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Exploring the potential of 5G to bridge the digital divide in South Africa

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Exploring the potential of 5G to bridge the digital divide in South Africa

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A research report submitted to the Faculty of Commerce, Law and Management, University of the Witwatersrand, in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business

Johannesburg, 2023

C2 General

ABSTRACT

5G adoption is expected to boost job growth and income, and reduce costs, contributing to the South African National Development Plan (NDP) 2030 goal of a connected society, especially in underserved areas, and improving affordability and broadband infrastructure accessibility. This research study sets out to explore the potential of 5G in bridging the digital divide in South Africa.

The researcher undertook a qualitative study through semi-structured interviews of industry experts using an interview guide as the research instrument. The sample was made up of a qualitative study of the perceptions of 14 participants from the telecommunications sector, a research council, the government, and SMEs, with first-hand experience in 5G deployment and manufacturing of 5G equipment. The themes that emerged during the process of data analysis were derived using a thematic analysis.

The study findings revealed that South Africa to is ready to adopt 5G technology and confirmed 5G technology's potential to transform South African lives, businesses, and industries through Enhanced Mobile Broadband (eMBB), Massive Machine-Type Communications (mMTC), and Ultra-Reliable and Low Latency Communications (uRLLC) use cases, thus aligning with the International Mobile Telecommunications (IMT) 2020 vision. 5G offers significant potential for improving service delivery in South Africa, enabling e-government, and saving time, money, and convenience in various sectors. However, 5G technology's potential to revolutionize life and work faces socioeconomic challenges and slow government implementation, hindering its potential to bridge the digital divide. Recommendations have been posited for each of the stakeholders involved in the 5G ecosystem in South Africa to help overcome the digital divide.

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KEYWORDS

3G, 4G, 5G, broadband, digital divide, ICT, mobile evolution, policy, spectrum

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DECLARATION

I, Sebongile Dumako, declare that this research report is my own work except as indicated in the references and acknowledgements. It is submitted in partial fulfilment of the requirements for the degree of Master of Management in the field of Digital Business at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination in this or any other university.

Name: Sebongile Dumako Signature: 

Signed at ……Centurion……

On the ……30…….. day of ……June…… 2023…..

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DEDICATION

The study is in memory of my late father and late sisters; thank you for the inspiration.

C2 General

ACKNOWLEDGEMENTS

I would like to take this opportunity to thank my supervisor, Mr. Ashraf Patel, for the unwavering support, guidance, and wisdom he gave me throughout this research journey. I appreciate the persistence and consistent push to challenge myself and the encouragement you gave me throughout the process, even when I did not believe in myself. All this would have never been possible without you; may you be eternally blessed.

To the participants who sacrificed their time and shared valuable insights, thank you for the contributions you have made to my research. I appreciate your efforts and will forever be grateful.

To my husband and children, words cannot describe the gratitude and appreciation I have for all the love and support you have given in the last two years. You were my biggest cheerleaders and continuously encouraged me to push on. Thank you for being there for me.

To my mother, thank you for the continued love and support, words of wisdom, and advice when the going got tough. I hope I have made you proud.

To my family and friends who were always rallying behind me and understanding when I was absent, thank you for the love and support.

To my employer, thank you for giving me the opportunity, understanding, and support to further my studies and complete this research.

C2 General

TABLE OF CONTENTS

DECLARATION ..... **iv**

DEDICATION ..... **v**

ACKNOWLEDGEMENTS ..... **vi**

LIST OF TABLES ..... **xi**

LIST OF FIGURES ..... **xii**

LIST OF ACRONYMS ..... **xiii**

CHAPTER 1. INTRODUCTION **1**

1.1 STATEMENT OF PURPOSE 1
1.2 BACKGROUND OF THE STUDY 1
1.3 RESEARCH PROBLEM 5
1.4 RESEARCH OBJECTIVES 7
1.5 RATIONALE OF THE STUDY 8
1.6 DELIMITATIONS OF THE STUDY 8
1.7 DEFINITIONS OF TERMS 9
1.8 ASSUMPTIONS 9

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK 11

2.1 INTRODUCTION 11
2.2 THE DIGITAL DIVIDE 11
2.3 EVOLUTION OF THE MOBILE BROADBAND 24

C2 General

2.4 5G Technology 27
2.4.1 Challenges of 5G in South Africa 33
2.5 Spectrum 39
2.6 Impact of 5G in Reshaping Consumers and Industries 42
2.7 Mobile Broadband Sector Stakeholders 45
2.8 5G Benefits for Service Delivery 46
2.9 Analytical Framework 50
2.9.1 Ontology 50
2.9.2 Epistemology 50
2.9.3 Theoretical Framework 51
2.9.4 Resources and Appropriation Theory 51
2.10 Conclusion on the Literature Review 55

CHAPTER 3. RESEARCH METHODOLOGY 56

3.1 Research Approach 56
3.2 Research Design 56
3.3 Data Collection Methods 57
3.4 Population and Sampling 57
3.4.1 Population 57
3.4.2 Sample and Sampling Method 58
3.5 Research Instrument 59
3.6 Procedure for Data Collection 59
3.7 Data Analysis Strategies and Interpretation 60
3.8 Possible Limitations and Challenges of the Study 60
3.9 Quality Assurance 61
3.9.1 Transferability 61
3.9.2 Credibility 61
3.9.3 Dependability 61
3.10 Ethical Considerations 61

CHAPTER 4. PRESENTATION OF FINDINGS 64

4.1 Introduction 64
4.2 Background of the Participants 64
4.3 Results Pertaining to Proposition 1: 5G technology can bridge the digital divide in South Africa 66
4.3.1 Technology Evolution 66
4.3.2 5G Capabilities 69

C2 General

4.3.3 Challenges of 5G Technology 71
4.3.4 5G Adoption 74
4.3.5 Digital Divide 78
4.4 Results Pertaining to Proposition 2: The implementation of 5G technology is a crucial step towards a more equitable digital future for South African consumers and citizens. 82
4.4.1 Customer Experience 82
4.4.2 Industry Beneficiaries of the 5G Technology 88
4.5 Results Pertaining to Proposition 3: 5G Will Improve and Enhance Service Delivery in Multiple Sectors in South Africa 94
4.5.1 Benefits of the 5G technology 94
4.5.2 Service Delivery 96
4.5.3 Policy and regulatory intervention 98
4.5.4 5G Acceleration 102

CHAPTER 5. DISCUSSION OF THE FINDINGS 105

5.1 Introduction 105
5.2 Discussion of Objective 1: To Investigate 5G Technology's Potential to Bridge the Digital Divide in South Africa in Accordance with ICT Policy/Regulatory Frameworks 105
5.2.1 Technology Evolution 105
5.2.2 5G Capabilities 107
5.2.3 Challenges of the 5G Technology 109
5.2.4 5G Adoption 118
5.2.5 Digital Divide 119
5.3 Discussion of Objective 2: To Investigate The Socioeconomic Impact of 5G on South African Consumers and Citizens' Drive for Digital Inclusion 123
5.3.1 Customer Experience 123
5.3.2 Industry beneficiaries of the 5G technology 125
5.4 Discussion of Objective 3: To Investigate 5G Technology's Potential to Assist with Service Delivery in South Africa 130
5.4.1 Benefits of the 5G technology 130
5.4.2 Service Delivery 133
5.4.3 Policy and Regulatory Intervention 136
5.4.4 5G Acceleration 138

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS 141

6.1 Introduction 141
6.2 Conclusions 141

C2 General

6.2.1 CONCLUSIONS REGARDING PROPOSITION 1 141
6.2.2 CONCLUSIONS REGARDING PROPOSITION 2 144
6.2.3 CONCLUSIONS REGARDING PROPOSITION 3 146
6.3 RECOMMENDATIONS 148
DEPARTMENT OF COOPERATIVE GOVERNANCE; NATIONAL TREASURY; AND DEPARTMENT OF PLANNING, MONITORING AND EVALUATION 148
DEPARTMENT OF BASIC EDUCATION 149
DEPARTMENT OF COMMUNICATIONS AND DIGITAL TECHNOLOGIES 149
REGULATORY 151
MOBILE OPERATORS AND OEMS 152
6.4 SUGGESTIONS FOR FURTHER RESEARCH.....153

REFERENCES 154

APPENDIX A: Participation information sheet.....164

Appendix B: Interview guide 167

APPENDIX C: Ethics clearance approval 169

C2 General

LIST OF TABLES

Table 1: Mobile Broadband Sector Stakeholders. 43

Table 2: Consistency table: research questions, propositions, data collection, and data analysis. 59

Table 3: Demographics of participants 61

C2 General

LIST OF FIGURES

Figure 1: Internet usage by households in 2021, broken down by location, province, and urban/rural status (ICASA, 2023). 18

Figure 2: Evaluation of Wireless Mobile Generations (Salil et al., 2020). 25

Figure 3: South Africa's national population coverage 2022 (ICASA, 2023). ... 29

Figure 4: Resource and Appropriation Theory causal model (Van Dijk, 2020). 54

Figure 5: Frequency bands of 5G spectrum use cases (Devopedia, 2020). .. 115

Figure 6: Global economic impact of 5G use cases (GSMA, 2018) 133

C2 General

LIST OF ACRONYMS

1G	First-Generation Mobile Network
2G	Second-Generation Mobile Network
3G	Third-Generation Mobile Network
4G	Fourth-Generation Mobile Network
5G	Fifth-Generation Mobile Network
4IR	Fourth Industrial Revolution
AI	Artificial intelligence
AR	Augmented reality
CAPEX	Capital expenditure
CoGTA	The Department of Cooperative Governance and Traditional Affairs)
COVID-19	Coronavirus disease 2019
CSIR	Council for Scientific and Industrial Research
DCDT	Department of Communications and Digital Technologies
DCoG	Department of Co-operative Governance
DTPS	Department of Telecommunications and Postal Services
ECT	Electronic Communications and Transactions Act
eMBB	enhanced Mobile Broadband
GDP	Gross Domestic Product
GHz	Gigahertz
GPS	Global Positioning System
GSM	Global System for Mobile communications
GSMA	GSM Association
ICASA	Independent Communications Authority of South Africa
ICT	Information and Communication Technology
ICT White Paper	[used in this report to refer to the National Integrated ICT Policy White Paper, 2016]
IDP	Integrated Development Plan
IITPSA	The Institute of IT Professionals South Africa
IMF	International Monetary Fund
IoT	Internet of Things
IPTV	Internet Protocol Television
ISO	International Standards Organisation
ITRs	International Telecommunication Regulations

C2 General

ITU	International Telecommunication Union
LDC	Least Developed Country
LTE	Long-Term Evolution
mMTC	massive Machine-Type Communication
MIMO	Multiple input, multiple output
NDP	National Development Plan
NGMN	Next Generation Mobile Networks
NGO	Non-Governmental Organisation
NPC	National Planning Commission
OECD	Organisation for Economic Co-operation and Development
OEM	Original equipment manufacturer
OPEX	Operational Expenditure
PC4IR	Presidential Commission on the Fourth Industrial Revolution
PwC	PricewaterhouseCoopers
RAN	Radio Access Network
RRs	Radio Regulations
SALGA	South African Local Government Association
SDG	Sustainable Development Goal
SMMEs	Small, Medium and Micro Enterprises
UNDP	United Nations Development Programme
UNESCO	United Nations Educational, Scientific and Cultural Organisation
URLLC	Ultra-Reliable Low Latency Communications
UTAUT	Unified Theory of Acceptance and Use of Technology
VoIP	Voice over Internet Protocol
VR	Virtual reality
Wi-Fi	Wireless Fidelity
WOAN	Wholesale Open Access Network

C2 General

CHAPTER 1. INTRODUCTION

1.1 Statement of Purpose

The purpose of this qualitative study was to investigate the potential of 5G to bridge the digital divide in South Africa. The *digital divide* refers to the social and economic gap that exists between those who have access to information and communication technologies (ICTs) and those who do not, and the disadvantages of missing out on the information and services available (Gordon, 2022).

1.2 Background of the Study

South Africa is a poverty-stricken country constrained by inequality and lack of or poor connectivity. ICTs play a major role in contributing towards the country's National Development Plan (NDP 2030) goals of reducing and eliminating inequality and poverty. Policy frameworks must, therefore, address the existing gaps in communication platforms, universal access and services content. Thus, universal access is not seen as a tool but as a precursor to equality through the provision of communication services, as written by the Department of Public Works and Infrastructure in the National Infrastructure Plan first adopted in 2012.

In 2020, the Presidential Commission on the Fourth Industrial Revolution (PC4IR) proposed a vision of the Fourth Industrial Revolution (4IR) in which "South Africa will have a globally competitive, inclusive, and shared economy with the technological capability and production that is [sic] driven by people harnessing the 4IR to propel the country forward rather than falling behind." The COVID-19 pandemic emphasized digital technologies for crisis response and recovery planning (GSMA, 2021). Moreover, the crisis presented mobile carriers with an opportunity to hasten the continent's digital growth and create a more robust

C2 General

digital workforce. According to President Ramaphosa (2020), South Africa should be a more technologically driven country that finds solutions that move the country forward, with 4IR as a pivot for economic recovery. He urged the PC4IR to place 4IR at the centre of economic recovery, to enable the country to emerge from the damaging impact of the COVID-19 pandemic.

During the COVID-19 pandemic, connectivity was a major contributor in maintaining business as usual for companies and the entertainment industry, rendering continuous services in health care, and enabling employees and students to work remotely from home (Singh, 2021). However, the pandemic also highlighted the government's egregious failure to provide all businesses and citizens with affordable access to the entire spectrum of communication services, thus deepening the digital divide, which is characterized by differences in class, race, gender, and rural-urban disparities (Abrahams et al., 2022). In South Africa, the exponential growth in consumers' and businesses' demand for data to enable connectivity during the COVID-19 pandemic required the Independent Communications Authority of South Africa (ICASA) to allocate a high-value 4G and 5G radio-frequency temporary spectrum to mobile network operators to meet the demands of increased traffic and spectrum use. This enabled the switching of 5G to cater for and reduce the high traffic being experienced on mobile networks, due to many people using their mobile data to work from home (Singh, 2021).

The International Mobile Communications 2020 (IMT-2020) vision of having a standardised 5G technology would enable ICASA, the government, and mobile network operators to provide ultra-fast 5G services that are guided by standards and are secure, reliable and flexible. The ITU-R has identified three 5G use cases for IMT-2020: large machine type communications, ultra-reliable and low latency communications, and improved mobile broadband. IMT-2020's peak data rate of 20 Gbit/s and user-experienced data rate of 100 Mbit/s set it apart from its predecessor (El-Moghazi & Whalley, 2022). The IMT-2020 vision further states

C2 General

that future steps in the 5G mobile technology are aimed at a new paradigm of connectivity among people and things in a smart, networked environment encompassing big data, applications, transport systems, and urban centres (International Telecommunication Union/ITU), 2015). The ITU (2015) cites four pillars that govern the IMT-2020 vision:

1. New technological advancements should contribute to the development of a mobile, intelligent, and connected society that is widely distributed.

2. Any new technology should promote ideas that bridge the digital divide.

3. Technologies that can personalize and/or localize services should be supported by any future technology.

4. Any technology developed in the future should be able to enable computing and communication solutions that can handle real-world data ownership sensitivity.

Improvements resulting from the current roll-out of 4G and 5G have been observed in various sectors, such as automation, health care, smart city infrastructure, and digital commerce. The roll-out is creating opportunities because it is still in its early stages (Global System Mobile Association/GSMA, 2021). The enforcement and isolation due to the COVID-19 lockdown elevated the digital transformation in South Africa in an exponential manner, as we witnessed consumers having to quickly adapt to being online for home-based work, learning, e-health care and entertainment. This necessitated the advancement and acceleration of the 2020−2030 phase of the National Development Plan (NDP) 2030, which states that “ongoing e-strategy implementation and refinement will ensure that the ICT sector supports rather than limits South Africa’s competitiveness globally and [its] economic performance. The country will maintain or improve its ITU rankings” (NDP 2030).

