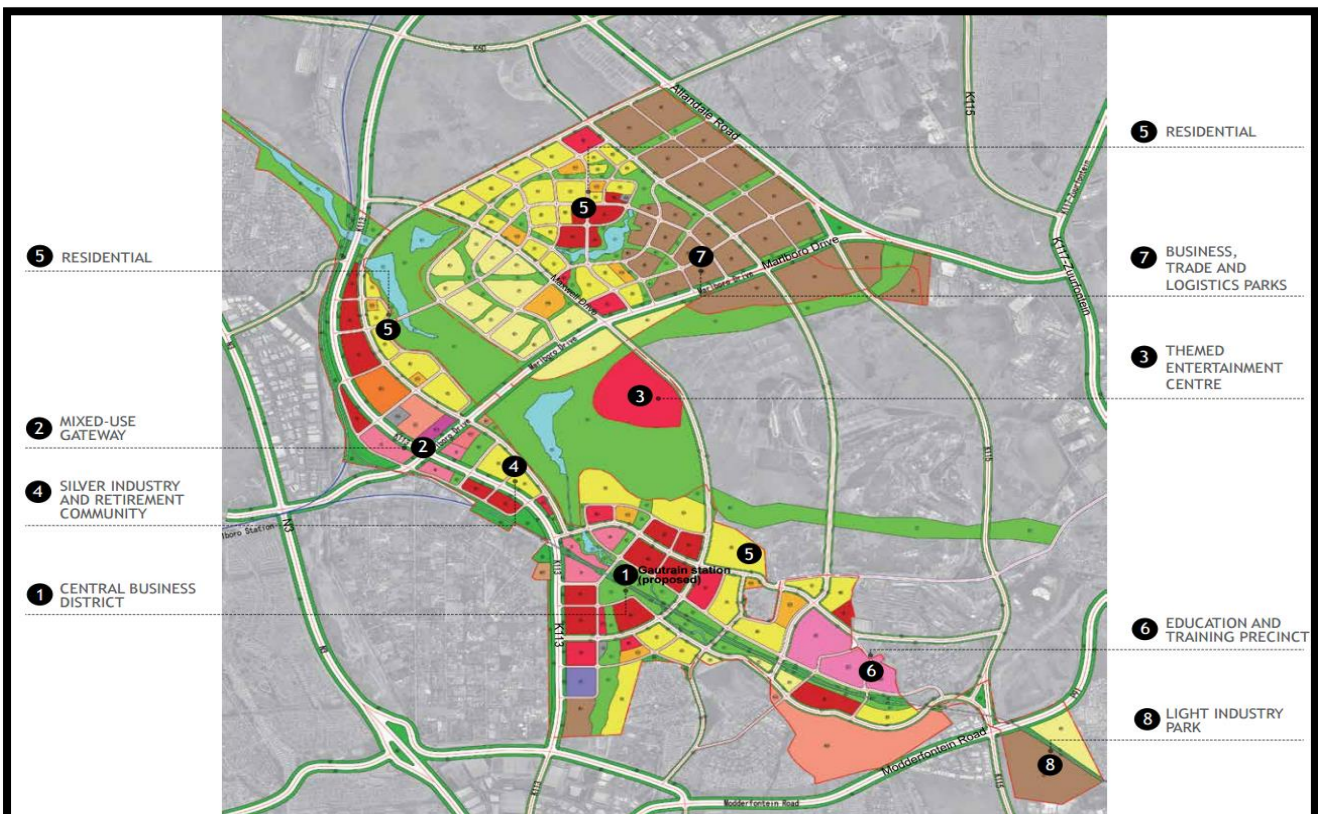


Figure 17: Mooikloof Mega City Master Plan map
Source: Project Details Mooikloof- Greendale, PPA26059, (Naidoo, 2023).

Modderfontein smart city

The planned smart city (figure 18) was a major development project in Modderfontein and was undertaken by the Chinese firm Shanghai Zendai. With an estimated cost of R84 billion, it would span across 1,600 hectares of land and is expected to be completed over 15 years. The master plan of the city includes various facilities such as a central business district, a sports and international conference center, a library, a hospital, churches, medical facilities, schools, and low-cost housing. Upon its planned completion, the smart city would accommodate around 30,000 families and produce up to 200,000 permanent jobs, offering employment opportunities to the surrounding local community. The project aims to create a self-sustaining community that offers a wide range of amenities and services for its residents.

Figure 18: Modderfontein Smart City Master Plan map.
Source: (BuisnessTech, 2015), figure.



In 2015 however, shortly after construction began, the project faced financial troubles and was ultimately abandoned in 2017. The reason for the failure of the project was cited as conflicting visions between Zendai and the City of Johannesburg council, as well as the low demand for housing and office space in that area. These two factors contributed heavily to the termination of this SC project. The city of Johannesburg wanted a more inclusive development, while the Chinese-aligned company Zendai remained committed to its originally agreed-upon vision. Ultimately, the project did not align with the city's real estate market and for this reason, faced huge financial difficulties.

The failure of Modderfontein highlights how African "edge-city" developments can be influenced by local government and the need to adapt to the existing urban context rather than push for 'wishful' projects that far exceed capacity. Similar developments across Africa have, however, also faced similar challenges as large-scale SC projects divert resources from the marginalized areas and lead to the impoverished not receiving the adequate services that they already struggle to get.

South African Smart Cities Framework (SCF)

The 38-page document "was developed by the Department of Cooperative Governance (DCoG)," to provide, "municipalities, national and provincial government, the private sector, civil society, and other role players," with updated guideline information," for smart cities in South Africa," (DCoG & CSIR, 2021). The SCF intends to aid the "decision-making process that would ultimately result in the identification of smart initiatives and technologies that are appropriate to the local context." The guideline utilizes the principles of Backhouse and the components suggested for a "successful smart city," (Backhouse, 2020). The document confirms the challenges the country faces mentioned previously and recognizes the importance of the country context for SC development (DCoG & CSIR, 2021). The SCF contains a useful analysis of the country within an SC context. The most notable being that "during the 2018/19 financial year, only 20 out of 257 municipalities produced financial statements and performance reports of acceptable quality," and then, "2017 SAICE scorecard, public infrastructure received an overall grade of D+," (DCoG & CSIR, 2021).

Apart from the information within the document itself, there is limited literature available on the SCF, so it is uncertain to what extent it is in use currently. It is noted that this document was published after the above-mentioned SC projects were initialized which accounts for its absence of mention. The SCF forms a guideline for SCs in SA that is easy to understand and follow, to act as a formal document for the country within the complicated topic of the 4IR and SC movement.

Figure 19 represents the framework of initiatives and indicators that the DCoG developed for the SCF, to ensure that the necessary information provided, was impartial and accurate for the key role players who implement SCs in SA (Chetty, 2022) (DCoG & CSIR, 2021). Figure 19 is in line with the overseas frameworks of figures 13 and 14, which is a strong indication that the country is learning from others. SA on a documentation level is strong and up to date with the world, however, on a practical scale, it leaves much to be desired as the country struggles with many challenges and sustainable implementation (Mulholland, 2022) (Mzekandaba, 2019).

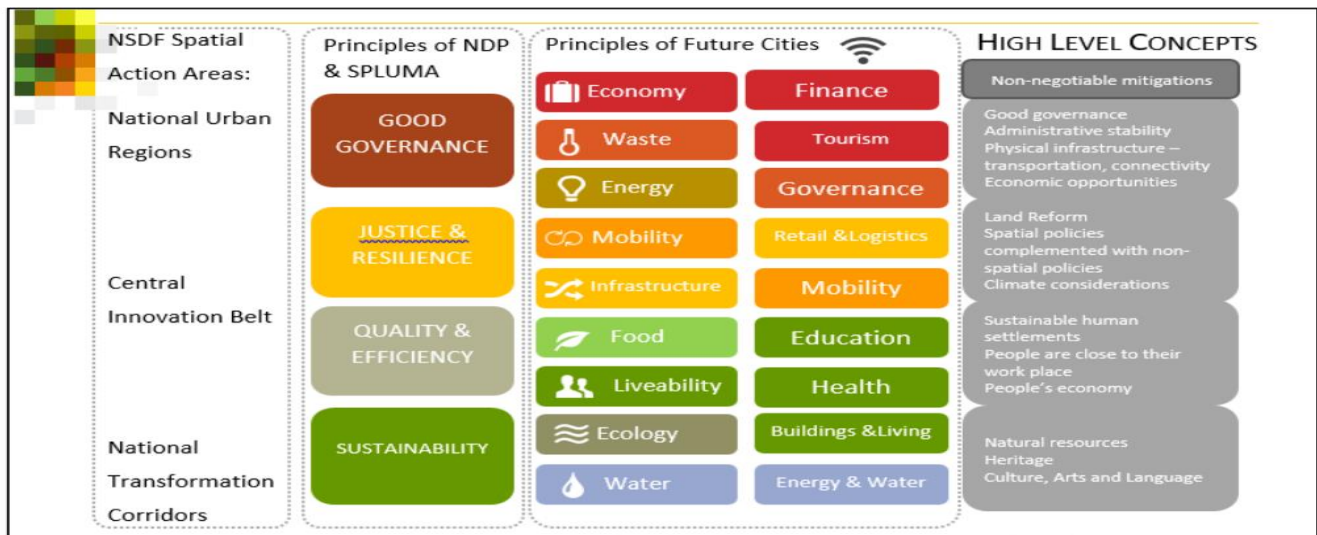


Figure 19: DCoG draft targets and indicators for the SCF Initiatives 2022
 Source: Smart Cities readiness report, figure 1, Pg 6, (Chetty, 2022).

2.5.2 Implementation and Challenges in South Africa

The understanding of what makes a successful smart city function allows for a blueprint to superimpose over a given nation or city. No shoe size fits all (Halliwell, 2021) but the above information indicates that the commonalities between SCs allow for certain patterns to emerge, in terms of where to search. Already figure 18 gives an example of the types of struggles that the country faces in terms of implementing projects effectively. The outcome of the project prompted the next section that is to investigate what are the major challenges that face the country concerning the 4IR and SC implementation. This information establishes what is understood about the country's situation and what it would mean in terms of answering the research question effectively. This section focuses on what inhibits the country's current progress and what this means for its planning profession. This will lead to what the gap in the literature is as all the necessary information would have been acquired. The first is to establish the wider picture which surrounds the country to determine its situation concerning its wider context challenges.

2.5.3 Africa's innovation progress

The African progress in terms of innovation will accurately establish the circumstances that surround the study area of South Africa. A report titled "Foresight Africa: Top priorities for the continent 2020-2030" includes a discussion of the African perspective on 4IR innovations. The 5th Chapter of the document focused on the attributes that are required in "Capturing the 4th industrial revolution," in Africa (Asmal, et al., 2019). This detailed report does support the substantial "Transformative potential of 4IR in Africa," however it raises concerns in several areas of the content (Asmal, et al., 2019). These highlighted sections will narrow down the focus/search for when the South African environment is investigated. These crucial areas identified are where the continent is struggling in terms of 4IR participation, therefore this information is used when considering the areas required to be investigated for this study.

Information and Communication Technology (ICT) development indicators are the primary measures used to judge Africa's readiness for the 4IR. Figure 20 is a set of tables that indicate the current position Africa has in several essential indicators required for 4IR interventions. These ICT indicators cover the areas of technology access, use, and preparedness. This is compared to the world, developed countries, and developing countries' positions. These tables focus on the sections of education, infrastructure, and technology access. These focus areas fall under the SC components of Smart people and infrastructure, which further reiterates the importance of having an operational SC framework (Backhouse, 2020). This information emphasizes these two components but due to the interconnected nature of an SC framework, these components would also require the other parts of the framework to still be operational (Mhene, 2019) (Madangombe, 2019).

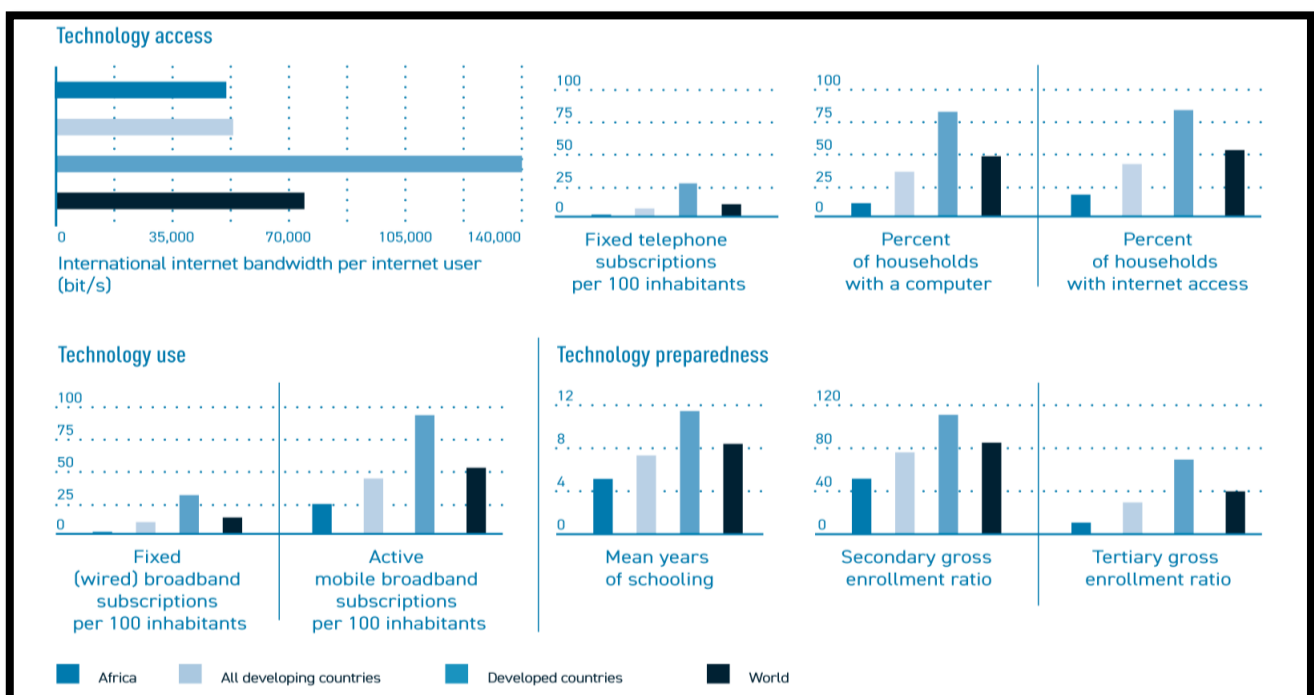


Figure 20: Africa's development indicators with ICT

Source: Hebatallah Adam, "The Digital Revolution in Africa: Opportunities and Hurdles." Measuring the Information Society Report: Volume 1 (Geneva: International Telecommunication Union, 2018).

Figure 20 shows that Africa is behind on the essential indicators for 4IR initiatives, especially in the areas of education, infrastructure, and technology access. This information shows that access to the internet, communication devices, and school enrollment 'is behind in Africa compared to the rest of the world. These results are not necessarily a reflection of the South African (SA) context however, it does indicate what the country's global image is tied to. The areas used to measure 4IR preparedness are tied to ICT's integration and reinforce the narrative that the 4IR is thought of as a technology-centered movement.

In short, the African continent is in a difficult position where it indicates that it is not ready for 4IR intervention statistically, however, it needs to participate to remain relevant on the global stage (Sello, 2019). This scenario creates a situation where nations within the continent venture into the 4IR with limited means to do so. This backdrop of Africa has highlighted key areas that will be focused on when South Africa is now investigated to measure the potential of the 4IR. It has been noted that the environment in which technology is implemented, plays a huge factor in determining effectiveness, as well as the present state of the country and its planning system are equally major determinants when considering 4IR potential.

2.6 South Africa's major challenges

The country's position in terms of the factors that affect the adoption of 4IR technology and SC components will be investigated next. For a full understanding to be achieved both the country's stance and the planning system will be covered. These are the key areas that determine the potential participants that the country can do within the 4IR and SC movement, due to the former acting as the context and the latter as the driving mechanism for implementation. For this reason, the following sections investigated will focus on the major challenges facing SA, since these are the areas that limit and determine to what capacity the country can accommodate the 4IR and SC initiatives bring, and the present planning system with how it is structured as well as its present setbacks.

The major challenges within the country are deep-rooted and do not have any fast solutions (Sello, 2019). The following areas will need to be taken into consideration in the context of 4IR and SC initiatives. These challenges are the most relevant to the context of the research and were identified through the required operational components of an SC framework, the African emphasis on ICTs and the associated variables used, and lastly factors that are considered in planning literature, most notably sustainability, social and economic factors.

A) Service delivery and state legitimacy are being undermined by corruption

There can be no debate if there is corruption within South African public services. This has been openly admitted by the trade union movement and government leaders (Naudé, 2022). The act of corruption in the country "diverts funds into private pockets," and leads to numerous challenges which "perpetuate poverty, inequality, and unfairness," (Mulholland, 2022). The main culprit is the government, which in this case is "the group of people with the authority to govern a country or state," (Mubangizi, 2019). This issue has been noted to be getting worse as there is insufficient coordination between the SA public service across many sectors and anti-corruption work (Pillay, 2004). The country has been quoted to be considered "rudderless," as "under-qualified staff whose aim seems to be to get rid of as much money as possible as quickly as possible," (Mulholland, 2022).

B) Inadequate infrastructure

The subsequent corruption within the government has had a profound impact on the infrastructure of the country. SA is at risk of experiencing multiple system failures within the transport, water, energy, and sewage sectors. Of the 824 water treatment plans across the country, only 60 release clean water. The budgets for the public transport sector are investing substantially more into repairs of ill-maintained systems rather than investing in building new transport infrastructure (Olaitan, et al., 2021). This has resulted in more than 70% of SA industrial cargo being transported by road, since the collapse of the rail infrastructure. “More than 60% of the country’s sewage and wastewater treatment works have been classified as in a poor or critical state,” (Gumede, 2022). The energy grid suffers from rolling blackouts due to poor maintenance of power stations and investments in alternative renewable energy sources. The result finds the country to not have a functioning integrated public infrastructure system and the real risk of the collapse of a large-scale system (Seery, et al., 2019).

C) The distribution and quality of education across the country

A report published in “Education at a Glance” 2022 (EAG) indicates that SA “has one of the most unequal school systems in the world,” (EAG, 2022). The top 200 schools have more distinctions earned in mathematics, compared to the next 6,600 schools combined. According to the Organization for Economic Co-operation and Development (OECD), the gap between the top 20% of schools compared to the other 80%, in terms of results, is the largest in the world. The country is ranked 75th out of 76 compared to the mainly rich nations and only 15% of the population has a tertiary qualification compared to the average of 47% across OECD countries. The present educational environment within the country leads to the country struggling to produce large amounts of skilled labor. This shortage leaves the country vulnerable when skilled labor immigrates or is “poached” by overseas countries.

D) A divided society and the lasting impacts of the past

The challenges which have been caused by the apartheid legacy are a key obstacle within the context of the country. “Despite positive strides made in the country since 1994, the South African society remains divided.” “The social, psychological, and geographic elements of apartheid continue,” (Mthethwa, 2020). Despite 28 years since democracy, the deep-rooted nature of the apartheid system still plagues SA. Social and spatial challenges due to this system are still being felt in the present day. Poorly located infrastructure slows down economic growth and limits social inclusion. This leads to a growing housing crisis as Reconstruction and Development Program (RDP) housing is being left abandoned due to being poorly built and placed far away from the opportunities of the city (Levenson, 2014). This creates long-term problems as despite there being a lot of land in the country, there isn’t enough housing being provided that caters to the growing percentage of people in extreme poverty. Extreme Poverty is defined as having less than \$1.90 of income per day, and by this definition, 18.2 million SA people live in extreme poverty.

The country also has a growing urban population which on average has been increasing by 2.3% per year since 1960 and is currently 67,85%. This migration of people into urban areas increases the number of urban challenges due to the influx of people pushing these areas to their limits. The split priority of addressing rural areas housing while also solving complex urban challenges on top of outdated spatial systems has led to many uncompleted or abandoned projects and is one of the reasons the country is having sustainability issues due to mismanaged resources. The combination of spatial challenges and social inequality present in the country means that these obstacles are a systematic part of the country's context.

E) Geographic difficulties

The geographic layout of SA is a crucial part of its context as it is riddled with many challenges. The Drakensberg and Karoo mountains divide the dry interior from the moist coastal regions. These coastal regions capture most of the annual rainfall of the country which means there is a water distribution imbalance. This imbalance is further complicated by the country only receiving on average 497mm of rain a year, which classifies the country as a water scare. The natural features of the country determine many crucial factors that make up the context of the country (Sello, 2019). The distribution of natural resources such as gold and coal is situated predominantly in the interior of the country. This distribution in the interior and the country's history of trade ships stopping over at Cape Point, has led to two main economic hubs being formed (Mahlako, 2016).

The main cities of Cape Town and Johannesburg are the main development points in the country. The province of Gauteng produces one-third of the country's Gross Domestic Product (GDP). This layout causes many challenges when it is accompanied by the country's size. South Africa is "5 times the size of the UK," which means land is not an issue in the country, however, the distribution of wealth, natural resources, and the scarcity of water has led to a layout that centers around a few key nodes. "There may be plenty of lands," but land that is positioned, "in strategically strong locations," is limited (Kotze, 2014) (Nwauche & Flanigan, 2021).

F) The digital divide

"South Africa's digital divide can be broken down into three factors: access to hardware, understanding digital means of communication, and internet affordability," (Mlaba, 2021). The access to hardware in the country is not only inadequate but also its distribution is unequal. A report conducted that investigated how to bridge the technology gap in SA found that 10% of households have personal internet access and 35% said they had seen no reason to want to access the internet (Reports, 2021). This is supported by figure 7 which shows that most households must access the internet from another location. This data also shows that the provinces of Gauteng and Western Cape, have a marginally better percentage of households. These provinces are the main economic hubs and have a higher percentage of wealthy people and developed infrastructure.

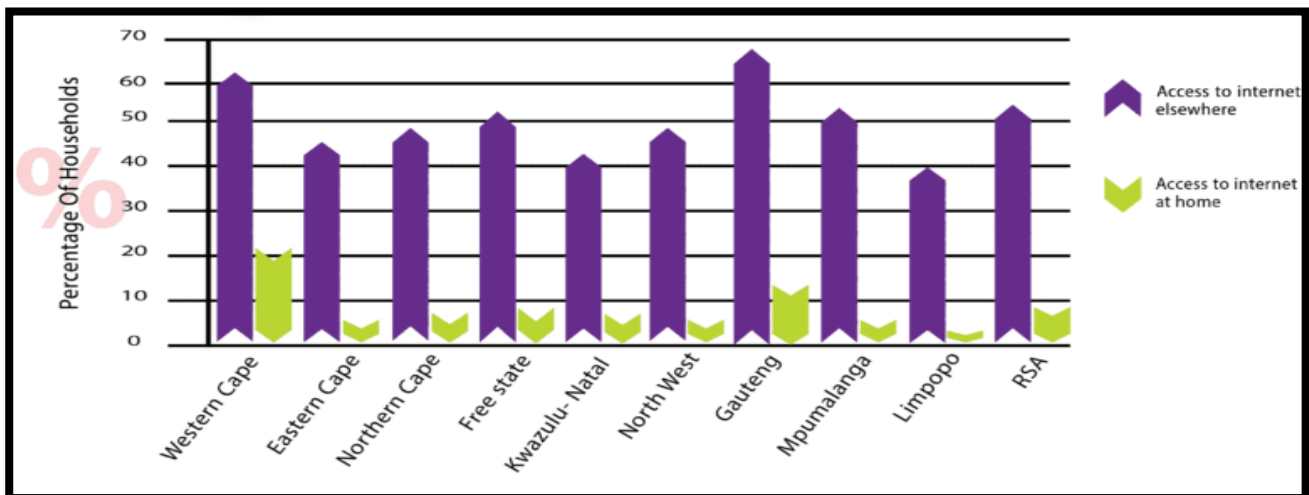


Figure 21: Percentage of households with access to the Internet by province in 2021

Source: General Household Survey of Statistics South Africa, Graphic designed by IOA.

The lack of access to and presence of technology systems is due to several factors that also stem from the reasons mentioned above. The education system and its shortcomings create more individuals who lack the awareness of the digital means available to them and the understanding of how to operate them to the intended efficiency. The affordability of these services also contributes to the decreased use and inequality of technology as, “7.5 million low-income South Africans are paying 80 times more than middle- and upper-income citizens for access to the internet,” (Mlaba, 2021). The fact remains that “people with higher incomes are more likely to get a good education,” and will therefore, be equipped with the skills “related to technology and digital literacy,” (Reports, 2021). This means that the technology divide is also a contributor to the inequality gap that is slowly widening each year.

G) Low technology innovation score

The innovation index is a global measurement of the level of innovation within a country. The score given to each country comprises 80 indicators, which include measurements from education, infrastructure, the economy, the political environment, and knowledge creation. The world average is 34.3 and the metric helps monitor the performance and benchmark countries against similar economies within the same regions of index score (WIPO, 2022). SA has a global index of 32.7, as seen from Figure 1, the country is below the world average of 34.3, which indicates that the country is lacking in the two key pillars of innovation output/input. This statistic shows that the country is behind in its institutions, infrastructure, business sophistication, market sophistication, and human capital. This data by the Global Economy standards also indicates that the “sub-index-based pillars,” comprised of creative, knowledge, and technology outputs, are also behind in SA. These statements are in line with the factors mentioned above which indicates that they are accurate assumptions even though they are based purely on data indicators. It is worth mentioning that similar developing

countries such as Brazil with 34.2 and Russia with 35.6, have similar innovation index scores (Ferro, 2021).

The obstacles in the country form a large part of the context of the country. For the study, these factors will need to be considered when investigating the potential of the 4IR and SC principles. These obstacles will play a crucial role as they will have to be factored into solutions when they are proposed since these limiting factors are entrenched in the country's context. The next section to be established is the status of the planning system and planners in SA. The ability of the planning body and the documentation available that governs planners and the two study areas being invested are the last sections that make up the SA context.

2.6.2 The shortcomings created by the challenges of the country

The SA economy is recovering slower than predicted, from the effects of the COVID-19 pandemic (Bank, 2022). Growth for 2022 was roughly only 1.9%, the labor market remains challenged, poverty is greater than it's been in a decade and inflation is at a "13-year high." The country's position was already weak before the pandemic with an average of only 1% in growth between 2012 and 2021. This led to a "contraction of income per capita of 5.6% during this period." These economic factors are accompanied by longstanding structural constraints, which importantly see the country have electricity shortages (Fengler, 2021). These structural challenges hinder the medium-term growth of the country and most of its net income is sourced from exports of raw minerals (Asmal, et al., 2019).

SA has limited skilled labor available as only 15% of the employed population has a tertiary qualification, 31% have completed secondary education and just under 50% have not completed their matric (Laubscher, 2018). "South Africa was rated 126th for the quality of the country's primary education system, 134th for higher education and 138th for science and math's education at the World Economic Forum's Global Competitiveness Report 2016/17."

The education system presently creates a large skill gap within and for the upcoming labor force. Unemployment in the country is on a steady rise, currently sitting at 33.9% and 46.5% for youth unemployment at the end of Q2 of 2022. This combination of poor education and high unemployment leads to a situation where the available workers in the country, are classified as only "semi-skilled." This is visually depicted in Figure 6 where most unemployed workers have not finished secondary education.

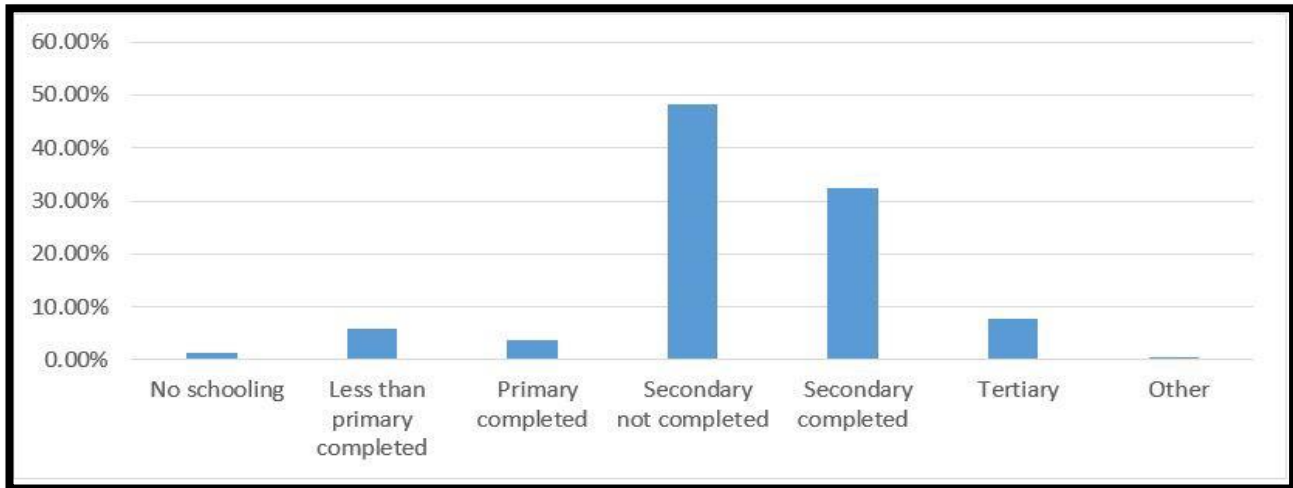


Figure 22: Level of education of the unemployed in South Africa

Source: StatsSA online data set of the education level of unemployed.

The skills present in the employed labor force are divided into 25% being skilled labor, 46% being semi-skilled and 29% being low-skilled (Writer, 2022). Skilled labor is also emigrating out of the country, faster than it is being produced (Halstein, 2021). This is due to the limited opportunities for skilled labor presently available in the country and the above-mentioned state of the country. These factors lead to skilled workers seeking out opportunities overseas and in turn, are a significant contributor to the limited skilled labor available.

The present statistics of the country detailed above form the outcomes of the major problems that have a role in hindering spatial development progress within SA. These challenges along with the country's progress to technology integration create the present environment of the country. The next section to be looked at within the SA narrative is the impact all the above have on the country's planning system. The purpose of this section is to establish what planning mechanisms are in place, how effective they are currently, the drawbacks present due to the state of the country mentioned, and what this all means in the context of 4IR initiatives.

2.6.3 The state of planning and the challenges hindering it

An effective planning system is a crucial asset for addressing the many complex challenges and inequalities that persist in SA's environment. However, the state of the planning system of the country is characterized by multiple challenges that hinder its progress. These are the gaps in skill and capacity, the unclear definitions and a lack of a shared vision present, poor intergovernmental relations which create isolated plans, low trust and participation from communities, and lastly limited financial resources being available (Abraham, 2015) (Coetzee, 2013) (Visser, 2019) (Balkaran, 2019). Understanding these flaws would enable an insight into what the current operational potential of the country's planning system is, with regards to the topics of the 4IR and SC implementation.

A) Flaws Hindering Planners of South Africa

The standing issue with the system shown in Figure 9 is it creates confusion between spheres of who has jurisdiction. This complication of power creates conflicting agendas/plans, tension, miscommunications, and a failed sense of direction (Visser, 2019) (Balkaran, 2019). The most dominant sphere is the local level (Koma, 2010), however, since SPLUMA this line has become blurred when dealing with projects that span across these three levels of government. These difficulties are further complicated by the various amounts of other shortcomings which are present within the system. Coetzee remarks that these will need to be addressed for the vision of the developmental state of the nation to be recognized (Coetzee, 2013). Coetzee states that there are still various shortcomings that need to be addressed to view the vision for the developmental state of the nation. These shortcomings/flaws present within the spatial system are therefore important to understand for the context of this study. These flaws are:

B) Gaps in skill and capacity

This is mentioned by Abraham as a major shortcoming within the planning dynamic of the country. He continues that the country requires a strong leadership that has the knowledge and ability to guide the country to a prosperous vision, however, he states there is a lack of adequately skilled individuals who fall into positions of power (Abraham, 2015). This creates an environment where people are underqualified for roles and perpetuates the local service provision backlogs as demands are not met adequately. This issue is further elaborated on by Coetzee, who mentions that since there is no dedicated department that facilitates planning and development, there is a lot of infilling of positions. This infilling leads unskilled individuals or private consultants to take up positions that they do not fully understand or comprehend the developmental tasks before them (Coetzee, 2010). This backlog is also explained by Laymen whom he accounts for them occurring due to the lack of capacity within departments. This means that internal clients cannot be served as well as external ones, which leads to a decreased ability between departments and ultimately on service delivery (Layman, 2003). This situation creates an environment where decision-making positions lack the vision or skills for their roles and the exchange of vital resources is backlogged on a slow chain of delivery.

C) Poor intergovernmental relations create isolated plans

This issue can be broken up into three parts and is present due to the previous shortcomings mentioned. The lack of clarity between the powers and functions of local municipalities and districts makes up the first part of this issue. The noted tension between these two is a cause for major concern for the planning body, (Policy Review on Provincial and Local Government 2009) (Malan, 2012). Secondly "Weaknesses in the practices of monitoring, support, and intervention in intergovernmental relations, are also contributing to the management of concurrent competencies in the spheres of

government.” These weaknesses create a communication breakdown within the government and contribute to the poor upkeep of policy and coordination for matters of state (According to the Draft Green Paper on Cooperative Governance) (Abraham, 2015) (Malan, 2012). Lastly, the human factor plays a huge part in intergovernmental relations. Relations are “complicated by the fact that different people and personalities are involved,” in the context of the country, human relations are made more difficult due to the diverse nature of the population (Malan, 2012). This is supported by De Villiers and Sindane, who state “that people dimension in intergovernmental relations and co-operative government should not be underestimated.” These relations occur not just in a formal setting but also informally and the line of communication present for these relations is “not clearly defined and adhered to.” (Malan, 2012)_(Villiers & Sindane, 2011).

These factors contribute to the confusion and lack of direction within the government. Not being a centralized point within the system where policies are created and assessed, leads to weaker plans that do not conform between the three spheres and the common spatial vision between planners. This leaves new documents to be isolated and separate from the goals of major documents. Isolation of plans wastes resources as a poor implantation mechanism is not able to support standalone documents (Abraham, 2015) (Ferro, 2021).

D) Low trust and participation from communities

The country struggles to effectively engage and receive input from the public that is being affected by projects. This is considering the SPLUMA (2013) document which mentions the importance and need for community engagement, for the sustainable implementation of future projects. This required interaction by planners from the community is not being supplied sufficiently (Nwauche & Flanigan, 2021). The reason for this low participation is due to the people, the access to technology, and the logistics surrounding participation. People are the biggest factor when considering participation since they are the providers of information. A study by Ideas 42 revealed that people do not participate for the following reasons; the forums used are predominantly English and they are not able to effectively read them, community members do not believe their opinions have any impact, it is not clear how to participate or not the information is provided of how to prepare before participating, outside issues are raised instead of participation (basic needs not being met), the government has a reputation of inaction so there is a level of distrust within communities and lastly individuals are pressed for time or lack the financial capabilities i.e. to buy data, money for transport, etc. (Ideas42, 2021).

The added costs from community intervention to projects are a huge determinant. The tight budget and high costs added by proper community engagement led to a situation where there is a reluctance to set aside resources to interact for programs. Even if programs set aside sufficient time and finances to adequately approach a community, for the reason mentioned previously, the required input may

not meet the standards required. This situation results in planners not receiving adequate data to ensure sustainable interventions are implemented for communities (Nwauche & Flanigan, 2021).