C2 General

Switching to 5G came with challenges, despite the temporary utilisation spectrum released by ICASA. South Africa, which had a spectrum auction on 17 May 2022. This spectrum allocation was considered a major milestone, taking place 17 years after the auction was initiated, as the process was halted because of political interference and ongoing legal disputes (Phillip, 2022). The sale generated more than R14.4 billion in income, all of which would be added to the national treasury. The *opt-in* phase auction was held on March 8, 2022, but the main auction process did not start until March 10, 2022, so the revenue amount (of R14.4 billion) was made from the opt-in phase (ICASA, 2022). The highest-bidding wireless carriers typically receive exclusive spectrum rights in spectrum auctions. Auctions are seen favourably by policymakers as a way of producing significant incomes. Auctions can, however, be counterproductive because they lower the amount of money available for infrastructure, thus weakening their own economic impact (International Telecommunication Union (ITU-R), 2012).

The roll-out of 5G data network and technology have been marred by speculation of negative health effects in society, partly due to linking and associating 5G networks with the COVID-19 pandemic (Matonda, 2021). Limitations in existing infrastructure is another key factor stalling the rapid adoption of 5G: the lack of fibre network connectivity is a major constraint (Singh, 2021). Delivery of the required bandwidth and throughput to homes, as well as sufficient fibre capacity, is a prerequisite for 5G (Singh, 2021).

Another major barrier to the 5G roll-out is the significant capital expenditure required by Telcos to upgrade their towers to support 5G and to deal with the significant network and operational complexity as 5G's diverse service offering is ushered in, along with a significant need for network automation (Singh, 2021). The lack of internet access and affordability, due to the scarce and expensive 5G devices in the country, is another challenge. According to Singh (2021), there are also inefficiencies within regulatory authorities and associated regulatory frameworks governing mobile broadband access and 5G.

C2 General

A switch to 5G promises to catalyse various benefits, involving job creation, income growth, consumer cost/time savings, pollution/greenhouse gas reduction, and quality-adjusted life-years gained (Mauro, 2019). This can only be realised through collaboration and co-ordinated efforts by government and the private sector to implement policy frameworks as outlined in the NDP 2030. According to the NDP 2030, South Africans will be guaranteed universal service, that is, affordable, reliable and secure broadband services that prioritise and cater for underprivileged and rural areas while enhancing economic growth. These concepts were used as an overall framework for the National Integrated ICT Policy White Paper (published in 2016) in respect of ICT development (DTPS/Department of Telecommunications and Postal Services, 2016). (Note: henceforth in this report, the National Integrated ICT Policy White Paper is referred to as the “ICT White Paper” (DTPS, 2016).)

South Africa's long-term development policy, the National Development Plan (NDP) towards 2030, “gives material meaning and purpose to the possibilities and prioritisation of pathways proposed by the 4IR.” Critical goals for the eradication of poverty, the reduction of unemployment, and the elimination of extreme inequality are included in the NDP. Implementing the plan means there is a chance to address the NDP's primary concerns and, in doing so, to provide a “policy-embedded path towards our constitutional objectives in the context of a significantly improved and altered future”, as stated in the NDP 2030.

1.3 Research Problem

By 2030, it is expected that ICT will support the growth of an active and interconnected South African information society, as well as a thriving knowledge economy that is more inclusive and successful (Statistics South Africa (Stats SA), 2017). According to Stats SA, the ICT White Paper (2016), which offers a framework for directing initiatives aimed at closing the digital gap, was approved by Cabinet in light of this. A broadband policy that aims to guarantee that

C2 General

everyone has access to broadband infrastructure and services by 2030 was also approved by the cabinet. The vision for broadband is 100 percent adoption and coverage, that is, for all South Africans to have access to broadband services by 2030 (Stats SA, 2017).

Although these policy frameworks have been commissioned and are being implemented by government, progress in realising the goals of eradication of the digital divide has been slow. According to Van Dijk (2006), the digital divide still exists in spite of government initiatives because of things like socioeconomic gaps, a lack of infrastructure, and insufficient access to digital technology. Hargittai (2002) identifies educational and socioeconomic barriers as the primary factors contributing to the slow progress in closing the digital divide gap. Millions of South Africans still do not have access to digital services (e-learning, e-government and digital economy), despite businesses and government aspiring to bridge the digital divide (The Institute of IT Professionals South Africa (IITPSA), 2021). A significant obstacle to the adoption of broadband services was the availability of reasonably priced data plans. South Africa has an unfavourable reputation for high data charges (Minister Mondli Gungubele, 2023). South Africans from marginalized backgrounds, particularly in rural areas, are disproportionately unable to adopt digital technology due to poverty and limited internet access, which significantly impacts their ability to acquire ICT tools and data (Shava & Ndebele, 2024). South Africa ranks 143rd in mobile data costs per gigabyte among 230 nations, with low-income groups consuming around 4.8 percent of their disposable income on mobile phone usage. South Africans still pay incredibly high rates for data consumption in general compared to Europeans, with the cost per megabyte per second being significantly higher (Venter, 2020). There has, however, been an improvement in the reduction of mobile data prices between 2021 and 2022. In April 2021, Vodacom and MTN in South Africa reduced their mobile data rates by 40% over two years. MTN only agreed to a one-time set of pricing reductions. Vodacom's prepaid packages saw reductions of 12.5 to 50 percent while MTN had data price reductions of 6 to 33.6

C2 General

percent (Chinembiri, 2020). The spectrum auction concluded by regulatory in March 2022, heightened the expectation of a further potential reduction in mobile data prices, which could potentially address the data affordability disparity for the underprivileged communities.

The vision of the PC4IR Strategic Implementation Plan is for South Africa to have a globally competitive, inclusive, and shared economy with a technological capability and production capacity that is driven by people harnessing the 4IR to propel the country towards its social and economic goals (PC4IR, 2020). According to an IMF Working Paper report on bridging the mobile digital divide by Alper and Miktus (2019), the 5G technology could help bridge the mobile digital divide in Sub-Saharan Africa. Interventions in policy frameworks to add adequate and necessary infrastructure would result in a reduced mobile digital divide in terms of knowledge, data privacy and affordability, and cybersecurity (Alper and Miktus, 2019). Although 5G is still in its infancy in Africa, it will expand quickly in the second half of the 2020s and will account for 0.4 percent of GDP by 2030. By 2030, there will be more than 90 percent of 4G or 5G coverage in South Africa (GSMA, 2022).

The current study investigates the potential of 5G to bridge the digital divide and the socioeconomic impact of the 5G technology on service delivery to drive digital inclusion.

1.4 Research Objectives

This study aims to determine the following:

1. To investigate 5G technology's potential to bridge the digital divide in South Africa in accordance with ICT policy/regulatory frameworks,
2. To investigate the socioeconomic impact of 5G for South African consumers and citizens by driving digital inclusion, and

C2 General

3. To investigate 5G technology's potential to assist with service delivery in South Africa.

These research objectives will be used as a guide to investigate and explore the rationale of the study.

1.5 Rationale of the Study

The significance of this study is its provision of insights into how 5G has the potential to bridge South Africa's digital divide problem. The research focuses on how 5G can help realize goal set forth in the National Development Plan (NDP) 2030 of a digitally linked society, especially in underserved areas; enhance affordability of devices and data; and improve low-income communities' access to broadband infrastructure.

The study will contribute towards a paradigm shift in which 5G is a catalyst that drives digital inclusion and improves socioeconomic development through service delivery, and mobile broadband stakeholders in South Africa (government, regulatory authorities, mobile network operators and equipment manufacturers) collaborate more effectively to accelerate 5G deployment and enable infrastructure policies to ensure that the digital divide is bridged, and service delivery is achieved.

1.6 Delimitations of the Study

This qualitative study focuses on understanding how the potential and capabilities of 5G in South Africa could bridge the digital divide. In addition, the study aims to understand how South Africa can leverage the ITU's IMT-2020 vision to contribute towards bridging the digital divide. This study does not focus on the technicalities of the 5G spectrum auctions conducted by regulatory bodies.

C2 General

1.7 Definitions of Terms

Term	Definition
5G	The fifth generation of mobile technologies (5G) connects people, things, data, applications, transport systems and cities in smart networked communication environments. 5G networks transport a large amount of data much faster, reliably connect an extremely large number of devices and process very large volumes of data with minimal delay (ITU, 2022).
Broadband	Access in which connection capabilities support data rates that are significantly greater than the narrowband rates (ITU, 2018).
Digital divide	The disparity between individuals, households, enterprises, and geographical areas with varying socioeconomic levels in terms of their access to ICTs and their usage of the internet for a number of purposes (OECD, 2002).
ICT	Information and communications technology to electronically gather, transfer, and display data and information (OECD, 2002).
Spectrum	A subset of the electromagnetic spectrum, here it refers to the set of radio frequencies assigned to mobile operators and other industries for communication over airways (GSMA, 2022).

1.8 Assumptions

The following assumptions have been made for the current study.

i. The POPI Act should be applied to interviews of employees from mobile network operators, regulatory authorities, and consumers:
    a. Interviewees will provide consent before the interviews take place.
    b. Interviewees from mobile operators will not divulge company information on their 5G strategies that may affect the competitive advantage they may deem to have on the 5G roll-out.

C2 General

ii. The study is based on the premise that consumers who are interviewed are knowledgeable in the 5G theory.

International 5G-related service standards can be used as a benchmark in the South African context.

C2 General

CHAPTER 2. LITERATURE REVIEW AND THEORETICAL FRAMEWORK

2.1 Introduction

A literature review can be defined as follows: “A substantive, thorough, sophisticated literature review is a precondition for doing substantive, thorough, sophisticated research. A researcher cannot perform significant research without first understanding the literature in the field.” (Boote & Beile, 2005:3)

The purpose of the literature review is to determine whether a study’s topic is researchable, to report the results of closely related studies (Rocco, 2009). This chapter focuses on reviewing and unpacking existing literature on the impact and potential of 5G in bridging the digital divide and the socioeconomic impact that 5G has on service delivery in South Africa.

The literature review provides guidance in identifying gaps that may exist in the literature to inform the direction of further research.

2.2 The Digital Divide

According to some researchers, 4IR can help South Africa overcome its problems with unemployment, poverty, and an unequal distribution of income (Olaitan et al., 2021). However, Olaitain et al. (2021) argue that it is unclear how well-prepared the nation is for the enabling technologies of the 4IR. The use and acceptance of new technologies, according to critics, would result in a considerable loss of jobs in South Africa (Adendorff & Collier, 2015). However, South Africa might be able to avoid the dangers associated with adopting new technologies by implementing solid national plans for the adoption and use of the 4IR (Marwala, 2019).

C2 General

Although it is anticipated that the use of digital technology would make it easier and less expensive for people to convey information, quick adoption (particularly as a result of price reductions) has brought up the issue of the digital divide (Sebatana & Makhubele, 2021)—the social and economic inequality in terms of accessibility to *information and communication technologies (ICTs)*. Those who lack access to the internet are disadvantaged by missing out on all of the information and services available through it (Gordon, 2022). The disparity in technology access and usage can lead to discrimination, social marginalization, and limited opportunities for career, education, and personal growth (Carbonell et al., 2022). The digital divide, caused by poverty, marginalization, and inequality, is made worse by factors like politics, unemployment, sociocultural norms, inadequate digital skill development programs, and rural exclusion from digital services (Aruleba & Jer, 2022).

The concept of the “digital divide” and its many facets has been extensively researched and discussed, and has evolved over time (Mubarak et al., 2020). Earlier researchers used the term to refer to the disparity between those who had access to ICT and those who did not (Van Dijk & Hacker, 2003). More recently, it has been used to refer to both the uneven access to digital resources that various social groups face, and the consequences that this difference has on already-existing socioeconomic disparities (Masley, 2021).

According to Vodoz et al. (2009), persons with higher education levels are likely to accept digital technology more quickly than those with lower levels or no education. Although the cost of computers, mobile phones, network connections, and internet access are recognised barriers that have been the subject of public debate, other factors such as a lack of abilities, opportunities, and even self-assurance may worsen the impact of the digital divide for some individuals (Van Dijk & Hacker, 2003).

The urban-rural divide has been a significant issue affecting the ICT access gap in developing nations. Emerging countries have a higher frequency of information

C2 General

flow, but rural areas struggle to keep up with the rapid growth of digital connections. Factors like lack of formal education, high costs of technology, and limited access to public services compound the issue (Aruleba & Jer, 2022).

According to Nielson (2006), the digital divide is composed of three stages:

i. *The economic divide* affects access to computers and internet for some people. Nielson predicts that poorer developing countries' citizens will lack access to computers for the next 20 years.
ii. *Usability divide* refers to the complexity of technologies hindering users' access to modern technology. Nearly 40 percent of the population has lower literacy skills, complicating the web's accessibility problem. More experienced and advanced users benefit from improvements in technology, while of lower-skilled users struggle with usability.
iii. *Empowerment divide* refers to the lack of understanding and power that digital technologies can provide individuals. Despite the ease of use, not everyone fully uses the potential of technology. Participation equality is a significant aspect of this divide, as people often rely on others to make decisions and lack initiative. This digital divide has persisted throughout internet growth, causing individuals to lack abilities and initiative.

As technology and society have advanced rapidly since the mid-1990s, studies on the digital gap have shifted our perception of the issue, focusing on various aspects of digital inequality (Gomez, 2018). Van Dijk et al. (2006) classified the first level of the digital divide that revolved around access to the internet and ICT. Scholars of communication and media shifted their focus to "beyond access" issues, including the skills users need to acquire, the various ways people use the internet, and the complexity of access, resulting in the "second-level divide" in research (Hargittai, 2002). Van Deursen et al. (2014) defined the second level as one where users do not have the same skills and knowledge of how to use digital resources, even with equal levels of access, which leads to different usage levels. Selwyn et al. (2004) also stated that the increasing awareness with regard

C2 General

to differences in access and usage of digital resources has consequences and fundamental outcomes in the real world; this is termed the third level of the digital divide. This concept of the third level, discussed by Ragnedda in 2017, refers to the advantages and offline results of using digital technologies, creating a “utility gap”. This perspective avoids the illusion of separation between online and offline reality, focusing on digital practices in social activities (Gomez, 2018).

According to Van Dijk (2020), gaining physical access to technology requires a motivation, mindset, and anticipation. It involves a continuous process of upgrades, ancillary devices, and subscriptions, rather than a single decision. Access cannot be justified if individuals cannot use the technology, so it requires specific skills and competencies. Access to high-speed internet connectivity is crucial for a nation’s prosperity in the digital era, potentially increasing productivity, fostering economic growth, and ultimately eradicating poverty by providing community members with access to broadband (Mhlanga, 2022). Uneven access to technology, such as poor internet quality and digitalization, leads to limited benefits and opportunity disparities in the community (Trofymenko et al., 2023). The accessibility and effectiveness of technologies directly impact socioeconomic and innovative development, affecting the spread of digital technologies, growth of digital infrastructure, assessment of their worth, and acquisition of digital skills (Trofymenko et al., 2023). According to Van Dijk, there are three levels of access associated with the digital divide:

i. *Physical access*: Research on the digital divide primarily focuses on disparities in access to personal computers and the internet among specific demographic groups, including age, gender, race, education level, and income (Van Dijk, 2020). Van Dijk et al. (2006) classified the first level of the digital divide that revolved around access to the internet and ICT.
ii. *Skills access*: Individuals require digital skills or media literacy to manipulate and use digital media once they have physical access to it; this is the digital divide’s second level (Van Dijk, 2020). Research on digital

C2 General

skills reveals that individuals of varying ages and educational backgrounds perform differently, with education level being the most crucial factor (Hargittai, 2002; Van Deursen, 2010).

iii. *Usage skills:* Usage refers to the third level of digital access and its main objective, measured by usage patterns, frequency, application variety, broadband or narrowband use, and creative or active use (Van Dijk, 2020). Researchers have identified a "usage gap" in the use of specific applications among individuals of different ages, educational backgrounds, and genders, which is currently greater than the education gap (Van Deursen & Van Dijk, 2013).