E) Limited financial resources

The last major flaw that hinders planners in SA is the limited financial resources available. The country's struggling economy and high poverty levels leave a scarcity of funds for planning in terms of development and initiatives (Creamer, 2018). In terms of 4IR development and SC investment, it is difficult for the profession to justify investments that do not address the present basic challenges of the country (Buccus, 2016). This added difficulty in securing sufficient funds for projects hampers the long-term sustainability of projects, as well as further obstacles to initial implementation. This flaw therefore lowers the number of effective strategies that planners can incorporate to address social, economic, and environmental issues within the country (Laubscher, 2021).

The flaws mentioned above make up the challenging environment in which planners in SA operate. There are many other factors, such as cultural, lingual, financial, and management barriers present, however, these are rooted in the previous section where SA and the 4IR were investigated. The present environment described, and the flaws mentioned, both have an impact on planning and planners within the country. By putting these areas together, a clear picture of the country can be created as well as the subsequent gap within the literature for this research paper to amend.

2.6 Conclusions

The literature review highlights the critical aspects of 4IR and SC principles, particularly those within the SA planning environment. While the definitions of the 4IR vary, they all have been noted to converge on the same idea that it is the blurring of boundaries between the physical, digital, and biological realms (Schwab, 2016). The key challenges tied to the 4IR include unequal access to technology and the global disparity in development levels (Nath, 2018). This has a direct impact on SDGs, since technology plays a pivotal role in the areas of infrastructure, clean energy, and sustainable communities (PwC, 2020).

In parallel, the SC movement focuses on addressing rapid urbanization and emphasizes sustainable, people-centered city planning (Patel, 2019). However, concerns about data privacy, cybersecurity, and the social implications of adopting SC technologies are mentioned frequently (Arroub & Zahi, 2016). SC frameworks encompass elements such as smart governance, infrastructure, and mobility, which are essential to managing modern urban environments efficiently (Wade & Pfäffli, 2016). Despite the global progress from all these technological improvements, SA faces significant obstacles in adopting 4IR and SC technologies, these include economic challenges, labor market limitations,

and inadequate infrastructure (Sello, 2019) (Balkaran, 2019). Further Mismanagement, financial constraints, and a divided society increase the complexity of SA's readiness for these innovations and delay the progression toward these innovations being implemented (Kotze, 2014) (Gumede, 2022). The gaps in SA's planning system, such as a lack of skilled labor, poor intergovernmental coordination, and limited financial resources, also pose barriers to successful implementation (Nwauche & Flanigan, 2021) (Abraham, 2015). These challenges underscore the need for a holistic approach to incorporating 4IR and SC initiatives in SA. Furthermore, the unequal distribution of technology deepens the digital divide, leaving the country lagging in innovation and readiness (Perrin, 2021) (Nyagadz, 2022).

Given the country's unique spatial challenges and wealth inequality, the potential of 4IR and SC technologies remains underexplored in the literature (Kotze, 2014) (Naudé, 2022). While the benefits of these innovations are discussed within a theoretical SA context, the specific implications for SA's planning system are not adequately addressed. This study is therefore crucial in filling this gap, exploring how 4IR and SC can enhance the town planning profession and management in SA and ensuring that the countries' resources are allocated more effectively to this potential smart future (Sibanyoni, 2021).

Chapter Three: Methodology

3.1 Introduction

This study aims to establish “the potential of 4th industrial revolution technology and smart city principles in South African planning.” South Africa is an emerging market on the global stage and is threatened with being left behind due to the world rapidly utilizing 4IR technology benefits. These benefits enabled through technology allow nations to be more efficient, sustainable, and productive than they previously have been able to (Arroub & Zahi, 2016). The research question is concerned with the capacity of the planning system of the county to participate in the 4IR and its accompanying SC movement.

The sub-questions to answer this are: 1) What is the relationship between the 4IR and SC movement? Does the country have sufficient plans for the 4IR and SC movement in its spatial development documents? 2) Do planners within the country have sufficient awareness of the 4IR and SC movement to implement this in practice? 3) The answer to these questions will provide the necessary information required to accurately answer the research question.

This chapter will describe the methods used for the data gathering and elaborate on why these decisions were taken. Firstly, this chapter will outline the research approach chosen for this study and the background rationale for why certain methods were favored over others. Secondly, the methods used for data collection and data analysis will be discussed. Thirdly, a brief section on the materials and equipment used for the study. Lastly, an evaluation of the study will cover the ethical considerations that are taken, the possible difficulties to be encountered, and the overall limitations of the study.

The first section to be covered next is the research approach and the rationale behind it.

3.2 Research approach

Generally, there are three types of approaches, namely qualitative, quantitative, and a combination of both called mixed methods.

Quantitative research methods deal with measurable forms and numerical values, that are used to justify an investigation. “It answers questions to justify relationships with measurable variables to either explain, predict, or control a phenomenon,” (Fleetwood, 2023). Examples of this research method are descriptive, survey, or correlational research. Quantitative relies mainly on primary data being accurate, valid, and complete with data collection, to be deemed sufficient for a research paper.

Qualitative research is a method that uses conversational methods for data collection and mainly comprises open-ended questions. The data responses are non-numerical and utilize participation or text to justify findings. Examples of qualitative methods include case studies, document analyses, focus groups, one-to-one interviews, and ethnographic studies (Fleetwood, 2023). These methods utilize both primary and secondary data to validate findings and justify conclusions.

This study utilized a qualitative approach. The research topic primarily focuses on planning and the potential that 4IR technology and SC principles can have for it, in SA. This means that due to the focus being planning, input from people who work in the field will be required, as the policy documents that they are guided by. The use of primary data from people and secondary data from official government documents means using a quantitative data approach was not suitable. Acquiring statistical data would have been difficult to use in the context of the research question due to the scale and broadness of the topic area.

The 4IR and SC principles do contain areas that make use of statistical data e.g., the increased efficiency of resource consumption given as a % of improvement due to 4IR technology intervention, However, to measure the potential in the context of planning and planners, goes beyond a singular system and focuses more towards the wider impact on the general planning environment. The potential across an entire planning network of a country would best be covered by the input thoughts of the planners in the field and the documents that govern and guide the country's development, to gauge the present stance of SA within the research topic. For this reason, a qualitative research approach was chosen over a quantitative one.

Due to qualitative being the chosen approach, the following pros, and cons of the method are acknowledged:

<u>Qualitative research approach</u>	
Pros	Cons
Can capture changing attitudes- A person's opinions, feelings and present knowledge can be revealed.	Sample bias- The selection of who is questioned may be unconsciously or consciously chosen to sway results.
Not bounded by quantitative limitations- Reveals what number cannot show and data outside the expected is still beneficial for qualitative.	Self-selection bias- volunteering to be selected for data can be biased as qualitative data should be random. Data is narrowed to those willing to give their views.

More flexible- if insights being captured are not useful, quick adjustments to questions or settings are possible to improve variable responses easily.	Having the right questions asked- you can only get answers to the questions you ask. Insight may be missed if the question is not asked.
Allows for more speculation- information obtained is not as finite as numbers would be. Data captured can prompt the researcher where to focus efforts of investigation to further explain findings.	The artificial nature of qualitative data- taking people out of their 'norms', can have unforeseen influences on answers due to the environment or if a group of people is put together for questioning.
Encourages discussion- Conversation about the research topic is promoted by engaging directly with people.	Required sample size- to make assumptions requires a sizeable percentage of the group being investigated.

Table 1: Pros and cons of the qualitative method
Sources: (Anpar, 2020) (Vaughan, 2021)

The table above visually shows the most relevant pros and cons to consider when using the qualitative method. The choice of data collection methods available was chosen with this table in mind. The purpose of this is to maximize the pros of the method and address the cons. This was done to ensure that the optimal outcomes of data are acquired that do not consist of the shortcomings of the qualitative method.

Therefore, a qualitative research approach was specifically chosen, in the context of this research topic, for the following reasons:

Firstly, for exploratory research questions, such as the one in this paper, which aims to comprehend several intricate and multidimensional issues related to the 4IR, SCs, and SA planning, a qualitative approach is more appropriate. Secondly, this method enables a deeper exploration of the perspectives, opinions, and experiences of planners working in the field and improves contextual document analysis in a way that quantitative methods are unable to adequately capture. In keeping with gathering current contextual data from planners and official government documents, the qualitative research method also permits the use of data collection techniques like document analysis and interviews. Thirdly, a qualitative approach also offers great flexibility, which allows for an adaptable approach during the research process, if it is found that there is a need to explore specific areas in further depth. This ability to be adaptable is important when navigating this topic area, as by nature it is dynamic and multifaceted. This is to be expected when considering the potential of 4IR and SC principles in planning, as these concepts are exceptionally broad.

Fourthly an additional advantage for this study was the ability for strong discussion and better engagement than quantitative allows for. Qualitative research promotes more engagement with participants and encourages free and open discussions. This is an asset for gaining an understanding of the subject matter that is SA planning and the planners that operate in it, especially within the field of urban planning since it involves multiple stakeholders and participants.

Lastly to ensure that there are no potential biases that are associated with qualitative data. It was acknowledged that there are potential biases in the qualitative approach (e.g., sample bias and self-selection bias), which were noted in the table above. A proactive approach will be taken to best manage the limitations of this approach and to ensure that the data was unbiased.

In summary, the choice of a qualitative research approach is due to its well-aligned principles with the complexities of addressing the needs of the research question. The answer requires a deep understanding of the perceptions, plans, and potential of 4IR and SC principles in SA planning. This approach allows for the gathering of qualitative data that can offer the necessary valuable insights into the research topic and its potential for the country's planning system.

3.3 Research design

Considering the complexity of the research topic and the limited understating of what the potential of the 4IR and SC interventions are for SA planning, it is clear that the use of case studies is particularly well suited for obtaining the sufficient information required. In this next discussion, which is of the research design. We will explore the methods, advantages, and challenges associated with case studies in research. This will end with an explanation of the chosen case studies of this study and support why these sites were chosen.

Case Study aspects	
Definition	A detailed analysis of a specific subject or instance of something used to illustrate a thesis or principle (e.g., a place, event, organization, etc).
Data collection methods	Consists of many methods to be utilized. These include interviews, observations, document analysis, survey questionnaires, etc.
Useful applications	Case studies are suited for exploring new or poorly understood topics and documenting cases in detail. They give more information about specific areas within a chosen environment to explain a wider context.
Generalizability	Case study design is often critiqued for its limited generalizability, as it primarily focuses on theory development and context-specific insights.

Case selection procedure	Typically, case studies are chosen in processes that involve purposive sampling based on the research objectives and criteria of a thesis. Chosen areas fulfill the required criteria to provide all relevant data needed.
Theoretical framework	Often used to act as a guide for analysis and connect the cases investigated to existing theories within the same realm.
Validity and reliability measures	Key methods for ensuring better validity in data are measures such as member checking, peer debriefing, and data triangulation. These measures enhance the credibility of the use of case studies in research.

Table 2: Contents for the aspects associated with Case Studies

Sources: (Neuman, 2014) (Creswell, 2014) (Priya, 2021)

The table above establishes that case studies are a detailed analysis of a specific subject matter or instance that is conveyed in areas such, as a place, an event, or an organization. The use of case studies is designed to illustrate details of an environment to give light to wider contexts or principles (Priya, 2021). Case studies are noted to employ a variety of data collection methods that include the use of interviews, observations, document analysis, and questionnaire surveys (Creswell, 2014). All these methods are used to gather comprehensive information about the chosen subject matter or topic area interested in (Neuman, 2014) (Creswell, 2014). Case studies are most notably useful for exploring new or poorly understood topics in detail. Case studies offer a focused and detailed perspective that can help explain connections that are associated with a broader context or subject (Priya, 2021) .

The selection of cases to use for a thesis needs to be purposeful in choosing and should be guided by the research objectives and criteria required of the research paper (Neuman, 2014). To enhance the validity and reliability of the data presented by case study research, there are many various measures to use, such as member checking, peer debriefing, and data triangulation (Creswell, 2014). These are commonly employed as with the use of case studies in research, it is important to note that there are common critiques that are often associated with the method. The most notable is their limited generalizability, as they primarily focus on theory development and context-specific insights rather than producing broadly applicable findings (Priya, 2021). These pros and cons of the use of case studies in research will be further elaborated on next to limit the drawbacks and optimize the strengths of the method, which will ensure that the data retrieved, and the sites chosen are sufficient. These factors are shown in the following table:

Case Studies

Pros	Cons
Rich data- the ability to provide detailed and context-specific information about a subject of interest, which makes it ideal for complex phenomena investigations.	Limited Generalizability- Findings from a case study are normally specific only to cases, which makes it a challenge to generalize results to a broader population
Real-world application- The data collected can be used to examine real-world situations and offers insights that can be applied to practical problems.	Subjectivity- Results can be influenced by a researcher's biases, own interpretation, and preconceived understandings. This potentially leads to subjective findings.
Qualitative data- This is the main type of data collected and it captures in-depth information and reveals human experiences and behavior	Resource intensive- Conducting thorough research will be time-consuming and resource intensive, as required access to materials, participants, and substantial data will all take an extended time.
Flexibility- The method offers much flexibility and can utilize different methodologies.	Lack of control- a researcher has limited control over variables which can impact the validity of findings.
Longitudinal perspective- They offer a perspective that allows for the ability to track changes and developments over time in specific areas of interest.	Difficulty in replication- Due to the unique and context-specific nature of case studies, it is often difficult to replicate or compare to other studies.
Practical insights- The insight gained is highly practical which allows for informed decision-making, better policy development, and best practices for problems currently encountered.	Ethical concerns- The privacy of the individuals or organizations involved can be complex and obtaining the necessary consent will be challenging, therefore this method requires ethical considerations to be taken
	Time sensitivity- A study may become outdated over time or lose its relevance, especially in a field that is rapidly changing.

Table 3: Pros and Cons of case studies.

Sources: (Denscombe, 2010) (Neuman, 2014) (Priya, 2021) (Drew, 2023)

The table above gives an overview of the pros and cons that are most typically associated with case studies on research. These factors were accounted for when considering the choice of which areas were to be chosen for the research, to mitigate the cons and maximise the pros of the case study method. With these factors considered the case study areas of the City of Tshwane Metropolitan

Municipality (CTMM) and the City of Johannesburg Metropolitan Municipality (CJMM), were chosen. The reasons for choosing these areas are as follows:

Central economic hubs: CTMM and CJMM are both major economic hubs in SA. With Johannesburg being the largest city and a key economic center for SA, and Tshwane serving as the administrative capital, is the largest metropolitan area of the country. These sites were chosen for study as these areas can provide detailed insights into the upper end of the urban economic development of the country. Major metropolitan areas are complex urban environments where the potential impact of 4IR and SC interventions can be significant, therefore the sites chosen are not only the largest of the metros present in the country but also for their strong economic status (Affairs, 2018) (Check, 2018). This is important as to measure the potential of a system, the assumption is that the highest possible potential will be measured, therefore the chosen case studies are picked considering being the strongest available candidates for SC and 4IR interventions.

Urbanization challenges: Both metro areas are facing present challenges that are in line with conventional SCs. These challenges include rapid urbanization, high levels of population growth, struggling infrastructure development, and meeting basic needs (Johannesburg, 2020) (Tshwane, 2020). The presence of these challenges is ideal for the selection of these areas as case studies. These challenges that can be associated with the 4IR and SC movement offer a valuable opportunity for insights into the urban planning and management of these metropolitan areas. This insight is advantageous when considering the accuracy of answering the research question as potential is limited by enabler systems, therefore the presence of modern challenges in these case studies will benefit the accuracy of the research answer.

Significant infrastructure developments: a critical aspect of all urban areas in the context of the 4IR is the infrastructure present. Infrastructure forms the backbone of SC initiatives and therefore the chosen case study requires a built-up urban area with a variety of developments. Both Johannesburg and Tshwane contain significant infrastructure and developments, which therefore makes them ideal candidates as they have the necessary structures to assess 4IR interventions (Johannesburg, 2020) (Tshwane, 2020). If a case study was chosen that was not as developed or contained inadequate infrastructure when compared to the chosen metropolitan areas, the data would be insufficient as the plans of that area would not be able to support 4IR interventions.

Detailed historical background: Both metropolitans have a rich place in the history of the country, which includes particularly the urban landscape from the apartheid past (Johannesburg, 2020) (Tshwane, 2020). The history of these well-known cities makes these areas optimal case studies to use, as the past of them will be well documented. This in terms of the context of the research means it is easier to gauge the ability of these areas in terms of change, developments, and social outcomes. To correctly assess the potential of initiatives that have not yet been attempted, will require case study

areas that can have their past initiatives and actions tracked. This factor will ensure further accuracy of results as a well-documented area will be able to provide the necessary information (Priya, 2021).

Connectivity and transportation: The CTMM and CJMM both have a vast array of transportation systems across each. The need for multimodal transport for the case studies chosen is essential as they provide insights into the mobility and accessibility of the area. This is needed as this plays a significant role in the impact and ease of urban development. To gauge the potential of a site the optimal transportation network will need to be evident as a site with a poorly developed transportation network would not be able to cope with 4IR and SC developments (Johannesburg, 2020) (Tshwane, 2020). Both the CTMM and CJMM score high in terms of the policy and transport networks present (Ferro, 2021). The insight that can be gained from having these present within the case study will be highly beneficial to the accuracy of answering the research question.

Large investments into Innovation and technology: lastly the CTMM and CJMM are investing in many alternatives to challenges and are embracing innovation and technology across various sectors (Johannesburg, 2020) (Tshwane, 2020). This is beneficial as a settlement that isn't incorporating large-scale innovative projects, or projects that make use of more modern technologies, will lack the priorities required in the context of the 4IR and SC movement. The indication given by undertaking more advanced solutions means that the areas are fit for being chosen as a case study as the potential can be measured based on the data projected by the current project progress.

By selecting CTMM and CJMM as the case studies for this research, the aim is to generate practical insights into the potential for 4IR technology and SC initiatives for the planning profession of SA. This insight and the reasons for deciding on these areas based on the above factors have the intention to provide informed decision-making strategies, future policy development, and best approaches for addressing the urban planning challenges associated with the context of introducing 4IR and SC initiatives. These insights will be highly relevant for answering the research question adequately and accurately

3.3 Research methods

The two qualitative collection methods used for this study are semi-structured interviews and document analysis. These methods were chosen to maximize the pros and address the cons of qualitative data, sufficiently cover the topic area, gather the necessary information needed, and lastly provide the best type of data that best suits the chosen method. Each component for the data analysis will be elaborated on and discussed in detail as to why it was chosen.

Locational sources- The data gathered through both sources will primarily be focused on the context of two metropolitan municipalities of SA. Since they both fall in the same province of Gauteng, the documents associated with the province will also be utilized for data. To improve the context and

accuracy of data, documents that govern the whole of SA as well as the province will be included. This approach will ensure that sufficient data can be gathered to achieve a higher standard of analysis and conclusions.

3.3.1 Data Collection

The semi-structured interviews were conducted with the people who work within the planning environment of the chosen study areas. This primary source of data was favored since it addressed many of the cons discussed in qualitative methods. Semi-structured allows for flexibility if additional information or detail is requested during the interview process, but still follows a set of predetermined questions to ensure that the required information is acquired. The Interviews were conducted on one, which limits the artificial effect of group-biased responses. Interviews are conducted at the person's convenience and responses given through discussion of questions were more genuine, due to the person answering verbally in the moment. The shortcomings due to bias are also addressed as any qualification within the field can have input and no interview will be omitted, as even outlier data is still relevant.

Participants

The people who were eligible for this study work and operate within any function of the town planning profession. The roles chosen were from both research areas of CTMM and CJMM. The interviews were conducted between November and early December 2022. The following positions from each research area were interviewed.

CJMM:

1. Spatial urban planner, in charge of policy design.
2. Spatial planner within the Department of Economics Development of Johannesburg planning
3. Urban planner, in charge of the city transformation directorate of Ward A

CTMM:

1. Spatial urban planner, in charge of Ward 5.
2. Deputy director of the spatial research and city planning division.
3. Head of the metro police department for Tshwane.
4. Spatial development planner, involved with the economics of development in Tshwane.

In total 7 people were interviewed, with 3 being from the Johannesburg research area and 4 from the Tshwane research area. The questions of the semi-structured interviews conducted can be seen in Appendix A and the consent form that participants signed before the interview can be seen in Appendix B. The questions were communicated to participants a day before the meeting so that ample time was given for participants to form structured answers to them. Participants who are interviewed

sign the consent form before the interview takes place and all involved are kept anonymous to ensure privacy and free discussion. Interviews are fully online to ensure the person interviewed is in their preferred environment and it makes scheduling multiple interviews across two cities manageable for a single person to do.

The process of collecting data from interviews was done in the following manner: permission to conduct interviews with people within the planning sector will be obtained from the study areas' research departments. Once permission was obtained, the contact information of people within the study areas' planning departments was requested. The acquired contact information received a formal email, that detailed the study and requested that the individual offer their input on the topic area. When the applicant accepted an online meeting was scheduled which best suited their timetable. The interviews were no longer than 30 minutes and comprised 13 set questions that act as a base for conversational topics. The interview was favored over a survey as it not only eliminates the risk of not receiving the answer not asked but also allows for flexibility and follow-up questions that will inevitably occur as the discussion proceeds. This flexibility and the pros of qualitative data encouraging discussion were required for this study since the research focused on assessing the awareness of planners in the country about the 4IR and SC movement. The information acquired for each question from each person was typed out on a personal device and saved, to be used in the later findings chapter. The information was grouped by question where key quotes and requiring themes from answers were noted. Each theme was given a color in line with the second data collection method of policy and document reviews. This will be elaborated on further in the thematic analysis breakdown.

A) Documentation review of policies and plans

The documents that were investigated are related to the planning profession of SA. This secondary data was extracted from official government documents, spatial plans, and policies, for each of the two metropolitan areas. Documents that are relevant for further understanding the surrounding context will also be incorporated. These documents ranged from the national and provincial levels of the country. They are relevant and required because they will either be directly influencing planners or guiding the vision of the chosen study areas. This surrounding context component is required due to the country of SA operates on a three-tier system of National, Provincial, and Local authority.

The chosen explanatory approach focused on finding relationships between variables, therefore the more flexible the document choice, the greater the potential of findings will be. To best coordinate and narrow the documents that will be used, specific themes were used to ensure data continuity toward the research question. The themes are broad areas that ensure that information in documents is relevant, and time is not wasted on irrelevant literature. The chosen documents investigated will be in line with at least one or more of the following themes: the 4IR, SC, and SA

planning/developments/policy/spatial context. The chosen documents that fit within these themes were as follows:

1. **NDP 2030**
2. **SPLUMA 2013**
3. **NSDF**
4. **Gauteng Spatial Development Framework (GSFD)**
5. **Growing Gauteng Together 2030**
6. **South African Smart Cities Framework (SCF)**
7. **Johannesburg SDF 2040**
8. **City of Johannesburg Metropolitan GAU**
9. **City of Johannesburg IDP 2022-2027**
10. **City of Tshwane Metropolitan GAU**
11. **Tshwane Metropolitan Spatial Development Framework (MSDF) 2021**
12. **City of Tshwane IDP 2020-2025**

These chosen documents primarily focussed on the country's future spatial vision as well as the policies that guide these areas' plans. Investigating and understanding the contents of these documents will enable a clear vision of these areas' position and future trajectory concerning 4IR and SC intervention. Due to the numbers and complexity of these documents, the method to compile and investigate these documents needed to be specific. The chosen approach required flexibility, while the broad nature of the topic and the sheer amount of information needed to be encapsulated in an easily digestible size. The thematic approach was chosen due to the following properties that the method offers.

3.3.2 Data analysis: Thematic analysis

A qualitative data analysis method is best used when a researcher wants to involve participants in the research analysis process (Braun & Clarke, 2006). The method involves reading through literature/data, such as documents or in-depth interviews, and identifying common patterns to derive meaning and themes across all the sources. This type of analysis is best suited for this study as allows for data from interviews to be combined with information from official literature documents. The topic being broad means that grouping by themes will also make the analysis process more manageable and organized.

The thematic approach being taken means that the following advantages and disadvantages are accepted:

<u>Thematic Analysis</u>	
Advantages	Disadvantages
Flexibility- the method can make use of different data sources and research questions	Time-consuming- the method can be time to compile if there is a large amount of data.
Inductive- allows for a researcher to discover themes and patterns without any preconceptions.	Lack of generalizability- the findings of a thematic analysis cannot generalize an entire population and are mainly useful for explorative research.
Versatility- can be used in various research fields and many research designs.	Vulnerable to subjectivity- This method relies on the researcher's interpretation of data, which leads to potential subjectivity and bias in the analysis.
Transparency- a simplistic method that is easy to understand and replicate.	

Table 4: Advantages and disadvantages of thematic analysis.
Sources: (Braun & Clarke, 2006) (Cooper, 2012)

With this table in mind, the following process was conducted for the thematic analysis: all data gathered from the interviews and literature documents were categorized and grouped into main themes. Once grouped, the visualized data was reviewed for common patterns or frequently occurring information. These patterns were then investigated, and through explanations of why they occurred, answers were found. The interpreted data was elaborated on and supported by either direct quotes from interviews or documents. This approach helped to reduce the issue of subjectivity mentioned in the table, as backing each statement with evidence minimized the risk of bias from interpretation. Since these findings formed the basis for conclusions to the research question and sub-questions, minimizing subjectivity was a main priority. The broad nature of the topic areas and the volume of data made this process time-consuming; however, through organized grouping and concise language, the time required was manageable for a single person to compile.

The chosen flexibility of the two methods of interviews and document/policy analysis, is deliberate due to the broad nature of the topic, the unpredictable manner of interview answers, and the potential unforeseen information that may lead to further avenues that will be encountered. Adapting to explain the potential outlier or unexpected answers from the interviews was beneficial to the study as explaining the potential of a system, required a level of in-depth reasoning and explanation of

information found. This themed collection of secondary data means that the method of analysis will follow the same process.

From these sources and by undertaking the research process discussed above, common themes were established and are visually presented in Figure 24. These themes and accompanying sub-themes are grouped into three main categories, which were used to better organize data to answer the sub-questions and main research question of this paper. This organization is visually shown in Figure 23 which summarizes the levels of information used to provide answers to the research questions.

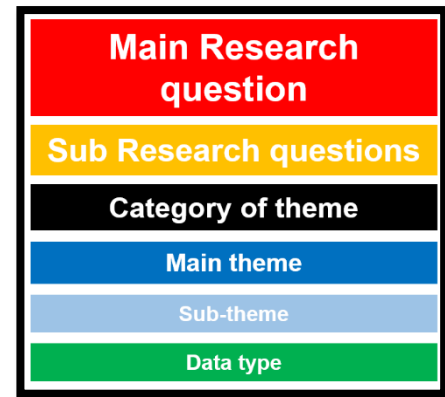
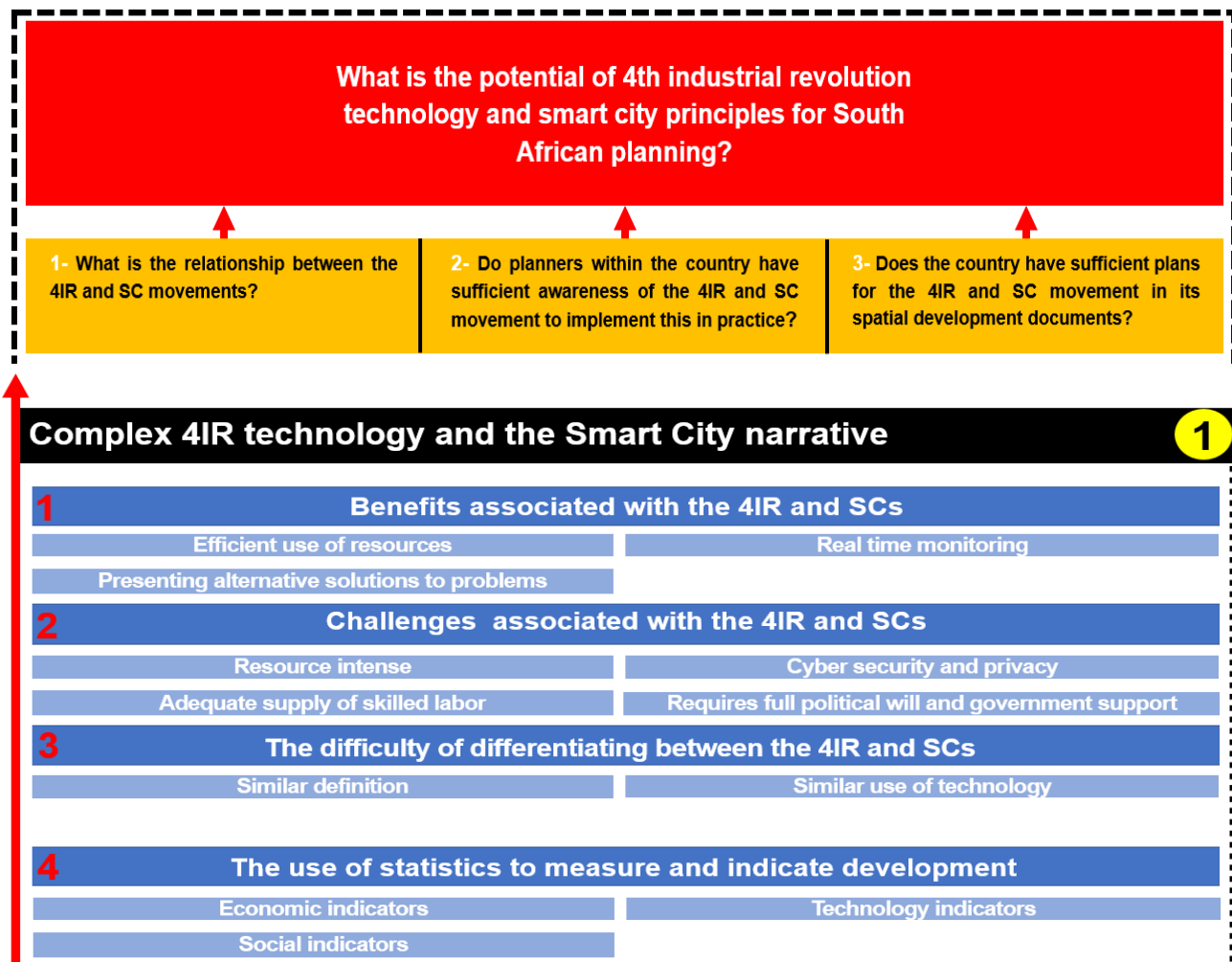


Figure 23: Visual summary of figure 24 layout
Source: (Author)

Figure 23 shows the process where the data types of interviews and document analysis had common themes extracted. The first was minor themes which were later grouped into main themes and lastly grouped into a common category. The information from each category will be elaborated on and from there the information which pertains to each sub-research question will be organized.



The turbulent context of South Africa

2

- 1 **Limited access to technology and skills**
 - Lack of skilled labor
 - Limited access to affordable technology
 - Access to technology inequalities
- 2 **Inadequate infrastructure**
 - limited access to reliable electricity
 - Outdated movement systems
 - Insufficient connectivity and network coverage
- 3 **Lack of resources**
- 4 **Lack of coordination between the different levels of government.**
 - Conflicting priorities across the levels of government
 - Poor internal communication within government

The gaps within SA planning

3

- 1 **Lack of awareness of 4IR technology and SC principles**
 - Partial understating of either 4IR or SC movement
 - Unsure of exact SC principles
 - irregular sources of information about the 4RI and SCs
- 2 **The complex structure of the planning profession**
 - Lack of standardization
 - Inflexibility of the present system
- 3 **The scarcity of 4IR and SCs plans in major documents**
 - Political priorities
 - "Tick box" attitude to 4IR and SC inclusion in documents
- 4 **Uncertainty surrounding 4IR technology and SC principles**
 - Fear of getting it wrong
- 5 **The urgency for South Africa to Partake in the revolution**
 - The fear of being left behind
 - The prospective benefits it can bring to the country

Government documents

Interviews

Figure 24: Visual representation of structure to answer the main research question.

Source: (Author)

Summary table of methods and data collection of research questions

-Question	Objective	Method	Data Collection
Sub	What is the relationship between the 4IR and SC movements?	Qualitative	Document/ policy analysis
Sub	Does the country have sufficient plans for the 4IR and SC movement in its spatial development documents?	Qualitative	Interviews and document analysis
Sub	Do planners within the country have sufficient awareness of the 4IR and SC movement to implement this in practice?	Qualitative	Interviews

3.4 Limitations of study

The study was limited by the number of people who agreed to be interviewed and the number of participants who will be part of the same role within the planning profession. Each component of the planning employee structure will have a different skill set taught to everyone. This limits the number of views from a position as municipalities generally do not have many people employed with the same role. The study is also limited to only two research areas and is not a representation of the entire country. The voluntary nature of the interviews means that the views of people who are willing to participate are given, while the views not given by unwilling/busy participants are missed. This limits the study on participants as within an entire department that is reached out to, the majority will likely be too preoccupied to participate as they do work within the government.

3.5 Ethical considerations

For the preliminary stages, a process of an ethical clearance form was undertaken through the University of Pretoria. This clearance process involved detailing the study's intentions and agreeing to follow a strict set of instructions when including participants in this research paper. These instructions were followed, and clearance was first obtained from the municipality before clearance was given by the university to proceed. From the time of clearance by all entries, only then were participants approached.

When approaching potential participants, the purpose of the study was explained to participants via email. The purpose of this was to inform the participants of every detail of the study and the role they were required to play. When the willing participants communicated that they were willing to participate in the study, further communication would be sent which contained Appendix A and B. The consent form was to ensure written documentation of the willingness of the participant to be involved. Confidentiality and anonymity were assured, and no participant was forced into their involvement. The

names have been omitted and only the positions and number of interviews were used to identify. The people who were all contacted from each research area were all on the list of approved contacts that were sent with the consent of the research division of each study area. This approval ensured that participants felt secure in engaging in an interview for this study. With all the necessary steps taken mentioned above, the semi-structured interviews were conducted through November and early December of 2022. All participants contacted did sign and consent form as shown in Appendix B.

3.6 Conclusion

This chapter focused on the methodology that was used for this study. An explanation of the reasoning and choice of qualitative research as a method for data collection was given. The measures and justifications were followed next for the data collection approaches. The use of interviews and document /policy review were elaborated on and a detailed explanation of how the data was compiled. Lastly, the limitations and ethical considerations were discussed, and the use of appendixes 1 and 2 was clarified.

This concludes chapter 3 of this study, the next chapter to follow is the contextual chapter.

Chapter Four: Context

4.1 Introduction

Since 1994, South Africa's planning system has undergone significant changes. Particularly noteworthy is the restructuring of provinces and municipalities following the advent of the new government (Rogerson, 2004). The number of provinces increased from four to nine, but this re-demarcation process faced numerous challenging political issues. It wasn't until 2004 that the system began showing signs of progress with the initiation of provincial development planning (Lodi, 2006). While the national level failed to effectively introduce integrated development concepts, provisional planning at the local level started adopting these measures. However, early attempts at local-level planning proved insufficient, prompting the government to prioritize a more comprehensive approach to planning across all spheres (Harrison, 2001).

In the post-apartheid era, the government's new approach prompted municipalities to utilize spatial planning tools to realize their visions. These tools included Integrated Development Planning (IDP), aimed at bridging the gaps between different spheres of government, and Spatial Development Frameworks (SDF), which replaced outdated guide plans and structure plans in the country (Abraham, 2015). Future policies sought to address the spatial inequalities caused by apartheid-era plans. Nonetheless, challenges remain in effectively rectifying these injustices through SDF, highlighting the ongoing struggle (Harrison, 2008).

The purpose of this chapter is to establish a grounded foundation for the subsequent exploration of the chosen research areas that were discussed in the previous chapter. This chapter is structured in a top-down approach, where its journey begins at the broad national level of SA and proceeds to progressively zoom in on the chosen research areas of the CTMM and CJMM. This order of sequencing is intentional as it ensures all surrounding dimensions are adequately covered, before investigating in depth the two research areas.