In terms of physical access, affluent nations account for 70 to 98 percent of internet users, compared to an average of 40 to 42 percent in developing nations. Nonetheless, the disparity in physical access between wealthy and poor nations has continued to grow, from 29 percent in 2000 to 40 percent in 2018 (Van Dijk, 2020). The discrepancy of South Africa's digital divide was brought even more starkly into focus as citizens increasingly relied on technology as a lifeline to stay connected to the outside world during the COVID-19 outbreak (Delport, 2020). According to Delport (2020), in the 4IR era, 5G is swiftly taking shape as a major enabler of a future technology-driven world. 5G was created as a more effective technology than its predecessors to address the world's expanding data and connectivity needs (Delport, 2020). The roll-out of 5G networks is expected to boost cellular speeds, power a surge in devices on the Internet of Things (IoT), and open up a new realm of technological potential. Using technology and the data economy's potential could promote achievement of the United Nations' Sustainable Development Goals in Africa, from promoting growth and boosting prosperity to eradicating poverty (Alper and Miktus, 2019). Smart connectivity, encompassing AI, 5G, IoT, and Blockchain, is a crucial enabler for achieving the Sustainable Development Goals (SDGs). Connectivity supports sustainable economic growth, disaster relief, and job creation, making mobile technologies essential for achieving SDG 1 (no poverty). The 5G network is a key component

C2 General

of this technology, ensuring the world economy's sustainability (Carbonell et al., 2022). 5G technology can significantly contribute to the achievement of SDG 1 by 2035 by increasing internet connection and fostering economic growth (Fowdur et al., 2022).

Smartphones will act as a leapfrog technology for connection to the online world, and 4G and 5G are anticipated to help bridge the digital gap (Alper and Miktus, 2019). Additionally, by taking appropriate steps to provide the underprivileged in Sub-Saharan Africa's rural and underdeveloped areas with smartphones, as well as by rethinking the taxation of mobile phone-based transactions, which currently slows the pace of the continent's ongoing mobile revolution, the advantages of 5G adoption can be increased (Ndung'u, 2019). In South Africa there are over 90 million mobile connections. According to Statista (2023), South Africa's mobile network companies, Vodacom, MTN, and Cell C, hold 90 percent of the market share. Vodacom dominates with 40 percent of users, while MTN and Cell C account for 30 percent and 17 percent respectively. Smartphones are used by an estimated 20-22 million individuals. Projections suggested that by 2023, there would be over 25-27 million additional smartphone users (Statista, 2023).

According to Marwala (2019), South Africa is a rapidly evolving society that is marked by extreme inequality and injustice; despite the enormous benefits provided by digital technologies, we cannot overlook the digital divide, which is similar to many other divisions in our country. Critical building elements for advancing our broadband demand, access, and use are our national backbone infrastructure and global internet connectivity.

The internet has become significantly more accessible over the years, making it an indispensable tool for communication and information gathering (Stats SA, 2023).

The majority of the population in Least Developed Countries (LDCs) remains offline, even while vulnerable countries are steadily upgrading their essential

C2 General

national internet infrastructure (Utoikamanu, 2020). The ITU (2021) reports that in 2019, the number of active mobile broadband subscriptions in Africa per 100 people was 33.1, which was far below the global average of 75 per 100 people. The ITU defines broadband access where the connection capabilities support data rates substantially higher than narrowband rates (ITU, 2018).

As of the beginning of 2023, 16.66 million South Africans or 27.7 percent of the country's population were using the internet (DataReportal, 2023).

According to ICASA (2023), in 2022, 21.4 percent of homes in South Africa had fixed line access to the internet. Households in metro areas (at 21.4 percent) accounted for the majority of this connectivity, followed by the urban areas at 10.7 percent. Rural areas, however, only accounted for 1.6 percent of mobile broadband connectivity, demonstrating a geographic digital divide between metropolitan, urban, and rural areas.

The most common way to access the internet is through a cell phone. The vast majority of South Africans, or 78.7 percent of the population, accessed the internet on mobile devices in 2023, a 9.1 percent increase from 2022.

Therefore, it is evident that mobile internet connectivity has greatly increased rural households' access to the internet. 69.6 percent of all internet users in the country have accessed the internet using mobile devices. While internet access via mobile devices is still less widespread in rural regions (at 61.1 percent) than in urban (71.2 percent) and metro (74.1 percent) areas, it is far more frequent than via any other means, such as internet cafes or work computers (Stats SA, 2023). Figure 1 illustrates internet usage by households and locations.

C2 General

Place where Internet is accessed	Rural/ Urban status	Province (per cent)									
		WC	EC	NC	FS	KZN	NW	GP	MP	LP	RSA
At home	Metro	39,4	15,6	,	7,1	15,1	,	19,6	,	,	21,4
	Urban	29,0	3,8	9,4	5,4	9,0	7,6	11,4	6,3	9,3	10,7
	Rural	5,1	0,5	6,3	7,9	1,1	0,5	12,8	2,0	1,9	1,6
	Total	**34,7**	**6,6**	**8,4**	**6,2**	**8,3**	**3,5**	**18,6**	**3,9**	**3,4**	**13,0**
At work	Metro	17,7	16,6	,	10,2	17,8	,	19,9	,	,	18,6
	Urban	25,2	8,7	12,9	7,6	13,9	9,7	15,5	6,0	12,6	12,7
	Rural	16,2	4,8	6,7	8,9	3,9	3,7	2,8	4,2	2,7	4,1
	Total	**19,8**	**9,8**	**10,9**	**8,6**	**11,6**	**6,2**	**19,3**	**5,0**	**4,8**	**12,9**
Using mobile devices	Metro	70,8	69,5	,	70,6	86,7	,	72,6	,	,	74,1
	Urban	67,6	69,7	67,8	66,9	75,9	73,5	64,6	82,0	68,2	71,2
	Rural	41,3	55,9	62,6	68,7	61,6	60,2	46,0	71,7	58,9	61,1
	Total	**68,5**	**63,6**	**66,1**	**68,2**	**74,6**	**65,7**	**71,5**	**76,2**	**60,8**	**69,6**
At Internet cafes or educational facilities	Metro	17,3	12,4	,	8,2	10,4	,	19,1	,	,	16,6
	Urban	19,4	6,4	4,2	7,8	4,8	7,6	11,9	6,3	5,3	8,7
	Rural	3,9	3,7	1,8	2,3	3,7	3,1	8,6	4,5	1,7	3,2
	Total	**17,3**	**7,4**	**3,4**	**7,3**	**6,6**	**5,0**	**18,2**	**5,3**	**2,5**	**10,8**

Figure 1: Internet usage by households in 2022, broken down by location, province, and metro/urban/rural status (Stats SA, 2023).

The population using mobile digital devices grew significantly from over 25 million in 2013. According to Statista (2023), there were 43.5 million internet users in South Africa as of January 2023, showing growth of approximately 400,000 compared to the prior year. There were around 47.8 million mobile internet users in South Africa in 2023. Statista (2023) predicts that by 2027, this percentage will rise to more than 90 percent.

Almost half of all countries for which data were available had subscription rates below the African average of 33.1 per 100 inhabitants, whereas just above a sixth of countries in Africa, including South Africa, Ghana, Gabon, Seychelles, Botswana, Mauritius, and Cabo Verde, had active mobile broadband subscription rates per 100 inhabitants above the world average (ITU, 2021). There is a noticeable disparity in internet usage between more developed and less developed nations (Utoikamanu, 2020). In South Africa, despite relatively high

C2 General

internet coverage and access to digital devices, most people cannot afford to go online because of high data costs and lack of digital literacy (Global Innovation Fund, 2021).

Digital technologies and devices have proliferated quickly over the past several years; they are now pervasive and omnipresent and, in many cases, have stimulated growth, opened up new opportunities, and enhanced service delivery (UCT, 2020). The digital dividend, which measures their combined impact, has fallen short and is dispersed unevenly (World Bank Group, 2016,). The digital divide is not the problem, but the problem is low income, slow socioeconomic development, and the lack of literacy that divides the rich from the poor (Van Greunen, 2013).

In South Africa, the state needs to quickly re-establish the nature and extent of its participation in the sector – ideally well before 2030. A new policy framework will be needed to achieve the objective of a fully interconnected society. In the future, the government's main responsibilities in the ICT industry will be to promote competition and private investment, assure effective regulation where market failure is clear, and to interfere directly to fulfil particular social goals (NDP 2030). Policy implementation involves the processes, assets, and connections connecting policies to program execution. It involves carrying out, performing, fulfilling, generating, or finishing a specified activity precisely. Understanding policy implementation is crucial, as it can sometimes not be carried out as planned and not provide the desired consequences (Mthethwa, 2012). High-level players and prominent leaders can discuss policy justification and methods and advocate for cooperation and coordination for policy implementation (Bhuyan, 2005). Van Dijk (2019) asserts that a typical fallacy in government goals was the belief that granting internet access would eliminate the issue of the digital divide. However, the digital divide is now recognised as a multifaceted phenomenon that goes beyond having access to digital technology (Billon et al., 2009; Chipeva et al., 2018). Policymakers need to prioritize content infrastructures above access

C2 General

infrastructures. This includes local content-hosting capacity as well as content delivery networks and datacentres. The whole network, from global connectivity to the last-mile link that enables users to access the internet, must be considered by policies supporting access infrastructure (Mhlanga, 2023).

As ICTs affect everyday lives, they also impact on macroeconomic growth, which in turn affects society by enabling infrastructure and improving the standard of living. ICTs are our most effective instrument for making South Africa a successful developed country where unemployment, inequality, and poverty are not commonplace. “How can I best participate in this digital revolution?” should be the question that every one of us asks, according to Minister Siyabonga Cwele of the Department of Telecommunications and Postal Services (DTPS, 2015). Even though the term “socioeconomic development” is frequently used in research and practice, its exact definition is not always obvious (Sebatana & Makhubele, 2021). The term “development”, which implies progress or advancement, can be interpreted as the whole set of activities carried out in a society with the intention of making that society better (Stec, Filip, Grzebyk, & Pierscieniak, 2014).

Ceding of telecommunication services is crucial for economic growth, and there is a strong linear correlation between the two. Notably, socioeconomic status is one of the major causes of the digital divide and is a consequence of the digital divide (Steele, 2018). Therefore, the ultimate goal of the ICT White Paper is to make sure that everyone can use opportunities provided by ICTs, either individually or collectively (regardless of who they are, where they reside, or their social or economic standing); addressing market failure, as demonstrated by the actual access gap and smart subsidy zones, will require competitive private sector investment and suitable relevant targeted public action (DTPS, 2016). Zhang (2013) and Quibria et al. (2003) found a favourable association between GDP and the uptake of the internet. This is supported by the World Economic Forum (WEF, 2014), which states that each time 10 percent of internet penetration is added, it can lead to a 1.2 percent increase in the per capita GDP

C2 General

growth of emerging economies. According to the NDP 2030, technology has expanded and accelerated global interconnection, allowing for more growth, a leap in trade, and a significant increase in international investment. Over the next 20 years, the pace is anticipated to go up even more as information flows, money movements, trade, and migration all pick up speed. The estimated effect of socioeconomic indicators on ICT adoption is still unclear (Mubarak et al., 2020).

According to several studies, lower population density makes the financial case for providing 5G services in rural areas extremely difficult (Oughton and Frias, 2017). While users who already struggle to access devices will need to deal with the harsh fact that the majority of existing devices are simply not 5G ready, mobile network operators will need to spend on upgrading equipment at their towers (Marwala, 2021). Any evaluation of the possible macroeconomic effects of 5G shows substantial problems due to the technology's current early stages of development and some of its intrinsic features (Deloitte, 2018). According to research, insufficient access to data puts users at the risk of lagging behind in the 4IR. We cannot afford this risk, especially in light of the ominous forecast for our economy. With cheaper and faster internet, we may advance past other growing nations, particularly those in Asia, and begin to close the digital divide (Marwala, 2021). The National Infrastructure Plan (NIP) 2050 Phase 1 report states that "low-income communities will be able to afford and have access to high-speed broadband in underserved areas".

Armstrong (2020) states three ways in which the digital divide can be bridged:

i. *Universal access* in which operators must play a role and ensure that mobile data prices are re-balanced to achieve digital inclusion through enabling affordability by all citizens: Armstrong (2020) further states that to achieve universal access in South Africa, an efficient wholesale market should be created irrespective of whether the Wholesale Open Access Network (WOAN) may or may not work. He also notes that the release of the spectrum not earmarked for WOAN must be done immediately by government and, lastly,

C2 General

that in order to solve the lack of device availability, there must be creativity and political will to manage and overcome this challenge.

ii. *Unlimited usage* through skills intervention in basic education, with a focus on literacy and numeracy, digital service delivery, government and private sector investment in increasing digital literacy, outsourcing of digital service delivery to SMEs, and creation of government-employee skills development programmes: Armstrong further states that government must place an emphasis on breaking language barriers through promoting content in local languages, using content translation technology, and enhancement of English proficiency.

iii. *Impact at scale* of closing the digital divide through nurture of usage ecosystems, development and adaptation of soft infrastructure, digital service provisioning, management of regulatory and legal policy frameworks, and fostering of digital enabling skills.

5G requires a significant amount of spectrum in order to reach faster data speeds and enormous network capacity (Rahman, 2021). For our nation, the licensing of the spectrum through an auction provides significant economic and social benefits. Through the use of ICT networks and digital platforms to create economic value, this process offers a vital stimulant for economic recovery and has the potential to boost employment (Modimoeng, 2022). The allocation of a new spectrum is an opportunity for the government to use communication technology for economic development of the country as a whole (Worldwide Worx, 2020). Based on the frequency plan that the government has developed and authorised, the regulator will allocate spectrum and issue licenses according to government policy. According to the ICT White Paper, the regulator will be accountable for spectrum monitoring, assessment, and auditing to successfully carry out its spectrum management role, which is restricted to regulatory responsibilities (DTPS, 2016).

C2 General

According to a study conducted by ICASA in 2021, survey participants highlighted that 5G will aid in closing the digital divide if sufficient amounts of the mobile spectrum are assigned to operators in a timely manner, including coverage bands (taking advantage of the propagation characteristics of low bands to extend 5G coverage and capabilities to rural and underserved areas). However, there are additional limitations for deployment relating to the spectrum licence, ongoing licensing costs, and the overall deployment costs, according to Nugent (2021), who further highlights that unfortunately, some governments and regulators look at the 5G spectrum as a revenue-generation process. This sometimes causes a reduction in the amount of investment left for actual 5G deployment, which can exacerbate the digital divide and limit the expansion into some rural areas.

Infrastructure sharing is another key solution for facilitating quick deployment of 5G networks and bridging the digital divide, considering the high cost of upfront investment required to deploy a mobile network (ICASA, 2021). 5G acceleration and coverage reach to rural areas could be realised from encouraging more competition in the mobile operator ecosystem. According to the South African Broadband Policy (2013), the market's structural restrictions, brought on by the dominance of vertically integrated operators, might be addressed under the WOAN regime. The strategy also specifies that WOAN will strengthen service-based competition to better address the country's unmet need for reasonably priced broadband services.

African authorities will have to concentrate on both economic (market) and development (public value) demands to take advantage of the digital dividend and offer the spectrum required for advanced telecom and broadcast infrastructure (Abrahams et al., 2021). Spectrum should be managed as a national resource for South Africa's development, in a manner that encourages competitiveness and addresses requirements relating to universal access. Wholesale network services should make it possible for businesses to provide accessible, sustainable services and encourage healthy levels of competition

C2 General

(NIP 2050 Phase 1, 2022). However, Mamushiane et al. (2021) stated that only established mobile network operators can afford the high capital expenditure (capex) and operational expenditure (opex) required by the vertically integrated business model. As a result, there is now an infrastructure entry barrier that prevents new operators from entering the telecom industry, creating a monopolistic telecom sector.