The emphasis of this preliminary focus on the wider SA context has the aim to elaborate on the contextual data that will serve as the main foundational backdrop, in which the two research areas operate. This foundation sets the basis for the subsequent analyses of the proceeding and a more detailed look at the progressively smaller scale around the research areas. The following context to follow is the provincial level of the country, which is the province of Gauteng. To investigate this region's present statistical landscape and policies will further anchor the context of the research areas chosen, and since both research areas reside within this province, examining the contextual environment becomes necessary, as it directly molds the immediate surroundings of the study areas.

The last level of investigation of the metropolitan level serves to fully ground the two research areas in meticulous detail. Each area will be presented with an overview that fully encapsulates key

contextual factors, such as the location, layout, and statistical data of both. A comprehensive planning profile of each area is also included which seeks to encapsulate the current planning policies, governing documents, and spatial framework that guides the municipality landscape. This is included in the context of the two research areas to fully encapsulate the present circumstance both on a statistical and spatial scale.

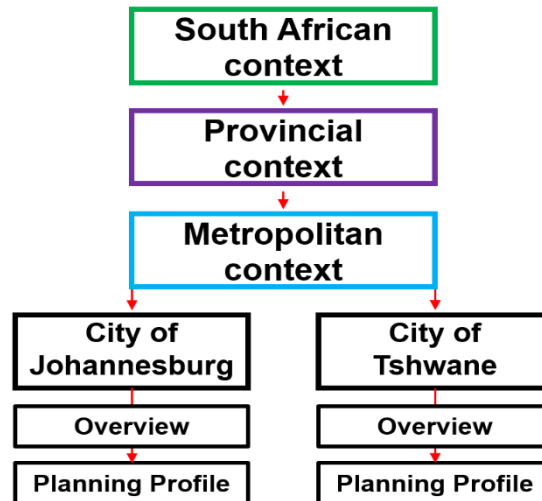


Figure 25: Visual representation of chapter structure
Source: (Author)

The above-mentioned approach is illustrated in Figure 1, which visually shows the structural flow of this chapter from the national to the provincial, to the local level. This arrangement ensures that each layer that is examined is done comprehensively for each research area. The first section to be covered next is the context of SA.

4.2 Context of South Africa

Located at the southern tip of the African continent, the country of SA is the 25th largest in the world and is bordered by Mozambique, Botswana Zimbabwe, Namibia, Lesotho, and Swaziland. The country has an extensive coastline that rapidly rises to a large flat interior plateau. The geographic layout and size of the country lead to contrasting weather patterns and make the interior significantly drier than the coastline. The country is classified as a water-scarce nation, due to it receiving just 497mm/year of rainfall, which is far below the world average of 860mm/year. This factor sees many major dams being constructed across the country to try to combat the constant threat of a water crisis (Igamba, 2022) (Hagan, 2018).

The country has a population of around 60.6 million (Stats SA, 2021), and roughly 68% are living in urban areas. This figure is constantly growing as people in rural areas migrate to urban areas to seek more opportunities. There are still large pockets of unindustrialized rural areas within the country, that are from the lingering past of a segregated structure. The country is a young democracy (28 years)

and still is plagued by apartheid-era policies that are entrenched within the infrastructure. SA has been referred to as a “Rainbow Nation” due to its racial diversity present. There are 11 official languages spoken in the country, which adds to the diversity of the people you can meet (Hagan, 2018).

SA is the second largest economy in Africa and is classified as an industrialized nation. The SA economy is more diverse than the usual African economy and has contribution sources of income. “The service, manufacturing, financial, and retail sectors together make up about half of the GDP output,” (Hagan, 2018). Despite this, the country most notably suffers from high levels of inequality, poverty, and unemployment. These matters are further complicated when the governmental system presently suffers from a high amount of corruption and the country’s energy grid battles to provide the necessary power needed to keep the lights on. The country has 1st world qualities and services present however it is still suffering from 3rd world issues such as basic provisions for its people (Feldman, 2017).

4.2.1 The South African Planning System

To determine the potential of the 4IR and SC principles for planning in SA, the planning system present is required to be overlooked and understood, to ground the capabilities of the system. This section will cover the legal and primary spatial frameworks of the country that determine what a planner in the country is guided by within the planning system. This section will set the narrative of the planning body of SA and the backdrop to the study areas chosen.

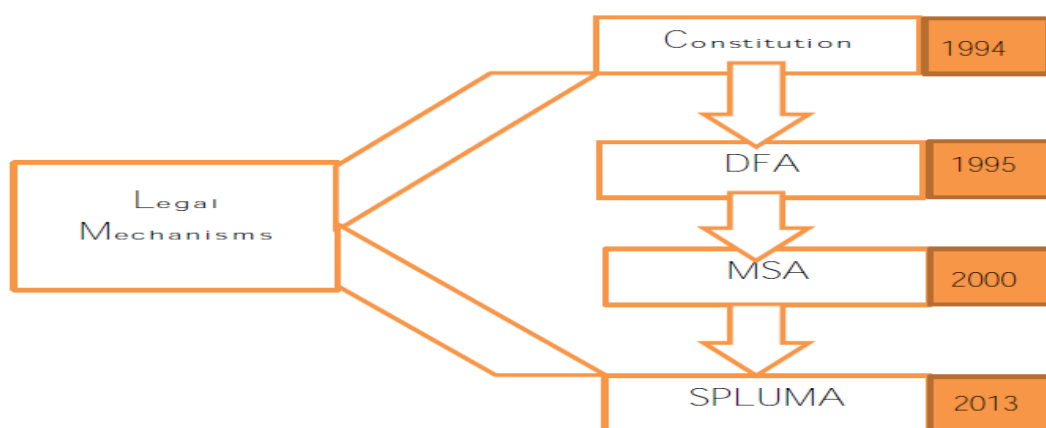


Figure 26: Diagram representing the history of the South African legal framework
Source: (Abraham, 2015), page 36-figure 3

The legal systems present in the country that govern planning and policy are depicted in Figure 2. Each one mentioned had a role that shaped the current planning profession in the country today. Therefore, it is necessary to establish the role that each mechanism played and still does in the present SA planning context to understand what they do for future SC initiatives.

The Constitution of South Africa-1996

The foundational legal document of SA has a direct impact on the planning system. The notable impact it has had is that it defines the three spheres of the government system- national, provincial, and local, and the powers each has, such as the national plans of the country being allowed to overrule by provincial. “The provincial level has exclusive legal competence.” (Abraham, 2015).

Impact on SC Development: The Constitution delegates the powers of influence for the documents within the planning system. Most notably, it establishes the structure of national plans can override provincial-level plans, indicating and establishing the hierarchical nature of planning authority within SA. The implication this has is the coordination of national-level initiatives is filtered down and supported by the lower-level documents. An example is such as matters related to supply chain initiatives, which with provincial and local planning efforts, are systematically tracked to support and achieve the high-end strategic goals of the national plan’s visions (Asmal, et al., 2019).

Development and Facilitation Act (DFA)-1995

A less notable document in the present day due to it being transitional legislation, however, it made changes to planning legislature and norms. Abraham notes that this act mentions, for the first time, sustainable objectives, as well as including plans to restructure segregated apartheid layouts. Another notable point of this act was the focus on “city planning objectives,” and counter-urban sprawl schemes.

Impact on SC Development: The introduction of sustainable objectives aligns with present-day contemporary SC principles. Sustainability forms a part of the key considerations in the modern supply chain and sustainable city management. The further emphasis on restructuring the mistakes of past structural layouts also suggests a heightened awareness of the spatial impacts caused by these developments (Madangombe, 2019). This restructuring enables any further developments which may require additional present adjustments for SC initiatives, to be more effective as the data of this act can be observed and better finetuning for higher implementation is possible (Abraham, 2015).

Municipal Systems Act (MSA)- 2000

This act made municipalities require an Integrated Development Plan (IDP), as well as a Spatial Development Plan (SDF). These documents are present within the study areas chosen and are used as tools to guide spatial outcomes (Abraham, 2015). This document is also notable for its regulation of processes that assign powers and functions to local government. It also assists in the coordination of the three spheres mentioned.

Impact on SC Development: To make the requirement for municipalities to have IDP and SDFs, indicates a clear focus on integrated and spatial planning objectives. These are seen as essential

requirements for effective long-term municipal management and in turn sustainable spatial models. Through regulating processes and coordinating between all the government spheres, the MSA document contributes to the more streamlined and coordinated approach that is required when it comes to SC development and 4IR initiatives (Arroub & Zahi, 2016).

Spatial Land Use Management Act (SPLUMA)-2013

Being the latest document added to the legal framework of the country, SPLUMA can be considered to include a more modern approach to planning. The act puts forward two key planning ideas. The first is a set of five principles, these are spatial sustainability, spatial resilience, spatial justice, good governance, and efficiency. The second main idea of the document is that it puts forward a new spatial planning system for each level of government. This new system sees “local municipalities be at the center of spatial decision-making related to land use management,” (Mphethi, 2017). SPLUMA reinforces the vision of the National Development Plan 2030 and looks to try to deal with the “socio-economic issues crippling,” SA, through the modern idea of spatial transformation.

Impact on SC Development: The modern principles of SPLUMA align with current trends of SC management, where the emphasis on efficiency and sustainability of city functions are prioritized. This focus extends to the local municipalities and spatial decision-making. This document is a guide but provides the adaptably and necessary policy that allows local needs to be catered for. This document provides the necessary flexibility and install principles that in the long run will positively impact SC implementation and sustainability.

The National Spatial Development Framework (NSDF 2050)

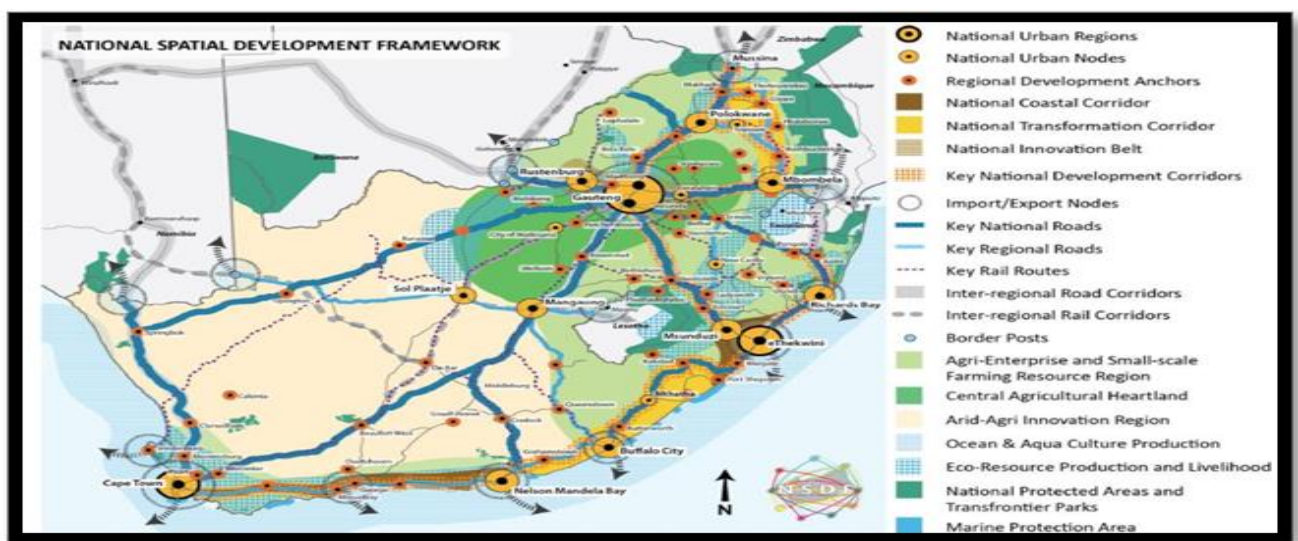


Figure 27: Map of Proposed NSDF 2050 outcomes

Source: (NSDF, 2022)

The NSDF is a strategic long-term plan that aims to guide spatial development in SA until 2050. This framework is required by the SPLUMA 2013 act and must importantly, be in harmony with the NDP plan for 2030. The creation of the NSDF was overseen by the Department of Agriculture, Land Reform and Rural Development (DALRRD) along with the Department of Planning, Monitoring and Evaluation (DPME) are all guided by Figure 27.

Impact on SC Development:

The NSDF impacts significantly on SC development, by providing a strategic long-term vision for 2050. This ensured alignment with national policies such as SPLUMA 2013 and the NDP 2030, promoted integrated and coordinated planning across government sectors, and facilitated the smooth implementation of SC initiatives. The framework's key focus being on inclusivity, guided by the CSIR's Inclusive Smart Settlements and Regions (ISSR), also ensures that SC will address the needs of all citizens. Lastly, it directs resource allocation towards areas of high impact and encourages innovative and sustainable urban development practices. This is all encapsulated by the mechanisms for effective monitoring and evaluation through the DPME.

The legal framework of the country creates the current spatial framework in which planners operate. The SA planning system does show characteristics that can be aligned with an SC framework component mentioned previously, however, these documents only briefly mention the coming SC movement to "tick the boxes." In many cases, documents only include a page or two on the SC movement, within a 400+ page document (Ferro, 2021). Understanding the system created by the legal framework and its inherent flaws will allow for a fair assessment when considering the potential of the 4IR and SC principles within the planning system. The systems within the planning framework form the structure that enables and regulates change. The 4IR comprises drastic changes to an environment, and therefore the SA framework will be explored to further ground the context of the country and to improve the assessment of potential later in the study.

4.2.2 The spatial framework and three spheres of South African planning

Figure 28 depicts the planning and development framework of SA, the three spheres, and the relevant documents that reside within each level. This is the system which planners operate with, and the documents produced have been in response to challenges that the country endures. These challenges are associated with the obstacles mentioned previously that define the context of the country. Despite the detail and efforts that are evident in documents to combat the challenges of SA, the intended impact is falling short of its targets. This leads to a scenario where documents that encounter shortcomings have new documents written to amend them. Despite these efforts, the

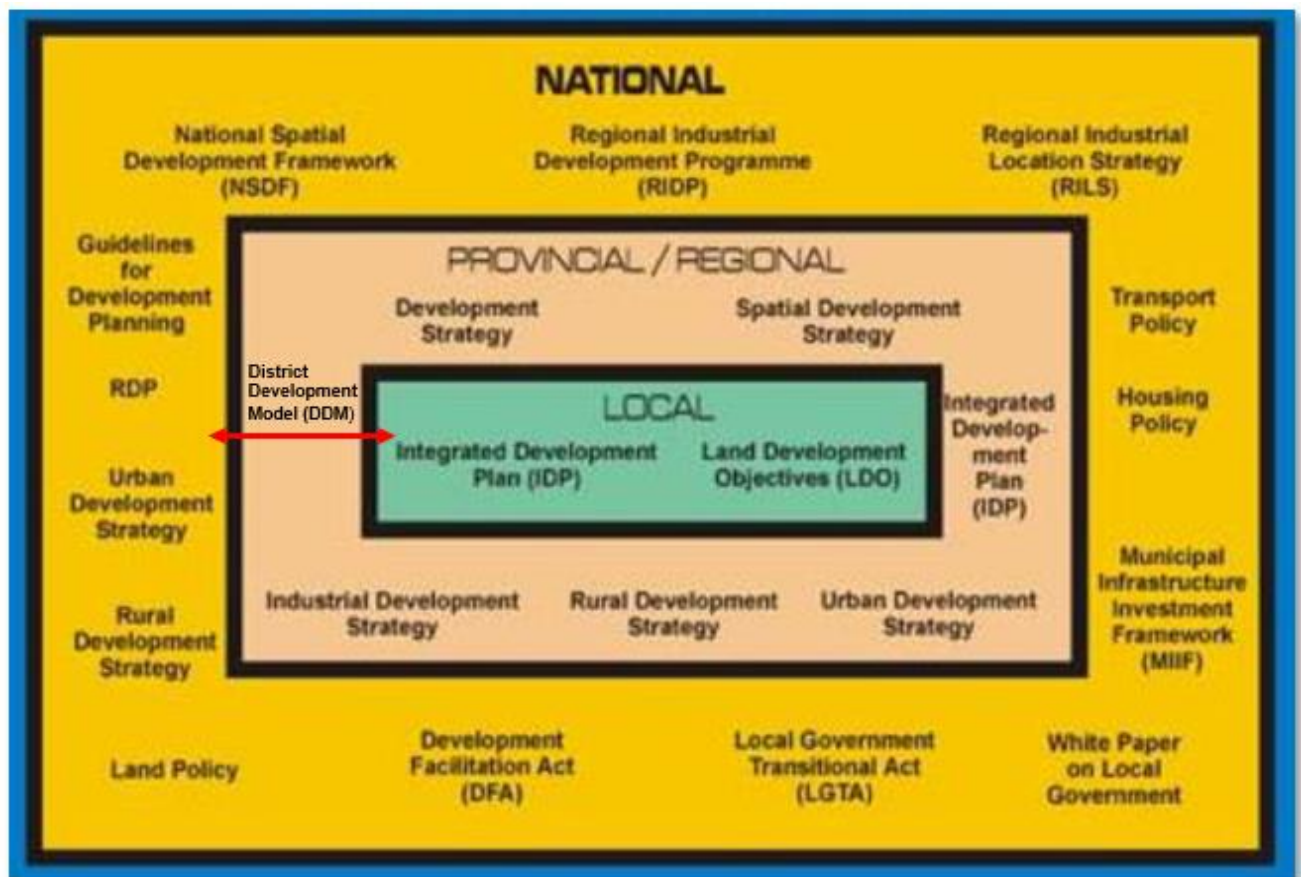


Figure 28: Visual representation of the spatial framework of South Africa
Source: Page 40-Figure 4, (Abraham, 2015), addition, (Author).

The spatial framework is a document in SA planning that refers to the dimension of planning development that focuses on the physical space influenced. This involves the distribution and arrangement of land use, infrastructure, and resources within the given space of an area. In SA the spatial planning element is crucial when addressing common urban issues, such as the rise of urbanization, the need for environmental conservation and sustainability, and social equity within the country.

The key components relevant to SC development, in the SA spatial framework include:

SDF being mandatory creates plans that purposely guide the spatial realm of an area, to ensure alignment with the broader national and provincial visions. Municipalities being given this responsibility ensures that developments are regulated and guided towards common goals, which in terms of SC development, is necessary as such initiatives require a coordinated effort to be effective. The further Integration that is created between land use and Infrastructure planning developments, also ensures that future developments are not only sustainable but also meet the needs of the population that resides in the areas influenced. This forms another major component where the rural

and urban development needs have been addressed, which in turn allows for the document's aims of reducing spatial inequalities and promoting a balanced regional development progression, to progress evenly.

The three spheres of the government of SA follow a system where each layer within the government has its responsibilities and powers. Each layer as shown in Figure 28, comprises many documents that regulate and guide the vision of the sphere of influence. Only the documents that are relevant to the study will be further investigated. These three spheres and the roles that they play in SC planning developments are:

The outer national government sphere (figure 28) is responsible for matters that are associated on a national scale in terms of issues such as defense, foreign affairs, and national economic policies (Abraham, 2015). The national government sets what the overall end goals are for frameworks of development, which includes the broad policies primarily related to spatial planning. The national-level planning documents set the president for what the smaller spheres are meant to develop towards. The most notable of these documents is the NDP 2030.

The interior provincial government sphere is responsible for issues and developments that affect the 9 provinces of the country. This primarily includes the matters which relate to health, education, economy, and aspects of spatial planning. Each province has its SDFs that plan to align with the national framework's vision and aims. The provincial sphere in terms of planning set to cater to the unique provincial context and has adjusted plans to better suit the spatial and geographic environment present. This is significant as provincial plans will differ between each province which in terms of SC developments means solutions and encountered problems will be different.

The inner local government sphere is responsible for all matters that are on the smallest level of the local level. The issues primarily associated with this sphere include basic service delivery, local economic development, and spatial development planning initiatives on the municipal level. Each municipality within a province develops its own unique SDF plans that are aligned with both national and provincial visions and aims. In terms of SC developments, the local level is the most crucial in terms of implementing sustainable initiatives. The initial projects of SC development and 4IR technologies will be small-scale until enough traction is gained to progress to larger integrated systems, it is therefore the local level is highly crucial in the broad scale of long-term success. This level is further unique as the smaller nature of this sphere in terms of the context of each area, means that documents and policy approaches will be catered to the environment present. This further complication means that objectives and goals will be different between local areas both in terms of solutions and the time frame of initiatives.

To the present day, SA has been actively working towards improving spatial planning development procedures, implementation, and organization. The government emphasizing the importance of integrated and sustainable development is a major stepping stone on the road to effective SC development. This is crucial in terms of a planning perspective, especially in addressing historical spatial inequalities, social issues, and sustainable spatial practices. The next section of the provincial context will further elaborate on the broad areas surrounding each research area, which is the Gauteng province.

4.3 Provincial Context

South Africa includes nine provinces. Both the chosen study areas fall in the Gauteng province. The province is located on the highest part of the interior plateau of the SA Highveld. Despite Gauteng only making up 1.5% of the country's landmass, it holds roughly a quarter of the total population. The province contains the largest share of "Financial and business services, logistics, manufacturing, property, telecommunications, and trade are some of the most important economic sectors," (Government, 2022). The province is classified as an integrated industrial complex, that consists of major areas of economic activity. Although Gauteng is largely urbanized there are pockets of farming (e.g., corn, peanuts), market gardening, and dairy farming (Britannica, 2017). The province contains large concentrations of gold and various other minerals such as chromite, iron ore, platinum, and uranium from the bushveld area. Despite this, the primary resources sectors only account for 6% of Gauteng's total income and only 31% of its export earnings (InfoSA, 2020). The province dominates every other major market except mining, agriculture, and quarrying.

The resources and wealth accumulated from the other sectors have made Gauteng a rich economic hub, which is the reason for its high density (Britannica, 2017). The province contributed 35% of the country's GDP and was Africa's 7th biggest economy pre-COVID-19 (Check, 2018). To the present day, the province is still the leading economic power as the latest figures showed it has the fastest growth of the 9 provinces (0.6%) (SA, 2021).

The main spatial planning documents that oversee the development of the province are the GSFD 2030 and the GGT 2030.

Gauteng Spatial Development Framework (GSDF)

The purpose of the Gauteng Spatial Development Framework (GSDF) is to guide the Gauteng province to an equitable and efficient development, which aligns with the envisioned national plans, for the municipal sectors policies and development planning goals. The document is a projected plan for the year 2030 which is in line with SA NDP 2030 targets. The GSDF 2030 is an intended spatial framework that seeks to guide the planning, land development, and investment decisions of the province (GSFD, 2022).

This framework is guided by and plans to uphold the SPLUMA 2013 principles of spatial justice, sustainability, efficiency, resilience, and good administration. This document is further informed and in line with the national legal framework, international, national, and provincial policy directives, and municipal spatial planning policy directives (GSFD, 2022).

Growing Gauteng Together 2030 (GGT230)

The GGT2030 is involved with engaging the various stakeholders with the intent of fostering a shared understanding and working towards the common goals that are set within the planning visions of the country (Mbada, 2021). The purpose of the GGT is to place further emphasis on coordination, collaboration, and mobilizing the society present, to be actively participating in the developmental journey, alongside the government (Magoro, 2021).

The key elements of this plan involve a placed focus on policy coordination, performance monitoring, and the re-establishment of the Policy Unit within the Office of the Premier. This is all set out to ensure an effective implementation (Magoro, 2021). GGT2030's priority areas include economic development, education improvements, access to healthcare, human settlements, safety, social cohesion, and importantly sustainable developments. The commitment in the document is clear to use scientific evidence and data-driven decision-making to ensure the accuracy of initiatives (Mbada, 2021).

The success of the GGT initiatives is measured by the modernization of the public services sector, enhanced public participation, and improved accountability across all sectors. The ultimate vision is a prosperous Gauteng in 2055 which looks past this document and uses its goals to set a promising future. The document is aligned with the principles of equality and prosperity for all as outlined in the Freedom Charter (Mbada, 2021).

These two main spatial documents guide the Gauteng province's planning direction and indicate the placed emphasis on coordinating with national documents, ensuring the public is involved, efficiency is improved across sectors, and above all, implementation is effective. These documents set the precedence for what the local narrative will strive to replicate for the larger 2030 vision to be realized.

In short, Gauteng remains the economic engine of the country and of the sub-continent. The province is the heart of the commercial business and home to the country's administrative capital. The province is divided into two district municipalities, which are further divided into six local municipalities and three metropolitan municipalities - the City of Tshwane, the City of Johannesburg, and the City of Ekurhuleni Metropolitan Municipalities. The government of Gauteng forms a part of the provincial sphere of the country's governing system and consists of a unicameral legislature and an executive

branch that is headed by a premier. The executive branch contains the heads of the different major departments of the province.

4.4 Metropolitan Context

The following section will establish the context of the research areas of CTMM and CJMM. Figure 28 shows the location of these two metropolitan municipalities. An overview of the basic statistics and relevant information will be provided for each of the study areas, as well as the planning profile. The planning profile will consist of the documents and planning policies that the study area planners are currently guided by and operated with. The planning profile also seeks to establish what are the current development projects being undertaken, to establish the focus areas of initiatives. Through this discussion, the main principles for each research area will be reflected to assist with the interpretation of the findings in the following chapter. All information from each research area is specifically chosen considering the relevance of the information to the research topic of 4IR technology and SC initiatives.

The following image is a visual representation of the locational context of the chosen study areas. Figure 29 depicts the country's location within the African continent, the provincial context within South Africa, and lastly the chosen metropolitan areas of the province (indicated by the yellow circles). The study areas of CTMM (upper larger circle) and CJMM (lower smaller circle) are indicated in Figure 29. This image serves to give context to the research areas chosen and to place them in space within the bigger picture of SA. The first of the research areas to be covered is the CTMM and the structure will follow that which is mentioned above in the previous paragraph.

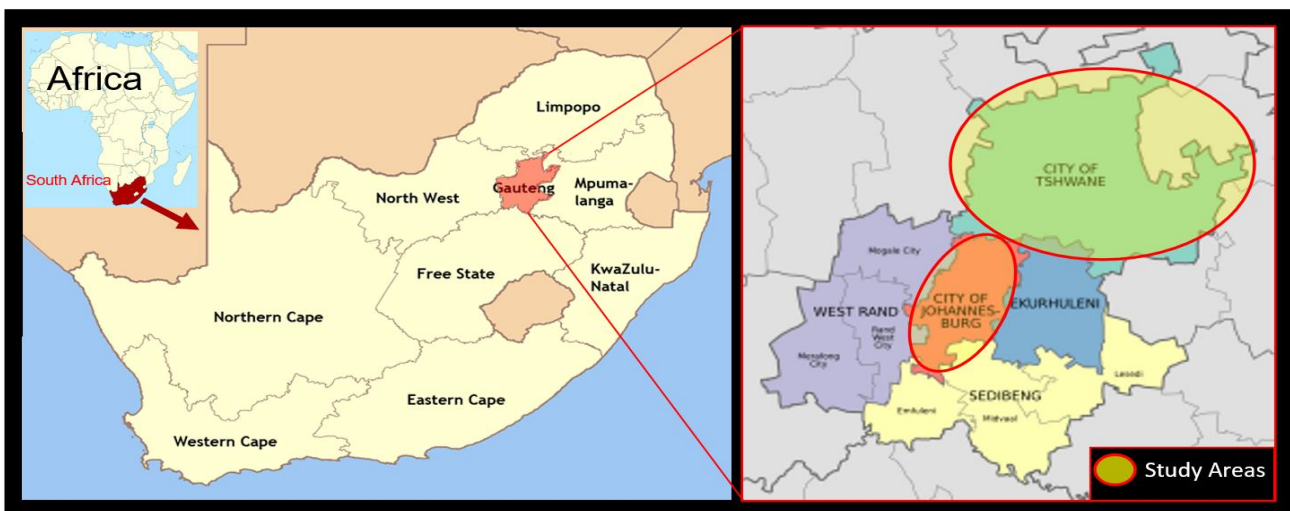


Figure 29 Locational context of the study areas
Sources- (Author)

4.4.1 City of Tshwane Metropolitan Municipality

Also known as the “Jacaranda City,” the CTMM (figure 30) is the largest metro in Gauteng and the largest out of the 8 metros in South Africa. The population is estimated to be around 3.6 million (2022) and spread across 7 regions, 105 wards, and 210 councilors (SA, 2022). The metro has a diverse economy that sees its main sectors of income from “community services and government, followed by finance and manufacturing.” The economic output of the CTMM contributes 26.8% to the province’s GDP and 9.4% to the country’s GDP. Despite its large size, the municipality has a relatively small population when compared to the other municipalities of the country. Despite being above the country average (34.4%) in terms of unemployment (35.8%), the CTMM has a high level of labor force participation (72%), when compared to the country (57.5%).

The goal of the municipality is to take active measures to achieve its goal of being the leading capital city in the country. This goal has seen the municipality place a large focus on the manufacturing, steel, and automotive sectors and the municipality aligning itself with climate change goals, having signed the Compact of Mayors’ Declaration. The city is therefore part of the C40 cities climate leadership group and is recognized as a leader in climate change. “In addition, the Gauteng government will be unlocking more than R60 billion investment in key areas over the next decade.” This includes investments into the Automotive SEZ, infrastructure investment to revitalize townships and create economic opportunities, Menlyn Maine development of High-Tech SEZ, and Expansion of the Innovation Hub. All these measures are to contribute towards the set vision of the municipality of creating an innovative ecosystem within Gauteng (Tshwane, 2020).



Figure 30: Region map of Tshwane metropolitan municipality
Source: https://e-gis002.tshwane.gov.za/E_GIS_Web/

Planning Profile

The metro contains an extensive amount of planning documents, policies, and spatial development. Many of these documents are mandatory for the municipality to have, such as an Integrated Development Plan (IDP) and a Spatial Development Framework (SDF). Since Tshwane falls within the Gauteng province, it forms a part of the Growing Gauteng Together 2030 plan (GGT2030), and many of its projects conform to that document's visions. The CTMM also has its own set of documents that look to future prosperity in the years to come. Tshwane 2055 and the Tshwane Vision 2030 make up the documents that guide the future end goals of the metro, while the latest Municipal Spatial Development Framework (MSDF) 2021 and IDP (2021-2026), guide the present. These are the core documents that guide the direction of planners within the municipality.

The core guide documents are preceded by many smaller documents and projects that are intended to achieve the set-out vision. This has seen the metro undertake more sustainable approaches to development, (Bioregional Plan for the City of Tshwane 2016), as well as many TODs- Transit Oriented Developments, (A Re Yeng – Tshwane Rapid Transit system). All these documents and policy plans are directed to “Enhance Tshwane’s transition to a green economy and facilitate a sustainable development path,” (Tshwane, 2020). These planning projects occur primarily to improve the social and spatial realms within CTMM. All the projects, documents, and policies that make up the planning structure, layout, and guidelines of Tshwane are monitored and evaluated yearly. This was recently done in the form of the Annual Municipal Budget and Benchmark Engagement 2021/22, and the Built Environment Performance Plan 2020/21.

The multitude of documents is governed respectively by the sphere of government each one pertains to. The metro’s Inter-Government Relations (IGR) plan focuses on coordinating these separate entries of the governmental spheres. The latest progress in this regard was the creation of the “City of Tshwane District Development Model One Plan,” in 2021. This forms part of the District Development Model (DDM) of Gauteng. This model focuses on ensuring a shared vision across the spheres of government so that the development plans conform to future goals set within the province (GGT2030) and the country (NDP 2030).

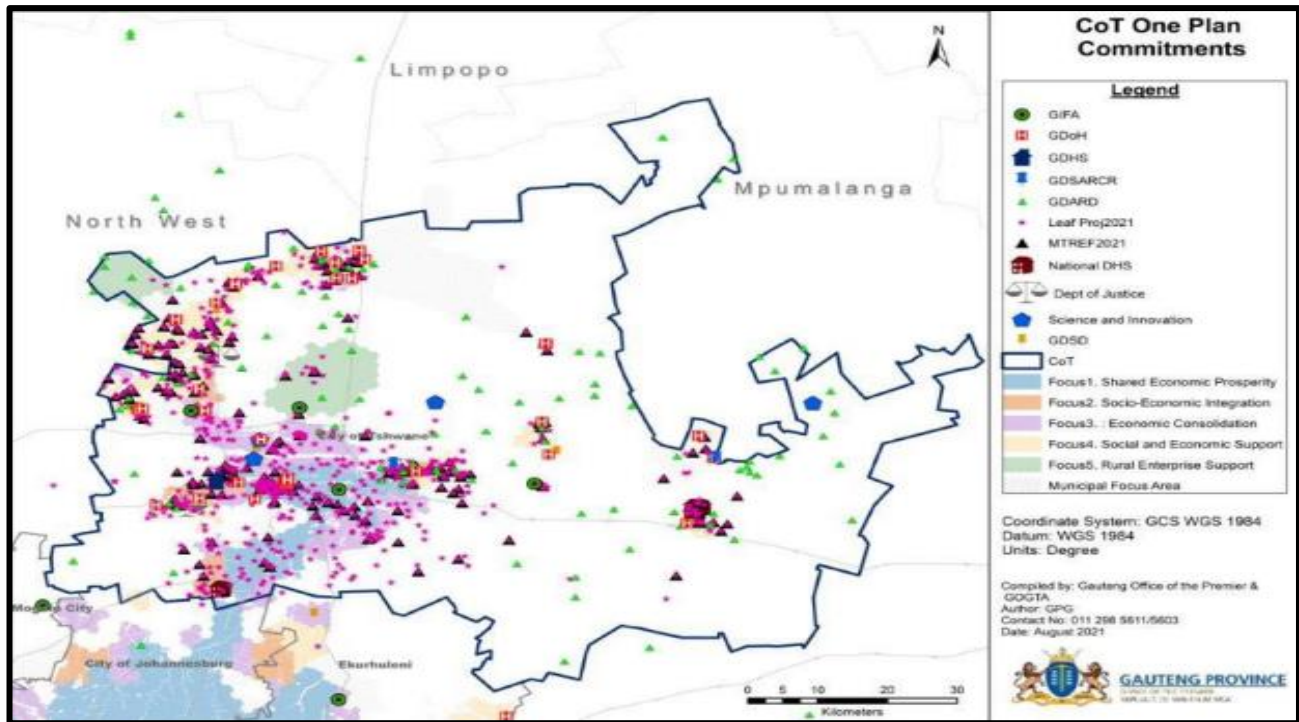


Figure 31: Map showing Sector Commitments in the City of Tshwane Metropolitan Space
Source: Figure 12, (Tshwane, 2020).

All the documents mentioned above follow a strict format that starts with a contextual evaluation of the affected areas. Each document is highly detailed and contains many pages due to the layout requirements. The CTMM's planning profile, therefore, consists of documents that set goals for the future and present plans to assist in achieving these goals. Figure 31 is an example of this as it shows the commitments of the Provincial Government. These commitments are primarily focused on the interior and to the West of the municipality. This diagram is one of many plans set and it exhibits the scale at which planning documents operate within the CTMM.

In summary, the planning profile of Tshwane is best captured in the conclusions of the District Development Model One Plan. Tshwane, "is aware of the challenges presented by current urbanization and economic development demands." The plans and policy in place, are set with full intention to benefit the CTMM in the coming future (Tshwane, 2020).

Tshwane planning principles

The CTMM follows the basis of the five main spatial principles of the SPLUMA 2013 act. This document is in line with the modern standards globally and therefore indicates that the CTMM is on the right trajectory. From these principles, the MSDF of Tshwane specifically targets key sectors that support the 2030 vision. These principles are service delivery excellence and innovation, economic growth, and job creation, promoting a safe and healthy city, social cohesion, inclusion, and diversity and lastly participation, collaboration & partnerships with citizens, the government, and stakeholders

(MSDF 2021). These principles project a clear direction for what the CTMM is envisioning and what implemented initiatives are targeting specifically.

This concludes the contextual analysis of the research arm of the CTMM. The next area of the CJMM will be looked at and will follow the same format that was done to contextualize the CTMM.

4.4.2 City of Johannesburg Metropolitan Municipality

The CJMM popularly referred to as “Jozi” or “Joburg,” is the largest metropolitan municipality in terms of population and economic output in the country. The estimated population in 2023 is 5.77 million and covers an area of 1.645 sq. km and the municipality generates 16% of SA's total GDP. The highest contributing sectors to the Johannesburg economy are finance, community service, and trade. Johannesburg is one of the world's youngest major cities that owes its rapid growth to gold mining which leads many people to seek opportunities to travel to it. This established the city with a reputation of opportunity for those seeking work and this label carries on to the present day. The municipality employs 48.88% of the total workforce in Gauteng and 12% of the total national workforce. This makes the municipality a “magnet for entrepreneurs and work seekers,” however post-COVID pandemic has seen a sharp decline in the manufacturing and mining sectors. The low economic growth contributed to a high unemployment rate and presently sees the municipality struggling to create jobs (Johannesburg, 2020).

Despite the challenges of inequality (Gini Coefficient 0.624), poverty (20% of the population), crime (1 in 59 chances of being robbed), and unemployment (33.9%), the city is still considered the most advanced commercial city in Africa and the municipality is still the number one choice for job seekers in the country. This leaves the municipality to be a crucial building block in the country as it is the main economic hub/force of SA. It plays a critical role in the country's structure and identity, therefore in the present day it can be considered a critical location for development and the starting point for future prosperity across the country.

Planning Profile

The planning documents within the municipality are primarily targeted toward the current challenges mentioned previously. To consolidate Johannesburg's position within Africa, the planning department, the private sector, and various spheres of government have partnered up to embark on significant developments to improve the municipality and inner city (Johannesburg, 2020). Development projects are focused in the areas of Midrand, Fourways, Rosebank, and Sandton, while the inner city of Johannesburg focuses on regeneration through the “reconstruction of the Provincial Government Precinct,” and the revitalization of townships. The municipality is also focusing on more joint ventures with the private sector, with current major development plans for the “Lanseria Airport City,” and over R150 billion of private development investments over the next ten years (Johannesburg, 2020).

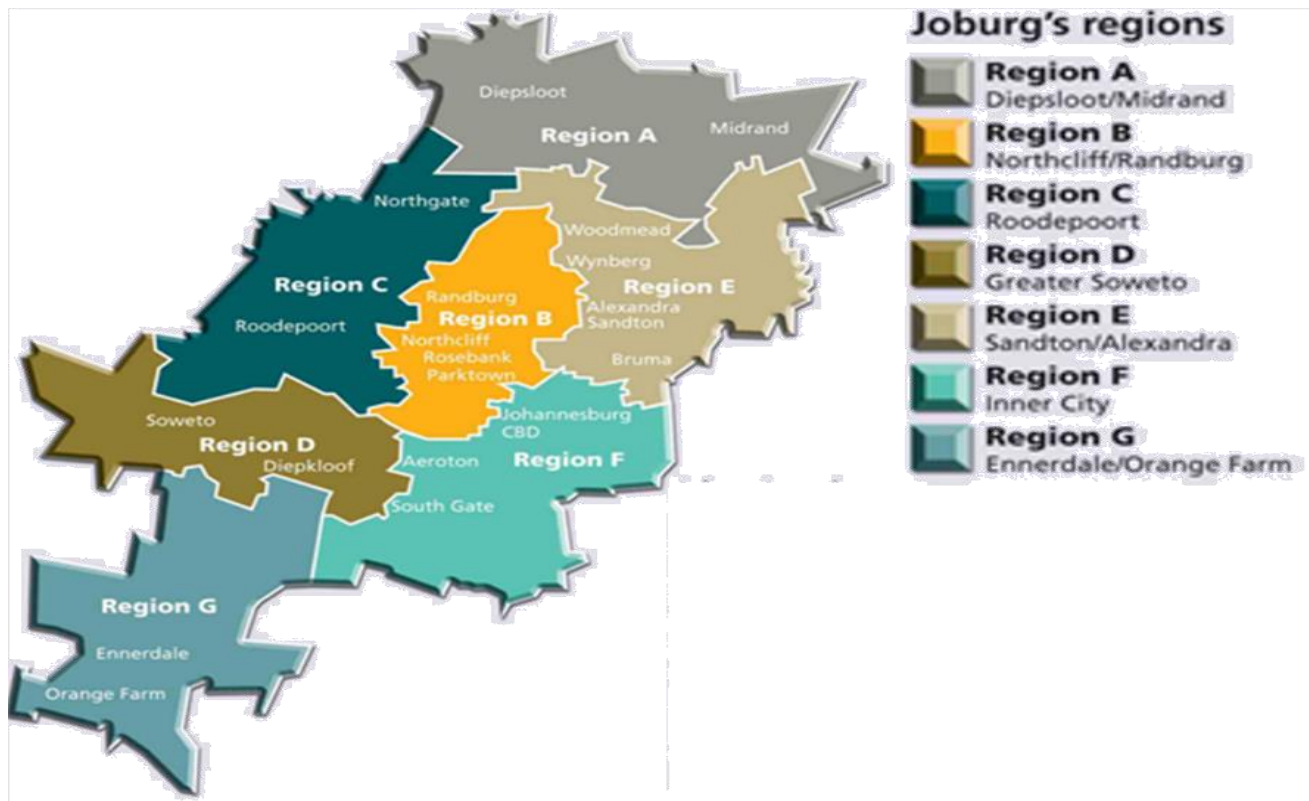


Figure 32: Region map of Johannesburg metropolitan municipality
Source: Figure 3, (Network, 2020).

To provide citizens effectively, the city is divided and operates on a regional scale. Figure 32 visually illustrates the seven regions (A-G) that the metro is divided into. The regional layout, in general, has the “northern regions carry more wealth,” than the southern regions, as these “were previously designed as labor-sending areas,” (Affairs, 2018). The focus of spatial development investments is mainly towards economic stability and refurbishing/maintaining infrastructure.” The Consolidated Infrastructure Plan, (CIP), provides guidance,” for upgrades and “maintaining the functionality of existing networks.” The structure of the \ departments of Johannesburg is divided into separate groups as well, to keep better origination across the regional layout. The planning departments within this structure are Development Management, Land use Management, Planning Control and Enforcement, City Transformation and Spatial Planning, and Urban Management Coordination (Johannesburg, 2020).

Planning documents that guide planners, development and spatial projects follow a similar structure to that of the previously mentioned metropolitan area of Tshwane. Similarly, the CJMM is part of the GGT 2030 plan and has an “SDF 2040” vision that has a yearly report published and an IDP 2022-27. The city also has a Growth Development Strategy (GDS) set for 2040 that acknowledges the realities of the city and formulates a strategy on what needs to be done for a more functional future. Other relative documents include the Lanseria Master Plan and the climate action plan of 2021 (Johannesburg, 2021). The Lanseria Master Plan is one of the few SC developments in the country

and the climate action plan is like Tshwane's, which means the CJMM is a part of the C40 cities climate leadership group. The vision that all the documents, strategies, and planners are building is best summarized by the Climate Action Plan 2021. The vision is to build "a World Class African City of the Future – a vibrant, equitable African city, strengthened through its diversity; a city that provides real quality of life; a city that provides sustainability for all its citizens; a resilient and adaptive society," (Johannesburg, 2021).

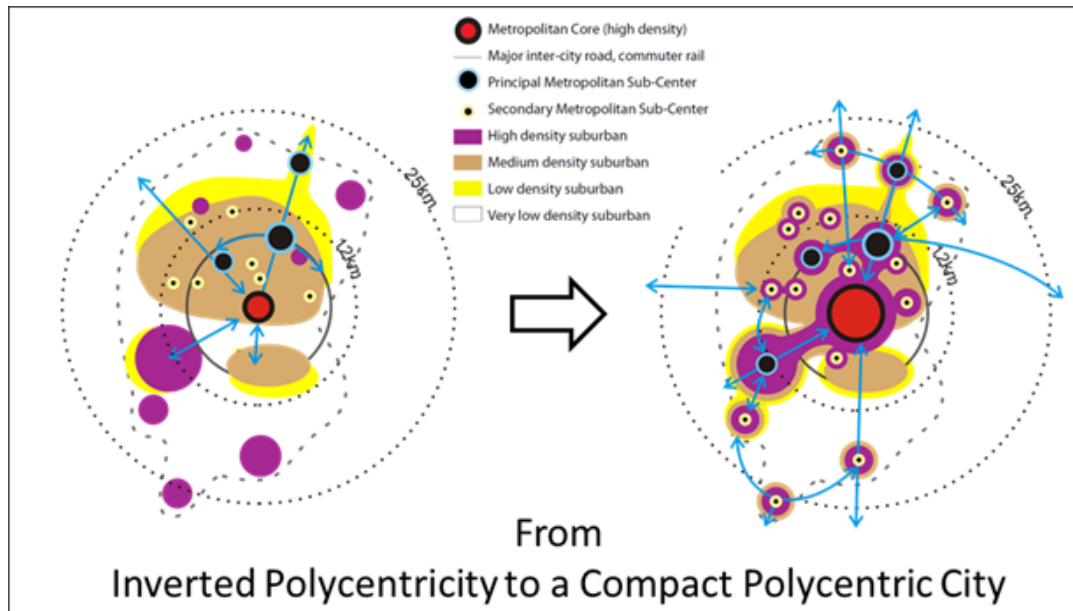


Figure 33: SDF 2040 principles are visually represented in a compact model
Source: Johannesburg SDF 2040, pg. 18-19, Figure (2,3)

Figure 33 illustrates the strategy to address the major issues in Johannesburg's social and spatial landscape. This model works off the advantages given by a compact city and is the main method to achieve the vision set out by policy and documents within the planning profile of the CJMM. In short, the city is aware of its present situation and utilizes spatial planning and policy to begin the process of amending its challenges. The focus areas are in line with modern standards and are detailed with the 5 principles of the SPLUMA 2013 document. The present planning profile of the CJMM is therefore working towards a structural state that is efficient, resilient, sustainable, equitable, and fair for its occupants.

4.5 Conclusion

The country of SA grapples with diverse geographic challenges, which include low rainfall and classifies the country to be a water scarce nation. With a population of approximately 60,6 million and 68% currently living in urban areas, the country is witnessing significant urbanization, which is marked by large-scale migration from rural to urban areas, as people search for opportunities. SA is a young democracy and is often referred to for its racial and cultural diversity. The country still struggles to address the legacies of apartheid both socially and structurally. SA is the second largest economy in

Africa, and it is classified as an industrialized nation, however, despite this, the country faces numerous persisting issues such as high levels of inequality, poverty, and unemployment, which are all made more challenging coupled with the issues such as high government corruption and energy grid shortages.

With regards to the country's planning system. SA operates under a set of key legal documents (figure 2) and policy documents that guide the country's spatial and initiative direction. The Constitution impacts planning the authority hierarchy, the MSA sets the requirement for IDPs and SDFs to be mandatory, and SPLUMA ensures that modern spatial principles for planning are being utilized. Two key issues relate to the three spheres system of SA and its spatial framework documents. The SDFs are mandatory documents that focus on the realm of physical space that planning development influences. These documents promote coordinated efforts for effective long-term management of key projects, which are envisioned to improve the future of the country. The three spheres of government (national, provincial, and local) have distinct responsibilities and within each sphere are planning documents that manage that level. The key point from this section is that the local government at the municipal level, is the most crucial for the implementation of sustainable initiatives. Local plans are the most critical level as they cater to more unique environments due to the smaller scale compared to national and provincial levels.

The key issues that plague the planning system of SA is its ineffective Implementation of initiatives. Despite the detailed documents and ordered structures mentioned, the intended impact often falls short of targets. A cycle of documents that incur shortcomings being replaced by new documents to amend those shortcomings is another key issue noted. Literature suggests that the leading policy documents are more aspirational rather than practical. The recent efforts indicate the importance of integrated sustainable development and a further placed emphasis on the implementation of projects. This emphasis was noted as it further backs the importance of the role that local government has. It is a key factor in determining the rate of successful implementation.

The next section that was contextually evaluated was the provincial context, which in the case of this research paper, was the province of Gauteng due to both research areas being in it. The key takeaways from this section were that though the Gauteng province only covers 1.5% of the country's land mass, it holds a quarter of the total population and is a main economic powerhouse that makes a significant impact on the national GDP (35%). The province of Gauteng has its own set of planning documents that guide the future development direction. These two documents are the GSFD 2030 and the GGT 2030. These documents aim for equitable and efficient development that emphasizes the spatial principles mapped out in the SPLUMA 2013 act. These documents are aligned with the national vision for the country (NDP 2030) and are set to guide the local documents of each area within the region. The main issue noted in this section is the lack of coordination between documents

and the recurring issue of being too optimistic about the current capacity of the province. From establishing the provincial context, the next section elaborated contextually was the two research areas of the CTMM and the CJMM.

The CTMM, which is also known as “Jacaranda City” is the largest metro in SA. It contributes significantly to the province's GDP and focuses on community services, government integration, finance, and manufacturing. From a planning perspective the CTMM primarily is guided by an IDP, and an SDF, and the metro follows the principles that are set out in the SPLUMA 2013 act. From this, the planning profile of the CTMM shows that there is a great emphasis on the green economy, sustainably, and social development and a clear indication to align with the visions set out by the GGT2030. Similarly, the CJMM is the largest metropolitan municipality in terms of population and economic output in SA. Despite challenges such as growing inequality, poverty, crime, and unemployment, the CJMM remains a crucial economic hub. Due to this, the CJMM is involved with major developmental projects, and partnerships with the private sector, to achieve regeneration of specific areas. The planning documents and projects present include the usual SDF and IDP, the SDF being aimed for 2040, a climate action plan, and most notably the Lanseria Master plan. All projects and documents are in light with the key focus to align with the GGT2030. The CJMM also follows the SPLUMA 2013 acts principles and focuses on resilience, efficiency, sustainability, equity, and fairness.

In conclusion, both the CTMM and the CJMM actively contribute to the wider vision of spatial planning in Gauteng and the country. The efforts align with the national and provincial vision that is outlined in the GSFD 2030, GGT2030, and NDP2030. The focus of the two research areas chosen is to create a sustainable and efficient urban environment that addresses the present challenges being encountered, to pave the way for a prosperous future. The similarities of focus between the two research areas are highly beneficial to the study as it set the president for the common themes encountered and what sectors are being emphasized considering the coming n4IR and SC innovations and initiatives.

The next chapter will cover the findings of the research paper.

Chapter Five: Exploring the Potential of 4IR and Smart Cities in South Africa

5.1 Introduction

4IR technology and SCs have been gaining attention globally, as nations and cities continue to leverage technology to improve the quality of life for citizens. The potential contribution of 4IR technology and smart city principles to global development is significant. For SA it offers an opportunity for the country's national development strategy and future visions. However, the integration of 4IR technology and the development of SCs in SA is still in its preliminary stages. The context of the country and its numerous challenges leaves the topic of integration technology 4IR and the creation of SCs as a big question mark.

This study is aimed at exploring the potential that 4IR technology and SC principles will have for the SA planning system. This was done by investigating the perspectives of urban planners working within the Town Planning profession, as well as examining official documents that guide the country's development. The first section will deal with elaborating on all the main issues that emerged from the issues that were noted from the data collection processes as well as the implications of them, followed by a summary of these matters discussed at the end of the chapter.

The purpose of this chapter is to discuss the identified key issues that emerged from the data that was collected in the study. From the coding of the semi-structured interviews and literature from the document analysis, several recurring patterns were identified. These identified issues provide insight into the central findings from the associated data collected. This information gives a comprehensive understanding of the thoughts and awareness of planners, and the SA planning profession.

Each of the main issues will be discussed, highlighting the significance of each to the study. Evidence will be provided to support the presence of these issues, either through direct quotes from planners or from the documents investigated. Each main issue also encompasses sub-issues that fall under the same area. Insights from these issues will form the foundation for answering the main research question of this research paper. The layout of the issues will mirror that of the literature review, starting with the broadest topics of the 4IR and SCs and lastly concluding with SA.

5.2. Complex 4IR technology and the Smart City narrative

This category consists of all the issues that are related to 4IR technology and SCs. These two terms were noted to be used in conjunction with each other and therefore have been cast in the same category. The following issues were sourced mainly from document analysis, in line with the information noted from the literature review, and in part from the interviews conducted that contained

questions of the two topics of this category. The following information from each of the issues was noted.

5.2.1 Benefits associated with the 4IR and SCs

This issue was associated with the benefits and advantages that accompanied the 4IR and SC movement. Bouchrika discusses how the integration and progression of the 4IR, brings many benefits to society (Bouchrika, 2022). This discussion was further supported by a leading sustainability company, Ibedoral, which indicated that the advantages of the 4IR are evident with clear signs of increased efficiency, productivity, quality, decision making, and improved competitiveness (Ibedoral, 2022). In an article by PWC titled “Harnessing the 4th Industrial Revolution for Sustainable Emerging Cities,” the idea, of the end benefits being seen as the main driver for why the world is actively implementing these systems, is put forward (PWC, 2017).

This idea of the benefits being the main driver was supported by the information from the interviews, as many planners spoke about the appeal of the improvements that 4IR technology and SC initiatives can bring to the country. The main benefiting areas that interviewees discussed were associated with the improvements that advanced technology brings within the areas of industry, society, and the environment. Interviewee 2 when asked about their understanding of the 4IR and SC movement, immediately spoke about the benefits and how the 4IR “makes a beneficial eco-system through the integration between humans and machines.”

The benefits were most notably discussed in the country’s SCF document. The framework details on many occasions for educating stakeholders of the numerous benefits that the 4IR can bring to the country, as well as mentioning the extensive number of websites that promote a wide variety of benefits associated with SC implementation. Not all documents of the country equally spoke about benefits. An example of this would be from the GGT2030, where it discussed improving and upping the priority installing of smart initiatives rather than the inherent benefits. This is carried through into the following sub-issues as these areas are consistently referred to when there is a mention of benefits associated with 4IR technology and SC principles.

A) Efficient use of resources

PWC dedicates an entire section, in its report to using 4IR technology to unlock SDGs, toward the potential improvements to the efficiency of resource management (PwC, 2020). The report indicates how technology systems limit waste and improve efficiency where a person would normally not be able to. This idea is reciprocated in the NDP 2030, where improvements to utilizing the present resources more efficiently are mentioned, the SCF, where the efficiency of present systems such as healthcare and service delivery are discussed, and the GGT2030, which lists efficiency in all aspects of the province such as waste management, development, public services, and smart and efficient digital spaces.

This is important as this sub-issue forms the basis for why nations and the world are progressing towards 4IR integration and SC construction, as the improvements of efficiency of resources are critical in a future where there is increasing demand for it. To produce more output from the same input of a resource is a highly appealing trade for only upgrading a few services with more advanced technology. This idea was shared by a planner from Tshwane (interviewee 7) where it was said that even in industry, the technology is appealing as it limits waste and maximizes the resources that were inputted. This forms a critical part of this issue as all the benefits can be linked to a form of efficiency improvement.

B) Real-time monitoring

Alongside the efficiency improvements was a common component of real-time monitoring, which was cited as a key enabler for the benefits associated with 4IR technology. Buonocore reiterates this as well discussing potential benefits, real-time monitoring of a production line was covered and how this technology enables prompt intervention in the event of anomalies, which lowers the risk of errors that can reduce the production of a line (Buonocore, 2022). This technology extends beyond just analyzing production chains as Immerman protested in his work that covered technology 4.0 advantages and disadvantages. He elaborated on how the use of 4IR technologies can monitor all services where required, such as leak detection in pipes and monitoring activities impact on the environment e.g., carbon and pollution levels (Immerman, 2018).

This understanding is reiterated in the GGT2030 where the integration of intelligent transport services was put forward. Such technology would not only improve service delivery but also use real-time communication and access to information, transport would be safer, contain less traffic, and have a reliable on-demand system to report faults. This sub-issue has been identified as a key enabler for the 4IR as the advantages extend across all systems and drive the sustainability narrative. PWC in its report on unlocking 4IR technologies to achieve SDGs, summarizes it the best by detailing real-time systems as sensors that give up-to-date data with close to zero latency. Such monitoring enables quick detection of anomalies and increases efficiency through reaction times that human labor cannot do (PwC, 2020). This addition of real-time monitoring links to the last sub-issue noted this issue, where the inclusion of more data presents alternative solutions to problems that previously were not possible.

C) Presenting alternative solutions to problems

Brcic discusses the role of smart mobility in SCs, and how congestion and transport challenges can be addressed due to the leaps in 4IR technology. The benefits gained through sensors of real-time data of traffic allow for alternative methods to be utilized to address challenges (Brcic, 2018). These alternative solutions that are brought about by 4IR technology are not only isolated to just mobility

improvements and this sub-issue extends to all sectors where the technology can be implemented. Perrin elaborates on this by detailing how the next generation of clean distributed grids will begin creating millions of alternative renewable sources (Perrin, 2021). This is due to technology benefits extending into the renewable energy sectors, as advances in technology are enabling alternatives that weren't previously viable with the technology that was present.

These alternative energy types are noted as appearing in SA planning documents, where the GGT2030 emphasizes a reformed energy sector that utilizes alternative energy, such as solar, biofuel, and battery storage, to support the growth of emerging sectors along the entire value chain. Similarly, the GSFD 2030 also covers the need for the nation to begin development of utilizing alternative energy sources, to lower the reliability of coal to generate the country's electricity. The SCF focuses more on the reduction of consumption resource management, which links to SC efficiency mentioned previously, and due to this the ability to important alternative infrastructure designs and management. An example of this is smarter drainage systems which once enabled by the technology will provide alternative answers to a water-sensitive urban design.

This information was reiterated by interviewed planners when asked what their understanding of the 4IR and SC movement was. Planners from Tshwane and Johannesburg in general mentioned alternative solutions in the communication sector. The planner from Johannesburg's Spatial Planning Department mentioned that the new technology provides more options in terms of communication with the public on a local level. This is about planners of the country trying to engage more with public participation, which is recommended by the SPLUMA 2013 Act. This shows an indication that the component of public participation has been instilled within the metropolitan planning process.

In summary, the integration of 4IR technologies and SC principles brings with it, a multitude of benefits. The efficient use of resources, real-time monitoring, and the presentation of alternative solutions to challenges stand out as the key sub-issues of this section. Documents such as the PWC report, NDP 2030, GGT2030, and GSFD 2030 highlight which key positive and transformative impacts of the 4IR are being emphasized to be implemented. This emphasis is placed on efficiency improvements, innovative monitoring capabilities, and the ability to address challenges across various sectors by alternative means. The real-time monitoring aspect, which can be found within nearly all 4IR smart systems, is crucial for zero latency anomaly detection, which allows for quick responses to any matter. Additionally, the adoption of 4IR technology provides more alternative solutions, particularly in renewable energy and infrastructure sectors, and reflects a key focus toward the sustainability goals that the future requires. The insights gained from interviews further emphasize and comment on the widespread understanding and appeal of these benefits. This issue overall gives an understanding of the underlying pivotal role that 4IR and SC initiatives will play in shaping the desired efficient, responsive, and sustainable global future.

There are always two sides to a coin, and due to this issue discussing mainly the benefits, there is always the opposite, which in this context of the 4IR and SCs, is the challenges that are associated with its widespread implementation.

5.2.2 Challenges associated with the 4IR and SCs

Immerman described it best when he elaborated on how industry 4.0 certainly does come with amazing benefits and has progressed far in the few years of its serious inception, however, there are still some challenges that need to be overcome as they are a part of the technology revolution (Immerman, 2018). This issue is the inherent opposite of the previous, and it can be considered the issue that encapsulates the challenges that accompany 4IR technology inclusion and SC implementation. The PWC report on using 4IR technology to further SDGs also expressed this concern that the benefits gained, do not come without risk, and to get it wrong comes with its own set of consequences (PwC, 2020). With regards to the literature such as Beevor and Drew, the problems presented by 4IR technology and SC creation are well documented, the common challenges stemming from the huge financial toll, access to data concerns, equal implementation for all classes, skilled labor acquisitions and general impacts to social circles (Beevor, 2018) (Drew, 2023). The specific challenges are regularly discussed in conjunction with the benefits as one usually goes with the other. For example, automation of production lines or even the increased reliance on AI technology will increase efficiency, but also create the challenge of less low-skilled jobs being available (Immerman, 2018). This relationship leads to the understanding that for every potential benefit, there is an equal and opposite challenge that would need to be accounted for.

This relationship is further complicated as the two are not mutually exclusive to one another, an idea that Jansen puts forward where one shoe size doesn't fit all when it comes to 4IR implementation across different nations (Jansen, 2021). This idea is reciprocated by Oláh where even within sustainability initiatives, the benefits are normally fixed with an initiative however the potential consequences or challenges to be encountered vary in the present environment (Oláh, et al., 2020). This means that challenges encountered are different for the same type of beneficial initiative, depending on the circumstance and context surrounding the project. An understanding shared by Kotze in his discussions on addressing SA's urban challenges, where the unique context of the nation is explained to affect the way projects should be approached. A similar understanding as Jansen, where projects that worked in other nations won't necessarily have the same outcomes or problems faced as the factors such as present challenges within a country will play a crucial role in end outcomes (Kotze, 2014).

It was noted that the literature of the country did not discuss or cover challenges as much as the potential benefits from the previous issue. The common challenges were only briefly referred to. The NDP 2030, GGT2030, and GSFD 2030 all mention the need to address the challenges of urban

sprawl. Apart from the GGT2030 and the SCF mentioning and addressing climate and environment challenges, there was a noticeable decrease in the discussion of challenges that relate to smart cities compared to the expected city challenges. This can be explained by initiatives benefits addressing present challenges, but in short SA documents are focused on change and opportunities rather than elaborating on present challenges.

This is understandable due to the nature of the documents chosen but this contrasts with what interviewed planners from Johannesburg and Tshwane's spatial divisions expressed, as this was the opposite in terms of quantity. The Interviewees focused more on challenges in the country rather than the understanding of the benefits associated with the 4IR. A clear indication that aligns with Balkaran's fears of the country having misplaced priorities when it comes to 4IR implantation discussions (Balkaran, 2019). The most common challenges mentioned by planners from both Tshwane and Johannesburg metros were corruption, financial constraints, and poor infrastructure, most referred to the country's energy grid. This is a clear indication that there are higher plaguing issues that are disrupting meaningful progress and that no matter what sound theory or methods are used by planners, the greater issues will persist to inhibit progress if not addressed. The circumstance firmly indicates that outside the field there are issues that planners within the field can only work around or navigate around, rather than be able to fix.

With authors like Balkaran explaining that SA is misplacing its priorities by pursuing the 4IR, instead of addressing present challenges such as equality and poverty (Balkaran, 2019), the importance of context was noted as it is clear that the challenges associated do not directly correlate to benefits, but instead are grouped into categories where the benefits of a system are associated with specific challenges based off the present circumstance which surround the initiative. The recurring pattern of challenges encountered that were associated with 4IR and SC implementation was noted in lower sub-issues. Which were as follows.

A) Resource intense

A frequent challenge that was mentioned across most literature, reports, or studies, is where the increased demand for smart technology benefits comes with associated challenges of resource supply (Balkaran, 2019) (Immerman, 2018) (PwC, 2020) (Smith, 2018). This challenge centers around the increased burden that is placed on a system as well as the supplies that need to be obtained before initiatives can be implemented effectively. Smith explains the financial cost of new technology systems is not yet at the supply levels where they are affordable for everyone (Smith, 2018). This view was supported by interviewee 1 from Johannesburg, who also discussed how the financial requirements to even start partaking in the 4IR, are immense. Similarly, Balkaran and Immerman comment that the subsequent challenge that follows instillation is the added load to a country's systems, such as data storage and the higher energy consumption of electronics (Balkaran, 2019) (Immerman, 2018).

Such challenges raise the costs as upgrading the capacity and infrastructure of a system will be a requirement. This challenge in particular poses extra problems for SA as the interviewee describes that the energy grid of the country presently wouldn't be able to support the extra loads associated with the smart technology instillation of the 4IR. A problem that ties into the desire for efficiency, as sensors and devices are only as effective as the amount of data they can collect and operate with, which means any interruptions or downtime will limit the overall effect. The counterargument to this was stated by Drew and in the Report by PwC, which note that developing nations are not entirely left out as the advancements in renewable energy sources do offer strong alternatives when it comes to energy applications (Drew, 2023) (PwC, 2020). Many initiatives are seeking to become self-sufficient however the costs of such technology applications are still a remaining cause for concern, not only due to the systems being recently developed and in low stock but also the sheer scale in which installations would need to be implemented to have desired effects.

From the sources mentioned an area that was frequently mentioned as a cause for concern, when large data acquisition becomes a necessity for efficiency, is the social conflict and boundaries that arise with the privacy of individuals and the security of data acquired.

B) Cybersecurity and privacy

"No matter the upside of a technology, the potential for its unintended use must be considered." This is a quote by Stefanie M. Falconi, a lead tech advisor at USAID, who states the underpinning of this sub-issue. 4IR and SC implementation for all its good and challenges, does pose risks that although not intended, can be causes for concern. As elaborated on by Drew and Immerman, privacy and data security are the greatest long-term risks that 4IR integration is associated with. Both authors emphasize the need for policy and careful understanding of the required measures to have data security (Immerman, 2018) (Smith, 2018).

This risk that was associated with malicious intent was equally expressed as early as Schwab's literature on the 4IR. He expressed an understanding that the move to overreliance on technology for day-to-day living leaves a system exposed to vulnerability if these systems crash or stop functioning (Schwab, 2016). This idea of overreliance links to the dangers of cyberattacks and how a system, if infiltrated and shut down, can cause unintended harm or damage. This of course is the extreme but as Dagada warns in his article on the unintended cyber-attacks enabled by the 4IR, the rapid adoption of 4IR technologies will lead to a mushrooming of cybersecurity incidents, since the billions of deceives of the world are connected wirelessly and not all tightly secured (Dagada, 2021). This expresses that the dangers are also on a small scale as this unintended danger enabled by the 4IR will require emphasis, especially for less developed nations as they will have less experience and policy for such risks (PwC, 2020).

This risk and cyber security however are not present in the SA documents covered and the interviews only had half the planners mention cyber security as a challenge for the country, but no further detail was given. This information given by planners from Tshwane and Johannesburg is reflected in the documents as instead of cyber security, the country is focused on food and water security. The NDP, GGT, GSFD, Johannesburg and Tshwane SDF, and IDPs discuss extensively plans to secure the water availability and food provisions for the country, while these documents including the SCF also cover plans for improved security of people, such as the protection of people and belongings. These can be linked to addressing the challenges of high levels of poverty and unemployment mentioned in chapter 2. The country on the fundamental planning level, as far as documentation guides, cyber security is not mentioned as the focus was emphasized to be on basic needs and crime prevention measures. The country is a developing nation, and this is expected as smart technology is not yet common it would be included in planning documents that are approaching their deadlines in 2030.

C) Adequate supply of skilled labor

The other consequence of rapidly implementing technology to gain benefits within production and efficiency was the toll felt on the labor force. The challenge associated with raising the skill ceiling on operations is to have the labor with the necessary skills to provide. The PWC report elaborates as it describes that the way that future work is rapidly changing, taking many tasks out of human hands through automation, while spurring the demand for a digital skill set, is increasing the demand for labor so high that hiring can hardly keep pace (PwC, 2020). Within the literature, authors tend to agree that the benefits of automation come at the cost of both misplacing labor and creating a challenge to fill spaces with adequately skilled labor (Immerman, 2018) (Smith, 2018). It is also seen as a natural order of progression when it comes to change with regards to industrial revolutions, where similar challenges, such as encountered in the 3rd industrial revolution, where skilled labor was naturally acquired over time as systems became more familiar (Smith, 2018).

This contrasted with what the SA planning documents had written, where from the IDPs of Tshwane and Johannesburg, automation was seen in a positive light, with regards to benefiting the economy and services sectors. The SCF focuses on the benefits of automation as well and specifically highlights the efficiency it brings to service delivery for municipalities. This is understood as the mention of labor and employment has the NDP, GGT, and GSFD focusing on job creation and goals, rather than the immediate challenges associated with acquiring skilled labor, as the country still struggles to allocate employment, specifically for the youth, of the working population (Philipas, 2020).

This was also expressed by the planners from Tshwane and Johannesburg, where one interviewee from spatial planning in Tshwane commented that the country lacks skills that are necessary to operate new technology, so it is not useful to invest in owning it yet. This ties into Jansen's worries about misplaced priorities as planners understand that without operators for smart machinery and

initiatives, they are not able to be utilized to their full potential (Jansen, 2021). This sub-issue indicates that the acquisition of labor is important for 4IR initiative sustainability, as well as the emphasis on planning for compensation of the displaced labor that will be incurred, however as seen from the planning documents of SA, there are still opportunities for further job creation despite the clear skill gaps being mentioned. This understanding leads to strong policy being a key driver in terms of creating workers for the future, and this is where the emphasis of strong government support for such initiatives, was found.

D) Requires full political will and government support

Lye explains that if government agencies are too slow to adopt new technologies, they will fail to generate the efficiency gains needed to keep public services going (Lye, 2017). A common understanding is that if the government and its policies are not all geared towards a common goal, such as the 4IR, the attempts made will be nothing more than a waste of resources (McLennan, et al., 2022). A problem that was present within the SA planning documents such as the NDP, GGT, all SDF, and IDPs, where the idea of smart initiatives and 4IR integration does not make any significant features. The mention of smart principles does appear in the IDPs of Johannesburg and Tshwane, while the only document with a clear understanding is the countries' SCF, the NDP 2030 does discuss how whatever challenges the country has, refusing to participate in the technological revolution is not an option. A clear indication of a disparity in direction while the country is still focusing on the basics, there is a clear desire to participate in the 4IR and SC implementation regardless.

The backing of government is frequently discussed in the frameworks of the cities of London, Albert, and Singapore, where the link between the people and government was frequently emphasized (Albert, 2019) (Ormond, 2021) (SCS, 2020). A key component which is also mentioned by backhouse of these frameworks is the presence of the smart government principle, which sees an adaptive government with flexible policy and understanding present (Backhouse, 2020). These successful SCs did have the advantage of being more finically capable, however, the guiding documents of each showed a clear indication and understanding of the role of government and its strength. This view was also supported by planners from Tshwane and Johannesburg, which was discussed that a government needs to be fully on board as they guide the country and are the crucial first steppingstones for implementing any new change.

Projects are only as effective as the resources and backing that they receive. This issue indicates the importance and role of government concerning 4IR and SC implementation. These Projects are only as successful as the system allows them to be and due to the complexities of the topic area, if the system is not entirely geared or supplied towards fully committing to smart initiatives, you will be in a similar situation as the leading guide documents in SA, where they are only partially committing, and therefore projects are never given enough time to show results. With the government declaring its full

commitment (SONA,2019), but the research and authors writings in literature discussing a misplaced priority (Jansen, 2021), due to part of the problem being the lack of full and clear direction or commitment to one, the country clearly seems to be out of touch of what it can feasibly do, but instead leads with sweeping statements of commitment, without consideration of applicability.

The further exploration of 4IR and SC implementation reveals the other side of the coin in terms of the challenges that accompany them. Immerman highlights the challenges that come with pursuing the benefits, and PWC cautioning against the risks of failing to address challenges. The literature commonly referred to the challenges of financial burdens, data security concerns, and societal impacts. The SA planning documents, however, were more focused on the opportunities rather than the associated challenges, since the opportunities are seen as addressing other pressing challenges that the country is currently facing. In contrast, the interviewed planners from Tshwane and Johannesburg emphasized the challenges more, such as corruption, the country's financial constraints, and inadequate infrastructure. The idea of undertaking the 4IR in the current state of the country was made clear to be a misplaced priority.