2.3 Evolution of the Mobile Broadband

The mobile industry has revolutionized society over the last 30 years through the development and evolution of the major networking generations, including the 1G, 2G, 3G, and 4G technologies (Attaran, 2021; Salil et al., 2020). The evolution of mobile wireless communication in the world has become more important since the emergence of 5G. In the 1980s, a new technology was introduced to the mobile community. Voice was significantly prioritized in the underlying circuit-switched network design of the older 1G and 2G technologies (GSMA, 2022).

Mobile 1G technology was introduced in the 1980s, followed by 2G in the 1990s, 3G in the 2000s, and 4G in the 2010s (Rahman et al., 2021). Figure 2 is a graphical view of the evolution of the five generations.

C2 General

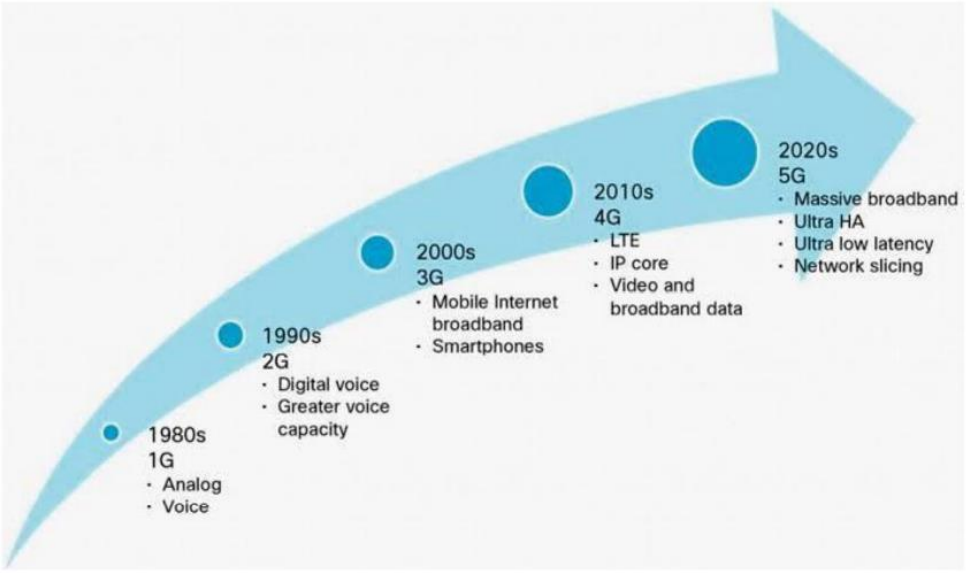


Figure 2: Evolution of wireless mobile generations (Salil et al., 2020).

According to Kaur (2012), the 1G technology introduced full duplex communication in analogue form. 2G and its derivative technologies brought operator-free automatic digital communication, text messaging and data-packet switching. Many issues with 2G and 2.5G networks, including the slow speeds and inconsistent use of TDMA and CDMA in various countries, were solved by 3G networks (Akhtar, 2009). 3G brought faster data transfer speeds, enabling services such as video calling and mobile TV. Broadband internet access, media downloads, and uploads are just a handful of the services made possible by 3G technology. It could also use Wi-Fi networks, although the network's user density had a significant impact on performance; therefore, users in dense areas would not necessarily benefit fully from this 3G technology (Chukwuere and Pilatso, 2022). 4G brought with it broadband-like speeds. The major 4G technology, *long-term evolution* (LTE), was the first data-only network, meaning it could bypass circuit switching altogether (Kaur, 2012).

The mobile telecommunications requirements of the IoT cannot be met by the current 4G and 4G LTE networks (Attaran, 2021). In the early 2010s, 5G technology research began to improve data transfer rates, latency, and capacity.

C2 General

The first phase, Non-Standalone (5G), uses current 4G infrastructure, while the second phase, Standalone (5G), uses a new 5G core network (George & Fernando, 2023). 5G promises radically faster download and upload times (Shailemo, 2021). It is described as “an end-to-end ecosystem to enable a fully mobile and connected society” by the Next Generation Mobile Networks (NGMN) Alliance (2014). 5G technology is set to revolutionize technology by enabling faster service and app development, transforming our work, interaction, and play experiences (Maulani & Johansyah, 2023). According to Marwala (2021), it will be so quick that downloading a movie will only take six seconds.

In comparison to 4G and earlier mobile network versions, 5G is anticipated to dramatically boost mobile network capacity, enabling more people to connect to the network than ever before (Kliks et al., 2018). However, Marwala (2021) notes that so far, Africa has only participated as a spectator and client, from 1G to 4G. We run the risk of becoming spectators once more, but this time, we might not even be customers if we are careless with 5G. The NIP 2050 Phase 1 (2022) also states that despite the country’s great internet availability, the majority of households do not have easy access to it in a way that suggests meaningful digital connectedness.

Future 5G systems are anticipated to offer considerable advantages over 4G in terms of faster data speeds, superior connectivity, and expanded coverage (Chavez-Santiago et al., 2015). Since mobile networks can be seen as extensions of fixed networks, 5G signifies a development in mobile technology and will increase broadband capabilities in all spheres of digital economies and societies (OECD, 2021). 5G is an evolving technology that performs all the same functions as 4G while having the ability to do considerably more and on a much larger scale: extremely low latency, excellent levels of reliability, and lightning-fast download speeds (GSMA, 2022). 5G’s increased capacity enables faster device connectivity, crucial for IoT growth. It is expected to connect billions of devices, fostering automation and interconnectivity in industries like healthcare,

C2 General

agriculture, manufacturing, and smart cities (Carbonell et al., 2022). Industry stakeholders have expressed the opinion that 5G is not just the next generation of mobile technology but also a new strategy for converged communication systems that use the hardware, software, and spectrum resources in their networks more effectively to enable better and new services and applications for consumers and businesses (OECD, 2019).

2.4 5G Technology

The rapid development of mobile devices and the surge in multimedia data traffic calls for a restructure of the current cellular mobile communication technology and transition to the fifth generation of cellular technology (Maluleke et al., 2022). The 5G technology has revolutionized telecom networks, outperforming competition by the end of 2018, with global growth expected to continue (Pujari & Patil, 2021). 5G is aimed at introducing a major transformation in communication network architectures with its transition to cloud-native networks. This transformation will enable new unique service capabilities that will drive the development of innovative applications (Solazabal et al., 2018). The fifth generation of 5G network operators is expected to meet capacity demands for real-time and bandwidth-hungry applications due to its infinite bandwidth, decreased latencies, and virtualization possibilities. It aligns with Sustainable Development Goals (SDGs) in the ICT sector, aiming for increased bandwidth, latency reduction, and emissions reduction to combat climate change (Maluleke et al., 2022).

5G aims to support IoT, driverless cars, and smart cities by offering faster speeds, reduced latency, and more capacity. It can boost economic growth by facilitating new business models, creating new employment, and increasing productivity. Additionally, 5G can enhance the quality of life in healthcare, education, entertainment, and transportation (George & Fernando, 2023). It has the potential to drive economic growth, improve quality of life, and create new business models

C2 General

and job opportunities in technology and digital innovation. It can also enhance accessibility to essential services, particularly in underprivileged areas (Shaji & Sagayarajan, 2023). Compared to other technologies, 5G technology revolutionizes different sectors by providing faster, more efficient data connections, boosting productivity and operational efficiency, reducing production costs, increasing profits, and fostering new opportunities for industrial innovation and product development (Maulani & Johansyah, 2023).

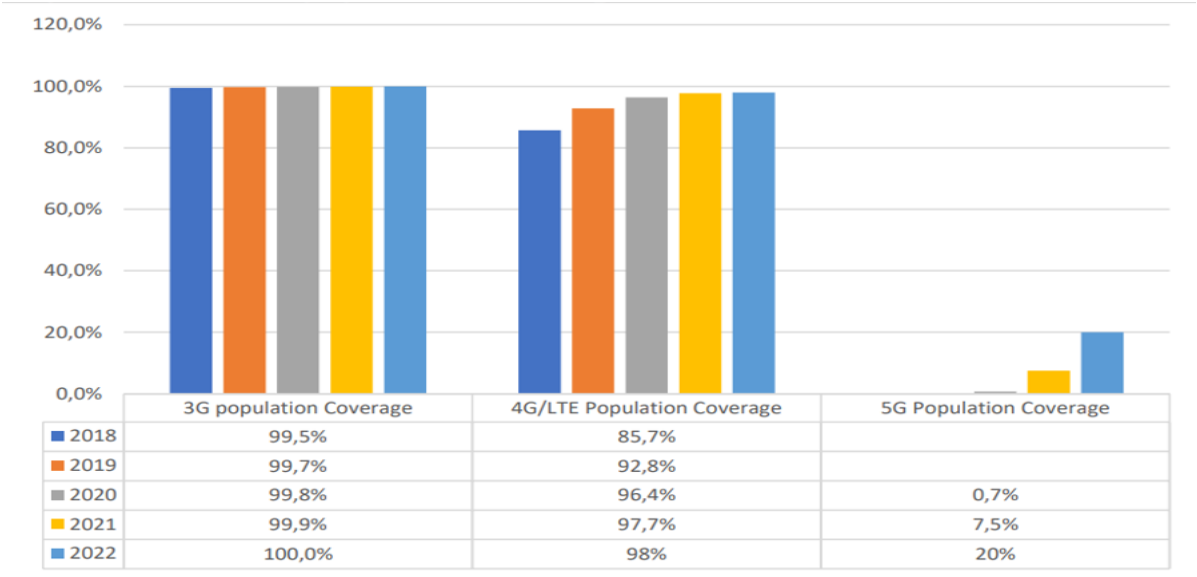
ITU (2018) noted that densely populated metropolitan areas, always the most lucrative locations for operators, can make a strong argument for investing in 5G. ITU further stated that a business case for investing in 5G networks outside of these regions will be more difficult to make, especially in the early stages of 5G adoption. As a result, 5G investment will be less likely to reach rural and suburban regions, thereby widening the digital divide. Doubt also arises due to lack of standardisation and the absence of cost-effective 5G-enabled smartphones, causing bottlenecks (ICASA, 2021). Data from GSMA Intelligence also demonstrates that 5G adoption in the initial years after each of its releases is quicker than that of 4G and 3G. By the end of 2022, a little under four years after the first 5G commercial network went live, there were 1 billion active 5G connections. Comparatively, 3G and 4G took around 11 years and roughly 8 years, respectively, to attain the same milestone (GSMA, 2022). According to Sear and Khan (2020), governments can accelerate AI, VR, AR, and IoT adoption with 5G improved connectivity, accelerating usage and adoption (Sear and Khan, 2020).

Additionally, 5G is positioned to facilitate socioeconomic changes in a variety of ways, including those that improve well-being, sustainability, and productivity (The Next Generation Mobile Networks Alliance, 2014). 5G technology could significantly contribute to lowering poverty and achieving SDG 1 by 2035, by improving internet connections, generating economic output of USD 3.6 trillion, and creating 22.3 million jobs globally in the near future, thereby enhancing the

C2 General

overall development of the planet (Carbonell et al., 2022). Furthermore, 5G may bring about societal benefits in 11 crucial areas of the SDGs, especially through supporting greater health and well-being, as well as by enhancing infrastructure, boosting sustainable industrialization, and stimulating innovation (WEF, 2020). Although the general roll-out phase of 4G mobile networks has not yet been completed, the majority of the Least Developed Countries (LDCs) have only recently deployed them (Rahman et al., 2021).

Vodacom and Nokia launched the first 5G network in Africa in May 2020, with 190 stations in Johannesburg, Pretoria, and Cape Town. MTN expanded its network in June 2020, with over 1,000 stations in 2021 across various spectrum bands. MTN plans to significantly expand its 5G network using 3.5GHz spectrum (Ookla, 2023). The population coverage of 4G/LTE has increased over the past five years, rising from 85.7 percent in 2018 to 98 percent in 2022. The population coverage of 5G has also increased significantly, rising from 7.5 percent in 2021 to 20 percent in 2022 (ICASA, 2023). Figure 3 illustrates the national population coverage for 3G, 4G and 5G.



	3G population Coverage	4G/LTE Population Coverage	5G Population Coverage
2018	99,5%	85,7%	
2019	99,7%	92,8%	
2020	99,8%	96,4%	0,7%
2021	99,9%	97,7%	7,5%
2022	100,0%	98%	20%

Figure 3: South Africa's 3G, 4G and 5G population coverage 2022 (ICASA, 2023).

C2 General

The 2030 targets must still be in place – even if South Africa fell well short of the NDP's objectives in 2021 – because of how crucial connection is becoming. If the NDP Plan 2030 is organised and carried out through private−public partnerships, South Africa still has the potential to achieve these goals (NIP 2050 Phase 1, 2022). The delivery approach will also depend more on active private sector involvement and combined finance. In the medium term, it is anticipated that between R30 billion and R80 billion will be raised to support the roll-out of government broadband and services. Due to rising energy prices and sustainability goals, operators and other ecosystem players will need to put more effort into using renewable energy for network operations.

Other significant areas where 5G can add social value include fostering responsible consumption, enabling sustainable cities and communities, and fostering decent employment and economic development (WEF and PwC, 2020). As mobile networks can be seen as extensions of fixed networks, the advancement in mobile technology known as 5G will increase the availability of broadband in all areas of digital economies and societies (OECD, 2018). A wide range of options, including the optimization of service delivery, decision-making, and end-user experience, will become available as a result of 5G's primary functional drivers (Galal, 2021). 5G signifies a development in mobile technology and will increase broadband capabilities throughout all areas of digital economies and societies (OECD, 2019). Galal (2021) further states that 5G will be crucial because it will allow for unprecedented levels of connectivity, upgrading 4G networks with five key functional drivers: extremely fast broadband, extremely reliable low-latency communication, massive machine-type communications, high reliability/availability, and efficient energy use. Between various devices and the global IoT, 5G offers extremely fast, low-latency, and highly marketable communication (Dangi et al., 2019). A very flexible paradigm for creating a new generation of applications and industrial objectives will be availed by 5G (Kang, 2020). Dangi et al. (2019) explains the following services that are offered by 5G.

C2 General

Enhanced Mobile Broadband (eMBB)

Enhancing mobile broadband is a key application for the 5G system, which provides extremely fast connection over a large variety of locations by using huge MIMO (multiple input, multiple output) antennas, mmWave, and beamforming techniques (Dangi et al., 2022). MIMO is an antenna technology for wireless communications in which multiple antennas are used at both the source (transmitter) and the destination (receiver). eMBB can be used to enhance e-learning in low-income, rural, and urban areas, which would benefit students, professors, researchers, and educators in South Africa. Carbonell et al. (2022) are also of the view that 5G connectivity can enhance online learning and provide access to educational materials for underprivileged groups, especially those living in remote areas or with limited access to traditional institutions, thus enhancing employment and economic development opportunities. The public schools will be able to teach current and competitive content with the aid of the 5G network (Maluleke, 2020). Maluleke (2020) further suggests that tactile manufacturing would be made possible by 5G, allowing engineers to fine-tune their product in real-time while monitoring its performance in populated regions. This will advance simulation activities that produce consistently accurate outputs and instantaneous, intelligent, and autonomous decisions.