The main challenges were resource intensity, cybersecurity, skilled labor needs, and the necessity of political will. These main points were most notably mentioned by planners from Tshwane and Johannesburg and confirmed through policy analysis which indicated measures to address or improve these areas mentioned. The countries' documents reflect a partial commitment by the government to 4IR and SC initiatives, which differs from successful international examples investigated, which emphasized strong government support and flexible policies in their respective planning documents. This issue underpins the need for a comprehensive understanding of challenges, contextual-specific planning approaches, and an unwavering government that is on the same page and committed to successful implementation.

5.2.3 The difficulty of differentiating between the 4IR and SCs

This discussion is focused on the difficulties encountered by officials from the planning profession and the trouble that documents had with clearly separating the 4IR from SCs. It was noted that the planners frequently gave similar answers when asked about the 4IR and SCs, with one planner from Tshwane explaining he did not know the difference as it was the understanding that they are interchangeable. This encountered challenge had different questions being answered identically as it was clear that the two terms were the same thing. This problem was reiterated in the literature documents where the terms were interchangeably used, such as by Malik and Zervoudi who commonly referred to both the 4IR and SC movement as one entity (Malik, 2017) (Zervoudi, 2020). In general, the SC movement would be described as the 4IR, as one planner from Johannesburg explained, that the confusion most likely stems from the 4IR being an enabler of the construction of SCs, so people often just think that SCs are what is the 4IR, when it is simply a product of it. While

another planner apart of spatial research mentioned that “Poor understanding has contributed to my lack of ability to differentiate, but from hearing and reading about it, I would say it’s all a part of the same tree and these are just different fruits on it.” This statement indicates further how both the 4IR and SCs are seen to be a part of the same “tree”, and therefore are known to be two different “fruits,” but are still seen to be the same.

This mindset is evident within the SA planning documents such as the SCF, where the mention of the 4IR specifically is only used a few times to describe the technology, but for the rest of the document, the primary focus is purely on smart technologies being used within the SC environment, when in fact it is 4IR technology advancements which are installed into a city to make it smart. This did not explain why the confusion is persistent as the country's main NDP 2030 vision plan has no mention of the 4IR, as out of the 485-page document, there were only two instances of a “technology revolution,” (pg.94,96) mentioned, one of an “energy revolution” (pg. 91), and one of a “green revolution” (pg.89). documents created later however, such as the Tshwane and Johannesburg IDPs, do contain a greater presence of content on the 4IR and SCs, but the greater documents such as the MSDFs of both research areas, and the GGT2030 have little to no mention.

The mention there is for example, for the Tshwane MSDF, page 109, chapter 2 section 7, describes how the technology is defined by the revolution it falls in and how it interacts with its surroundings. A similar understood definition but Schwab described the 4IR to be more the fusing of technology into all aspects of our daily lives (Schwab, 2016). From this understanding it was clear that the main areas that cause this confusion are the definition and the technology involved being similar, as the guiding documents do contribute to this disparity in knowledge however apart from the potential of documents being read which interchange the two, the lack of understanding of the two was more of a contributor than the general information which can be obtained by planning documents, readings, and research. The understanding that definitions varied between documents and how the confusion about where technology resides within the 4IR and SCs, two were the main sub issues that contributed the most to the challenge of differentiating between the two.

A) Similar definition

A recurring challenge that previous research has shown leads to a mismanagement of direction and goals which is what was encountered when investigating the SA planning system and the measures it needs to take to cope with the upcoming 4IR (Ferro, 2021). This risk was reciprocated by one interviewee who explained that to them the definition changes based on where you work, and for them, the definition is still the same except one is just within the location of the city. A clear indication that separating the two is not a major priority as the general understating of technology being used to aid present systems (Desk, 2019), is understood both by planners and spatial planning documents of SA. The priority lies elsewhere but links to the challenge of having the entire system required to be

geared towards 4IR and SC implementation. The presence of multiple definitions and interpretations is a strong indicator of disparities of direction from the fundamental starting points such as documentation guides.

The difficulty of the challenge is finding common ground and fixed definitions for aspects associated with the 4IR and the other elements that fall into creating an SC. The challenge continues past definitions but also the confusion, which is associated with the similar technology being used, which contributes to the 4IR and SCs being thought of as the same.

B) Similar use of technology

A contributing source to the challenge of differentiating between the 4IR and SC movement is further complicated with the technology usage being in conjunction. One interviewee described how they are both similar if not the same, because the 4IR uses cyber technology and as we get smarter and build more tech-based cities, we will not be able to separate the two since they utilize the same technology. A point that Backhouse describes as the marriage of 4IR technology, and cities allows the development of SCs (Backhouse, 2020). The confusion is seeing new technology as the 4IR, when the answer is far more complex, as a smartphone on its own, is not considered to be a part of the 4IR, but when specific services and apps, that tap into a SC framework to communicate data, are installed, then it becomes a tool in an SCs arsenal, but the same phone based in a rural environment that is only used for phone calls, texts, and does not connect to a Wi-Fi hotspot, is not considered to be a part of the smart technology normally associated with the 4IR (Facilitator, 2021).

The context of a technology device is just as important as its functional use, where a device in isolation is not in line with the smart interconnected support base that the 4IR is based upon. The confusion shows the dangers of incorporating smart technology into the wrong circumstances as without specific criteria being met, like a connection to a wider set of sensors and framework, the same technology does not function to the intended efficiency and uses. The challenge to differentiate between technology goes beyond grouping devices into the categories of 4IR technology and SC initiative tools, but also between what criteria make a device a part of these areas. The same device can be smart in one context but considered redundant in another.

The difficulty of distinguishing between the Fourth Industrial Revolution (4IR) and Smart Cities (SCs) emerges from planners in the planning profession struggling to separate the two concepts. Planners often equated the terms, attributing to the interchangeable use found in literature documents. The confusion is exacerbated by planning documents, like the South African SCF, primarily focusing on smart technologies within the SC environment, neglecting the role of 4IR technology in making cities smart. The lack of consistency in definitions across documents and the similarity in the technology used contribute to the challenge. The recurring sub-issues include the similarity in definitions and the

overlapping use of technology. Similarly, the confusion arising from the similar use of technology is exemplified by the belief that 4IR and SCs are inseparable due to shared cyber technology.

The context of technology devices and the criteria for their inclusion in 4IR or SCs further complicate differentiation. This challenge extends beyond categorizing devices to understanding the specific criteria determining their role in these domains.

5.2.4 The use of statistics to measure and indicate development

The use of statistical data to measure or predict potential/operations/risks of developments from the 4IR was a critical component noted when benefits and disadvantages were elaborated on. This issue was encountered more in literature and the planning documents of SA, but it was occasionally used in description by planners from the interviews. The literature frequently utilized statistics to justify claims of improvements, such as Cambridge, which detailed solar farms' advantages for long-term sustainability, using statistical data and efficiency increases of clean energy produced (Cambridge, 2022).

This was encountered regularly in SC frameworks as well, where the cities of Singapore and London used the marginal percentage efficiency improvements that smart initiatives brought, such as food production increases, transport movement efficiency, recycling improvements, etc. (Lee, et al., 2016) (London, 2023) (Mahizhnan, 1999). In short statistical data was used for any material that was associated with the 4IR and SCs, whether it was for explaining the relationship between innovation score and a country's progress with SDGs (PwC, 2020), to show how 1st world countries are typically further along the LDC's, or the use of statistical figures to reflect the challenges present, such as SA and its struggling educational scores of subterfuge who start at school and the amount who drop out before finishing high school (EAG, 2022). The use of data, graphs, and figures was inevitable to encounter within any literature associated with the 4IR and SCs, but this was in line with what the data revolution was, and therefore it was always expected, along with the understanding that the source materials used would naturally justify or support themselves with quantitative data.

The planners also utilized statistical data where one planner from Tshwane mentioned that since the unemployment of the country is around 30%, the integration of technology could be used to promote job creation. This highlights how data played a role in being an indicator for describing a problem.

This emphasis on data is also used for contextual purposes, as in the GSFD where it established that 97% of the province's population resides in urban areas. This contextual fact is used to justify future initiatives which focus on urban renewal, due to projects being aimed at the highest impact areas.

The emphasis that is placed on data is a firm indicator of what drives the 4IR and SC movements. Just as the associated benefits and challenges accompany the integration, they all come within a

measured bracket of improvements and risks. The importance of data therefore cannot be understated due to its constant approach within the research topic. Through this understanding indicators that appeared more frequently both in terms of improvement and hindrance, were noted to be the high-impact areas that play the biggest roles in the success or failure of 4IR and SC implementation. These indicators assist with the understanding of statistics to measure and indicate the development understanding of the relationship between these measures' purpose, which is the main indicator of the potential of a system. Due to these measures being identified as the most frequently used to either justify or assess projects or initiatives, the following sub-issues form each crucial indicator.

A) Economic indicators

Economic indicators were a frequent topic that commonly was seen as a limiting factor for 4IR and SC implementation. Both benefits and challenges impacts were determined by the financial equity that a nation would have at its disposal. PwC in its report on SDG found that LDCs often lacked basic internet and sufficient infrastructure to support smart systems, specifically mentioning Africa as its internet penetration rate was just under 40% and that 800 million people lack access to electricity (PwC, 2020).

The recurring emphasis on financial factors was reciprocated by planners who were interviewed. One planner maintained that the country should first be financially stable before incurring additional costs from upgrading the country with 4IR services. Financial factors are also mentioned within the major SA planning documents, such as the GSFD 2030, which refers to strong financial capital being important to secure the sustainability of projects. The GGT2030 emphasizes financial security and support for the future prosperity of the province, and the NDP 2030, ties the two documents together as they follow the guide to create a financial center for Africa and all the necessary services and provisions that need to be made. The significance of financial indicators is clear.

The emphasis and constant mention of financial indicators are understood from the challenges that accompany the 4IR and SC integration. The technology is not cheap, as well as systems would need to be upgraded to support such advanced initiatives that compromise sensors, data, and connection. This difficulty affects the developing world more than the developed (Nath, 2018), as financial superpowers generally already have the required infrastructure to support smart technology, while developing nations, even the leading ones part of BRICS, still struggle to meet the basics in terms of provision, and to incur additional costs to install projects that contextually may not meet goals is a risk. The financial strength of the nation has been linked to success with 4IR and SC implementation, as well as success being linked to a higher innovation score (PwC, 2020). The statistical side constantly measures technology indicators to predict the future success of a nation concerning the 4IR and SC topics.

B) Technology indicators

PwC found that technology adoption and economic development are inherently linked, with countries that have strong digital readiness and innovation capacity being the ones who show the greatest progress with global goals, while less innovation generally fared less well (PwC, 2020). This relation leads statistical economic data to be commonly paired with technology indicators and data. Ormond reinforces the importance of technology innovation by detailing how greater innovation attracts and retains the population and requires wealth for a well-functioning commercial sector (Ormond, 2021). The recurring inclusion of such data leads to the understanding that the technological ability of a nation is a key component when determining future potential success with 4IR innovation and SC construction.

This understanding was found to be evident within the SA planning documents as well, with the NDP and the GGT 2030 focusing on primarily basic service data, such as piped water and Wi-Fi percentage coverage. Documents such as the Johannesburg and Tshwane IDPs most notably used data to define contextual challenges rather than detailed statistics of technology improvement potentials. A stark contrast to the Singapore and London frameworks which detail improvements by initiatives to marginal increases, such as transport efficiency being improved by 5% annually and water waste reduction by 10% per household (Lee, et al., 2016) (London, 2023).

The significance of the role that technology indicators played was understood, since the 4IR is digitally centered, a nation's technological infrastructure and systems present would naturally influence the difficulty of further applying and upgrading related services. Technology indicators alone however are not an accurate measure, concerning the chapter 2 Figure 1 diagram, where some nations with higher innovation scores (SA), had lower successes with global goals than other nations (Ecuador), who had less innovation scores. It was clear that wealth and present technology innovations were key factors that determine potential success, but another key factor had a role in determining success. This factor was natural for those who were most affected by 4IR and SC implantations, which were the citizens and people. Social indicators and statistics would be noted as being the last key part of this issue of statistical data usage.

C) Social indicators

The use of social data was used to elaborate on challenges, PwC's report found that an estimated 44% of companies lack access to sufficient talent to adopt their AI strategy fully (PwC, 2020), as well as benefits, that Fox and Signe described that new 4IR policies can assist in reducing the gender gap in access to and use of mobile phone and internet services (Fox & Signe, 2023). The use of social indicators was seen to aid in guiding plans towards addressing problem areas as well as measuring the potential impact that initiatives can have on specific social contexts. The common measures link to the skilled labor acquisition challenge, where the education of the population is the highest of

priorities. The links to what Backhouse discusses in terms of smart principles, where smart people are an essential requirement for SCs (Backhouse, 2020), as the people are the ones who were the operators of implemented technology. This explains why educational statistics are frequently utilized when measuring the potential of a country's adoption for successful SCs and 4IR technology utilization.

This idea was reciprocated by planners both from Johannesburg and Tshwane, as one planner discussed how the amount of "government participation and synergy with the people, can usually impact the success of projects," (interviewee 6). This ties into the challenge of government will be a factor but also the furthered understanding of the role that the social context plays in the creation of sustainable SCs. This understanding is supported in the SPLUMA 2013 guide for SA planners, where public participation is frequently mentioned alongside sustainability. SA documents such as the NDP, GGT, and GFSD 2030, emphasize public participation, with plans to improve the links to the public and encourage its usage more in the preparation phase of new developments.

The role of the social realm was clearly shown to form a critical part of the success and longevity of smart initiatives. The literature frequently highlights the role of the individual and how as the operator and producer of data, they are a determining factor in the efficiency and success of implemented 4IR and SC projects (Khanna, 2021). These social indicators are a key measure of a country's ability as nations that exhibit poor social characteristics such as struggling education statistics and large wealth gaps, are highlighted to struggle with regards to 4IR participation.

This issue reveals that the utilization of statistical data is a fundamental part of gauging the potential of 4IR technology and SC principles within a nation. The key indicators which were used to gauge a country's ability were its economic, technological, and social components. Economic indicators, such as financial stability, play a significant role in the success of implementing initiatives, particularly in the cases of developing nations (PwC, 2020). Technology indicators underline the importance of viable infrastructure in supporting advanced initiatives but are not always an accurate indicator of success with the 4IR if the indicators are solely based on technology innovation scores. The final major indicator noted was the social indicators used to measure the potential success or challenges of a nation's implementation of the 4IR. The main indicator is the education system of the country, as this factor ties into how well a nation can create smart people who can operate implanted initiatives (Backhouse, 2020). Overall, statistical data is a vital component in understanding the potential a nation has in developing successful SCs and the long-term sustainability of 4IR integration.

5.3 The Turbulent Context of South Africa

This second main category is related to the worrying state/context of the country of SA. This category which focuses on SA, reflects the physical logistics of the country and was the product of an

investigation that was narrowed by the previous issues associated with the 4IR and SCs. The issues and sub-issues of this category are as follows:

5.3.1 Limited access to technology and skills

This issue focused on the country's shortcomings of having limited access to the technology and skills necessary for 4IR and SC initiatives. In an article that focused on bridging the gap for technology access in SA, it was noted that for the people of lower socioeconomic status in SA, it was a struggle to gain access to technology due to the high prices, which results in a digital divide between those who have access and for those who don't (Borgen, 2021). The urban planners support this as it was discussed that there were many businesses and various communities that lacked the necessary technology access or skills to be able to fully benefit from initiatives. This results in educational programs being a required investment before any intervention, which one planner from Johannesburg's spatial division said, "leads to an increase in time that projects can take and a higher price tag, due to the extra cost incurred for educational purposes."

The SA planning documents frequently cover this issue in the context of labor force figures and the coverage and supply of technology networks. The NDP focuses more on long-term goals concerning basic access, such as 'pro-poor' electricity tariffs and an end goal of at least 85% of integrated household energy coverage (Pg.176), which has been seen as a solution to provide affordable access to energy sources within the country. The SCF's focus was different and targeted more towards ICT infrastructure access, which primarily comprised broadband and mobile coverage for rural settlements (pg.17), with regards to addressing fair access.

The skills required for operating 4IR initiatives noted in the previous issue were also a cause for concern noted from the planning documents. The IDPs of Tshwane and Johannesburg exhibit many references for the need for digital literacy. Specifically, the Johannesburg IDP, which has committed the city to become an SC, highlights the importance of inclusive development and targets five core pillars of "reliable digital infrastructure, affordable connectivity, digital skills, local content, and data collection," (Pg.29). This was a clear indication that the documents understand the importance, but also acknowledges the countries present shortcomings and are planning to amend them, to be prepared for transitioning to a SC.

The following areas emerged to be a recurring problem that contributes to the turbulent context of SA, in terms of access, technology, and skills.

A) Lack of skilled labor

The skill shortages within SA have been identified by the presidency as the second biggest impediment to economic growth (Bloomberg, 2023). The lack of skills that was assumed by the PwC report when it covered less developed nation challenges in terms of 4IR implementation (PWC, 2017),

was noted to contain some accuracy, as the country of SA struggles with this exact problem mentioned. The statistics speak for themselves as what Halstein ended when discussing the country's employment crisis (Halstein, 2021). The country has peaked at almost 32% unemployment rate with a youth unemployment rate of 51%, with no clear signs of slowing down. This lack of employment was shown in the SA planning documents, as to why the appeal of the 4IR and SC integration, is so high. The job opportunities that it does provide would be a boost to the country's economy, however, documents such as the SCF and GFSD, indicate that the present digital divide would need to be overcome to fully tap into this job market opportunity.

The planners reciprocated these worries from the documents, where one interviewee discussed how the shortage of skilled workers in the areas of cybersecurity, data science, and advanced IT programming, is holding back the country in terms of realizing the potential of the initiatives that would be implemented. Another Planner from Tshwane's research division explained how "the source of the problems stems from the education system," as to create higher skilled laborers, education needs to be at the same level. The required skilled labor will equally require an education system that produces enough learners equipped with the necessary skills and information, to be able to pursue and be a part of the higher tier of skilled labor.

The country's loss of skilled labor due to immigration, was not an unknown characteristic of developing countries, as a study by Dondani and LaPorte dubbed the movement "brain drain," which was the loss of skilled workers from a nation, who left to seek better opportunities and salaries in other countries (Dodani & LaPorte, 2005). This was noted to occur more regularly in developing countries, and since SA has at least 5 high standard universities, skilled labor is being produced but due to the challenges mentioned about SA with regards to unemployment and energy shortages, the emigration of skilled labor leaving is higher than what is produced (Halstein, 2021).

The long-term implications with regards to the 4IR and SC implementation were not only a lack of skilled labour being supplied, but also the challenges associated with outsourcing workers to aid in the construction of initiatives, and the impacts that would have on job creation outlooks.

B) Limited access to affordable technology

Associated with the challenge of added economic burden and the important role that a country's economy has on potential success with 4IR initiatives, SA was noted to struggle in terms of access to affordable technologies for the people. One planner from Johannesburg discussed how many communities simply cannot afford the technology upgrades required to participate in smart initiatives. This information leads to the understanding that investment into training and educating people for smart technology use, was not viable as the cost of the technology is not yet affordable. This idea was supported by Kayembe and Nel (2019), who elaborated that major challenges with funding lead

to inadequate skills and infrastructure to prepare graduates or citizens for participating in the 4RI. The problem therefore with not providing affordable technology is the priority to educate in the use of it also suffers as there is no need to train individuals on technology that they cannot obtain.

This is reciprocated by the planning documents such as the NDP, GSFD, and GGT 2030, which focus on many projects and goals toward financial stability and income outsourcing. The fixation on cutting down on costs and emphasizing more reliable long-term financial support was a firm indicator that the finances were not at the desired level presently, before the inclusion of 4IR technology and SC interventions. This was a key point in Olaitan and the company's framework which assessed SA's readiness for the 4IR, where it was shown that SA was struggling to embrace the 4IR due to financial constraints (Olaitan, et al., 2021). This struggle is reciprocated by Zake and Poll who discussed the long-term ramifications of not creating affordable 4IR technology, where they detail insufficient funds for producing technology at a rate that makes it affordable, creating difficulty for committing resources by companies (Zake & Poll, 2021), and government.

The lack of procurement or commitment to creating affordable technology, although understood due to the country being financially constrained since the Covid pandemic (Olaitan, et al., 2021), has created outreaching challenges that are linked to this challenge. The lack of affordable technology adds to another encountered challenge of fair access and the digital divide. The access to technology was being made worse.

C) Access to technology inequalities

The digital divide was a recurring challenge mentioned within the literature, where Fredrick (2019) noted that despite all the type of benefits of the 4IR, there exists a potential for an emerging technological era to create an entirely new facet for the digital divide. This reinforces the understanding from the previous sub-issue where the lack of affordable technology was contributing to a widening gap in the digital divide. The problem was covered by the Borgen Project, which was a focused endeavor for addressing the digital divide in SA and elaborates on the dangers associated with Fredrick's notes on 4IR's potential to worsen the digital disparities within a social context. The document mentions how people in lower-class areas of SA also lack access to basic services and employment opportunities presently, this results in an environment where basic digital literacy is scarcer and the prospect of high-paying jobs or higher education, was difficult (Borgen, 2021). These present difficulties would only be worsened with the inclusion of smart 4IR technology initiatives, as on top of lacking the basics in digital utilization, the ceiling would only be raised higher in terms of the educational curve to learn digital systems.

This raising of the ceiling for required skills, ties into the shortage of labor due to the lack of affordable technology, educational resources needed for operating 4IR systems, and economic strength to fund all the above mentioned for this issue, a scenario that was difficult to navigate was noted. The need

to educate the population was clear due to SA's clear desire to participate in the 4IR and create SCs, however, the will to invest was noted to be underwhelming as the technology availability was not at an affordable level yet, due to the limited funds of the country rather being diverted to needed basic service issues. This order of challenges leads to long-term difficulties in procuring skilled labor, as the environment present within the country leads to an accelerated 'brain drain' of skilled individuals from higher education that are produced. Overall, this issue covers the countries' struggles with the demand requirements of the 4IR and SC initiatives. Mainly in the sectors of skilled labor, technology acquisition and affordability, and fair distribution.

5.3.2 Inadequate infrastructure

The support of infrastructure was noted to be a key component and limiter, for successful 4IR integration and SC construction. This understanding was supported by the emphasis on infrastructure noted from the previous issues, where the determining factors tied to infrastructure, were key to a nation's overall benefit potential and source of primary challenges. This idea was supported by Govender who discusses how overcoming infrastructure challenges, was the key to 4IR's success (Govender, 2019). Govender highlights the need for connectivity within a nation and goes on to discuss that connective infrastructure is a foundational requirement for the 4IR technology services. This is further supported by Olaitan and companies' assessment of SA's 4IR readiness, where a key focus on the country's IT infrastructure was noted. A country with high levels of technological development would support the 4IR better, however, it was seen that SA was not considered to have adequate IT infrastructure (Olaitan, et al., 2021). The literature highlights the importance of infrastructure as IoT applications would require advanced support measures, such as reliable 5G mobile connections and energy supply (Olaitan, et al., 2021). This area being highlighted as a key determining factor for potential future 4IR success by Govender, was found to be understood within the context of SA and its planning profession.

The planners reported that the country should prioritize investment into the basic infrastructure of the country if the country would like sustainable long-term success with 4IR technology and SC initiatives. This was considering Gumede who warned that if nothing was changed within the country rapidly, the country would head towards a system failure, where the entire public infrastructure system across the country is likely to collapse over the coming period (Gumede, 2022). This warning indicates that the country was still struggling to provide the basics in terms of infrastructural systems. This is evident from the planning documents such as the NDP, GGT, and GSDF 2030, where priority on broadband, water, and electricity coverage is mentioned to be a key focus. This commitment further establishes that the country was still addressing the basics while future smart applications were only briefly mentioned concerning benefits to infrastructure. Most mentions in this regard were towards alternative energy provision. The noted concerns and shortcomings from planners, SA planning documents, and literature, regarding the infrastructural integrity of the country, formed the sub-issues. These areas

are linked to the challenges that contribute to the uncertainty of the potential the country can have with 4IR technology and SC construction. This idea was founded on the understanding of what necessary components are required for successful SCs, and the key focus areas that are measured statistically to determine the potential impact mentioned previously (Backhouse, 2020)(PwC, 2020).

A) Limited access to reliable electricity

In South Africa, Eskom, the sole electricity provider, struggles to supply electricity (Du Venage 2020). The act of regularly having to ration power makes it difficult for any thought of the country to adopt and utilize new 4IR technologies as energy security is crucial for the adoption of 4IR (PwC, 2020). Regular energy supply is essential for the successful adoption of new technologies as well as to facilitate IT infrastructure, so the country cannot be said to be ready when it has not attained full energy security (Gumede, 2022). Gumede also links to the issue of political will requirements for success as he continues establishing that power outages will continue in the coming decade unless there is strong political will.

This understanding was noted by planners from both Tshwane and Johannesburg, with one explaining that energy is a key enabler of the 4IR and SCs. On top of it all, it needs to be affordable, as right now it feels as if it's just not being provided in many parts of SA. This ties into the issue of affordability and the lack thereof, as well as highlighting energy to be another key component for 4IR technology. This understanding of energy is a key component was noted within the SA planning documents, where the major documents of the NDP, GGT, and GSDF 2030, all mention the struggles of the country's energy grid, and the necessity to seek alternative means of energy production. This drive for alternative energy production methods ties into the sustainable aspect which sees the modern world moving towards long-term sustainable energy goals (PwC, 2020)

The nation's move towards sustainable energy and the emphasis on its power grid shortcomings was a clear indication that this was one of the greatest limiting factors concerning 4IR and SC integration. This factor weighs heavily on both sides of the scale of potential as the indicated lack of energy will limit devices' effectiveness/installation, but the prospects offered by the developments of renewable energy infrastructure did offer a promising outlook for long-term solutions for SA.

B) Outdated movement systems

In a study done by Mbatha which specifically explored how 4IR technologies can be a solution to traffic congestion in Johannesburg city, it was noted that most congestion was caused by the number of private vehicles on the road (Mbatha, et al., 2021). The high volumes of private cars, coupled with rotational load shedding as mentioned above, and vehicle accidents, were all found to be contributing factors to road traffic in the city, and in short, were reducing economic productivity. The implications of the study showed that private vehicle usage was more reliable than the use of public transport, which in turn would account for the high levels of congestion

(Mbatha, et al., 2021). The study formed a prime example of the high levels of private car usage in a major city of the country, due to alternative transport measures being less efficient. An outdated car-driven structure that reduces efficiency within the system, which in terms of 4IR potential, does play a significant role as a successful SC requires a functional Smart movement component (Backhouse, 2020).

It was noted that the SA planning documents paid close attention to future movement networks, such as the GSFD 2030 which extensively covered major movement infrastructure to create activity spines. This is reciprocated by the Tshwane TOD program which was indicated to be a priority investment area in the Metropolitan Municipalities District Development model. The NDP 2030 conveyed how the country's road systems are under strain and are suffering from significant maintenance backlogs, which is a contributing factor to poor road safety. The NDP supports Mbatha's findings by also elaborating that despite public transport efforts, city dwellers are still utilizing their private vehicles. This has led the NDP to dictate in its plans, major investment into road and transport infrastructure. The clear emphasis and admission of the poor state of the movement system of the country gives a clear indication that it was a shortcoming in terms of its current state. The number of projects that were associated with road network and movement infrastructure, was a strong indication of intent, but also served as an admission of the importance of this component with regards to the country's future and even the 4IR.

This understanding of the weak state of the SA movement system was noted by the planners from Johannesburg and Tshwane as well, with most mentioning the importance of the movement network in a system. One planner from Tshwane explained how the country "shouldn't consider building SCs without first ensuring that SA has a strong movement system." Another planner mentioned that our road and public transport capabilities are outdated if we were to compare SA to what the 1st world has. These thoughts by the planners are in line with what the country was experiencing, and a good understanding of the importance of movement was noted.

The negative impacts associated with an outdated movement system were clear to be able to affect an entire system, as not only is movement inefficient but the economic potential lowered, due to delays. The outdated car-driven environment contributes heavily to congestion within a city as road users have no choice of alternative transport and are forced to utilize private vehicles (Mbatha, et al., 2021). In short, the country has plans to address the present issue within its planning documents however they share the concerns of poor road maintenance, which shall affect the long-term sustainability of projects.

C) Insufficient connectivity and network coverage

One of the main strengths of smart systems was noted to be the interconnectivity between devices and the ability to communicate and utilize large amounts of sensory data (PwC, 2020). This benefit was therefore only limited by the amount, quality, and rate of data that was gathered for interpretation and ultimately efficient execution (Lebeck, 2014). These limits are what ultimately affect the overall potential of these smart systems and this understanding led to this sub-issue being crucial in the context of SA's inadequate infrastructure. As Gumede

introduced it, from his discussion of the major challenges that SA faces regarding the 4IR, he noted that one of the major challenges was the digital divide present within the country. He continues with the mention of the notable gap between people who have technology access and those who do not, especially in rural areas (Gumede, 2023). From this, it was clear that the country lacked the necessary infrastructure to provide sufficient connectivity and network provisions for everyone.

The presence of this gap can be accounted for by the previously mentioned challenge to provide affordable technology in the country, but the outcome of this was noted by planners as they expressed a cause for concern about the connectivity services in the country. One planner explained that it was not always “profitable for large communication companies to invest in isolated rural areas.” This pushes not only the challenges of financial constraints and affordable technology in the country but also the widening of the present digital divide as it was clear that rural areas will be less favored for upgrades due to profit and feasibility margins. Another planner from Johannesburg mentioned that they were aware of a few projects to expand the country's digital network, but it was elaborated that the country has a long way to go if it wants to ensure that all its citizens have access to reliable communication technologies and infrastructure.

This poor connectivity within SA, for this issue, was a clear indication of the lack of physical infrastructure present to support and provide the necessary coverage across the country. The digital divide present was only worsened as urban areas were far more practical for investment when compared to rural communities on the fringes and isolated areas of the urban peripheries. The interviews indicated that this challenge of providing connection was sighted to limit the potential of 4IR initiatives and SC developments, as smart technologies fundamentally require an integrated connection between each other for maximum efficiency. This factor was an indication that additional expenses would need to be planned for as upgrades to the infrastructure would be required before undertaking extensive 4IR implementation.

Overall, it was clear that, the integration of 4IR technologies and SC construction within SA was due to inadequate infrastructure. Most notably in the areas of electricity supply, movement systems, and network connectivity. Govender emphasized the importance of overcoming infrastructure challenges first to ensure 4IR success (Govender, 2019), while Olaitan and the company, highlighted SA's lack of adequate and required IT infrastructure (Olaitan, et al., 2021). Energy insecurity, as proved by scheduled power outages, hinders potential 4IR adoption and effectiveness as the present grid could never support additional loads incurred by 4IR technology (Gumede, 2022), while outdated movement systems contribute to traffic congestion and reduce economic productivity (Mbatha et al., 2021). Moreover, the insufficient connectivity and network coverage within urban areas and between rural communities widens the present digital divide (Gumede, 2023). SA's planning documents acknowledge these challenges and emphasize the need for further investments in infrastructure (NDP, GGT, GSDF 2030), as well as the planners present for the main metropolitan areas, who acknowledge the country's shortcomings in this issue and indicate that it was a cause for concern for the future of 4IR and SC

adoptions. Overcoming these infrastructure limitations is crucial for realizing the potential of 4IR technologies and SC initiatives in SA.

5.3.3 Lack of resources

The lack of resources centered around the scarcity of resources that the country of SA possesses, namely within the financial sector means and production capabilities of SA. This issue ties into the abovementioned as the constant recurring issue that lays the foundations for a lack of affordable technology poor infrastructure and low network coverage. The financial and production resources of the country, are a recurring challenge frequently mentioned by the literature, planning, and planning documents. One planner from Tshwane explained how at one stage they accessed a handy “pothole” reporter app that was highly successful for the first year. The app was not yet self-sufficient and when the budgeted funds dried up, the app was cancelled. This was a clear example of funds being the main limiting agent to the further integration of smart devices through an app into the country.

Another planner frequently reported that the growth and financial strength of the country is a great hindrance to progress with the 4IR and SC initiatives. The lack of funds makes budgeting for the longevity of projects challenging. The slow growth of the country that was compounded by the COVID-19 pandemic has led to a poor financial status for the country. “Money is one of our greatest obstacles to overcome, especially motivating for money to be utilized in specific areas.”- (interviewee 5) This statement not only conveys what one of the country’s main obstacles was, but also that the acquisition of funding to specific areas was equally challenging, which in terms of 4IR implantation, means financial resources are not consistent.

Most notably a planner discussed how the country was heading towards a dire stage due to the growing GDP to debt ratio. The planner continued that SA borrows 80% of what it produces, and this was one of the main causes for the erosion of the country’s tax, and because of this, there isn’t enough revenue to work on all projects. The planner finished off by mentioning that recent reports say SA needs to grow by at least 8% yearly to meet targets, however, it was currently sitting under 2%. This was supported by the planning documents of the country, as the NDP, GGT, GSDF 2030, and both IDPs the metropolitan areas, frequently mention the need to grow the economy of the country, promote employment, and invest in the manufacturing of raw materials. The indication of policy that supports growth was a clear indication that it was understood that the country cannot overcome its present challenge without growth within all major sectors.

A report by The SA Reserve Bank by Mnguni (2020) elaborates on this by critically analyzing the economy of the country. It was noted that SA’s manufacturing performance was below the EM (Emerging Market) average. An emerging market is a country, that is developing, compared to a DM (Developed Market) which is a developed country, and the measure was biased off GDP growth performance. SA was flagged as an EM of the world however its manufacturing sector was noted to

be below that of just the average when compared to similar EMs (Mnguni, 2020). Mnguni continues that this sector has failed to diversify, and manufacturing remains concentrated in energy and capital-intensive subsectors within SA, which is in line with the above-mentioned constraints and challenges of the country. It depicts that due to the challenges of energy stability and capital growth, The country primarily focuses on those areas, which leaves other areas, such as the rest of the manufacturing sector, to fall behind and lead to the country being forced to import manufactured goods and export unrefined resources, to function. The impact this has on the potential of 4IR and SC successes in the country was that of the nation being underequipped to industrialize into the future or having severe limitations to industrialize to the standards of 4IR components.

Overall, the issue revolves around SA resource scarcity, particularly within the financial and production areas, which in turn contribute to hindering the creation of affordable technology, the outcomes of poor infrastructure within the country, and low network coverage. The lack of funds for the sustainability of projects posed a recurring challenge, which was also affecting the integration of smart initiatives, such as a “pothole” reporting app, that once its funds were depleted, had to be discontinued. The planner also cited financial weakness and slow growth to be the key contributors to the countries' challenges as well as a dire GDP-to-debt ratio. Planning documents, such as the NDP 2030 and GGT2030, also stressed the need for economic growth, employment promotion, and further investments in manufacturing which supports the claims made by planners. SA's manufacturing additionally shows its performance falling below the EM average due to the country's concentration in energy and capital-intensive sectors, which in turn was shown by Mnguni, to be limiting diversification and hindering progress and the potential of 4IR and SC integrational success (Mnguni, 2020).

5.3.4 Lack of coordination between the different levels of government.

The lack of coordination is reflected in SA planning documents, the planner's responses, and the literature. This issue within the different levels of government was frequently mentioned by the interviewed planners, who reported that there was a lack of a shared vision, direction, or leadership across the various levels of government. These statements by planners were commonly linked to the priorities of government being unclear and often contradictory, in terms of what is planned, announced, and realistically feasible. One planner mentioned that “the 5-year cycle of reshuffling the cabinet leadership of the country does contribute to this problem,” as new members don't necessarily have the same ideas as previous members and new members wish to make a statement in their short 5-year cycle. This situation, according to another planner, “leads to projects being rushed or replaced regularly and overall,” Meaningful progress is lacking because South Africa needs projects that receive consistent support, rather than being abandoned when new plans or documents are introduced.

This problem was further noted in the literature and there were cases of duplicate efforts and conflicting priorities. Quinot continues by elaborating that the main challenge the government faces is the lack of horizontal regulatory coordination (Quinot, 2020). This weakness was reiterated by the Department of Planning, Monitoring, and Evaluation (DPME), where the problem of horizontal regulatory coordination was identified in the consultation process (Masiteng, 2018). The DPME also noted the lack of linkages between established plans and their budgets, the lack of prioritization in the actions taken by the government, and the lack of clarity on the function and powers of the DPME department, despite being the center of overseeing government tasked planning, and lastly the clear lack of coordination between the plans and programs of the three spheres of government (Masiteng, 2018). In short, the lack of harmony between established plans and their budgets was in line with the challenges that face the country, in terms of documentation plans to implementation difficulties (Nwauche & Flanigan, 2021). It was noted that the disorganization of the government and its misaligned priorities contributed to the disconnect between well-founded documents, wishful plans, and poor implementation (Balkaran, 2019). An idea that Oranje's reading supports as he creates a similar picture where the leading policy documents of the country are a wishful dream, rather than a serious driver for change (Oranje, 2010).

The SA planning documents such as the provincial documents of the GGT and GFSD do align with the goals of the NDP 2030 as well as contain the principles of SPLUMA 2013. The IDP and SDFs of both study areas were also noted to be in line with each other, however, there were noticeable disparities between direction and priority, which is elaborated further in sub-issue A. The overall evaluation from the literature, planners, and planning documents, shows a clear indication that there was an element of cohesion between older documents (Ferro, 2021), however, concerning the research topic, modern documents have been noted to stand alone and operate without a concise and detailed shared vision (Masiteng, 2018), such as the countries SCF document which does align with the values of inclusivity as seen from the documents mentioned, however the documents modern focus of SC's is not shared and the issue covered by Balkaran of misplaced priorities of the country continues where significant documents don't reflect the promises of government (Balkaran, 2019).

A) Conflicting priorities across the levels of government

This sub-issue was noted to manifest in various ways within SA, which reflected a lack of consistency in goals and objectives across the levels of authority. This inconsistency creates a significant challenge to implementing cohesive smart initiatives, as noted by Interviewee 6.

In terms of planning documents, at the national level, the NDP 2030 lays out its main vision as aiming to eradicate poverty and reduce inequality by the year 2030, which emphasizes these areas for national goals and initiatives to focus on these outcomes. The municipal documents such as that of Johannesburg and Tshwane set out their visions for themselves, where Johannesburg's SDF 2040

aspires to create a spatially just and world-class city, based on a compact polycentric growth model, and Tshwane aims to become a prosperous capital city through the tools of fairness, freedom, and opportunity. It is worth noting that these local visions when broken down, are often prioritizing the immediate and localized concerns of the country, such as job creation and urban renewal development. This leads to smaller-scale plans to show signs of deviation from the admittedly broader national objectives and visions outlined in the NDP 2030. Even between the two research areas the visions, as mentioned previously, are different, which was understood since the contexts of each are not the same, however, the priorities and overall end goals were noted to not be like each other or even that of the NDP.

Additionally, the vision for Gauteng in the GFSD 2030, notes the challenge of balancing regional and national priorities. While it does aim for integrated, connected spaces that can cater to the needs of all residents within the province, the vision additionally highlights the importance of economic growth within the province. The difference in approach however was noted as the GFSD focuses on achieving results through, nodes and multi-modal activity corridors. Achieving this vision therefore requires coordination and collaboration across various levels of government, which with the above in mind, may be hindered by the conflicting priorities noted between the documents of the different levels.

This disparity of priority was subsequently seen to run parallel with an additional challenge of internal communications within the government. An issue that was noted to walk hand in hand with sub-issue A is poor communication is both a contributor and outcome of conflicting priorities.

B) Poor internal communication within the government

In a document published by SA Cities, which covered the disjuncture between constitutional principles and political realities, the contents noted further add to the troubles within the government concerning operational efficiency. While the Constitution envisioned the local government as an equal and autonomous partner within a non-hierarchical structure of the three government spheres, political arrangements, and party structures were noted to introduce hierarchical dynamics (Cities, 2021). The outcomes of this dilutes the voice of local government, where more influence was often given to provincial leaders and officials. Moreover, the document elaborates that the involvement of national and provincial governments in localized affairs, along with the lack of fiscal decentralization, ultimately leaves municipalities under-resourced and financially unsustainable.

This centralized decision-making process and resource allocation was noted in the document to create challenges for local priorities and ultimately it impedes effective governance within that sphere (Cities, 2021). This information supports the claim by Creamer's investigation of the links between business output and government communication. It was stated by Creamer that authors concluded that, across almost all indicators, there was evidence of a lack of internal coordination within

government, which makes processes more burdensome across all levels (Creamer, 2018). The poor internal communication was further evident in the previous sub-issues argument as conflicting priorities between and even horizontally across the levels of government (Masiteng, 2018) (Quinot, 2020). The problems of poor coordinated priorities as seen above, are largely the product of internal difficulties across all levels being lackluster as there was no discernable direction with regards to visions between planning documents or commonality between the main spatial vision of the NDP and documents below it.

The distinct lack of coordination between the different levels of government within SA emerged as a significant issue across various sources. The planners frequently cited the lack of a clear shared vision, direction, and leadership across government levels. A challenge attributed to the unclear and contradictory priorities of the government, which additionally has been made worse by frequent reshuffling of the cabinet every five years. This lack of coordination leads to rushed projects and wasted resources due to stand-alone projects not being as effective. These factors hinder meaningful progress and were highlighted by both planners and literature sources (Balkaran, 2019). The DPME also identified similar issues, such as the lack of regulatory coordination, unclear departmental functions, and poor linkages between plans and budgets (Masiteng, 2018). Additionally, conflicting priorities were also noted between the national and municipal levels, which further complicated matters as municipal visions, often prioritizing localized concerns, overlooked the broader national objectives outlined in documents like the NDP 2030, therefore national documents lack support from lower-level documents (Ferro, 2021). This disparity of priorities was also noted to be worsened by the poor internal communication within the government, as noted by a report that highlighted the hierarchical dynamics and centralized decision-making processes that sidelined local governments and impeded effective governance (Cities, 2021). These issues of this issue underscored the important roles and impact that improved coordination, communication, and alignment of priorities can have for a country.

5.4 The gaps within SA planning

This final category consists of all the issues that are related to the SA planning profession, most notably the gaps within it. This category forms the core area of investigation for the research question, therefore the results from this category are crucial to the study. The main issues and subsequent associated sub-issues that were noted from the literature, SA planning documents, and interviews conducted are as follows:

5.4.1 Lack of awareness of 4IR technology and SC principles

The lack of awareness of 4IR technology and SC principles by planners was the most notable issue of this category. The majority of planners exhibited uncertainty concerning the two topics and frequently were unable to fully elaborate or describe the 4IR and SCs. The planners were noted to

give similar responses when trying to differentiate between the 4IR and SCs, as they were not fully aware. The planners who could differentiate between them also only showed a partial understanding of each as specific in-depth details were hard to obtain.

One interviewee when asked, answered that they were unsure of what it is exactly, but guessed that it was the integration of more technology into the basic work environment. This response projects an image where the modern planner and associated roles surrounding it, are not well informed or aware of the 4IR and SCs, as the knowledge that was noted to be understood, was from irregular sources of information. This disparity of knowledge sources creates an environment where the basics, such as SC principles are not widely known or understood.

This issue encapsulates the planner's uncertainty about the topics of the 4IR and SCs, which was most evident through the many irregular responses or in some cases, planners admitting that they were guessing. This irregularity led to the following recurring sub-issues to be noted of this issue:

A) Partial understating of either 4IR or SC movement

The planners only had a partial understanding of either the 4IR or the SC movement. One interviewee explained that they thought they had less of an understanding than they should on this matter. The planners would normally provide what they thought to be the correct interpretation of the questions of the 4IR and SCs, however, a lack of depth and detail was clear. Another planner was aware and provided more accurate answers, however, in terms of finer details it was explained that they saw it as unnecessary in their work environment, as it was hardly present and only discussed as theory. This indicates and confirms what was encountered in the SA planning documents, where a notable lack of mention was given to 4IR and SC principles (Ferro, 2021).

Another planner mentioned that the 4IR, was more familiar to the younger generation, as the topic was still up and coming when they were still at university. This point suggests that interviewed planners were older and received their knowledge outside formal education. Similarly, the partial understanding was further accounted for by the understanding that studying for the profession did not yet include detailed information due to the movements not yet being mainstream within the countries' systems or documents. This partial understanding accounts for the next issue related to a vague understanding of SC principles.

B) Unsure of exact SC principles

The partial understanding and depth being provided were most notable concerning what are the smart principles that make up a successful smart city. These principles were present in the SA SCF document, where Backhouse principles were referenced and cited within a diagram that illustrated potential SC principles for the country. These principles are seen as the necessary areas which are required for a functional and successful SC (Backhouse, 2020), therefore an understanding of them would be crucial if the potential were to be explored for the applications of 4IR technology and SCs within SA.

Planners were all found to be unsure of these principles with one stating that they were not aware of a list but were sure there must be a set of defined principles for SCs. Additionally, planners who were partially aware, gave a few principles, most notably smart movement, but it was noted that details of these named principles were challenging to answer both generally and in the context of the country. One planner from Johannesburg spatial division was noted to explain they were sure it was the normal principles of a city, just with the word smart in front of it, but also showed only a partial understanding of city principles. Additionally, the inverse was true where a planner was noted to say that there were too many components to explain as there must be hundreds.

This disparity between answers further emphasized that the topic was not fully understood despite the countries' SCF document elaborating on the potential model for principles to be built off. The understating of SC principles was noted to be mentioned; however, answers were commonly associated with what normal city principles are, and the word smart was added to the answer. This was made evident by the lack of detail that planners were able to provide of each principle they named, and while some were able to give the required details, a clear indication of partial understanding was prevalent.

This partial understanding across all areas associated with the 4IR and SCs relates to irregular sources of information.

C) Irregular sources of information about the 4IR and SCs

There was a diversity of responses from SA planners regarding their awareness of the 4IR and SCs, with no clear pattern emerging. In terms of sources of information that informed the planners of the topic areas of the 4IR and SCs, a clear lack of regularity emerged. One planner mentioned that they were informed through conversations in the workplace, and a presentation by the CSIR, and occasionally would hear about it in the news. Another planner said that they were not entirely sure, and thought it was a combination of political speeches on YouTube and Television. These disparities in information sources were noted and firmly indicated that there was no primary source where planners could all say that they were educated on the intricacies of 4IR initiatives and SC development. It was noted that the media and the governing body, in terms of organizing education programs for planners, were the main sources of potential information concerning the 4IR and SCs.

Additionally, a planner did mention that some knowledge was obtained at university. However, it was not yet mainstream or studied in detail and was not yet common information at the place where they worked within the Metropolitan study area. This not only reinforced the idea that within the planning environment of the country, the 4IR and SCs are not regularly discussed or taught but also the furthered understanding that university education was only teaching these topic areas recently and that the interviewees were not as exposed from their time in higher educational institutions.

The irregular nature of the sources of information in which SA planners were informed about the 4IR and SCs, was a firm indication that the information that was obtained was predominantly sourced by the interviewees' own

accord. The varying depth of partial information being obtained was an indication that although the 4IR and SC conversation has been gaining traction, the environment of the profession contrasted with what the political will of the country announces to the public e.g., SONA 2019 address by the president. Additionally, the awareness of what the country has in place presently (the SCF), was noted to be minimal as the desired information of depth with regards to 4IR technology and SC principle, was evident in the 2021 document. The lack of awareness by SA planners was therefore noted to be contributed significantly by the irregular means by which information was obtained, but also by the working environment of the profession not proactively being involved with the topic areas, which therefore means that planners within this profession do not need to be informed due to there being no need.

Overall, the lack of awareness regarding 4IR technology and SC principles among SA planners emerges as a prominent issue. Planners displayed uncertainty, unfamiliarity, and only partial understanding of these two concepts. Many were noted to struggle with differentiating between the 4IR and SCs, with responses provided often lacking sufficient depth or informed clarity. This uncertainty was accounted for by the irregular sources of information that planners utilized to obtain insight into 4IR technology and SC principles. These ranged from simple workplace conversations to regular media sources, such as YouTube and political speeches. This highlighted a lack of consistent educational resources being made available for SA planners but further widened the understanding of this noted issue. Additionally, despite the references to SC principles in established planning documents, planners struggled to recite these established principles or be able to elaborate on the intricacies of each. This further added to the gap in understanding among the planning professionals of SA. This irregularity of information sources underscores a clear disconnect between the government's intentions of 4IR and SC participation for SA and the level of awareness that was not present within the planning profession. The limited integration of these topics into either formal education avenues or professional environments was noted to be the main culprit for the low awareness discussed above in this issue.

5.4.2 The complex structure of the planning profession

This issue was centered around the rigid nature of the SA planning profession's structure and the problems that arise for any person/entity involved. The planners questioned reported regularly that the SA planning system in which they operate, was slow in its adaption to change, due to complex procedures involved and poor interdepartmental communication. This information considering the ever-increasing pace of the modern world, was a noted cause for concern since adapting and implementing 4IR and SC initiatives requires flexibility (Govender, 2019). planners were noted to express frustration in the flexibility and complexity of the SA planning system; however, one planner did discuss how planning was a long-term investment that requires patience, which might explain this slow process being encountered

Another planner reinforced this by explaining that the country has slow government approval, an example given was the two-year nodal review step in projects, with the planner arguing that the system was far too complicated and slow to be efficient. The planner continued by elaborating that the ruling powers being rotated every five years does not help with the consistency of plans and progress goals. This links to the previous issues and reinforces the idea that the five-year system itself, has a wider-reaching impact than may appear at face value. This irregular progress of goals and plans, coupled with the rigid system and complexities mentioned, leads to a profession that is unable to perform its desired impacts that its documents dictate.

Additionally, the literature also indicated that the system present is confusing, due to the difficulty noted in navigating and understanding documents that pertain to the procedures involved within the planning profession. This issue was also highlighted by Sihlongonyane (2018) where in an article on generational standards of the planning profession in SA, he noted that the disarray and complexity of the system, had non-planner professions containing planning duties and the blurring of professional boundaries had become a source of confusion. This indicated that the present system was so complex that the outcome was that of the planning profession being unsure of its roles or identity. The complex structure is further impeded by the following issues:

A) Lack of standardization

The National Policy Development framework when reviewing the planning system of the country, found that policy-making challenges prevail within the profession of the country, as the government does not have a standardized or systematic approach (Cabinet, 2020). This was noted to be a factor in the confusion and complexity within the SA planning profession since a lack of standardization creates scenarios that are dealt with case by case and not within set parameters and procedures. It was worth noting that the lack of standardization was noted and present in planning documents, planners' responses, and literature, but in the form of addressing the issue.

The issue was seen to be well identified and accounted for and its recurring mention was that of the measures to amend this challenge in documents such as the NDP 2030, which calls for more standardization of systems, and organizations such as SACPLAN, which implemented regional planning programs that better align higher education standards with educating future planners on navigating the planning system (Lewis & Nel, 2020). The interviewed planners, despite their admission of the lack of communication between departments within the planning environment, did indicate that there were signs of improvements in terms of standard procedure.

One planner from Johannesburg, however, mentioned that the differentiation between systems from other municipalities, provinces, and the 3 levels of government, creates a system whereas a planner, to navigate any of them would need to specifically operate at just one level and area, as to move

around would require learning a new system. This indicated further that although a plan was in the works to address the challenge of standardization, the physical system present was fractured to a point where there weren't enough areas standardized to traverse between layers or areas.

B) The inflexibility of the present system

Another challenge highlighted by one planner was the country's slow adaption to change, and this increased the struggle for the country to keep up with the fast pace of modern demands. This challenge was noted across all sectors of the country and links to the previous issues by being a contributing factor to the previously mentioned challenges, such as education, finance, and inter-governmental relations. This was further supported by a report by Bulbulia (2019) in which the adoption of 4IR technology was investigated in SA business enterprises. The report suggested that SA was less than enthusiastic about the prospect of adopting newer technology, such as AI integration. The considerable obstacle to adoption was cited to be the high presumed cost and lack of skills present to implement (Bulbulia, 2019), which further supports the previously mentioned challenges facing the SA context. The report additionally stated that in terms of the SA system, the 4IR will be cherry-picked rather than taken up within businesses, as the associated risks are not outweighed by the advantages (Bulbulia, 2019).

The overall understanding provided was that the country, due to the challenges it faces, was slow to change due to the system not only being rigid, in terms of policy adoptions and incentives but also the mindset adopted by business and planners alike was that of the risks involved, proceeding would be with slow caution. The country being on the edge of collapse (Gumede, 2022), it was understood that there were clear grounds for this slow adoption to be contributed by caution. This stays true for the planning system of the country where the clear lack of the 4IR being mentioned within planning documents (Ferro, 2021), as well as only marginal progress being made in terms of SC implementation schemes (Chetty, 2022), as dictated by Chetty's SC readiness report. The inflexibility of the present system was clear and in terms of the required pace needed for potential success with 4IR technology and successful SCs, the country and its planning profession were not in a strong position to impellent meaningful change on a timely scale.

Overall, this issue encapsulates the SA planning system facing challenges due to its rigid structure, slow adaptation to change, and lack of standardization (Govender, 2019) (Sihlongonyane, 2018) (Cabinet, 2020). There were noted efforts to address these issues, which included initiatives that were outlined in the NDP 2030 and actions by the main planning organization SACPLAN (Lewis & Nel, 2020). However, these challenges persist presently due to disparities between the different levels of government and reluctance to adopt newer technologies, due to the risks associated with the context of the country. This was noted to hamper progress (Bulbulia, 2019), and overall, these factors were mentioned in this issue. Impede the profession's ability to effectively respond to the approaching modern challenges and opportunities that may come with it (Gumede, 2022) (Ferro, 2021) (Chetty, 2022).

5.4.3 The scarcity of 4IR and SCs plans in major documents

This issue was the noted scarcity of the associated areas of the 4IR and SCs, within the future visions from the major SA spatial planning documents. Planners regularly were noted in reporting that any mention of 4IR or SC initiatives within their plans or policies, was not covered in enough detail. The projects that were mentioned by planners were associated with the 4IR and SC movement, and as one planner elaborated, they were only stand-alone projects that weren't cemented within major policies or literature yet. Another planner explained that they would be misleading if they said otherwise when committing about the country's lack of 4IR and SC initiatives within SA planning documents. They continued that only policies and guidelines that are a part of main documents would mention the 4IR and SCs as they are required to. Due to this fact, the planners estimated that roughly 80% of all documents would not likely contain any mention of the 4IR and SC's.

Few documents mentioned 4IR and SC, as a major document of over two hundred pages would only contain two pages devoted to the 4IR or SC development inclusion (Ferro, 2021). Additionally, it is worth mentioning that even the larger documents, as indicated by the planners, such as the IDPs and SDFs of both research areas, the GGT 2030, and NDP 2030, lack sufficient detail or mention of 4IR technology integration or SC initiatives plans. However, one document apart from the SCF, was noted to contain a high level of detail in terms of SC plans. The COJ's IDP (2022-2027), stands out from the rest of the documents investigated, as it contains not only all the SC principals explained by the backhouse but also detailed plans for each principle. Priority 7 of the COJ IDP, titled "A Smart City," was a well-detailed plan and set a clear future intention for the COJ. The document elaborates on plans for achieving principles, such as "Digital Joburg," which focuses on smart governance, and "Smart Integrated Nodal Economics," which focuses on the Smart Economy principles and attached linkages of Smart Tourism and Smart Nodes. This individual document did show that there was an intention for 4IR and SC pursuit by the planning profession for the country, however, this document was noted to reinforce the above issues further despite it being a strong outlier of noted results and only aided the investigation in answering the research questions in the findings section.

The following issue regularly contributed to the outcomes of the poor presence of 4IR, and SC mentioned within major SA planning documents.

A) Political priorities

Building on the previous issue, of government priorities being misaligned, it was noted that political priority contributed heavily towards this issue. One planner elaborated that the limited mentioned 4IR and SC interventions within the main documents of SA were a clear indication of priority. They continued by discussing that the main priorities of the government are not yet fully directed towards the 4IR since the country was still struggling to provide the basics. This sub-issue was detailed above in terms of government mismatched

priorities, however, the consequences of this were found to be in the form of major documents lacking clear or distinct mention or plans for 4IR integration and SC construction.

Documents such as the GGT and GFSD 2030, were noted to only be focused on areas associated with smart growth, such as financial initiatives, while the difference between the MSDFs of the two research areas was firstly noted to be different from each other and secondly not in line with the provincial vision. One planner mentioned that although metropolitan areas' goals and initiatives may be different from the provincial documents, they do indirectly support for example the TOD of Tshwane does in theory support the financial growth of the province and in turn support financial goals. The planner elaborated that the difference between municipalities was too great, and municipal priorities were not aligned with provincial ones. The understanding gained by this was that approaches towards provincial visions can be interpreted differently and it was clear that metropolitan areas had vastly different priorities.

B) “Tick box” attitude to 4IR and SC inclusion in documents

The second noted contribution towards the scarcity of the mention of 4IR integration and SC principles within SA planning documents, was the attitude adopted towards the inclusion of it. One of the planners said that the documents that do mention the 4IR and SCs, will be brief as they are just set requirements to publish them. This reinforces the lack of detail of plans mentioned in previous sections and was clear to be a case of the “box “being ticked in terms of requirements. This was also confirmed by another planner from Tshwane who similarly remarked that the inclusion of the 4IR in the countries' documents was to fill in the box and not as a serious intention.

This recurring sub-issue of the “tick box” attitude directly correlates to Oranje’s reading of where the leading policy documents of the country are a wishful dream, rather than a driver for change (Oranje, 2010). Although the reading can be noted to be from over a decade ago, the statement was bearing fruit as the attitude noted towards 4IR and SC inclusion in documents, leads to a present scenario where such plans are called into question as the “tick box” mentality, potentially reins throughout all major documents. Additionally, plans that are more detailed and elaborate, with the country’s present challenges of implementation, it was noted that “dreaming too big”, and wishful, was just as prominent if not more dangerous than adopting a brief detailed, and tick box mentality.

The section discussed the scarcity of 4IR and SC initiatives and plans within major SA spatial planning documents. It was mainly noted that planners reported a lack of sufficient detail or coverage of 4IR or SC initiatives in the plans and policies that they work with. The projects that were mentioned were noted to be standalone plans, rather than integrated and fixed strategies into broader policy documents. Official major documents were cited typically to have devoted minimal space for 4IR and SC development plans, with even the larger documents of hundreds of pages, containing only a few pages on the topic areas. The COJ IDP however, stood out for its detailed SC plans, highlighting intentions for an SC through the detailed plans of implementing the principles of

successful SCs dedicated by Backhouse and found in the SA SCF (Backhouse, 2020). Despite this detailed document the political priorities overall were noted to be in the form of a "tick box" attitude towards the inclusion of 4IR and SC plans in major planning documents. This was identified as a contributing factor to their poor presence, as government priorities were reinforced to be further seen as misaligned and were still focusing more on basic needs than on advanced technology integration. Additionally, there was a noted understating that mentioning 4IR and SC initiatives within major documents was often a formality rather than a genuine commitment to the implementation of projects. This understanding reinforces Oranje's observation that leading policy documents in South Africa may be more wishful than practical drivers for change (Oranje, 2010).

5.4.4 Uncertainty surrounding 4IR technology and SC principles

This issue was associated with the uncertainty that surrounds 4IR technology and SC initiatives, within the context of SA. Planners reported numerous uncertainties concerning the place, justification, or implementation of 4IR technology and SC initiatives within the SA landscape. One planner from Tshwane Spatial division explained that the future was unclear and that there were many uncertainties for SA concerning 4IR and SC developments. This literature reinforced this as the number of documents that were warning of the problems SA would face with 4IR and SC inclusions, was far higher than that of documents that supported it.

The common issue noted was the uncertainty that surrounds how these initiatives would affect the country. Balkaran explained how it was a misplaced priority, saying that the country should get the basics function first before wasting resources on expensive smart technologies (Balkaran, 2019). This stance was reinforced by Erasmus who discussed that the SA environment was making the poor even poorer and that their great risks for overlooking the basics (Erasmus, 2022). This corresponds to Gumede's (2022) view, who paints a picture of a SA that was on the verge of complete collapse and was clearly shown to be in no strong position to logically peruse serious 4IR and SC integration. Additionally, the documents that cover the strong benefits that would be made available to the country due to the 4IR (Sello, 2019), also express concern and uncertainty, since all that can be discussed was theories backed by my data and examples from other case studies.

It was noted that for any document that discussed the benefits, the uncertainty of how possible they were practically was never far away to follow up. The measures in which the literature and planners must make predictions/assumptions of the future potential of the 4IR within the country were noted to be driven by statistical data, field examples, and current procedures observed occurring in SA. Due to the context of the country being revealed to be highly turbulent, there was an underrating of where the uncertainties came from.

A) Fear of getting it wrong

A noted challenge by the PWC report on the 4IR impact on SDGs, where details were given on the risks associated with getting it wrong in terms of 4IR development. These include job displacements, pollution, biodiversity loss, and compromised security (PwC, 2020), to name a few for example. This concern was concurred by planners when it was revealed that the country will run risks if it heavily invests in the 4IR, with one planner from Tshwane elaborating that the country was still mostly hesitant because of how uncharted the topic was on a large scale within SA.

This fear was not present within the SA planning documents as the real sense of urgency was noted to be from the literature, such as Balkaran, Gumede's, and PWC's warnings. In general, the planning documents were more reluctant to give detail on 4IR and SC initiatives. Similarly, another planner from the COJ spatial department, consistently expressed concerns about undertaking too much, with the key fears being noted as wasting limited resources, abandoning basic needs further, and trying to pursue developed nation initiatives on a "shakey" 3rd world base. The fear of getting it wrong was felt by the planners and reinforced by literature concerns. The current context of SA contributes to this greatly as the limited resources can be better spent, if what was undertaken with the 4IR fails to deliver (Balkaran, 2019), due to the numerous reasons above.

Overall, this issue covered the uncertainty surrounding the integration of 4IR technology and SCs within SA. The main concerns noted were the unclear future of the country and the numerous uncertainties that led to the place and implementation of these topic areas being called into question. The literature was noted to warn that potential problems would outweigh the present supportive features of the country. These concerns were voiced by planners, who expressed fear of the potential misplaced priority of partaking with the 4IR and SCs, due to the present inequalities of SA. This was noted to contribute to the hesitancy as there were risks mentioned that align with the PWC report, of the risks of increasing job displacement and environmental degradation (PwC, 2020). Caution was the tone of this issue, which was supported by authors such as Balkaran and Gumede, who openly warn of the country's poor position and context (Balkaran, 2019) (Gumede, 2022).

5.2.3.5 The urgency for South Africa to participate in the revolution

The last issue of this category was associated with the urgent need for SA to utilize 4IR technology and partake in SC initiatives. All planners reported that SA should participate in the 4IR and make the necessary investments and plans, to incorporate the upgrades, initiatives, and strategies that are associated with the 4IR. One planner from Tshwane elaborated that the country cannot pass up on the opportunity and the potential benefits for the country. The planner went on to say that the mechanisms of the 4IR should be further investigated and implemented as soon as possible. This was noted to be in stark contrast to what was found in terms of the levels of awareness since the indication to participate was noted by all planners but equally, the groundwork or awareness was seen to be behind.

The planners all confirmed the benefits that the country may have from 4IR integration. These ranged from job creation, increased economic growth, better efficiency, improved sustainability, and better tools for government being made available. It was noted to also frequently discuss this issue on the premise of the benefits the country can reap from the revolution, for example, Borgen with bridging the gap of technology access (Borgen, 2021), and Gumede with the improvements for the production lines (Gumede, 2023). The literature followed a recurring structure where first the expressing of the benefits of 4IR and SCs initiatives were for the country, and secondary always followed up with the same warning of risks associated as mentioned above. This was an indication that all benefits come with risks and there was a noted relationship that there is no advantage without challenges to address.

This risk-to-reward ratio was noted to only worsen the urgency to partake as the need to participate was made clear but was also shown to come with complementary risks. The need for the country to participate was accompanied by the urgency to not “being left behind” on the global stage, was what one planner remarked. These issues clearly relate to the next.

A) The fear of being left behind

The planner from Tshwane’s research division, said that the “country cannot be left behind,” admitting that there are positives and negatives to navigate that are tied to the 4IR, but the country should try to focus on the positive aspects. This fear of being left behind was mentioned extensively and the understanding gained was that of missing out on an opportunity to progress the country towards its visions.

B) The prospective benefits it can bring to the country

A planner from the COJ discussed that the “benefits were undeniable,” especially for local planning, where analyzing and capturing data was so important for project success. The prospective benefits were a clear driver in the appeal of tackling the challenges of implementing the 4IR and SCs, as Borgen and Gumede detailed (Borgen, 2021) (Gumede, 2023). However, this same appeal was noted to be the main contributor towards the urgency to participate. This urgency arises from the prospect of missing out, as Schwab warned that the rapid pace of technology will only increase, the later the country starts, the further it will be behind and never be able to catch up (Schwab, 2016).

Overall, this issue discusses the urgency for SA to embrace 4IR and SC initiatives. Planners were noted to emphasize the importance of investing and implementing 4IR technologies and strategies to reap the potential benefits such as job creation, economic growth, efficiency, sustainability, and better-governing tools. Despite the noted lag in awareness, there was an agreed consensus among participant planners and the literature, about the necessity for SA to not fall behind on the global stage. The fear of missing out on opportunities and the potential benefits were noted to serve as a

key driving force behind the issues noted urgency. The urgency was further underscored by the rapid pace at which technological advancements were progressing, which further emphasized the need for participation as the deficit may lead to the country's irrelevance (Borgen, 2021) (Gumede, 2023) (Schwab, 2016).

In summary, the analysis of the key issues that emerged from the data collected for this study demonstrated the intricate relationship between 4IR technology, SC principles, and SA planning. The identified issues, which ranged from the fear of being left behind to the prospective benefits as well as dangers that were associated with 4IR advancement, underscore the urgency as well as the complexity that surrounds a nation when navigating this evolving landscape.

5.5 Conclusion

The chapter covered the key issues that emerged from data collection from the literature, SA planning documents, and interviews, which were related to the 4IR and SCs, within the SA planning profession. The discussion highlighted the main challenges, opportunities, and intricacies associated with implementing 4IR and SC initiatives within the SA context. The planners in particular expressed multiple concerns such as increased financial burdens, data security, impacts on society, and the need for greater political will. Additionally, the planners noted difficulty in differentiating between the 4IR and SC, frustrations present over the complexity of the planning system, and slow approval processes, which all points indicated to hinder any efficient progress. The lack of standardization and poor internal communication within the government was also identified to be a major contributing factor as it was seen as an underlying problem.

The Tshwane and Johannesburg metropolitan areas are the two major cities in SA; however they differ significantly in their urban planning approaches and documents, which reflected the unique development priorities and challenges present even within geographically similarly located areas within the country. Tshwane's planning documents, such as the Tshwane Vision 2055, emphasized creating a sustainable, resilient city with a specific focus on integrating green spaces, promoting public oriented transportation, and enhancing social equity through equal access to spaces. The city's plans often highlighted and cantered around the long-term goal of the need to protect its present natural environment, using protecting and creating the many parks and nature reserves, while still fostering a progressive and inclusive economic growth trajectory, through targeted infrastructure investments in underdeveloped areas and within the main city hub.

In contrast, The Johannesburg metropolitan planning documents, such as the Johannesburg Spatial Development Framework 2040 (SDF), prioritized addressing the challenge of the city's rapid urbanization and socio-economic disparities present. The COJ plans focused heavily on managing rapid unplanned urban sprawl, improving housing affordability, and upgrading the various informal

settlements. The city also emphasized its economic development, like Tshwane, but rather through urban regeneration projects, particularly in the inner city, and aims to create a more compact concentric model, which focusses on connected urban form by improving public transport and reducing the spatial divide inherited from apartheid.

While both metropolitan cities share the same provincial documents and goals of sustainability and inclusivity, their approaches reflect their distinct socio-economic contexts and unique developmental challenges, despite both metros being located within proximity. This further reinforces the notion of SA's complex urban and social environment and supports the "one shoe size does not fit all," mentality, when considering solutions to challenges and 4IR and SC initiative inclusion.

Furthermore, the major planning documents of the country were noted to support the claims made by planners, as the frustrations mentioned were noted to have pertaining plans to amend the noted difficulties. Documents tended to focus on the basics rather than have targeted 4IR initiatives. There were documents such as the Johannesburg SDF and SCF, which were up to a higher standard, however, most key documents such as the NDP, GGT2030, and GFSD, lacked any capacity of the mention of 4IR or SC initiatives. Additionally, this lack of mention was reinforced by planner's lack of awareness as the two were of an equal level.

Chapter Six: Conclusion

6.1 Introduction

Tomorrow's urban frontiers associated with 4IR technologies and SC principles present an opportune transformative potential for urban planning worldwide. For the context of SA, where urbanization and developmental challenges are highly prevalent, the integration of these innovative approaches holds a potential major significance for its future. This final chapter seeks to encapsulate the extensive investigation into what these potential intricacies and opportunities are, in terms of the application of 4IR technologies and SC principles within the South African planning profession. At the centre of this research, lies the pivotal question: What is the potential of 4th Industrial Revolution technology and Smart City principles for South African planning? This question has served as the guiding direction throughout this research paper and has steered the investigation toward a deeper understanding of the potential within the SA context.

The research primarily focused on the SA planning profession and investigated the major documentation guiding the spatial visions and the perspectives of the planners within major metropolitan cities such as Johannesburg and Tshwane were also investigated. Through a structured approach of semi-structured interviews, policy analysis, and a review of relevant supporting literature, this research sheds light on the opportunities, challenges, and potential benefits associated with the integration of 4IR technologies and SC principles within the SA planning profession.

The study acknowledges the limitations of the study relying on secondary data analysis and interviews, with a limited number of planners from select metropolitan areas. In recognizing these constraints imposed by this methodological approach, it is essential to emphasize that these findings may not be universally applicable across all of SA's other major cities. Furthermore, the study refrains from diving into the technical feasibility and financial implications associated with the implementation of 4IR technologies and SC principles within the planning environment, due to the study being focused on the practicality and potential outcomes.

This chapter presents the main findings of the research paper, the implications of these findings for theory and practice, and consideration for future research.

6.2 Closing the loop

SA is a country that is rapidly developing and is facing numerous challenges with its urban development. These challenges include high levels of unemployment, inequality, and structural degradation. The benefits associated with 4IR technology and SC principles have been identified as potential solutions to these pressing challenges. The country has made it clear it intends to participate in and implement 4IR initiatives, however, this is a debated topic, and the outcomes are unpredictable.

This discussion draws from the findings of the research, to explore the potential that 4IR technology and SC principles can have for South African planning. This discussion is structured around the three main sub questions identified in the introduction.

The relationship between the 4IR and SC movements

The findings frequently mentioned either the 4IR or the SC movement, as the same entity. The reason this occurs is due to the similarities in the relationship between the two. Although the similarities tend to link two concepts, they are different in practice. The 4IR is an enabler of the SC movement, as 4IR technology is utilized within an SC framework. This key point is what unites the two and causes confusion in separating them. SCs are just one of the by-products of integrated technology. This relationship can be found in all the components that make up a functional SC since each principle is centred around the use of smart and accessible technologies. This creates a narrative where people associate the 4IR with SCs, due to the technology being present in nearly all aspects of what an SC is. This clear narrative blurs the lines between the two and is the reason that the literature and even professionals involved, often consider the two as a singular entity.