Massive Machine Type Communication (mMTC)

5G technology enables massive IoT connections, improving applications in construction, agriculture, and other industries without human intervention, enhancing interconnection between units without human intervention (Dangi et al., 2022). According to Rahman (2021), mMTC was designed to enable hundreds of billions of IoT devices to stay connected through mobile networks rather than Wi-Fi or Bluetooth. Wireless flexibility, lower prices, and the viability of applications that are not achievable with present technology are the main benefits of 5G in industry automation (Maluleke, 2020). Important 5G use applications include logistics and tracking of freight. Through the use of location-

C2 General

based information systems, the 5G network can enable tracking of merchandise and packages wherever they are. Additionally, when delivering in far-off places, drivers can precisely plan their routes (Maluleke, 2020). According to PWC (2021), the most prominent benefit of self-driving trucks is for businesses along the supply chain. Self-driving trucks can operate 24/7 without limitations, boosting productivity and enhancing system capacity, potentially boosting efficiency.

Ultra Reliable Low Latency Communication (URLLC)

URLLC service offers autonomous actions, secure transport, high-speed communication, industrial connectivity, security principles, real-time machine administration, and low latency communications, enabling remote medical treatment, procedures, and operations in various sectors (Dangi et al., 2022). It offers in-the-moment machine management, quick vehicle-to-vehicle communication, industrial connectivity, and security principles. The URLLC was created for human-to-machine interaction, whereas the eMMB and mMTC were exclusively intended for use by humans and machines, respectively (Rahman, 2021).

Among the industry's best poised to gain from the rollout of 5G technology is the healthcare sector. In addition to enabling new applications like remote surgery, virtual consultations, and real-time patient monitoring, 5G networks' high-speed connectivity and low latency can enhance medical care (Shaji & Sagayarajan, 2023).

In the automotive and technology industries, 5G will make it possible for vehicles and other road users in South Africa to share real-time information on traffic and road conditions (Maluleke, 2020). 5G can improve traffic management by automating traffic control, enhancing traffic flow, and delivering real-time information on public transportation (Sear and Khan, 2020). Maluleke (2020) further notes that low-income, rural, and urban communities in South Africa will

C2 General

benefit from 5G through connected cars and trucks, public safety, navigation and augmented reality, and ecosystem.

2.4.1 Challenges of 5G in South Africa

The NIP 2050 plans for a seamless information infrastructure to be available and accessible to everyone by 2030, at a cost and quality that are at least equivalent to those of South Africa's peers and competitors (NIP 2050 Phase 1, 2022). The 5G network's effective deployment is expected to reduce poverty by promoting economic growth, improving access to essential services, and closing the digital divide in underserved regions. The 5G network, despite its potential to alleviate poverty, has several drawbacks that need to be considered (Carbonell et al., 2022).

Infrastructure Investment

Utilities to existing 2G, 3G, and 4G infrastructure in South Africa are limited, such that infrastructure sharing will become critical to ensuring that all operators are able to deploy 5G networks (ICASA 5G Board Committee, 2021). This considers the fact that emerging architectures and higher-frequency bands will require a significant increase in the densification of towers and rooftop infrastructure and installation of smaller coverage base stations. One of the main challenges is the substantial infrastructure investment required for 5G rollout, including the construction of new base stations and modernization of existing ones (George & Sagayarajan, 2023). Operators are sceptical of the business case due to the high amounts of investment required to establish 5G networks (ITU, 2018). Since 5G requires a robust and costly infrastructure, which includes fibre optics, base stations, and antennas, poorer communities may find it challenging to make use of the 5G network's benefits due to potential constraints in the availability and deployment of critical infrastructure in rural and low-resource locations (Carbonell et al., 2022).

C2 General

Furthermore, 5G faces challenges in accessing spectrum bands due to government regulations that limit the range of frequency bands available, potentially preventing the successful rollout of this technology (George & Sagayarajan, 2023). Compared to earlier network generations, 5G is more energy-efficient per gigabyte. The difficulty of network energy management is further exacerbated by 5G's massive MIMO antennas and the power needs for cell site densification (GSMA, 2022). Significant investment is still required in passive infrastructure, such as base stations, fibre, power supply, and edge data centres (ICASA, 2021). Despite the advantages, there is concern that the introduction of 5G is premature, and warnings are being issued. A survey conducted by the ICASA 5G Council Committee in 2021 indicated that participants from 16 South African industry stakeholders were concerned that the 5G network demands substantial infrastructure deployment to meet its requirements (dense small cells, Massive MIMO capacity, and a millimetre wave spectrum). There is, therefore, a need for South Africa to realise the most cost-effective deployment solutions, which will entail different scenarios for different geographical areas (i.e., informal settlements and dense urban, peri-urban, and rural areas), according to the participants (ICASA 5G Board Committee, 2021). Lavery et al. (2018) stated that economic and geographical gaps are the main causes for the digital divide in South Africa and that they are due to lack of connectedness to market-driven deployment. Lavery et al. (2018), further stated that 160 000 km of fibre, which requires substantial investment, will be needed to produce network access that is on par with developed countries; this may lead to an impassable economic barrier to producing even the most basic network infrastructure. This was echoed in a news article by Wits University (2018), which asserted that "if South Africa's gap was to be addressed by state-of-the-art optical fibre, then an additional 160 000 km of fibre would be needed. This is possible but very expensive. But getting people connected is a priority, particularly for South Africa, where Broadband has been estimated to raise GDP by R130 billion and create 400 000 jobs."

C2 General

Access to Data

ICT accessibility is a crucial predictor of ICT usage, but it is not equally distributed among nations, especially among underdeveloped and impoverished communities, who require fair daily access to data (Mhlanga, 2022). With over one million fibre-based internet customers in 2021 and accounting for nearly half of all such subscriptions in Sub-Saharan Africa, South Africa has had the most substantial increase over the last year (Digital Council Africa, 2021). However, despite the policy and regulatory framework, network roll-out remains skewed towards urban areas, and there are low chances of providers deploying modern broadband services in rural and less affluent areas without government intervention, according to government policy documents (National Planning Commission (NPC), 2021). The main challenges that have underpinned the rural digital divide include an ineffective policy regime, the concentrated broadband infrastructure market and the high cost of communication (DTPS, 2016). High-speed broadband will be accessible and available in all communities by 2024/5, achieving access comparable to that of competitor nations, according to the National Infrastructure Plan 2050 Vision. Free basic data for consumers with low incomes will be considered, as is the case for access to water and electricity. According to a report by the Competition Commission South Africa (2019), South Africa currently performs poorly relative to other countries, with expensive data prices. The 2019 report adds that the ITU data indicate that South Africa ranks poorly when compared to a worldwide selection of countries and that its prices are considerably higher than the cheapest offers. It is acknowledged that 5G technology, particularly in the most disadvantaged areas with the least access to digital technologies, has the potential to help reduce poverty and inequality worldwide. To guarantee that 5G technology is accessible and beneficial to everyone, particularly the most vulnerable and impoverished, it is also stressed that the implementation of 5G technology must be supported by sound policies and strategies (Carbonell et al., 2022).

C2 General

Affordability and Access to Devices

The current digital divide between different socioeconomic categories and between urban and rural regions may become more pronounced with the rollout of the 5G network. Poorer areas may fall behind and not take full advantage of the prospects presented by 5G technology if the access inequalities are not resolved (Carbonell et al., 2022). There is considerable concern that the roll-out of 5G could simply serve to aggravate the digital divide (GSMA, 2020). The 5G network, despite its potential, faces challenges like infrastructure requirements, spectrum distribution, and regulatory issues, potentially exacerbating digital inequality in areas with inadequate infrastructure or high access fees (Carbonell et al., 2022). According to ICASA (2023,) as of 2022, only 73 883 537 subscribers had access to a smartphone, compared to the 145 371 879 population who have mobile cellular subscriptions (ICASA, 2023). Beyond network implementation, user uptake and usage are crucial for growing 5G in Africa and strengthening the business case for a more extensive rollout of 5G (GSMA, 2022). GSMA (2022) further stated that the greatest potential obstacle to consumer 5G adoption and usage in Africa is device cost and availability. The adoption of 5G networks may be restricted by the high cost of accessing compatible devices and services, which will mostly benefit people with higher incomes.

This has the potential to exacerbate the digital divide and limit underprivileged groups' access to possibilities (Carbonell et al., 2022). Having access to a smartphone is a major—and sometimes the only—way to access the internet (Trofymenko et al., 2023). Most companies lack the necessary equipment for 5G technology, such as laptops, scanners, and smartphones, which can lead to additional costs and training. To fully benefit from 5G's benefits, businesses must upgrade their infrastructure, either by updating current devices or purchasing new ones that support 5G technology (Attaran, 2021). This, however, requires government to continue to provide support to the private sector's investment

C2 General

efforts to offer low-cost devices to the underprivileged and rural residents (Mhlanga, 2022).

Spectrum

The increasing demands on mobile communication networks necessitate the intelligent use of spectrum. To meet these demands, mobile networks must optimize their existing spectrum, increase capacity at comparable frequencies, and manipulate higher frequencies in millimetre and centimetre wave bands (Pujari & Patil, 2021). Several South African mobile network operators (i.e., MTN, Vodacom, Rain, and Liquid Telecom) have already deployed non-standalone and commercial standalone 5G networks. This was achieved largely through the allocation of the spectrum approved by ICASA, on a temporary basis, for operators to meet increased traffic demands and increased use of the spectrum during the COVID-19 pandemic. According to Abrahams et al. (2021), public education and health services are two industries in which a strong future demand for broadband is anticipated. These industries face public value issues when allocating the spectrum to support the availability of broadband for public use. The 5G technology faces challenges in accessing spectrum bands due to government regulations overseeing their distribution, which may restrict the rollout of this technology compared to earlier cellular network generations (George & Fernando, 2023). Controlling spectrum availability and accessibility, especially for 5G private network deployments, is a challenge in the business-to-business market, and poor decision-making may impede the adoption of 5G (Magnaghi et al., 2023). As spectrum allocation ultimately affects consumers, it is crucial for governments and regulators to take the competitiveness of the mobile broadband market into account. Market concentration, the spectrum allocation technique, and pricing are all important factors to take into account (Gaetsewe, 2023).

Security

C2 General

5G networks experienced many difficulties because of their ambitious objectives. Beyond what is employed in 3G and 4G systems, the higher capacity and data rates possible by 5G may necessitate the usage of far more spectral resources and spectrally efficient technology (ITU, 2022). The adoption of 5G technology has raised concerns about privacy, security, and potential socioeconomic exclusion and inequality (George & Fernando, 2023). The rapid speed of 5G technology will accelerate breaches, increasing the risk of more hardware being exposed as more tiny cells are added (Attaran, 2023). An increase in open-source technologies and designs is also brought on by 5G technology. Collaboration and creativity are accelerated by open source, but it also has the potential to introduce security flaws (Attaran, 2021). According to a new survey by Ericsson, businesses are still having trouble overcoming obstacles that prevent them from fully using 5G technology. Furthermore, 5G networks face security risks including secure device-to-device communication, network slicing, and privacy protection, with ongoing development posing new security and privacy issues (Sachdeva et al., 2020). According to Shaji & Sagayarajan (2023), 5G technology adoption raises privacy and security concerns, with fast data transfer and low latency potentially posing new cybersecurity risks like hacking and data breaches. The support of a vast IoT also introduces significant security risks such as spoofing attacks, replay attacks, system capture attacks, sniffer and tampering attacks, etc., for which protection systems are very challenging to scale owing to the massiveness of the number of devices (Rahman et al., 2021). Ericsson (2021) however, contends that 5G technology ensures reliable, safe, and privacy-preserving wireless network connectivity for mobile apps and devices, providing resilience, communication security, identity management, and security assurance, making it ideal for large-scale, security-sensitive systems.

Energy

The other concern is that 5G technology will increase operating costs due to increased capacity, sophisticated infrastructure, and high-energy network

C2 General

devices. Although it can reduce transmit energy per bit, it cannot reduce operating energy, as the price and energy used for transmission are proportionate (Dange et al., 2021). In comparison to earlier generations, 5G technology necessitates a larger number of smaller cell sites. Because of the increased network densification, more energy is needed to power and cool the extra equipment.

2.5 Spectrum

5G requires a spectrum in the low bands (below 2 GHz), middle bands (2 GHz to around 6 GHz) and high bands (above 6 GHz) to achieve the full IMT-2020 vision of mobile broadband for the mass market, including serving rural areas that have not always benefitted from mobile communications (ICASA, 2021). The Sub-Saharan Africa region has advanced significantly in recent years and is still doing so in its efforts to expand the deployment of broadband infrastructure. The deployment of 4G is anticipated to continue serving as the main engine of economic gain throughout the future medium term. Furthermore, in the near future, Sub-Saharan Africa's use cases favour 5G applications that rely less on the mmWave spectrum. However, the mmWave spectrum will continue to have a substantial economic impact in the region in the future (GSMA, 2018). 5G technology is expected to revolutionize smart agriculture, remote healthcare, and online education, but challenges like network infrastructure and spectrum scarcity hinder its widespread rollout in rural areas (Carbonell et al., 2022).

It is crucial that Africa's regulatory policy and framework follow the same guidelines as those of European nations because Africa is a participant in ITU Region 1. This will allow network equipment and device manufacturers to take advantage of the resulting economies of scale (Ngcaba et al., 2022). The urgency with which authorities must provide the necessary spectrum while simultaneously ensuring that the existing allocated spectrum is reused is further highlighted by Ngcaba et al. (2022). Furthermore, the swift release of the 5G spectrum by Africa would help to realise the full benefits of 5G and foster innovation and

C2 General

competitiveness. Recently, some African nations, most notably South Africa and Nigeria, allocated spectrum to carriers for 5G services. In contrast to the rest of the world, 5G spectrum assignment is still in its early stages. Another issue is the legacy networks' use of priceless spectrum in the low and mid-bands, which could postpone the introduction of 5G in the impacted markets. Replanning based on globally harmonised methods will maximize the value of spectrum in areas with fragmented legacy assignments (GSMA, 2022).

The COVID-19 epidemic revealed the digital gap amongst higher education institutions (Vilakazi, 2021) which is preventing the adoption of blended teaching and learning paradigms where online training takes the lead. Marwala (2021) emphasised that although there are more people in South Africa with access to an internet connection, this access is not evenly spread, particularly between urban and rural areas. He added that the current regulatory environment has made it difficult for about a third of South Africans to access the internet. "There is no other place like this in the world." The infrastructure for 5G mobile telephony will be needed for advanced IoT applications". However, South Africa has yet to switch over to digital terrestrial broadcasting from analogue, which would free up important spectrum for rural mobile data coverage, provide people without it access to the internet, and hasten the transition to 5G (Olaitain et al., 2021).

Coordination between the international community, regional telecommunications organisations, and NRAs is necessary for the allocation and identification of globally harmonized spectrum over a variety of frequencies. For NRAs, this is one of the biggest obstacles to the effective rollout of 5G networks (ITU, 2018).

To use the spectrum that is already accessible more effectively, spectrum sharing should also be considered. Historically, mobile providers have received exclusive spectrum allocations from NRAs. However, sharing may be a solution to the expanding requirements (GSMA, 2022).

C2 General

The cost of spectrum is still another issue. According to a recent research, spectrum costs in LDCs are often more than three times greater than those in industrialized nations. Therefore, the price of spectrum may be a key variable that affects how 5G is implemented in various nations (Rahman et al., 2021). Operators have been forced to use the existing spectrum for 4G and 5G services as a result of the lack of spectrum allocation for nearly 20 years, meaning that the spectrum that was not suited for high-speed internet had to be modified for it (Goldstuck, 2022). This indicated inefficient spectrum use, which is a waste of money. All operators are constrained, with Vodacom, MTN, and Cell C each having less than 80 MHz; therefore, ICASA's spectrum auction came at the right time. Telkom had 120 MHz more total spectrum but no low band (Hoare, 2022). To enable cost-efficient, wide-area 5G coverage and improve mid-band and high-band spectrum use, it is necessary for mobile network operators to consider both current and innovative ways of using the spectrum (ICASA, 2021).

President Cyril Ramaphosa (2022) said that the recently concluded auction of the high-demand radio frequency spectrum in South Africa would be catalytic, not only for bridging the digital divide for those still without internet access but also for economic growth and development. He stated in his address that *"the licensing of this additional spectrum will be followed by agreed social commitments to link public schools, medical facilities, and police stations during the following three years. Radio spectrum is a precious national resource that should be utilized for the benefit of all South Africans, similar to the mineral wealth that exists beneath our country."*

- **Proposition 1**

  5G technology can bridge the digital divide in South Africa.

C2 General

2.6 Impact of 5G in Reshaping Consumers and Industries

A paradigm shift in network infrastructure models is currently occurring in the mobile industry, with operators of all sizes progressively taking new network deployment and operational models into consideration (GSMA, 2022). 5G is a paradigm shift in the field of handling huge machine-type communication (MTC) traffic to support the Internet of Things (IoT) network, in addition to offering much improved performance for conventional phone, data, and video applications (Borkar and Khan, 2020). Since 5G operates in the higher frequency bands of 24 to 100 GHz, this increased frequency range opens up a market for end users to improve their business models by enabling safe, low-latency communication and fast wireless connectivity between industrial 4.0 and IoT devices (Dangi et al., 2022). 5G will enable businesses to innovate and connect in novel ways, transforming how we work and play and resolving many long-standing issues (PWC, 2021). 5G is expected to revolutionize end-user experiences, applications, business models, and services with gigabit speeds, improved network performance, and reliability, paving the way for a new era (ITU, 2020). However, 5G service network coverage is still quite constrained. Additionally, all 5G devices introduced before 2023 would depend on existing 4G infrastructures, a situation known as a “non-stand-alone” (NSA) network, until carriers install a standalone network. It would take some time until standalone 5G networks replace 4G LTE and 4G networks (Bello, 2021). The enterprise industry would need to effectively communicate 5G capabilities and value propositions to customers (GSMA, 2022).

Mobile broadband services’ evolution is driven by user expectations, with traffic growth expected to increase 10-100 times between 2020 and 2030. Expanding devices and services, better cost, and user experience demands creative solutions. By 2025, 50 billion devices will be connected to the internet (ITU, 2022). For consumers, 5G provides a flexible internet connection for creating smart homes, schools, labs, safer cars, and excellent healthcare facilities across multiple devices (Dangi et al., 2022). The COVID-19 epidemic, technological

C2 General

improvements, and rising data needs are predicted to cause demand for telecom services in South Africa to expand by a 5.32 percent compound annual growth rate over the next five years (Mordor Intelligence Report, 2023). For both businesses and individuals, 5G offers improved connections. However, before users can enjoy the benefits, mobile operators must first invest in 5G infrastructure, which will cost more. Higher connection speeds, more capacity, and lower latency are just a few of the significant advancements 5G networks provide over earlier generations. Due to their improved performance, 5G networks will be able to support new use cases and applications that will have a favourable effect on many different industry sectors (GSMA, 2022).

The healthcare sector is poised to benefit greatly from the adoption of 5G technology, as its high-speed connectivity and low latency can enhance virtual consultations, remote surgery, and real-time patient monitoring (George & Fernando, 2023). According to PWC (2020), the growing use of 5G, supported by developments in robotics, IoT, and AI, will facilitate the formation of a new, linked healthcare ecosystem in line with the idea of “4P” medicine: predictive, preventive, personalized, and participatory. In order for doctors and nurses to monitor patients anywhere, at any time, 5G networks and services offer benefits to mobile health platforms, including integrated mobility and improved connectivity. Patients can send their health status and symptoms through wearable technologies thanks to 5G technology (Attaran, 2021).

Digital technologies are becoming more and more essential to productivity and effectiveness in the manufacturing industry and along supply chains. By substituting cables with wireless connectivity in factories, 5G may release machines from being tied to a certain place and provide manufacturers with a far higher level of flexibility (PWC, 2020). According to Attaran (2021), manufacturing businesses will have the ability to create smart factories using augmented reality, automation, and artificial intelligence to solve problems. An important technology

C2 General

for manufacturing industry digitization, 5G improves connectivity, quality, speed, latency, and bandwidth.

Agriculture may benefit from connectivity by becoming more data-driven to boost crop production. Additionally, it can help farmers monitor crop prices to boost their revenue (ITU, 2022). According to Attaran (2021), drones might hover above a field of crops while using sensors on the ground to sort, pluck, feed, and water individual plants. 5G sensors gather real-time data regarding the demands of animals, fertilization, and moisture, which helps with energy conservation (GSMA, 2022). 5G connection can aid rural farmers in making informed decisions and increasing crop productivity by providing real-time meteorological data, agricultural product prices, pest control information, and smart irrigation systems, thereby saving costs and increasing output (Carbonell et al., 2022).

The mining sector still faces a number of difficult problems, such as the unpredictable geopolitical environment and the disruption of the digital economy, which puts more pressure on operations since productivity must grow (Deloitte, 2021). According to a case study conducted by Ericsson, optimizing the flow of ore demands constant improvement in productivity, transportation, and metal extraction in the mining sector. However, as incremental advancements encounter declining returns, the sector is rapidly focusing on automation as the next area of opportunity (Ericsson, 2021). According to an IDC 2021 Worldwide Mining Decision Maker Survey, 86 percent of mining businesses want to invest in wireless infrastructure during the next 18 months. Because of its increased bandwidth and reduced latency, 5G was cited by the majority of participants as their top priority. This indicates that industry participants recognize the importance of high-performance private wireless networks in achieving Mining 4.0’s goals (Jadoul, 2021). A case study conducted by GSMA (2021) at a mine enabled by China Mobile and Huawei highlighted that robots equipped with 5G inspection capabilities are placed underground and above ground to keep an eye on chairlifts, the major inclined shafts’ belt conveyors, the central substation, the

C2 General

pump houses, the winches for the main and auxiliary shafts, and other systems. Shearers, scraper chain conveyors, and transportation belts may also be remotely controlled by a central command and control centre above ground thanks to 5G connectivity (GSMA, 2023).

- **Proposition 2**

  The implementation of 5G technology is a crucial step towards a more equitable digital future for South African consumers and citizens.

2.7 Mobile Broadband Sector Stakeholders

An efficient strategy for 5G deployment is required to realise the economic and societal advantages of 5G (WEF and PwC, 2020). The national, regional, and global forums and institutions that make up the internet governance ecosystem have a complicated structure (Calandro, 2015). The 5G ecosystem features numerous players with unique objectives and interests, and it is anticipated that other vertical businesses will also utilize wireless communication due to this emerging technical paradigm (Magnaghi et al., 2023). In order to accomplish this, it was first necessary to precisely identify issues that are currently plaguing various 5G ecosystem components and the stakeholder(s) in charge of each issue. The stakeholders are listed in Table 1.

An individual, group, or organisation that has a direct or indirect interest in a certain organisation is referred to as a stakeholder. These could be corporations, members of civil society, governmental bodies, research institutions, or non-governmental groups (Calandro, 2015). Rathje and Katila's (2021) study highlights the importance of government and private sector cooperation in shaping the emerging 5G ecosystem, highlighting "government policy" as the third boundary condition for 5G business cases. It is argued that 5G technology is not just a technical artifact but is socially produced, with different actors including users, private actors like MNOs and government agencies, non-private

C2 General

actors like universities and research institutes, and “new actors” entering the ecosystem due to new opportunities the technology may bring (Magnaghi et al., 2023).

Table 1: Mobile Broadband Sector Stakeholders

Stakeholder	Role
ITU	The ITU’s primary responsibility is to regulate and establish standards for international telecommunication. International Telecommunication Regulations (ITRs) and Radio Regulations (RRs) stand out as the most significant responsibilities. RRs and ITRs lay out broad guidelines and norms for the radio-frequency spectrum and radiocommunication technologies, respectively (Wingfield, 2017).
GSMA	GSMA is a global organisation that unifies the mobile ecosystem to discover, develop, and deliver innovation that is foundational to positive business environments and societal change (GSMA, 2022).
Mobile Operators	Telecom operators are fundamental for the digital transformation; they invest in, build and operate the networks. They bring businesses and communities together in ways we never thought possible, thus enabling a more productive and professional environment (OECD, 2021).
ICASA	The primary goal is the public interest regulation of the telecommunication sector. A wide range of telecommunication services must be available; economic growth must be encouraged and supported; investment in the public telecommunication network must increase; there must be a level playing field where competitors are allowed; and users’ and consumers’ interests must be protected (Mokgosi, 2006).
DCDT	DCDT ensures that ICT infrastructure is accessible, vigorous, dependable, affordable, and secure to meet the needs of the country and its people. DCDT to promote the maximisation of investment in the ICT sector and the creation of new, competitive business opportunities for the growth of the ICT industry for socioeconomic development.
Consumers	A consumer is defined as any natural person who engages or plans to engage in an electronic transaction with a supplier on behalf of the ultimate consumer of products or services the supplier provides (ECT Act, 2002).

2.8 5G Benefits for Service Delivery

5G aims to reduce transmission costs, optimize spectrum assets, and improve service quality, potentially transforming society and the economy beyond traditional human-to-human communication patterns, and potentially transforming the way we communicate in higher bands (Mendonca et al., 2022).

C2 General

5G mobile communications can enhance the development and enhancement of mobile government services and apps for both companies and individuals, thereby meeting the demand for high-quality public services through its enabling environment (Mensah et al., 2021). The policy framework for Public Service Corporate Governance of Information and Communication Technology stated that the top priority is building an ethical, capable, and developing state through e-government for improving service delivery (DPSA, 2022). E-government is an effort on the part of the government to guarantee the highest possible level of service delivery and administration. The performance of government agencies serving the public must go hand-in-hand with this (Naidoo, 2012). According to Sear and Khan (2020), governments can accelerate AI, VR, AR, and IoT adoption with 5G's improved connectivity, accelerating usage and adoption. They further stated that the first government services that will use 5G will be smart city services. Medium or high spectrum bands, which are ideal for covering urban areas, are now being used in commercial 5G rollout (Sear and Khan, 2020). According to Attaran (2021), 5G technology enables improved networking in modern society, enabling smart cities to manage various tasks like power plants, schools, libraries, transit networks, hospitals, water supplies, waste management, and community services securely. Moreover, 5G can improve traffic management by automating traffic control, enhancing traffic flow, and delivering real-time information on public transportation (Sear and Khan, 2020).

According to an article in Business Tech (2021), provincial governments are currently working on at least three smart city projects in South Africa, with developments taking place everywhere from middle-class suburbs in Gauteng (Lanseria and Mooikloof) to small towns in the Eastern Cape (African Coastal Smart City). With 5G, IoT devices will be able to interact with extremely low latency and use cloud data as needed, increasing the appeal of smart homes. Additionally, this will enable users to access gadgets from anywhere in the world (Maluleke, 2020). Cities started using the term "smart" from the beginning of the

C2 General

1990s after putting in place ICT infrastructure, implementing e-governance, and attempting to attract high-tech companies to spur economic growth (DcoG, 2021).

The provision of necessary infrastructure, health care, and educational services both influences and is influenced by the threat of poverty, inequality, and unemployment, which has a substantial impact on the future prospects of South African society. According to DcoG (2021), inclusivity should serve as the foundation for ’a smart city. In essence, this means that a smart city program should benefit all residents and improve their well-being, in all the city’s communities. The super-fast technology that all other applications use is created by 5G, making 5G technology the glue that holds everything smart together (PC4IR Report, 2020). Further recommendations made in the PC4IR Report (2020) include the necessity for municipalities, CoGTA (the Department of Cooperative Governance and Traditional Affairs), the South African Local Government Association (SALGA), premiers’ offices, industry, and universities to begin working together to develop smart city concepts that are influenced by the SALGA Smart City Framework.

5G technology enables telemedicine and telehealth, improving healthcare access in rural or underserved areas. Fast, dependable connectivity enhances remote health services, improving disease detection and treatment, especially in areas with limited healthcare access (Carbonell et al., 2022). 5G mission-critical applications in mHealth systems enable healthcare delivery in remote areas, expanding availability and quality. With 100 percent network coverage, 5G is expected to improve 4G service in rural and isolated areas, enhancing 4G services and enabling healthcare delivery in previously unviable locations (Malila et., 2019). There are 98 mHealth projects in South Africa, the greatest number in Africa, according to the GSMA mHealth tracker, a website that collects mHealth goods and services from across the world (GSMA, 2017). Future rural clinics with only nursing staff should be able to consult online with specialised personnel in large centres to carry out cutting-edge diagnostic and surgical treatments. City

C2 General

hospitals should be able to solicit specialised skills that are not available locally from anywhere on earth (CSIR, 2021). In addition, CSIR (2021) notes that 5G might help with drone-based medical sample and medication deliveries in both urban and rural areas. For drones to maintain their mutual distance from one another and receive accurate instructions, 5G offers a pervasive communication infrastructure.

The 5G capacity presents an interesting potential for online learning, according to CSIR (2021). It is theoretically conceivable to conduct real-time lessons across the nation or even the entire world, in addition to already existing online opportunities such as online courses and even knowledge sources such as YouTube movies. Through improved access to top teachers in the world for even the lowest-income children, 5G will also significantly contribute to social equality. The benefits of 5G would likely be more noticeable in higher-level education (secondary and, especially, tertiary) than in primary and elementary education, according to CSIR, because 5G cannot replace individual attention in the classroom. It can, however, undoubtedly help teachers, even in basic education, by granting them access to new methods and more sophisticated training.

Since there are not any ground-based base stations in a number of distant places, connection will be provided there mostly through satellite internet, and 5G will be essential for this. The 5G network will employ satellite systems to offer connection, and the satellite system uses a constellation of several tiny satellites to provide connectivity in urban and rural locations throughout the world (Dangi, 2021). According to an announcement by Communications Minister Khumbudzo Ntshavheni in June 2022, South Africa was preparing to launch its first communications satellite as part of a growing effort to increase internet availability. She stated that the satellite would address goals for media and broadband access and would contribute to strengthening the nation’s data and technological sovereignty.

C2 General

For 5G to succeed in Africa, an enabling policy environment is also necessary. In order to promote a cost-effective network deployment and the creation of new use cases to increase demand, governments and regulators must establish an environment that is supportive of investment and innovation (GSMA, 2022).

- **Proposition 3**

  5G will improve and enhance service delivery in multiple sectors in South Africa.

2.9 Analytical Framework

The analytical framework to be used in this research will be based on ontological and epistemological assumptions that will provide an understanding and shape the research methodology and design.

2.9.1 *Ontology*

Crotty (2003) described ontology as the study of inquisition. Ontology is concerned with the type of universe we are exploring, including the nature of character existence and the structure of reality overall (Crotty, 2003). According to Guba and Lincoln (1989), ontological presumptions are those that address the query “What is there that can be known?” or “What is reality’s nature?” Snape and Spencer (2003) also define ontology as the nature of the world and what we can know about it. In other words, ontology is associated with a central question of whether social entities should be perceived as objective or subjective.

2.9.2 *Epistemology*

In terms of how we know what we know, epistemology entails knowledge and expresses a certain idea of what knowledge entails (Crotty, 1998). In other words, it explains how we come to know what we know (Crotty, 2003). Another goal of

C2 General

epistemology is to provide a conceptual foundation for determining what types of knowledge are conceivable and how to assure that they are sufficient and valid (Maynard, 1994:10, in Crotty (Ibid:8)). Epistemology, according to Bryman (2008), is the study of the topic of what constitutes acceptable knowledge in a discipline.

2.9.3 Theoretical Framework

The theoretical framework serves as a study's overall *blueprint* for investigation. It gives the framework to specify how a researcher will approach a study as a whole from philosophical, epistemological, methodological, and analytical standpoints. It acts as the foundation upon which to develop and support a study (Grant & Osanloo, 2016). The theoretical framework essentially consists of what experts in a researcher's field of study have to say about the study's research question, the issue the researcher intends to look into, and may even contain recommendations for how to solve that issue, such as how to interpret the study's findings (Kivunga, 2018). A researcher uses this framework as a theoretical coat hanger for data analysis and result interpretation. It is a compilation of the ideas of luminaries in the researcher's field of study as they apply to the proposed study, as understood by the researcher, and as the researcher plans to use those theories to interpret the study's data.