The outcome of this narrative is a strong association that an SC is entirely a smart technology-based movement. Data used to justify or measure the SC principle's effectiveness was predominantly focused on the innovation, social, and economic associated scores of a country. Innovation scores measured the general technical environment of the country, such as internet access and general infrastructural integrity, social scores were focused on the operators and users of said technology, such as education ratings and percentage of higher skilled labour present, and lastly, economic scores would measure the strength of the country in terms of financial stability and the buying power possessed to afford upgraded smart technology. These were not the only indicators used but it was found that other important statistics, such as the political climate, were mostly left out due to the data being only concerned with technology adoption and usage. The political will and context of a country are however frequently mentioned as strong indicators for sustainable long-term management and adoption, but it is only mentioned as a strong indicator that to accurately measure these requirements would be difficult.

The overall advantage gained by understanding the relationship between the 4IR and SC movement is that common misconceptions can be overlooked, and a more synergized environment can be created. To see 4IR technology as the enabler of an SC is valuable since not separating the two would fall into the misconception that the movement is entirely technology centred. A city is a complex entity that has been described as a living organism due to its intricacies and functions being as diverse as a human body. This fact cannot be looked over when considering an SC framework as before a city is smart, it is still a city. Understanding this relationship between the 4IR and SCs will ensure that technology is not seen as overruling importance, due to the strong narrative existing discussed

previously. An SC is first a city and requires to still be treated as such before simply installing smart technologies. This is the great advantage of differentiating between the 4IR and SC movement, as 4IR technology is the enabler of turning a city into an SC and not the other way around where technology creates SCs. The narrative that excessive technology is needed to create an SC is due to combining the 4IR and SC movements as one entity. The correct understanding which was therefore found is that a SC does not have to be flooded with technology within every aspect, but a successful city with the addition of smart technology would be even more successful. The enabler of 4IR technology is therefore merely a tool to implement to improve or address challenges that a city faces, rather than seeing the 4IR as being a SC.

The presence of the 4IR and SC in spatial development documents in South Africa

The extent that the country has incorporated 4IR and SC development plans in its major documents, is far below what would be expected for a country that has made a clear stance to participate. This is expected as the country is only in its adolescence in terms of its adoption of 4IR technology and SC construction, however construction of smart cities and initiatives are underway despite the lack of policy or backing by the government, and the resources necessary to have long-term sustainability.

Documents containing a sufficient plan that was in line with 4IR and SC principles, were usually standalone documents that either were planned for a future date or were specifically an entire document devoted to investigating the 4IR or SCs in South Africa. This situation creates poor document cohesion as major documents are working towards different outcomes when compared to these standalone documents. This is a clear indication of misplaced priorities within the policy system and government officials of the country. There is a consensus on a vision that conforms to improving the quality of life for the people and strengthening the country in many sectors. However, the execution of this goal has no clear direction or agreed-upon approach.

Navigating the literature and planning structure of SA proved to be difficult due to the complexity of the system and elaborate documents that were many pages of information. The system itself was complicated to navigate in terms of poor jurisdiction clarity between the three spheres, poorly maintained websites for information and a general lack of user-friendliness. If a person did not know what to look for, they would not be able to find it, which in terms of being accessible to the average person, means the system does not cater to those outside the profession let alone other sectors who depend on the information to proceed with developments.

In general, the country is heading in the right direction but how this is being conducted leaves room for confusion, misinterpretation, and recourse wastage. The answer is the right direction because there are mentioned plans of an SC framework and desired participation in smart initiatives. However, how this is being conducted, even for a person who is accustomed to this field of research/profession,

is confusing and lacks a clear direction. These documents tend to stand alone with their contextual analysis and interpretation of major documents' vision goals, which in turn creates a multipage document that is far too long for any one person to fully digest. The resources devoted to creating such elaborate documents could be best used elsewhere. This manner of creating documents does have a purpose for base-level plans. However, in the context of incorporating 4IR and SC strategies it would be far too complicated and accounts for why there is little to no mention of such initiatives yet outside of major plans.

SA does have a strong and well-written policy document, and this can be noted as a strength. The shortcomings occur when it comes to the implementation and sustainability of projects. This has to do with the country's unique context and is also a weakness in the operation of the policy and planning frameworks. The slow process of approval and cycling of plans leads to an environment where documents are not given sufficient time to achieve intended outcomes. This cycling of documents and appointment of cabinet leaders on a five-year basis, which has a new set of individuals with different goals taking charge of previous projects, accounts for a lack of continuity issues between visions, plans and implemented projects. This situation has been shown to limit the inclusion of the 4IR and SCs because different agendas are imposed onto each document. The mention of smart initiatives is therefore a “tick the box” type of exercise where it is included for the sake of being covered. This is known by the details of some of these plans being less than two pages within a two-hundred-page document.

The stance of the country firmly indicates a strong desire to participate, and while some projects are being implemented, they lack grounded documentation or a clear set directional purpose for being created. The lack of mention of the 4IR and SCs in major documents, rather in standalone recent literature, shows a clear sign of problems with the current policy system within the country. These problems carry over into the planning profession as documents and guides for planners are complicated, confusing, and have a high risk of being misinterpreted due to broad statements.

The awareness of planners related to the 4IR and SC movement to implement this in practice

One of the key drivers for change within this topic area will be the planners that organize, implement, and maintain these initiatives. The knowledge and skills of the inner workings of 4IR technology and SC principles are therefore a critical requirement for present-day planners. The state of awareness of planners within the SA planning system was lower than would be expected for a nation intending to undertake the 4IR and SCs. It is acknowledged that there may be individuals who far exceed the awareness encountered, but most of the planners in the two major metropolitan areas lacked sufficient awareness. This could be reflective of other planners in the country too.

The grounds to say that there is a knowledge gap present in the awareness of planners, lies within the nature that these professionals were made aware of, the scarce detail they were able to provide, and the lack of separation of knowledge between differentiating between the 4IR and SC movements. Comparisons were made against the information obtained from the literature review on what the 4IR and SCs were, and the gaps were noted. The lack of detail and gaps in awareness were from the information that was provided, being found to be similar to what a basic search from the internet would reveal. This easily obtainable information is a strong indication of shortcomings within the planning system and evidence that backs the previous sections' reasons for insufficient mention of 4IR and SC initiatives in major documents. What was noted was that the documents that did have the strong mention of 4IR and SC initiatives, such as the COJ's SDF 2040, seemed to not be mentioned by planners and indicated a further lack of awareness for what may be in the major documents which spatially dictate the country's future. It seems to suggest that many of the planners, do not read the documents published that guide visions, which further reinforces the notion that the 4IR is not a priority, as it is not commonly known in the planning work environment.

The underlying issue is professionals in the field are not informed about the 4IR and SC movements. The inconsistent means of how planners, who have been working in the profession for many years, are informed creates this gap of awareness and lack of detailed understanding. Some mentioned of presentations by the CSIR and occasional talks about topics associated with the 4IR and SC movement however, these information sources only cover the basics and are more of an introduction to the approaching future. This is counterintuitive to what was found concerning plans as SA has three SCs planned and even under construction. Many of the planners did not know these existed, which is a clear indication of either poor inter-communication between departments or the priority of these initiatives is not at the centre of the profession, and it is entirely possible that the planning profession is not being utilized for these projects as much as it needs to be. Unreliable sources of information are an indication that there is no strong active plan to educate planners on the 4IR and SC future. The information that planners possessed was most notably not from a higher education source, which is correct as these topics have only recently been introduced into the higher education curriculum. This shows a strong indication that individuals at the forefront of planning in the country, are less equipped with regards to the 4IR technology and SC principles, compared to newly graduating planners in the present day.

This gap is accounted for by the priority focus of the country not being in unison. The country is split between, getting the basics rights such as sanitation, education, and poverty eradication, and the clear benefits that 4IR initiatives can have for the country. There is a clear urgency to participate, however, the priority to achieving this is not reflected by the country's policy or investments. The sources of information that current planning professionals are educated on the 4IR and SC initiatives, do not match the direction the country is indicating. Scarcity within major policy documents and the

clear lack of government intervention in educating planners show this disjointed priority. The country is struggling to meet the basic needs requirements and investments into the 4IR will not occur where aid is needed most. The possible consequences associated with diverting resources before addressing the basic needs of the less fortunate will lead to the widening of technology and poverty gaps, which is a clear problem that leads to this hesitancy that surrounds the 4IR and SCs within the SA planning context.

The awareness and knowledge of planners are important factors to consider in the long-term sustainability of 4IR projects within SA. Current and previous projects that were either in line with the smart narrative or were a steppingstone to it, all followed a similar trend of not operating in the long run. Financial backing being dropped or initiatives not being self-sustaining due to them being incorrectly placed in context, were noted as the main reasons for projects falling short. The country and the planning profession, therefore, project an image of a rudderless ship that lacks a clear direction despite the quality and frame of the vessel. The country shows a clear indication of participation however the contradicting views, visions, directions, priorities, and intentions evident within the planning profession and the country, limit the extent to which the country may benefit from the potential offered by the 4IR and SC movement.

The potential of 4IR technology and SC principles for the SA planning profession

The potential opportunities for SA planning, associated with 4IR smart technology and SC development principles, are undeniable. The inverse is also true where the potential for misfortune and risk is equally undeniable. The answer to the main question is open-ended, referring to the extent to which SA planning can participate in this digital future. The answer provided intends to factor in the context of the country and profession to formulate a clear picture of the potential that 4IR technology and SC principles can be incorporated. The main purpose of this answer is to provide an insight into what balance can the country find in terms of progression, while still being able to operate and cope with the present challenges.

The circumstances and present context of the country are not ideal in terms of the basic recommended requirements for 4IR participation. The four key factors that SA lacks are a strong educational system, a stable economy, a strong government will, and a reliable energy grid. These four main challenges will be the greatest roadblocks for the country in the long run, concerning 4IR and SC development.

The education system is responsible for processing and training the future labour force and not producing enough skilled labour severely limits the availability of people who can operate new smart technology. This problem extends to the smart people component of SCs. Even if new technology

services are installed, people will need to be taught how to operate them effectually, or else the services will not be optimally utilized.

A stable economy is a requirement as smart initiatives require steady initial capital since the benefits they produce are only returned in the medium to long term. The initial cost to install and maintain smart projects would require a debt that can only be paid back later. SA's financial instability and challenges are a cause for concern due to the nature of how expensive smart upgrades are in the short term. The fact the benefits will not be immediate is unavoidable and for a financially weak country, the risks are even higher as getting a project wrong will ultimately be a huge capital loss, when the funds could have been better spent on other challenges.

The government is found to be the main driving force for projects and change, which makes it a critical role player in long-term effective 4IR and SC development. A nation is only as good as its support structure and policy backing, as no matter how experienced the people who install these smart upgrades are, e.g., the engineers, scientists, and planners, they will be negligible in the long run with a weak government will. SA is no exception and to find a clear lack of priorities between major documents and professionals is a clear indication that this component will be a limiting factor for the long-term sustainability of 4IR and SC initiatives in the country.

The unreliable energy grid of the country is the final key component that SA lacks. The management and decline of the country's power grid is a major concern due to 4IR upgrades predominately requiring electricity to operate. The country suffering from consistent rolling outages is a great problem that exhibits underlying infrastructural management issues. The country and planners would need to factor in the additional strain that smart initiatives would invoke on the energy grid of the country. Systems considered should all factor into this issue and consideration towards alternative energy sources.

The potential therefore for the planning profession of SA is full of many questions, doubts, uncertainties, and confusion. The context of the country itself is a huge obstacle and the state of the planning system is a by-product of the turbulent circumstances of the country. The potential will be rooted within the solutions that play to the strengths of the country or at the minimum, have the highest long-term impact for the least amount of risk. The capacity of the country would firmly indicate that the country is not ready to progress as it is still battling with the basics. The country, however, cannot avoid the opportunity presented and progress should therefore always factor in the context and long-term implications. The potential will favor smaller-scale projects rather than grand schemes. The underlying fact is that the country is already making use of 4IR technologies and principles since mobile phones, apps, and online government services, already serve as smart devices. The approach to incorporating 4IR technology and SC principles in SA would require a more practical base rather

than a theoretically documented base. The potential will only be converted into benefits if projects are implemented into reality, rather than disappearing by replaced paper projects.

With this in mind the conclusion is that the potential will predominately focus on the balance between cause and effect for the country and the long-term implicational requirements. However, it is important to note that the successful implementation of 4IR technology and smart city principles in South Africa will depend on the availability of necessary infrastructure and the ability to overcome challenges such as data privacy and cybersecurity. Additionally, it will be important to ensure that the benefits of these technologies are equitably distributed among all residents, particularly those in low-income communities.

In summary, 4IR and SC principles have the potential to improve the efficiency and effectiveness of urban services in South Africa, but it is important to address the necessary infrastructures and challenges first, before undertaking large-scale projects as the capacity for the country cannot yet support it.

6.3 Implications for theory and practice

The nation struggles with complex challenges such as high unemployment rates, inequality, and deteriorating infrastructure, which the potential solutions for, are offered by 4IR technology and SC integration. However, the integration of these innovations into the planning profession and the countries' frameworks is not without its difficulties. This section focusses on the implications for the theory and practice of the Planning profession of SA. By examining the key areas of the above findings, the aim is to understand the potential impact of 4IR technology and SC principles on SA planning, while also being mindful of the challenges that must be navigated to realize the opportunities and full potential.

Relationship between 4IR and SC movements:

This section highlighted the need to understand the distinction between 4IR technology and SC principles, as they were often confused to be thought of as one entity. While 4IR was found to enable SC development, they are not synonymous and are distinctly apart from one another. This understanding is crucial to avoid misconceptions and ensure that SCs are seen as more than just technology-centric initiatives and rather as an enabled outcome from the technology made available by the rise of the digital age of the 4IR.

Planners within the profession need to understand the separation between the two and recognize that SCs are cities first, with technology serving as an enabler rather than the primary focus. This dictates that planning efforts within SA should prioritize holistic urban development primarily, with technology integration only incorporated when appropriate to address specific challenges or as an improvement

of efficiency, rather than the inverse, where technology is seen primarily as a solution, and the basics are left out. This prioritized approach of urban development priority over technology-driven development, would see fewer projects fail in the short term and create long-term sustainability of potential smart projects.

Existence of plans for 4IR and SC movement:

The lack of cohesive planning and integration/mention of 4IR technology and SC initiative into major planning documents of the country indicates a gap in policy implementation, government will/ priority, and miscommunication between all relative departments and entities involved. This section underscores the importance of aligning planning frameworks and government, with the future approaching technological advancements, to drive sustainable development that is in line with the visions of the country.

Planners need to strive for more coherent and integrated planning approaches that incorporate more 4IR and SC principles into spatial development strategies. This requires better coordination between government departments and stakeholders to ensure effective implementation as well as a more driven stance in terms of future policy development. The journey in undertaking the 4IR and constructing SCs will only be as effective as the documents and government that steers the ship. The inverse, which is occurring sees documents not being coherent, failing to mention the 4IR and SCs further than the “tick box” requires, but a government that intends to pursue this future, despite the lack of grounding within policy or country capacity.

Awareness among planners:

The findings suggest a clear lack of awareness among planners regarding 4IR and SC principles, which is a huge hindrance in their ability to effectively implement such technologies, which the government intends to undertake, in practice. This information indicates the need for further capacity building of the skills of planners and education of the 4IR and SC initiatives within the planning profession.

Planners should be actively seeking out opportunities for professional development and training in 4IR technologies and SC principles. Additionally, there is a greater need for better communication and education of information associated with the 4IR and SC development, within the planning community, to ensure that planners are well-informed about these emerging trends and strategies. The present outcome requires a better program for the education of planners but also for planners to regularly be in the discussion of the 4IR and SCs, as the need to do so is not required and therefore not entertained. The irregularity of sources of information would need to become more streamlined as at present, despite major planning documents containing a scarcity of plans/mention of 4IR or SC

initiatives, they are further in development than the awareness of planners. To ignore this step would lead to the potential of documents being sufficient the enactors, the planners, are not aware enough to correctly develop and implement the visions planned.

Potential challenges and opportunities:

The research identifies several challenges facing SA in terms of future development with 4IR and SC initiatives, including economic instability, weak infrastructure, and competing priorities of basic needs and future developments. These factors all impede the successful potential implementation of 4IR and SC initiatives and need to be addressed to improve the efficiency of projects in the long run.

Planners for the future must carefully consider the context and limitations of the SA landscape when designing and implementing 4IR and SC projects. This will involve prioritizing smaller-scale initiatives first that align with the existing infrastructure and addressing the fundamental challenges such as energy access, poor infrastructure, and economic development opportunities in terms of output and employment skills required. Projects that address all areas should therefore be prioritized on a small scale initially to generate opportunities, prove effectiveness, and allow for a benchmark for future progressive larger projects. The projects that meet all the criteria mentioned would therefore be the planning profession prioritizing alternative energy systems as they address all required aspects and can be done on a small scale initially. More importantly, they will provide a base of energy that addresses the main concern of the instability of the energy grid, which in turn can be used to power and ensure efficient 4IR technology integration and SC development.

6.4 Future research

In the examination of policy, planning capacity, governmental structure, and infrastructure readiness, SA's journey into 4IR and SC development is complex. Understanding the existing policies' effectiveness, planners' knowledge gaps, successful case studies, community perceptions, and infrastructure challenges are the main key steps toward having better-informed decision-making and inclusive urban development in the future.

Policy Analysis and Implementation: Future research could focus on conducting a more comprehensive analysis of existing policies related to 4IR and SC development in SA. This could involve examining the efficacy/effectiveness of current policies in driving technological adoption and urban development, as well as identifying the main barriers to implementation that need strategies to address. Additionally, the research could explore what strategies would be the most effective for overcoming these barriers and fostering a more coherent and integrated policy framework in the future.

Planner Awareness and Capacity Building: Further investigation into improving planners' awareness and understanding of 4IR technology and SC principles, could provide highly valuable insights for capacity-building training initiatives to address this. This future research could involve surveying a broader sample of planning professionals across different regions and cities, to assess their knowledge gaps and potential training needs. Additionally, exploring the most effective methods for teaching this information and providing training on 4IR and SC topics could be valuable for enhancing planner ability and capacity in the country, as present planners are past the years of higher education teaching and would require alternative methods to learn new approaches and understandings.

Case Studies and Best Practices: Conducting case studies of ongoing or completed 4IR and SC initiatives in SA, could offer valuable lessons and best practices for future planning efforts within the country. This research could involve examining similar successful projects, identifying key factors contributing to their success, and analyzing challenges encountered along the way and how they were addressed. By documenting and sharing these insights, planners, and policymakers can learn from past successes and failures to inform future decision-making and begin refining future policy, training, and developments.

Infrastructure and Technological Readiness: Following on from the previous mention of future research, Investigating the infrastructure and technological readiness of SA cities for 4IR and SC development, could be another required area of research. This would involve assessing the availability and quality of digital infrastructure, such as broadband connectivity and other smart utilities, as well as exploring strategies for overcoming challenges related to energy access, reliability, and structural ability to support future initiatives. Understanding the existing technological landscape of SA and identifying areas for improvement, can inform future investments and planning efforts to be better targeted for maximum future potential.

Community Engagement and Equity: Lastly, to research and explore community perceptions and engagement with 4IR and SC initiatives, could provide better insights into future considerations and social impact understandings. This could involve conducting large surveys, focus groups, or participatory workshops with residents from a variety of areas, for the purpose to better understand their perspectives and abilities to operate technological advancements and what their role is in the implications for future planning developments. Additionally, research can explore strategies and methods for ensuring that the benefits of 4IR and SC technologies are equally distributed among all residents, particularly those in marginalized or underserved communities, as the insight gained from this research would better inform of which technologies, training programs and initiatives would be best for a specific environment of people.

All these future research topics can make use of the information found in this paper, and all would form the greater picture of understating in greater detail how the country can better prioritize its resources, to find better success with 4IR technology and SC development that presently noted.

6.5 Concluding remarks

In concluding, the intricacies which surrounds the integration of 4IR technology and SC principles within SA planning, illuminates the complex landscape which is marked by both bright promises and equally pressing challenges. While there is the acknowledgment of the transformative potential of 4IR and SC initiatives to address the critical development issues within SA, such as unemployment, inequality, production constraints, financial instability and decaying infrastructure, the journey towards realizing this potential is not without its equal share of challenges that will run concernedly.

Central of this discussion is the imperative need to ensure that there is distinguishability between 4IR technology and SC principles, as recognizing this relationship between the two while ensuring they are not seen as a single entity is necessary. Understanding that 4IR serves as a key enabler rather than the sole driver of SC development, underscores the importance for grounding planning efforts in a holistic urban development framework model. In short, the emphasis should lie not solely on technological advancement, but also on the enhancement of city functionality and sustainability through the strategic integration of technology.

Additionally, the identified gaps within policy cohesion and planner awareness, underscores the necessity for more concerted action to bridge the divide between the theory of the 4IR and SCs, into the practice of the progression. Coherent policy frameworks that prioritize the integration of 4IR and SC strategies are necessary, as is the need for capacity-building educational initiatives to enhance planners understanding and proficiency with these areas. The fostering of community engagement and participation is also an additional essential to ensuring that the benefits of 4IR and SC technologies are equitably distributed among all residents as well as made use of effectively, particularly those in underserved communities. Projects without proper community engagement would not be sustainably for long term outcome vs investment.

Looking ahead, the trajectory of SA planning in the context of 4IR technology and SC principles requires a multi-faceted approach. Future projects should prioritize the alignment of theory with practice, which should have the intention to formulate coherence in policy frameworks and promote more inclusive and resilient urban developments. By leveraging the transformative potential bought about from 4IR technology and SC principles, SA can better chart a course toward building a more prosperous, equitable, and sustainable future, for itself and for all it inhabits.

Appendix A: interview questions used

1. What is your role within the department?
2. What is your understanding of what the 4IR is?
3. Do you think South Africa planning should invest in the 4IR?
4. How were you made aware of or informed about the 4IR?
5. Do any of your policies mention the 4IR?
6. Are you aware of any plans or projects within the metro which could be categorized to be a part of the 4IR?
7. What is your understanding of a Smart City?
8. Are you aware of the components which make up a functional Smart City?
9. Do your policies mention smart cities?
10. How were you made aware of or informed about Smart cities?
11. Are you aware of any plans or projects within the metro which could be considered as part of the Smart City movement?
12. Do you think there is a relationship between 4IR and SC?
13. What do you think could be the greatest obstacle to overcome when thinking about implementing 4IR technology and Smart City principles?

Appendix B: Example of consent form used

INFORMED CONSENT FORM

- Title of research project: **The potential of 4th industrial revolution technology and smart city principles in South African planning.**
- I hereby voluntarily grant my permission to participate in the project as explained to me by Alessandro Ferro.
- The nature, objective, possible safety, and health implications have been explained to me and I understand them.
- I understand my right to choose whether to participate in the project and that the information furnished will be handled confidentially. I am aware that the results of the investigation may be used for the purposes of publication.
- Upon signature of this form, you will be provided with a copy.

Signed: _____ Date: _____

Witness: _____ Date: _____

Researcher: _____ Date: _____

Chapter 7 References

1. Abraham, M. M., 2015. ASSESSING THE RELEVANCE AND THE GAPS OF THE CURRENT SPATIAL DEVELOPMENT PLANNING SYSTEM IN SOUTH AFRICA AGAINST RELEVANT INTERNATIONAL POLICIES, EXPERIENCES AND CASE STUDIES. *University of Pretoria*, pp. 1-116.
2. Affairs, C. G. & T., 2018. *City of Johannesburg Metropolitan GAU*. [Online]
Available at: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/08/Take2_DistrictProfile_JHB1606-2-2.pdf
[Accessed 11 January 2023].
3. Albert, S., 2019. *CITY OF ST. ALBERT SMART CITY UPDATE, VERSION 2.0 | DECEMBER 2019*, St Albert: StAlbert.ca.
4. Anpar, 2020. *Pros And Cons Of Qualitative Research vs Quantitative Research*. [Online]
Available at: <https://www.anparresearchltd.com/post/pros-and-cons-of-qualitative-research-vs-quantitative-research>
[Accessed 20 January 2023].
5. Apata, O., Ainah, A., Adebayo, V. & K., P., 2021. Renewable Energy Systems and The Fourth Industrial Revolution. *IEEE PES/IAS PowerAfrica*, pp. 1-5.
6. Arroub, A. & Zahi, B., 2016. A literature review on Smart Cities: Paradigms, opportunities and open problems. *International Conference on Wireless Networks and Mobile Communications*, pp. 180-186.
7. Artman, H., 2000. Old practices - New Technology: Observations of how established practices meet new technology. *PROFET - Performance and Readiness through Operationally Focused Exercises and Training*, Volume 1, p. 16.
8. Asmal, Z. et al., 2019. *FORESIGHT AFRICA-Top priorities for the continent 2020-2030*, Washington, D.C: Brookings Institution.
9. Backhouse, J., 2020. Discussion Paper on a South African Approach to Smart, Sustainable Cities and Settlements. *smartcity. za*, pp. 1-32.
10. Balkaran, S., 2019. SMART CITIES AS MISPLACED PRIORITIES IN. *JMA*, Issue 2, pp. 1-30.
11. Balkaran, S., 2019. SMART CITIES AS MISPLACED PRIORITIES IN South Africa. *JMA*, Issue 2, pp. 1-30.
12. Balwin, 2020. *Govt breaks ground on Mooikloof megacity development*. [Online]
Available at: <https://www.enca.com/news/govt-breaks-ground-mooikloof-megacity-development>
[Accessed 19 December 2022].
13. Bank, T. W., 2022. *The World Bank in South Africa*. [Online]
Available at: <https://www.worldbank.org/en/country/southafrica/overview#1>
[Accessed 28 October 2022].
14. Barclay, L., 2016. *De-complexifying the SPLUMA Principles: Focus on Socio-ecological Systems..* Capetown , Western Cape Government , p. 21.
15. Beevor, M., 2018. *6 Challenges Smart Cities Face and How to Overcome Them*. [Online]
Available at: <https://statetechmagazine.com/article/2018/12/6-challenges-smart-cities-face-and-how-overcome-them>
[Accessed 14 October 2022].
16. Berger, R., 2019. *The Smart City Breakaway*, Munich : Roland Berger .
17. Borgen, P., 2021. *Bridging the Gap: Technology Access in South Africa*. [Online]
Available at: <http://www.borgenmagazine.com/technology-access-in-south-africa/>
[Accessed 9 February 2023].
18. Bouchrika, I., 2022. What Is The Fourth Industrial Revolution: Risks, Benefits & Responses. *Research.com*.

19. Braun, V. & Clarke, V., 2006. Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3(2), pp. 77-101.
20. Brcic, D., 2018. The Role of Smart Mobility in Smart Cities. *Conference: Fifth International Conference on Road and Rail Infrastructure*, pp. 1601-1608.
21. Britannica, T. E. o. E., 2017. *Gauteng province, South Africa*. [Online]
Available at: <https://www.britannica.com/place/Gauteng>
[Accessed 4 January 2023].
22. Brooks, A., 2014. *New smart city alliance launches in Alberta*. [Online]
Available at: <https://www.itworldcanada.com/post/new-smart-city-alliance-launches-in-alberta>
[Accessed 21 July 2023].
23. Bruneckienė, J., 2014. The Concept of Smart Economy under the Context of Creation the Economic Value in the City. *Public Policy and Administration Journal*, 13(3), pp. 50-62.
24. Buccus, I., 2016. *Bottom-up development must start taking root in South Africa*. [Online]
Available at: <https://mg.co.za/article/2016-02-05-00-bottom-up-development-must-start-taking-root-in-south-africa/>
[Accessed 2 October 2021].
25. BuisnessTech, 2015. *Gauteng, Five multi-billion-rand cities being built in*. [Online]
Available at: <https://businesstech.co.za/news/trending/104473/five-multi-billion-rand-cities-being-built-in-gauteng/>
[Accessed 1 October 2023].
26. Bulbulia, T., 2019. *South African enterprises slow to adopt AI – study*. [Online]
Available at: <https://www.miningweekly.com/article/south-african-enterprises-slow-to-adopt-ai-study-2019-07-04>
[Accessed 5 January 2024].
27. Buonocore, F., 2022. *7 benefits of real-time monitoring in nonwoven production*, Norway : Nonwoven production line .
28. Cabinet, 2020. *NATIONAL POLICY DEVELOPMENT FRAMEWORK 2020*. [Online]
Available at: https://www.gov.za/sites/default/files/gcis_document/202101/national-policy-development-framework-2020.pdf
[Accessed 21 February 2023].
29. Cambridge, A., 2022. *HOW SUN EXCHANGE IS TRANSFORMING SOLAR ENERGY WITH PURPOSE DRIVEN INVESTING*. [Sound Recording] (RMB).
30. Chaudhury, D. R., 2020. *South Africa's active role in BRICS: Key to boosting African economy*. [Online]
Available at: <https://economictimes.indiatimes.com/news/international/world-news/south-africas-active-role-in-brics-key-to-boosting-african-economy/articleshow/79577451.cms>
[Accessed 26 July 2022].
31. Check, A., 2018. *Gauteng is Africa's 7th biggest economy*. [Online]
Available at: <https://businesstech.co.za/news/business/285272/gauteng-is-africas-7th-biggest-economy/>
[Accessed 4 January 2023].
32. Chetty, S., 2022. *SMART CITIES READINESS REPORT*, Johannesburg: Department of Cooperative Governance.
33. Chingono, M., 2009. The challenges of regional integration in Southern Africa. *Political Science and International Relations*, Volume 3, pp. 396-408.
34. Cities, S., 2021. *THE CHALLENGES AND ISSUES FACING LOCAL GOVERNMENT*, Johannesburg : BEYOND 2021: A LOCAL GOVERNMENT OUTLOOK.

35. Clothier, B., 2022. *The 4th Industrial Revolution and how it affects finance*. [Online]
Available at: <https://www.zaharasoftware.com/the-4th-industrial-revolution-and-how-it-affects-finance/>
[Accessed 23 August 2022].
36. Coetzee, J., 2010. Not another 'night at the museum': 'moving on' – from 'developmental' local government to 'developmental local state'. *Town and Regional Planning*, Volume 56, pp. 18-26.
37. Coetzee, J., 2013. The transformation of municipal development planning in South Africa (post-1994): Impressions and impasse. *Town and Regional Planning*, Volume 56, pp. 10-20.
38. Cooper, N., 2012. *What is Thematic Analysis? Advantages and Disadvantages*. [Online]
Available at: <https://www.theacademicpapers.co.uk/blog/2021/10/02/what-is-thematic-analysis-advantages-and-disadvantages/>
[Accessed 26 January 2023].
39. Creamer, T., 2018. *Poor internal coordination in SA cities adding to the cost of doing business*. [Online]
Available at: https://www.engineeringnews.co.za/article/poor-internal-coordination-in-sa-cities-adding-to-cost-of-doing-business-2018-09-19/rep_id:4136
[Accessed 12 February 2023].
40. Creswell, J. W., 2014. Research Design: Qualitative, Quantitative and Mixed Methods Approaches. *Open Journal of Leadership*, 6(1).
41. Dagada, R., 2021. *Gone phishing: The escalation in global cyberattacks is an unintended consequence of 4IR technologies*. [Online]
Available at: <https://www.dailymaverick.co.za/opinionista/2021-09-13-gone-phishing-the-escalation-in-global-cyberattacks-is-an-unintended-consequence-of-4ir-technologies/>
[Accessed 1 July 2023].
42. Dameri, R. P., 2016. Smart City Definition, Goals and Performance. *Progress in IS book series (PROIS)*, pp. 1-22.
43. DCoG & CSIR, 2021. *A SOUTH AFRICAN SMART CITIES FRAMEWORK, A decision-making framework to guide the development of smart cities in South Africa*, Johannesburg: CSIR.
44. Denscombe, M., 2010. The Good Research Guide. *Open University Press*, 1(4), pp. 272-308.
45. Desk, M. D., 2019. *What does 'fourth industrial revolution' even mean?* [Online]
Available at: <https://mg.co.za/article/2019-09-05-what-does-fourth-industrial-revolution-even-mean/>
[Accessed 17 August 2022].
46. Dodani, S. & LaPorte, R. E. L., 2005. Brain drain from developing countries: how can brain drain be converted into wisdom gain?. *JRSM*, 98(11), pp. 487-491.
47. Dong, L. E., 2023. *4 Commonly Used Smart City Technologies*. [Online]
Available at: <https://earth.org/smart-city-technologies/>
[Accessed 4 July 2023].
48. Drew, C., 2023. *10 Case Study Advantages And Disadvantages*. [Online]
Available at: <https://helpfulprofessor.com/case-study-advantages-and-disadvantages/>
[Accessed 25 October 2023].
49. EAG, 2022. *South Africa Overview of the education system*. [Online]
Available at: <https://gpseducation.oecd.org/CountryProfile?primaryCountry=ZAF&treshold=10&topic=EO>
[Accessed 1 November 2022].
50. Editorial, 2021. *Key Components Of Smart City Infrastructure – An Overview*. [Online]
Available at: <https://roboticsbiz.com/key-components-of-smart-city-infrastructure-an-overview/>
[Accessed 4 October 2022].

51. EDTEA, DTP, HATCH & IYER, 2018. *Durban Aerotropolis Master Plan Report*. [Online]
Available at: <https://www.kznedtea.gov.za/documents/Durban%20Aerotropolis%20Master%20Plan%20Report%20-%20July%202018.pdf>
[Accessed 12 December 2022].
52. eNCA, 2020. *Construction begins on the Mooikloof Mega City project in South Africa*. [Online]
Available at: <https://www.enca.com/news/govt-breaks-ground-mooikloof-megacity-development>
[Accessed 16 December 2022].
53. Erasmus, D., 2022. *SA's poor people are getting poorer as prices climb*. [Online]
Available at: <https://www.businesslive.co.za/bd/economy/2022-01-26-sas-poor-people-are-getting-poorer-as-prices-climb/>
[Accessed 7 June 2023].
54. Exner, J.-p., 2014. Smart Planning & Smart Cities. *REAL Corp Vienna* , pp. 603-610.
55. Facilitator, C., 2021. *Smart City – Elements, Features, Technology, and Govt. Approach*. [Online]
Available at: <https://www.constrofacilitator.com/smart-city-elements-features-technology-and-govt-approach/>
[Accessed 2 October 2022].
56. Farjood, C. P. & M., 2021. *Why truly smart cities are crucial for development*. [Online]
Available at: <https://www.undp.org/asia-pacific/blog/why-truly-smart-cities-are-crucial-development>
[Accessed 3 December 2022].
57. Feldman, H., 2017. *First-world problems in a third-world country*. [Online]
Available at: <https://www.news24.com/news24/opinions/columnists/howardfeldman/first-world-problems-in-a-third-world-country-20171025>
[Accessed 1 January 2023].
58. Fengler, W., 2021. *South Africa after COVID-19—light at the end of a very long tunnel*. [Online]
Available at: <https://www.brookings.edu/blog/future-development/2021/07/13/south-africa-after-covid-19-light-at-the-end-of-a-very-long-tunnel/>
[Accessed 3 October 2021].
59. Ferro, A., 2021. Exploring the changes that are required in the South African municipal development planning system to cope with the approaching future of the 4th industrial revolution and the smart city movement?. pp. 5-98.
60. Fischer, S., 2020. Smart Economy and Startup Enterprises in the Visegrád Countries—A Comparative Analysis Based on the Crunchbase Database. *Universal Design and Assistive Technologies for Accessibility in Smart Cities*, 3(4), pp. 1477-1494.
61. Fleetwood, D., 2023. *What is Research: Definition, Methods, Types & Examples*. [Online]
Available at: <https://www.questionpro.com/blog/what-is-research/>
[Accessed 21 January 2023].
62. Frederick, D. E., 2019. The Fourth industrial revolution and the digital divide. *Library Hi Tech News*, Volume ahead-of-print.
63. GAIN, 2023. *South Africa: Food Processing Ingredients*, Pretoria : Global Agricultural Information Network .
64. GAPP, 2022. *GREATER LANSERIA MASTER PLAN*, Johannesburg: GAPP Architects & Urban Designers.
65. Gawel, A. & Herweijer, C., 2020. Unlocking Technology. *World Economic Forum*, p. 48.
66. GFSD, 2022. *Gauteng Spatial Development Framework 2030*. [Online]
Available at: http://www.dwa.gov.za/downloads/ws/P_l/Adhoc/riaan/GSDF%202030.pdf
[Accessed 18 December 2023].