2.9.4 Resources and Appropriation Theory

With the rise of the information society, the Resources and Appropriation Theory, was developed by Teun A. Van Dijk, a socialist and linguist in the 1990s. The study has developed a paradigm for understanding how language and discourse reinforce power relations and social injustices, revealing how hegemonic groups maintain control over power and social institutions. The framework provides a comprehensive understanding of the digital divide in ICT, highlighting strategies

C2 General

for reducing it and promoting equal access to digital technologies by highlighting the resources needed for successful technology adoption and use.

The Resources and Appropriation Theory, a 25-year hypothesis on the digital divide, is based on four access phases: motivation, physical access, skills, and usage (Van Dijk, 2019). In identifying the potential of 5G to bridge the digital divide in South Africa, the resources and appropriation theory was considered. The phenomenon of the digital divide is intricate and ever-changing. Digital barriers come in many forms and are always evolving. Having the motivation to use digital media, including computers and the internet, is the first step towards gaining access to them. After that, to obtain a computer and an internet connection, users must have physical access. The next step is to acquire several digital skills. People can then choose between many programmes, depending on what is appropriate for them and accessible. In the end, they want to determine the benefits of using these mediums (Scheeder et al., 2017).

The theory is based on four fundamental concepts:

i. There are a variety of social inequities, both positional and personal, in which the fundamental claim is that different personal and positional categories of people have varying resources to follow these phases and reap the benefits (Van Deursen & Van Dijk, 2019). Proactive measures – such as infrastructure investments, affordability assurance, digital literacy promotion, and skill development – are necessary to tackle socioeconomic injustices related to 5G.
ii. The unequal allocation of resources is central to the issue of unequal access to digital technology (Van Dijk, 2013). Governments and policymakers need to address inequities in 5G technology allocation to ensure fair resource allocation and optimize its benefits in areas of infrastructure investment and spectrum distribution.
iii. Many methods of ICT access or types of technology have characteristics that contribute to unequal access to them (Van Dijk, 2013). As 5G

C2 General

advances, new use cases and access types are anticipated, transforming various industries, and altering how people interact with technology. Users that are disadvantaged will be marginalized due to lack of access to 5G technology.

iv. Many spheres of social interaction perpetuate existing inequalities, as uneven use of digital technologies leads to varying social involvement, resource allocation, and societal inequalities (Van Dijk, 2013). While 5G technology is expected to significantly impact various fields, sectors, and society in the future the inequality and lack of infrastructure that rural areas are faced with could lead to uneven coverage and access, with urban areas often receiving 5G services earlier and more thoroughly.

Fang et al. (2018) adds that the theory encompasses various mental (knowledge), material (income), social (relationships), cultural, and temporal settings. The theory posits that individuals with varying personal and positional categories have varying resources to effectively use and benefit from the four phases—i.e., the appropriation of technology (Van Dijk, 2017). Figure 4 illustrates the causal model of the theory.

C2 General

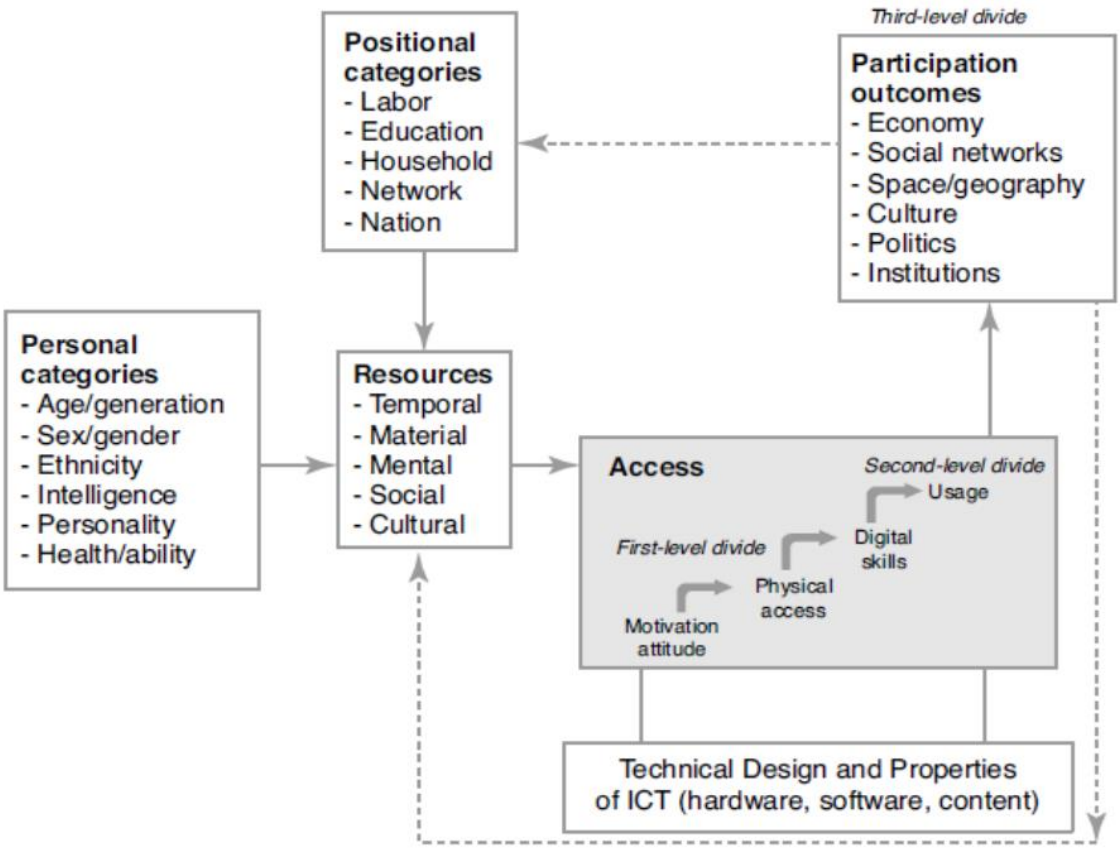


Figure 4: Resource and Appropriation Theory causal model (Van Dijk, 2020).

The factors that influence internet use are primarily computer and internet connection capabilities. The impact of these factors varies based on an individual's resources and social categories, including age, gender, and education, leading to different user classes: mobile and traditional (Lopez-Sintas et al., 2020). There has been a shift in the types of unequal access to computers and the internet, from unequal motivation and physical access to unequal skills and usage (Van Dijk, 2009). In future, in a networked society, understanding inequality variations in physical access, skills, and usage will become increasingly strategic (Van Dijk, 2013).

C2 General

Digital inequality plays a part in how economic, social network, and cultural inequality interact and affect social inequality more widely (Reynolds, 2020). Deliberate policy, training, and educational improvements at all levels can help to reduce the inequalities in the digital divide and digital skills (Van Dijk, 2005). Socially conscious facilitators must challenge social norms and beliefs about the digital divide, address complex issues related to ICT access and use, and reshape existing structures for a more equitable distribution of resources (Fang et al., 2018).

Up until recently, physical access was the only consideration in global digital divide policy. From the standpoint of global politics, this may still be the top concern in poor nations, but we are moving on to issues with skills and utilization (World Bank, 2016. The Resources and Appropriation theory highlights the significant impact of 5G technology on motivation, physical access, skills, and usage. It has the potential to enhance opportunities, increase access to high-speed connectivity, necessitate skill acquisition for efficient 5G resource usage, and enable the deployment of creative apps and services, motivating individuals, and businesses.

2.10 Conclusion on the Literature Review

The purpose of this literature review was to provide an analysis and understanding of the ongoing trend of the impact of technology on socioeconomic development. There is a clear and growing trend of the potential and opportunity for 5G to bridge the digital divide that continues to sow inequality due to lack of broadband access and affordability of data and devices for South African citizens.

C2 General

CHAPTER 3. RESEARCH METHODOLOGY

This chapter describes the methodology used to conduct the current study, aimed at developing an in-depth understanding of the potential of 5G in bridging the digital divide and the socioeconomic impact of 5G on service delivery.

This chapter is divided into the following sections: research approach, research design, data collection methods, population and sampling, and research instrument. This chapter also describes data collection, data analysis and ethical considerations.

3.1 Research Approach

The qualitative research approach was adopted in this study. Qualitative research allows for theory to emerge from the research. It yields deep, detailed and contextualised information that allows further questions that will guide the collection of subsequent data from the research participants to be developed (Creswell & Tashakkori, 2007). Qualitative data gathering requires researchers to avoid imposing their own perceptions of the meanings of social inquiry (Garcia & Quek, 1997).

The inductive approach should be used when collecting data and developing a theory based on the findings of the data analysis (Saunders et al., 2003). Using an inductive approach when collecting data means starting with specific data points and then using them to derive broader conclusions or theories through the process of analysis. The qualitative research method using the inductive approach was adopted in this research study.

3.2 Research Design

Research design can be defined as the strategic framework that connects the research question to the implementation of the research. The research design

C2 General

helps to guide the researcher on how to go about collecting and arranging data. Through planned observations, the researcher aims to understand and fulfil the purpose of the research (Blanche et al., 2006). Phenomenology is a scientific method that allows researchers to explore individuals' subjective experiences and worldviews (Creswell, 2013). Phenomenological research involves gathering detailed data through interviews, observations, and textual analysis to understand the essence and meaning of a phenomenon (Moustakas, 1994). The research design adopted is the phenomenological design, which is used to draw critical insights and challenge existing assumptions. The study employs analysis of primary data from interviews that were conducted with experienced stakeholders within the mobile sector industry to gain 5G technology insights.

3.3 Data Collection Methods

Data was collected from one-on-one semi-structured interviews with the participants to assist in gaining an understanding, gathering personal experiences, and discovering trends and insights to enable data analysis. Semi-structured interviews have the advantage of having a higher return rate as opposed to questionnaires, and they are flexible; this enables probing and additional questioning (Corbin & Strauss, 2014). Moreover, semi-structured interviews allow participants to openly share their experiences regarding the perceived influence of automation on employment (Creswell & Creswell, 2017).

3.4 Population and Sampling

3.4.1 *Population*

The concept of population is defined population as the entire group of individuals or objects that possess certain characteristics being studied (Creswell, 2013). The South African 5G ecosystem involves collaboration among government

C2 General

agencies, telecom operators, technology vendors, and academia to successfully deploy and utilize 5G technology, which is considered transformative in the telecommunications industry (Smith, 2020).

The population of this research study consisted of participants who were consumers of 5G technology in the context of South Africa. This population provided insights into the impact of 5G usage to understand how the benefits and challenges of the 5G technology impact the digital divide in South Africa.

3.4.2 *Sample and Sampling Method*

Sampling is a technique used to collect data from a subset of cases that is representative of a larger group. Therefore, the researcher can derive conclusions from the data that apply to the entire group (Walliman, 2011). Purposive sampling is ideal for qualitative research designs as it enables researchers to select participants with a range of viewpoints in order to fully comprehend the subject of the study (Creswell, 2007). A purposive sampling approach was used for this study to select participants who have expertise and knowledge about 5G technology. The sample size was 14 participants within the South African 5G ecosystem who were experts with direct involvement in 5G technology (through deployment, manufacturing, research, etc), employed by:

i. Consumers of Technology – 2 participants
ii. CSIR Research Council – 1 participant
iii. Mobile Operators (MTN, Telkom, and Vodacom) – 4 participants
iv. Mobile Operator Consumer Business Unit – 2 participants
v. Original Equipment Manufacturer – 3 participants
vi. The Department of Health – 1 participant
vii. The Department of Science and Innovation — 1 participant
viii. The South African SMMEs Association – 1 participant

C2 General

3.5 Research Instrument

An interview guide was used as the research instrument. Responses were manually clustered and themed to determine trends that arose (Creswell & Creswell, 2018). The semi-structured interviews had open-ended questions related to the research topic. The open-ended questions allowed participants to provide their opinions and comments.

3.6 Procedure for Data Collection

The primary data collection method adopted in this study was structured interviews, which were conducted using an interview-guided approach to ensure that the specific research topic was thoroughly covered. One-on-one semi-structured interviews were conducted with 14 participants through face-to-face interviews, or via Microsoft Teams for participants further away. The benefit of semi-structured interviews is that they yielded detailed and comprehensive data.

This approach ensured comprehensive data by anticipating any logical gaps in the data that needed to be filled (Patton, 2002).

The data were collected in the following steps:

i. The researcher contacted the identified participants to present the purpose of the research study and explain its goals.
ii. The researcher then asked participants to take part in the research study through interviews.
iii. Interviews were scheduled and questions were sent beforehand to allow the participants time to prepare, and consent forms were shared with the participants for approval and to give permission to record the sessions.
iv. Interviews lasted 40–60 minutes.
v. The researcher thanked the participants for their time and participation in the interview process.

C2 General

3.7 Data Analysis Strategies and Interpretation

According to Corbin and Strauss (2015), thematic analysis is suitable for interviews because it can be used to easily identify and analyse patterns and themes of the study. In other words, thematic analysis allows for identification and analysis of emerging themes in a study (Braun & Clarke, 2006). Inductive thematic analysis of the data was applied to identify themes and trends in the gathered data. The following approach was used to analyse and interpret the data:

i. Reading and re-reading the notes and interview transcripts was necessary to become familiar with the data.
ii. Coding ensured the data was arranged logically and methodically.
iii. the codes created were examined, identifying patterns within them and generating themes.
iv. Themes were reviewed to ensure that they were accurate and helpful depictions of the data.
v. Themes went through a final refinery, being defined and named.
vi. A report was written on data analysis.

3.8 Possible Limitations and Challenges of the Study

The following limitations were anticipated for this study:

i. Government officials identified for the interviews might be unavailable.
ii. The sample size might not be sufficient to yield the desired results.
iii. Data quality could be a challenge as it might affect the research findings and recommendations.

C2 General

3.9 Quality Assurance

3.9.1 *Transferability*

Transferability is the extent to which the results of a qualitative study can be transferred into different contexts with different samples (Creswell & Creswell, 2017). To ensure transferability, the researcher used triangulation through the use of interview recordings and notes.

3.9.2 *Credibility*

Credibility is the certainty of the research outcomes (Corbin & Strauss, 2015). The same interview guide was used as a research instrument for all interviews. Data collection from the interviews was thus consistent, comparable across all participants, documented, and archived to ensure credibility.

3.9.3 *Dependability*

Dependability involves findings, interpretation, and recommendations of the study that are supported by data that were received from participants of a study (Corbin & Strauss, 2015). The findings of the current study were consistent with the data collected and were thus trustworthy, and the study aimed to cover all aspects related to the study topic. The dependability of the study was established by an audit that was conducted by the research supervisor. This ensured the authenticity and validity of the data collected.

3.10 Ethical Considerations

Ethics is defined by Simons (1995), in Pring (2000:142), as the search for rules of conduct that enable us to operate defensibly in political contexts in which we have to conduct educational research. Chilisa (2005) highlights research ethics

C2 General

and legitimacy of knowledge by saying “ethical issues in research include codes of conduct that are concerned with protection of the researched from physical, mental, and/or psychological harm. The codes of conduct for protecting the researched include ensuring anonymity of the researched and confidentiality of their responses.

The following approach was undertaken to consider ethical issues:

i. Participants participated with informed consent and were made fully aware of the purpose of the study.
ii. Participants participated voluntarily in the research study without coercion.
iii. The information provided by the participants was kept confidential.
iv. The participants were kept anonymous in the study’s reports.
v. The researcher was all times transparent and managed the research process with integrity.