67. Govender, V., 2019. *Overcoming infrastructure challenges is key to 4IR success-Ubiquitous connectivity is vital to enabling the Internet of Things*. [Online]
Available at: <https://www.businesslive.co.za/bd/business-and-economy/2019-08-13-overcoming-infrastructure-challenges-is-key-to-4ir-success/>
[Accessed 21 December 2023].
68. Government, S. A., 2022. *South Africa's provinces*. [Online]
Available at: <https://www.gov.za/about-sa/south-africas-provinces>
[Accessed 2 January 2023].
69. Green, S. o., 2019. *SMART CITIES, Creating liveable, sustainable and prosperous societies - INSIDE THIS WHITE PAPER*. [Online]
Available at: https://stateofgreen.com/en/wp-content/uploads/2019/12/SoG_WhitePaper_SmartCity_210x297_V11_WEB.pdf
[Accessed 6 September 2023].
70. Green, S. o., 2023. *White paper: Urban green transition, Transforming our cities for a new reality..* [Online]
Available at: <https://stateofgreen.com/en/publications/urban-green-transition/>
[Accessed 3 September 2023].
71. Gumede, M., 2023. *SOUTH AFRICA'S PROSPECTS AND OBSTACLES IN THE FOURTH INDUSTRIAL REVOLUTION AND ARTIFICIAL INTELLIGENCE..* [Online]
Available at: <https://www.linkedin.com/pulse/south-africas-prospects-obstacles-fourth-industrial-mzokhona-gumede-1f/>
[Accessed 21 December 2023].
72. Gumede, W., 2022. *SA's entire infrastructure is on the verge of total collapse*. [Online]
Available at: <https://www.wits.ac.za/news/latest-news/opinion/2022/2022-07/sas-entire-infrastructure-is-on-the-verge-of-total-collapse.html#:~:text=South%20Africa's%20municipal%20sewage%20infrastructure,a%20poor%20or%20critical%20state.>
[Accessed 1 November 2022].
73. Hagan, O., 2018. *South Africa: A brief Introduction*. [Online]
Available at: <https://www.vacorps.com/knowledge-base/a-brief-introduction-to-south-africa/>
[Accessed 19 December 2022].
74. Halliwell, K., 2021. *Smart cities around the world*. [Online]
Available at: <https://www.rics.org/news-insights/smart-cities-around-the-world>
[Accessed 1 October 2023].
75. Halstein, J., 2021. *Skilled labour emigration in South Africa: Exploring the long-term implications*. [Online]
Available at: <https://sa-tied.wider.unu.edu/article/skilled-labour-emigration-south-africa-exploring-long-term-implications-0>
[Accessed 23 October 2022].
76. Hassan, V., 2021. A Triple Bottom Line Analysis of the Smart Cities Projects in GCC Countries. *Smart Cities, Citizen Welfare, and the Implementation of Sustainable Development Goals*, pp. 1-21.
77. Henzelmann, T., 2019. *Integrated thinking and central coordination are key to successful Smart City strategies*. [Online]
Available at: <https://www.rolandberger.com/en/Insights/Publications/Smart-City-Strategy-Index-Vienna-and-London-leading-in-worldwide-ranking.html#>
[Accessed 12 July 2023].
78. Heschl, M. K., 2020. *URBAN FARMING IN VIENNA*. [Online]
Available at: <https://and.dmaa.at/urban-farming-in-vienna>
[Accessed 12 July 2023].

79. Hexia, C., 2018. *[Integrated Energy] plays an important role, and the digital trend leads Denmark's smart energy city*. [Online]
Available at: <https://zhuanlan.zhihu.com/p/391124519>
[Accessed 3 September 2023].
80. Ideas42, 2021. *Community Participation in South African Local Government*. [Online]
Available at: https://www.ideas42.org/wp-content/uploads/2021/03/I42-Brief_OpenUp_3.pdf
[Accessed 6 November 2022].
81. Igamba, J., 2022. *The Water Crisis in South Africa: A Looming Threat*. [Online]
Available at: <https://www.greenpeace.org/africa/en/blogs/51757/water-crisis-in-south-africa/#:~:text=South%20Africa%20is%20already%20a,are%20distributed%20in%20the%20country.>
[Accessed 19 December 2022].
82. Immerman, G., 2018. *INDUSTRY 4.0 ADVANTAGES AND DISADVANTAGES*. [Online]
Available at: <https://www.machinemetrics.com/blog/industry-4-0-advantages-and-disadvantages>
[Accessed 9 February 2023].
83. InfoSA, 2020. *Gauteng*. [Online]
Available at: <https://www.infosa.co.za/provinces/gauteng/>
[Accessed 2 January 2023].
84. J.F.Burton, R., 2019. The potential impact of synthetic animal protein on livestock production: The new "war against agriculture"? *Journal of Rural Studies*, Volume 68, pp. 33-45.
85. Janowski, T., 2015. Digital Government Evolution: from Transformation to Contextualization. *Government Information Quarterly* 32, pp. 221-236.
86. Jansen, N., 2021. *How Artificial Intelligence Impacts Marginalised Groups*. [Online]
Available at: <https://digitalfreedomfund.org/how-artificial-intelligence-impacts-marginalised-groups/>
[Accessed 1 July 2023].
87. Jendemark, 2022. *Why 4IR is not a one-size-fits-all solution*, Pretoria: Jendemark Machining manufacturer.
88. Jha, S., 2020. *Can you sue an algorithm for malpractice? It depends*. [Online]
Available at: <https://www.statnews.com/2020/03/09/can-you-sue-artificial-intelligence-algorithm-for-malpractice/>
[Accessed 1 July 2023].
89. Johannesburg, C. o., 2020. *PROFILE: city of Johannesburg METRO*. [Online]
Available at: https://www.cogta.gov.za/ddm/wp-content/uploads/2020/08/Take2_DistrictProfile_JHB1606-2-2.pdf
[Accessed 9 January 2023].
90. Johannesburg, C. o., 2021. *City Of Johannesburg Climate Action Plan March 2021*. [Online]
Available at: https://www.joburg.org.za/departments/_Documents/EISD/City%20of%20Johannesburg%20-%20Climate%20Action%20Plan%20%28CAP%29.pdf
[Accessed 13 January 2023].
91. Kakderi, C., 2013. *Smart Governance for Smart Cities*. [Online]
Available at: <https://www.urenio.org/2013/11/19/smart-governance-smart-cities/>
[Accessed 20 October 2021].
92. Karjalainen, J. H. S. :. S. M., 2021. Peer-to-peer and circular economy principles in the fourth industrial revolution (4IR). *Great Electrification in Peer-to-Peer Society*.
93. Kathrada, B., 2019. *Don't dismiss President Ramaphosa's smart city idea*. [Online]
Available at: <https://www.iol.co.za/capeargus/opinion/dont-dismiss-president-ramaphosas-smart-city-idea-28721033>
[Accessed 3 October 2021].
94. Kayembe, C. & Nel, D., 2019. Challenges and Opportunities for Education in the Fourth Industrial Revolution. *African Journal of Public Affairs*, 11(3), pp. 79-95.

95. Keeton, R., 2019. Spatial challenges in contemporary African New Towns and potentials for alternative planning strategies. *International Planning Studies*, 24(3), pp. 218-234.
96. Khanna, P., 2021. *The future of 'smart living' will be a test of how smart we really are*. [Online]
Available at: <https://www.fastcompany.com/90684865/the-future-of-smart-living-will-be-a-test-of-how-smart-we-really-are>
[Accessed 6 October 2022].
97. Kim, J., 2022. Smart city trends: A focus on 5 countries and 15 companies. *Cities*, Volume 123.
98. Koma, S., 2010. THE STATE OF LOCAL GOVERNMENT IN SOUTH AFRICA ISSUES, TRENDS AND OPTIONS. *School of Public Management and Administration*, pp. 1-10.
99. Kotze, N., 2014. Addressing South Africa's urban challenges. *Urbani Izziv*, pp. 1-4.
100. Kovachek, M., 2019. *Is South Africa a Third World Country?*. [Online]
Available at: <https://destinationsscanner.com/is-south-africa-a-third-world-country/>
[Accessed 5 October 2021].
101. Laubscher, E., 2018. *Unskilled labour in South Africa*. [Online]
Available at: <https://medium.com/@erichlaubscher1/unskilled-labour-in-south-africa-af56852ed443>
[Accessed 26 October 2022].
102. Laubscher, L., 2021. Challenges on financial control and accountability in South African municipalities. *Journal for New Generation Sciences*, 10(1).
103. Layman, T., 2003. *Intergovernmental relation and service delivery in South Africa. A Ten Year Review*, Johannesburg : Commissioned by the Presidency..
104. Ibedorol, 2022. *Industry 4.0: which technologies will mark the Fourth Industrial Revolution*. [Online]
Available at: <https://www.iberdrola.com/innovation/fourth-industrial-revolution#:~:text=In%20the%20case%20of%20the,by%20developing%20customised%20products%20that>
[Accessed 11 December 2023].
105. Lebeck, S., 2014. *The 'smart city' movement: From experimentation to standardization*. [Online]
Available at: <https://www.greenbiz.com/article/smart-city-movement-experimentation-standardization>
[Accessed 4 October 2021].
106. Lee, C.-K., Lee, J., Tang, H.-L. & Lo, P.-W., 2011. Taiwan Perspective: Developing Smart Living Technology. *International Journal of Automation and Smart Technology*, 1(1), pp. 98-106.
107. Lee, S. K. et al., 2016. International Case Studies of Smart Cities: Singapore, Republic of Singapore. *IDB publications*.
108. Levenson, Z., 2014. The Politics of Postapartheid Housing. *The Berkeley Journal of Sociology*, Volume 58.
109. Lewis, M. & Nel, V., 2020. Setting standards and competencies for planners.. *Routledge Handbook of Urban Planning in Africa*, pp. 162 -176.
110. Lodi, J., 2006. A Critical Analysis Of Regional Planning In South Africa In The 21st Century. *WIT Transactions on Ecology and the Environment*, Volume 93, p. 10.
111. London, C. o., 2023. *Green City: London, England*. [Online]
Available at: <https://www.greencitytimes.com/london/>
[Accessed 5 July 2023].
112. Lye, D., 2017. *The Fourth Industrial Revolution And Challenges For Government*. [Online]
Available at: <https://www.ge.com/news/reports/fourth-industrial-revolution-challenges-government>
[Accessed 13 February 2023].

113. Madangombe, T., 2019. *Smart cities depend on adoption of 4IR*. [Online]
Available at: https://www.crown.co.za/images/latest-news-2019/mechchem-africa/Smart_cities_depend_on_adoption_of_4IR.pdf
[Accessed 29 July 2022].
114. Magoro, J., 2021. *Policy Research, Development & Socio-Economic Impact*. [Online]
Available at: https://sdgs.un.org/sites/default/files/2021-10/Gauteng%20Provincial%20Government-%20Policy%20Research%20Development%20%20SEIAS%20Presentation_Magoro_0.pdf
[Accessed 19 December 2023].
115. Mahizhnan, A., 1999. Smart cities: The Singapore case. *Cities*, 16(1), pp. 13-18.
116. Mahlako, T., 2016. Problems and challenges related to public policy implementation within the South African democratic dispensation : a theoretical exploration. *Boloko Institutional Repository* , p. 145.
117. Mahlangu, A., 2021. *Balwin Properties still talking to the government about water and power for its development*. [Online]
Available at: <https://www.businesslive.co.za/bd/companies/property/2021-03-30-balwin-properties-still-talking-to-government-about-water-and-power-for-its-development/>
[Accessed 12 December 2022].
118. Malan, L. P., 2012. Intergovernmental relations in South Africa- A revised policy approach to co-operative government. *School of Public Management and Administration- University of Pretoria*, 5(3), pp. 1-10.
119. Malik, Y., 2017. *Smart, Connected and IoT Based Devices. What's The Difference?*, s.l.: medium.com.
120. Malomane, R., Musonda, I. & Okoro, C. S., 2022. The Opportunities and Challenges Associated with the Implementation of Fourth Industrial Revolution Technologies to Manage Health and Safety. *Int J Environ Res Public Health*, 19(2), p. 846.
121. Marr, B., 2022. *The Problem With Biased AIs (and How To Make AI Better)*. [Online]
Available at: <https://www.forbes.com/sites/bernardmarr/2022/09/30/the-problem-with-biased-ais-and-how-to-make-ai-better/?sh=59ed58e14770>
[Accessed 1 July 2023].
122. Marsh, J., 2019. *What Impact Would a Fourth Industrial Revolution Have on the Planet?*. [Online]
Available at: <https://environment.co/impact-fourth-industrial-revolution-have-on-planet/>
[Accessed 1 October 2022].
123. Marwala, T., 2020. *Review, amend or create policy and legislation enabling the 4IR*. [Online]
Available at: <https://mg.co.za/article/2020-04-03-review-amend-or-create-policy-and-legislation-enabling-the-4ir/>
[Accessed 28 August 2022].
124. Masiteng, D. K., 2018. *A CONCEPT NOTE ON INSTITUTIONALISATION OF PLANNING IN SOUTH AFRICA*, Tshwane: DPME.
125. Mbada, M., 2021. *Growing Gauteng Together (GGT) plan remodelled as part of reconstruction and recovery of the economy Post-COVID-19*. [Online]
Available at: <https://www.jamboafrika.online/growing-gauteng-together-ggt-plan-remodelled-as-part-of-reconstruction-and-recovery-of-the-economy-post-covid-19/>
[Accessed 18 December 2023].
126. Mbatha, S. G., Gumbo, T., Oniya, O. & Moyo, T., 2021. Exploring 4IR Technologies as a Solution to Improve the Traffic Flow on the Roads: a Case of the City of Johannesburg. *REAL CORP2021 proceedings* , p. 8.
127. McGinnis, D., 2020. *What Is the Fourth Industrial Revolution?*. [Online]
Available at: <https://www.salesforce.com/blog/what-is-the-fourth-industrial-revolution-4ir/>
[Accessed 15 October 2021].

128. McLennan, M., Group, S. & Group, Z. I., 2022. *The Global Risks Report 2022 17th Edition*. [Online]
Available at: https://www3.weforum.org/docs/WEF_The_Global_Risks_Report_2022.pdf
[Accessed 22 August 2022].
129. Menon, J., 2019. The Fourth Industrial Revolution and Its Implications for Regional Economic Integration in ASEAN. *Journal of Asian Economic Integration*, 1(1), pp. 32-47.
130. Mhene, N., 2019. *Farmworkers and 4IR*, London : Mail Guardian.
131. Mirembe, J., 2017. A meta-perspective of the dialogues on emerging information and communication technology (ICT) and the impact thereof on people, space and planning. *University of Pretoria*, pp. 1-188.
132. Mkentane, L., 2019. *Ramaphosa eyes Silicon Valley in South Africa*. [Online]
Available at: <https://newsexpressngr.com/news/78454-Ramaphosa-eyes-Silicon-Valley-in-South-Africa>
[Accessed 26 October 2021].
133. Mlaba, K., 2021. *How Is South Africa's Digital Divide Making Inequality Worse in the Country?*. [Online]
Available at: <https://www.globalcitizen.org/en/content/south-africa-digital-divide-makes-inequality-worse/>
[Accessed 3 November 2022].
134. Mnguni, P., 2020. *South African Manufacturing: A situational analysis*, Pretoria : SARB .
135. Mphethi, W. M. & P., 2017. *A guide to the Spatial Planning & Land Use Management Act [SPLUMA]*, Hoedspruit: The USAID.
136. Mthethwa, N., 2020. *SA society remains divided*. [Online]
Available at: <https://www.sanews.gov.za/south-africa/sa-society-remains-divided>
[Accessed 1 November 2022].
137. Mubangizi, P. J. C., 2019. *Corruption in South Africa: The politics, the law and all the shenanigans in between*. [Online]
Available at: https://www.ufs.ac.za/docs/default-source/news-documents/opinion_politicsandcorruption_gb1.pdf?sfvrsn=3cd06c20_0
[Accessed 1 November 2022].
138. Mulholland, S., 2022. *How to fix SA? We need action and realism*. [Online]
Available at: <https://www.leader.co.za/article.aspx?s=1&f=1&a=2903>
[Accessed 1 November 2022].
139. Mustafa, S. Z., Kumar, H. & Gupta, S., 2017. 3: Smart People for Smart Cities: A Behavioral Framework for Personality and Roles: Smarter People, Governance, and Solutions. *Advances In Smart Cities*, pp. 23-30.
140. Mzekandaba, S., 2019. *Ramaphosa's 4IR smart city pipe dream*. [Online]
Available at: <https://www.itweb.co.za/content/5yONP7EEDyy7XWrb>
[Accessed 15 December 2022].
141. Mzekandaba, S., 2023. *'Smart Nation' Singapore gives SA smart city advice*. [Online]
Available at: <https://www.itweb.co.za/content/Pero3MZ3ml6qQb6m>
[Accessed 3 August 2023].
142. Naidoo, P., 2021. *South Africa's unemployment rate is now highest in the world*. [Online]
Available at: <https://www.aljazeera.com/economy/2021/8/24/south-africas-unemployment-rate-is-now-the-worlds-highest>
[Accessed 5 October 2021].
143. Naidoo, S., 2023. *Project Details Mooikloof - Greendale - Building*. [Online]
Available at: <https://www.l2b.co.za/Project/Mooikloof-Greendale-Building/26059#details>
[Accessed 2 October 2023].

144. Nath, S. S., 2018. *IMPACT OF THE FOURTH INDUSTRIAL REVOLUTION*. [Online]
Available at: <https://www.linkedin.com/pulse/impact-fourth-industrial-revolution-swikriti-sheela-nath>
[Accessed 23 August 2022].
145. Naudé, P., 2022. *Turning corruption around is an inter-generational task*. [Online]
Available at: <https://www.leader.co.za/article.aspx?s=1&f=1&a=2894>
[Accessed 29 October 2022].
146. Neiteler, F., 2021. *Stock themes: Technology and the Fourth Industrial Revolution*. [Online]
Available at: <https://www.moneyweb.co.za/financial-advisor-views/stock-themes-technology-and-the-fourth-industrial-revolution/>
[Accessed 15 October 2021].
147. Nelson, J., 2023. *Is a 15-minute city plan feasible for smaller communities?*. [Online]
Available at: <https://www.stalbertgazette.com/local-news/is-a-15-minute-city-plan-feasible-for-smaller-communities-6557168>
[Accessed 12 July 2023].
148. Netlingo, 2022. *smart tech*. [Online]
Available at: <https://www.netlingo.com/word/smart-tech.php>
[Accessed 25 July 2022].
149. Network, C. W., 2020. *Metropolitan Municipality: City of Johannesburg*. [Online]
Available at: <https://www.commonwealthofnations.org/partner/city-of-johannesburg-metropolitan-municipality/#>
[Accessed 10 January 2023].
150. Neuman, W., 2014. Social Research Methods: Qualitative and Quantitative Approaches. *Open Access Library Journal*, 4(10).
151. Ngwenya, K., Naude, M. J. & Wissink, H. F., 2022. The Durban Aerotropolis strategy for sustainable socio-economic development. *Africa's Public Service Delivery & Performance Review (APSDPR)*, 10(1).
152. Njontini, M. N., 2021. Disruptive technologies and the future of regulations - ICT regulatory structure(s) determined. *De Jure Law Journal*, 54(1).
153. Nwauche, S. & Flanigan, S. T., 2021. Challenges to Nonprofit Organization Participation in Social and Development Policy Planning in South Africa. *Nonprofit Policy Forum*, 13(2).
154. Nyagadz, R. P. A. C. M. & K. H. J. R. (e.), 2022. Digital technologies, Fourth Industrial Revolution (4IR) & Global Value Chains (GVCs) nexus with emerging economies' future industrial innovation dynamics. *DEVELOPMENT ECONOMICS*, 1(10).
155. Oláh, J. et al., 2020. Impact of Industry 4.0 on Environmental Sustainability. *MDPI*, pp. 1-21.
156. Olaitan, O. O., Issah, M. & Wayi, N., 2021. A framework to test South Africa's readiness for the fourth industrial revolution. *South African Journal of Information Management*, 23(1), p. a1285.
157. Oranje, M., 2010. National spatial development planning in South Africa 1930-2010: An introductory comparative analysis. *Town and Regional Planning*, Volume 56, pp. 31-47.
158. Ormond, V., 2021. *London – city of innovation*. [Online]
Available at: <https://www.knightfrank.com/research/article/2021-02-03-london-city-of-innovation>
[Accessed 12 February 2023].
159. Ornetzeder, M. & H. E. & K. H. & K. K. & H. W., 2008. The environmental effect of car-free housing: A case in Vienna.. *Ecological Economics*, pp. 516-530.
160. O'Sullivan, F., 2020. *Vienna's Cultural Approach to Going Car-Free*. [Online]
Available at: <https://www.bloomberg.com/news/articles/2020-01-29/use-cultural-attractions-to-boost-car-free-travel>
[Accessed 9 July 2023].

161. Owusu, P. A., 2016. A review of renewable energy sources, sustainability issues and climate change mitigation. *Cogent Engineering*, 3(1), pp. 878-902.
162. Oztemel, E. & Gursev, S., 2020. Literature review of Industry 4.0 and related technologies. *Journal of Intelligent Manufacturing*, 31(4), p. 57.
163. Parker, D., 2022. *At least 50% of Lanseria smart city's housing will need to be subsidised*. [Online]
Available at: https://www.engineeringnews.co.za/article/at-least-50-of-lanseria-smart-citys-housing-will-need-to-be-subsidised-2022-06-09/rep_id:4136
[Accessed 13 December 2022].
164. Patel, M., 2019. *Understanding the Role of Smart City & its Components in the IoT Era*. [Online]
Available at: <https://www.einfochips.com/blog/understanding-the-role-of-smart-city-and-its-components-in-the-iot-era/>
[Accessed 4 October 2022].
165. Pavid, K., 2022. *What is the Anthropocene and why does it matter?*. [Online]
Available at: <https://www.nhm.ac.uk/discover/what-is-the-anthropocene.html>
[Accessed 5 December 2022].
166. Perez, M. P., Dignum, P. V. & Ogie, R. I., 2017. Smart infrastructure: an emerging frontier for multidisciplinary research. *Smart Infrastructure and Construction*, 170(1), pp. 8-16.
167. Perrin, A., 2021. *KEY IMPACTS OF THE FOURTH INDUSTRIAL REVOLUTION*. [Online]
Available at: <https://telecoms.adaptit.tech/blog/fourth-industrial-revolution/>
[Accessed 22 August 2022].
168. Petrillo, A., Felice, F. D., Cioffi, R. & Zomparelli, F., 2018. Fourth Industrial Revolution: Current Practices, Challenges, and Opportunities. *Digital Transformation in Smart Manufacturing*, 1(1).
169. Peyper, L., 2021. *SA's high-risk reputation costs the country dearly*. [Online]
Available at: <https://www.news24.com/citypress/business/sas-high-risk-reputation-costs-the-country-dearly-20210820>
[Accessed 5 October 2021].
170. Philipas, G., 2020. *SA's smart city drive may not be such a clever move*. [Online]
Available at: <https://www.businesslive.co.za/bd/opinion/2020-03-23-sas-smart-city-drive-may-not-be-such-a-clever-move/>
[Accessed 16 December 2022].
171. Pillay, S., 2004. Corruption - The challenge to good governance: A South African perspective. *International Journal of Public Sector Management*, 17(7), pp. 586-605.
172. Portugali, J., 2013. *What makes cities complex?*. [Online]
Available at: <http://www.spatialcomplexity.info/files/2013/10/Portugali.pdf>
[Accessed 28 June 2023].
173. Postolache, O., 2019. Special Issue on Smart Environments and Healthcare. *Smart Environment and Healthcare*, 9(7), p. 3.
174. Preston, C., 2017. *Promoting Employee Happiness Benefits Everyone*. [Online]
Available at: <https://www.forbes.com/sites/forbescoachescouncil/2017/12/13/promoting-employee-happiness-benefits-everyone/?sh=58f3b53e581a>
[Accessed 8 December 2022].
175. Priya, A., 2021. Case Study Methodology of Qualitative Research: Key Attributes and Navigating the Conundrums in Its Application. *Sociological Bulletin*, 1(70), pp. 94-110.
176. Przybilowicz, E., Cunha, M. A. & Tomor, Z., 2017. Identifying Essential Organizational Characteristics For Smart Urban Governance. *Proceedings of the 18th Annual International Conference on Digital Government Research*, pp. 416-425.

177. Puttkamer, L., 2023. *LONDON: EUROPE'S SMARTEST CITY*. [Online]
Available at: <https://www.beesmart.city/city-portraits/london-europes-smartest-city#:~:text=A%20data%20driven%20future%20city,of%2073.7%20out%20of%20100>.
[Accessed 17 July 2023].
178. PWC, 2017. *Fourth Industrial Revolution for the Earth: Harnessing the 4th Industrial Revolution for Sustainable Emerging Cities*. [Online]
Available at: <https://www.pwc.com/gx/en/sustainability/assets/4ir-for-the-earth.pdf>
[Accessed 14 December 2023].
179. PwC, 2020. *Unlocking Technology for the Global Goals*, Geneva: World Economic Forum.
180. Quélin, B. & Smadja, I., 2021. The sustainable program of six leading cities. *Bouygues – HEC Paris Chair Smart City and the Common Good*, pp. 1-238.
181. Quinot, G., 2020. *Regulatory Justification and Coordination in South Africa*. [Online]
Available at: <https://www.theregreview.org/2020/04/29/quinot-regulatory-justification-coordination-south-africa/>
[Accessed 14 February 2023].
182. Ragoasha, M., 2021. *Smart cities initiatives in South Africa*. [Online]
Available at: <https://www.ukesa.info/library/view/smart-city-initiatives-in-south-africa>
[Accessed 14 December 2022].
183. Reports, S., 2021. *Bridging the Gap: Technology Access in South Africa*. [Online]
Available at: <https://www.borgenmagazine.com/technology-access-in-south-africa/#:~:text=Only%2010%25%20of%20households%20in,to%20their%20lower%20socioeconomic%20status>.
[Accessed 3 November 2022].
184. Richards, C., 2022. *What are the barriers holding back 4IR adoption?*. [Online]
Available at: <https://www.makeuk.org/insights/blogs/what-are-the-barriers-holding-back-4ir-adoption>
[Accessed 11 September 2022].
185. Ritchie, H. & Roser, M., 2018. Urbanization. *Our World in Data*.
186. Roser, M., 2014. Human Development Index. *Our World in data*, p. 15.
187. SA, S., 2021. *When talking economics, consider the provinces*. [Online]
Available at: <https://www.statssa.gov.za/?p=14171>
[Accessed 3 January 2023].
188. SA, S., 2022. *Census*. [Online]
Available at: https://www.statssa.gov.za/?page_id=1021&id=city-of-tshwane-municipality#:~:text=Tshwane%20is%20amongst%20the%20six,houses%20approximately%202%2C9million%20Residents.
[Accessed 9 January 2023].
189. Sassen, S., 2011. When Cities Become Strategic. *Architectural Design*, 81(3), pp. 124-127.
190. Schwab, K., 2016. The Fourth Industrial Revolution: what it means, how to respond. *World Economic Forum*, 14 January.p. 172.
191. SCS, 2020. *SINGAPORE SMART NATION INITIATIVES AND POSSIBLE OPPORTUNITIES*. [Online]
Available at: <https://www.scs.org.sg/articles/smart-nation-singapore>
[Accessed 11 July 2023].
192. Seery, E., Okanda, A. & Lawson, M., 2019. A TALE OF TWO CONTINENTS FIGHTING INEQUALITY IN AFRICA. *oxfam*, pp. 1-38.
193. Sekyere, E., Bohler-Muller, N. & Hongoro, C., 2020. The Impact of COVID-19 in South Africa. *AFRICA PROGRAM PUBLICATIONS*.

194. Sello, I., 2019. *The fourth industrial revolution (4IR) is unfolding on the continent, bringing with it African solutions for African problems. But is it a threat to livelihoods or does it provide an opportunity for Africa to leapfrog the earlier industrial revolutions?*. [Online]
Available at: https://www.investec.com/en_za/focus/innovation/4ir-and-africa-a-digital-divide.html
[Accessed 27 July 2022].
195. Shanmugaratnam, T. et al., 2022. *TOWARDS 2021/2022 HDR*, Singapore: UN .
196. Sibanyoni, M., 2021. *NDP 2030 Targets: SA's targets vs reality*, Johannesburg: SABC News Online.
197. Sihlongonyane, M. F., 2018. The generation of competencies and standards for planning in South Africa: Differing views. *Town and Regional Planning*, Volume 72.
198. Smith, J., 2018. *The Fourth Industrial Revolution: Challenges and Opportunities*. [Online]
Available at: <https://business.leeds.ac.uk/research-coscr/dir-record/research-blog/616/the-fourth-industrial-revolution-challenges-and-opportunities>
[Accessed 28 September 2022].
199. Smith, L., 2018. *SMART CITY PORTRAIT VIENNA: A COLLABORATIVE SMART CITY*. [Online]
Available at: <https://www.beesmart.city/city-portraits/smart-city-vienna#:~:text=%E2%80%9CVienna's%20three%2Dpronged%20plan%20sets,Founder%20of%20bee%20smart%20city>
[Accessed 9 July 2023].
200. Srivatsa, P., 2015. Rural Urban Migration: Disturbing the Equilibrium between Smart Cities and Smart Villages. *FIIB Business Review*, 4(3), pp. 3-10.
201. Thales, 2022. *Secure, sustainable smart cities and the IoT*. [Online]
Available at: <https://www.thalesgroup.com/en/markets/digital-identity-and-security/iot/inspired/smart-cities>
[Accessed 4 October 2022].
202. Thales, 2023. *Singapore as a Smart City*. [Online]
Available at: <https://www.thalesgroup.com/en/worldwide-digital-identity-and-security/iot/magazine/singapore-worlds-smartest-city>
[Accessed 21 July 2023].
203. Tomor, Z., Meijer, A., Michels, A. & Geertman, S., 2019. Smart Governance For Sustainable Cities: Findings from a Systematic Literature Review. *Journal of Urban Technology* , 26(4), pp. 3-27.
204. Tshwane, C. o., 2020. *City of tshwane metropolitan GAU*. [Online]
Available at: <https://www.cogta.gov.za/ddm/wp-content/uploads/2020/11/Tshwane-October-2020.pdf>
[Accessed 9 January 2023].
205. UN, 2010. *WORLD URBAN FORUM 6 – The Urban Future and Prosperity of the City*. [Online]
Available at: https://mirror.unhabitat.org/downloads/docs/11133_1_594453.pdf
[Accessed 3 October 2021].
206. UN, 2017. *Growing at a slower pace, world population is expected to reach 9.7 billion in 2050 and could peak at nearly 11 billion around 2100*. [Online]
Available at: <https://www.un.org/development/desa/en/news/population/world-population-prospects-2019.html>
[Accessed 28 December 2021].
207. UN, 2018. *68% of the world population projected to live in urban areas by 2050, says UN*. [Online]
Available at: <https://www.un.org/development/desa/en/news/population/2018-revision-of-world-urbanization-prospects.html>
[Accessed 28 December 2021].
208. UN, 2022. *The Sustainable Development Goals Report 2022*. [Online]
Available at: <https://unstats.un.org/sdgs/report/2022/>
[Accessed 24 August 2022].

209. UNDP, 2023. *Singapore Global Centre SMART CITIES*. [Online]
Available at: <https://www.undp.org/policy-centre/singapore/smart-cities>
[Accessed 22 July 2023].
210. Vaughan, T., 2021. *Disadvantages of Qualitative Research*. [Online]
Available at: <https://www.poppulo.com/blog/10-advantages-and-disadvantages-of-qualitative-research>
[Accessed 21 January 2023].
211. Villiers, B. d. & Sindane, J., 2011. Cooperative Government: The oil of the engine. pp. 1-44.
212. Visser, J., 2019. Municipal Law Making under SPLUMA: A Survey of Fifteen "First Generation" Municipal Planning By-Laws. *Potchefstroom Electronic Law Journal*, Volume 22, pp. 1-28.
213. Vyas, K., 2019. *Inventions of The Industrial Revolution 4.0*. [Online]
Available at: <https://interestingengineering.com/innovation/inventions-of-the-industrial-revolution-40>
[Accessed 28 August 2022].
214. Wade, M. R. & Pfäffli, M. P., 2016. *What is a Smart City anyways?*. [Online]
Available at: <https://www.imd.org/research-knowledge/articles/what-is-a-smart-city-anyways/>
[Accessed 3 October 2022].
215. Walbank, J., 2023. *Top 10 leading global smart cities*. [Online]
Available at: <https://mobile-magazine.com/articles/top-10-leading-global-smart-cities>
[Accessed 12 July 2023].
216. Washington, V., 2014. Local Government, the Internet, and Sustainability. *Public Administration Review*, 74(1), pp. 99-100.
217. Weiss, A., 2009. Smart infrastructure matches supply and demand Networker. *ACM Digital Library netWorker*, 13(3), pp. 18-25.
218. WIPO, 2022. *Global Innovation Index (GII)*. [Online]
Available at:
https://www.wipo.int/global_innovation_index/en/#:~:text=Envisioned%20to%20capture%20as%20complete,knowledge%20creation%20of%20each%20economy
[Accessed 11 July 2023].
219. Woetzel, J. et al., 2018. *Smart cities: Digital solutions for a more livable future*, s.l.: McKinsey Global Institute United States.
220. Wolfram, M., 2012. Deconstructing Smart Cities: An Intertextual Reading of Concepts and Practices for Integrated Urban and ICT Development. *Tagungsband*, p. 15.
221. Wray, S., 2018. *If South Africa wants to participate in the Fourth Industrial Revolution (4IR) and smart city development, it will face several challenges. Here are some of the key challenges that may need to be addressed.*. [Online]
Available at: <https://www.beesmart.city/en/strategy/financing-smart-cities>
[Accessed 11 June 2023].
222. Writer, S., 2020. *Ramaphosa has a plan for a new 'smart city' in Gauteng*. [Online]
Available at: <https://businesstech.co.za/news/technology/374270/ramaphosa-has-a-plan-for-a-new-smart-city-in-gauteng/>
[Accessed 4 October 2021].
223. Writer, S., 2022. *These 'semi-skilled' jobs are disappearing in South Africa*. [Online]
Available at: <https://businesstech.co.za/news/business/553208/these-semi-skilled-jobs-are-disappearing-in-south-africa/>
[Accessed 26 October 2022].

224. Zake, J. M. & Poll, J. A. v. d., 2021. Addressing the Impact of the Fourth Industrial Revolution on South African Manufacturing Small and Medium Enterprises (SMEs). *Sustainable Manufacturing and Supply Chain in the Context of Industry 4.0: Opportunities and Challenges*, 13(21).
225. Zervoudi, E. K., 2020. Fourth Industrial Revolution: Opportunities, Challenges, and Proposed Policies. *Industrial Robotics - New Paradigms*, pp. 1-8.