Table 2: Consistency table: research questions, propositions, data collection, and data analysis

Research objective number	Research objective	Proposition number	Proposition	Data collection detail	Data analysis method
1	To determine the 5G technology’s potential to bridge the digital divide in South Africa in accordance with ICT policy frameworks	1	The introduction of 5G will bridge the digital divide in South Africa.	Interview guide questions	Thematic analysis
2	To determine the socioeconomic impact of 5G for South African consumers and citizens to drive digital inclusion	2	5G is a catalyst and is indispensable in enabling/achieving an equal digital future for South	Interview guide questions	Thematic analysis

C2 General

Research objective number	Research objective	Proposition number	Proposition	Data collection detail	Data analysis method
			African consumers and citizens.		
3	To determine the 5G technology's potential to assist with service delivery in South Africa	3	5G will improve and enhance service delivery in multiple sectors in South Africa.	Interview guide questions	Thematic analysis

C2 General

CHAPTER 4. PRESENTATION OF FINDINGS

4.1 Introduction

The preceding chapter described the research methodology used to obtain research findings. This chapter focuses on the presentation and description of the research findings. One-on-one interviews were used to collect data from 14 participants across different sectors. the interviews were recorded and transcribed to assist with the interpretation and analysis of the data collected. Insights were drawn from the interviews conducted with the participants using the following research objectives:

1. 5G technology and its potential to bridge the digital divide in South Africa in accordance with/meeting the ICT policy/regulatory frameworks.
2. The socio-economic impact of 5G for South African consumers and citizens to drive digital inclusion.
3. 5G technology's potential to assist with service delivery in South Africa.

4.2 Background of the Participants

The demographic profiles of the participants consisted of participant type, gender, role within their employer's organisation and industry/sector. The participants comprised 12 males and two females. The composition and selection of the participants, based on their active involvement and understanding of network technologies, was key to the research study. The selection criteria had a positive impact on the study as the participants exhibited knowledge of policy frameworks, experience, technical skills, oversight, and digital capabilities that added valuable perspectives and insights. Table 3 illustrates the demographics of participants. The sample of the participants was made up of experts from (or working at):

C2 General

i. Consumers of technology (3)
ii. Original equipment manufacturers (OEMs) (3)
iii. Mobile operators (4)
iv. A research council (1)
v. SMEs in the ICT sector (1)
vi. Government (3)

The researcher achieved saturation as the participants provided a repetitive narrative during the interview process.

Table 3: Demographics of participants

Participant	Participant Type	Gender	Role in Organisation	Industry/Sector
1	Consumer of Technology	Female	Manager	Telecommunication
2	Consumer of Technology	Male	Executive	Telecommunication
3	Consumer of Technology	Male	Manager	Telecommunication
4	Mobile Operator	Male	Executive	Telecommunication
5	Mobile Operator	Male	Executive	Telecommunication
6	Mobile Operator	Male	Executive	Telecommunication
7	Mobile Operator	Male	Network Optimisation Strategy Manage	Telecommunication
8	SME	Male	CTO	ICT
9	Equipment Manufacturer	Male	Head of Networks	Telecommunication
10	Equipment Manufacturer	Male	Mobile Networks Business Centre Solutions Architect	Telecommunication
11	Equipment Manufacturer	Male	Principal Market Insight Manager	Telecommunication
12	Government Official	Male	HOD	Health Department
13	Research Council	Male	Researcher	Scientific and Technology Research
14	Government Official	Female	Director	Innovation and Technology

C2 General

4.3 Results Pertaining to Proposition 1: 5G technology can bridge the digital divide in South Africa.

In order to establish confirmation of proposition 1, the research sought to understand how the introduction of 5G will bridge the digital divide in South Africa. The research questions were set to uncover how mobile broadband technologies have evolved and their differentiators; understanding of what 5G technology is; challenges and disadvantages of 5G technology; readiness of South Africa to adopt and deploy 5G technology; the impact of 5G technology on the digital divide. This section presents findings as expressed by the participants as well as the key themes that emerged from the interviews. The themes that emerged from the interviews with the participants in this section were as follows:

i. Technology evolution
ii. 5G capabilities
iii. 5G challenges disadvantages
iv. 5G adoption
v. Digital divide

4.3.1 *Technology Evolution*

The participants were asked to provide a comparison of the three main generation technologies in terms 3G, 4G and 5G, to determine, how mobile broadband technologies have evolved. The comparison of the mobile generations by the participants assisted in shedding insights on whether or not 5G has superiority over 3G and 4G technologies, and if 5G can leverage off these existing technologies and yield benefits.

Participants highlighted that the 5G technology enhances power, frequency, and byte transfer efficiency by providing larger bandwidths, increasing network capacity and speeds. This technology significantly improves byte transfer, power,

C2 General

and frequency efficiency, raising the bar for mobile networks, enabling quicker, greater capacity, and more effective data transfer.

"*5G technology enhances efficiency in power, frequency, and byte transmission with advancements in technology and innovation*." (Participant 10).

"Mobile networks have evolved over time, with each generation introducing its own technological and architectural development. 3G marked the beginning of data networks, offering high-speed data rates and video calling. 4G evolved from 3G to 4G, improving speed and spectral efficiency. This shift towards data over telephony led to high-speed increases in LTE and LTEplus. Technical differences in 4G led to pure Internet packet base, with various technologies defining spectrum usage, spectral efficiency, and modulation schemes until 5G." (Participant 13).

The participants indicated that 3G technology introduced CDMA and WCDMA to improve data rates and capacity while 4G utilised OFDM and MIMO for spectral efficiency and data rates increment. One participant added that 5G is the first technology to introduce massive MIMO which offers significant improvements in capacity, speed, and coverage by increasing beamforming precision, reducing interference, and broadening coverage area.

"The 3G generation introduced CDMA technology in the early 2000s, transforming communication and information access. 4G has undergone long-term evolution and cost enhancements, introducing UMTS and 1 Mbps bps speeds. It also introduced carrier aggregation, making it more economical.5G is an overarching Big Brother of these technologies, making it an essential component in the automation space." (Participant 3).

"The usage of huge, massive MIMO by 5G, which was not possible with 4G, is a distinctive aspect of your various technologies. When compared to 3G and 4G, 5G can connect and offer better throughput." (Participant 5).

C2 General

“So, the glaring difference is the high-capacity capability; if you compare 4G for an example and, of course, the older generations, 5G stands out with a much higher capacity or bandwidth than those older generations.” (Participant 4).

“3G and 4G differ in air interface, multiplexing, and philosophy, with 3G having no channel elements, small carrier size, and different voice spot handling. 4G and 5G use packet-switched technologies like LTE or NR.” (Participant 9).

Participants understood that 3G offered a few Mbps, while 4G/LTE networks can reach speeds up to hundreds. 5G, with multi-gigabit speeds, can reach 10GB per second offering a seamless and enhanced user experience. Participants further noted that 3G introduced internet access and mobile app usage, while 4G introduced VoLTE, IoT, mobile gaming, and high-quality video streaming services.

“5G improves internet browsing experience by enhancing uploading and downloading speeds, reducing buffering and delays.” (Participant 1).

“3G was the third generation with 7.2Mbps connectivity, while 4G improved to 100Mbps. 5G, with higher delay sensitivity, requires lower latency and is used in online activities like artificial intelligence, machine learning, and the Internet of Things.” (Participant 2).

“3G provided faster data transfer speeds and multimedia capabilities, while 4G improved capacity and speed. 5G offers ultra-high speeds, low latency, and massive machine-type communications, enabling connections between people and things.” (Participant 7).

Participants revealed that 3G uses lower frequency bands up to 2Ghz, resulting in lower data rates, while 4G uses higher frequency bands up to 6GHz, enhancing capacity and data speeds. Most participants believed that 5G surpasses all other mobile generations due to its spectrum-driven approach, utilizing a wider range of frequency bands and lower bands, reaching up to and above sub-6GHz bands.

C2 General

"5G offers new 7GHz-8GHz spectrum, addressing congestion and providing capacity. South Africa's spectrum auction unlocks 700 MHz band capacity for low bands, while sub-6 GHz, 3500, and 2600 bands require additional coverage." (Participant 10).

"5G offers faster connections at sub 6GHz bands, surpassing 3G, 4G, and 2G, with a triple increase from current 4G." (Participant 12).

4.3.2 *5G Capabilities*

The principal task was to derive an understanding of what 5G technology means to the participants. Participants understood 5G technology to be an improvement from previous generations, enhancing user experience, management ease, and support. It offers significant structural changes and various use cases such as eMBB, uRLLC and mMTC that have the capabilities of faster speeds, lower latency, enhanced connectivity, increased capacity, augmented reality and improved virtual experiences, and stimulates economic growth.

"5G technology, inspired by the 4th industrial revolution, offers faster communication between humans and machines, enhancing overall efficiency and fostering a more efficient world." (Participant 1).

"5th generation wireless cellular technology aims for high-speed, resilient, and stable internet connectivity through high-capacity transmission, utilizing fibre mediums." (Participant 2).

"5G stands out for its unique capabilities in managing large devices and offering customization services for user support specifics. Its high-capacity eMBB and low-latency capability are priorities for South Africa's operators." (Participant 4)

Most of the participants viewed 5G technology as a leapfrog in revolutionising mobile technologies, with eMBB existing to address higher data rates and support newer services for consumers and businesses. Participants added that 5G offers

C2 General

lower latencies through the uRLLC use case, enabling virtual reality, e-gaming, and autonomous vehicle services unprecedented in mobile generations, mainly due to its higher carrier size and air interface.

"5G is the 5th generation of mobile networks, focusing on virtual connectivity for smart cities, offering 100 GB speed and low latency for various applications." (Participant 5).

"5G revolutionizes wireless connectivity with enhanced speed, capacity, latency, and network performance." (Participant 6).

"5G addresses three main use cases: eMBB, e-gaming, extreme reality, virtual reality, and self-driving cars. It offers ultra-reliable low-latency services with lower latencies, enabling faster latencies and better support for these applications. LTE's intrinsic design lacks these features." (Participant 7).

"5G in South Africa significantly improves LTE and 4G networks, offering faster transmission speeds, faster uploads, downloads, and low latencies. This technology catalyzes advancements in artificial intelligence, virtual reality, and augmented reality, making it an enabler for 4th-generation technologies." (Participant 12).

Participants added that 5G requires less carrier aggregation, allowing for additional spectrum utilisation. This technology offers increased capacity and reduced congestion. Further to that, participants noted that since 5G technology is software-based, it introduces the enhancement of the SDN concept, from which mobile operators benefit from improved hardware communication on their networks, thereby realising big data, network virtualisation, and network automation opportunities. Participants also indicated that 5G technology also introduces network slicing, which permits dedicated and logical functional layers (slices) on top of a common physical infrastructure. Supplying an end-to-end virtual network across several domains is enabled by 5G technology and allows

C2 General

mobile operators to service different customers according to their network business needs.

“5G is a shift from 4G to the next frontier, using OFDMA technology for multiplexing over the air interface and 15 kHz carrier spacing. It offers faster packet transmission with carrier sizes of 30, 60, or 120, resulting in a 20 percent speed gain compared to 4G. Larger bursts reduce system latency, making 5G a promising option for data usage expansion. It focuses on standardization, with a carrier size of up to 100 MHz, requiring less carrier aggregation for higher spectrum. This allows for more efficient and reliable communication.” (Participant 9).

“5G is the 5th generation of mobile communication networks, offering significant improvements and a paradigm shift from previous generations. It is software-based, focusing on software-defined networking and network function virtualisation, ensuring separation between control and user planes. Network slicing enables dedicated end-to-end segments for specific functions, setting 5G apart from other networks. (Participant 13).

4.3.3 *Challenges of 5G Technology*

Although 5G technology has a number of advantages, participants were asked to share their thoughts on any potential drawbacks or challenges that might prevent or postpone the implementation of 5G technology.

The biggest disadvantage and challenge participants emphasised was the issue of energy consumption in 5G technology equipment and devices, despite manufacturers’ efforts to address it. Participant further cited power consumption issues as a factor affecting 5G usage, exacerbated by the loadshedding crisis and power outages in the country. Some of the participants agreed that if a network is not built adequately with refarming modernisation, energy consumption becomes a negative contributing factor to 5G. It was further noted

C2 General

that the challenge of energy consumption has a ripple effect on the mobile operators' operational expenditure costs.

"5G technology consumes significant power, making it unsuitable for remote areas with unstable power. Reliable devices and Eskom's power are crucial for 5G users, affecting user experience. The technology's high deployment cost, high device penetration, lack of encryption, weakening gadget batteries, and smaller broadcasting range contribute to its disadvantages". (Participant 2).

"5G's main disadvantage is its energy consumption, negatively impacting OPEX, environment, and country. Despite not absorbing more resources, it still significantly impacts the environment and overall well-being." (Participant 9).

Secondly, most participants raised 5G deployment costs as a challenge, affecting adoption readiness and diminishing the possibility of bridging the digital divide. Participants raised the investment needed by mobile operators for densification of new radios due to 5G technology's high band access and utilisation on the spectrum. They also stated that deployment costs impact data costs, which consumers must pay for to enable mobile operators to recover their deployment costs. This reduces the possibility of data cost reduction, a contentious issue in South Africa.

"For 5G, more expensive devices are needed." (Participant 6).

"The slightly higher cost of 5G deployment for MNOs raises concerns about the cost of dropping data courses, as consumers must find a way to pay for it." (Participant 12).

"The capital outlay for fully fledged high bands requires densification, which requires significant money. The transport network is crucial, as increasing fibre rollout may disadvantage it. Sub-3 GHz offers slower speeds than 5G, but costs and infrastructure are crucial. Addressing battery theft is essential." (Participant 13).

C2 General

Thirdly, participants highlighted infrastructure challenges in South Africa, particularly in areas lacking fibre footprints, as 5G technology relies on this medium for fast speeds. Participants highlighted 5G technology's infrastructure requirements and complex challenges, including massive MIMO and wind loading space for the big antennas required on masts.

"The main disadvantage of massive MIMO is its infrastructure requirements, as it requires mass space for wind loading. Manufacturers are working to address energy consumption in new devices using solutions like PSN power settings, but it remains a key challenge for green technology advancement." (Participant 7).

Fourthly, 5G technology offers potential benefits but also introduces security risks as indicated by some of the participants. They mentioned that cybersecurity is increasing, making consumers vulnerable to hackers exploiting data they have access to. Participants also raised battery theft as a security concern affecting network availability and user experience during load shedding and power outages.

"Cyber security is a growing concern, but enhancing it is crucial for data safety, information protection, and promoting new technologies' benefits and preventing cybercrime." (Participant 3).

"5G presents a double whammy in the security industry, offering access to big data but also potentially attracting bad hacking actors." (Participant 12).

Participants mentioned the fifth challenge of expensive 5G devices affecting lower-class citizens' affordability. Participants highlighted that low device penetration leads to increased costs, resulting in low penetration and a wider issue of affordability. They indicated that expensive devices deepen the digital divide for those unable to afford 5G-enabled devices.

"For 5G, more expensive devices are needed." (Participant 6).

C2 General

The last challenge that one of the participants raised, is that digital illiteracy and a lack of education contribute to low 5G adoption and the digital divide, despite the technology's availability. However, one participant concerned that 5G technology may eliminate human intervention in functions, potentially leading to job losses and removing the human element.

"Educate people on technology usage and practice gadget usage, like Vodacom's township technology centres, to bridge the digital divide and encourage experimentation." (Participant 1).

"Every sector is bound to benefit from 5G. In a very cruel manner, it takes away the physical element and brings artificial intelligence. You no longer need five hands to be doing a function, you just need a machine that will perform all the work with so much intelligence that the human element might not necessarily be required." (Participant 8).

4.3.4 *5G Adoption*

The participants were asked about the readiness of South Africa for 5G technology adoption. The task sought to understand and gage whether South Africa meets the 5G technology "golden understanding of 5G" requirements, which comprise latency, connection density, and throughput that promote the adoption of 5G technology. It was also important to understand the actions required to meet the "golden triangle" in relation to spectral efficiency, infrastructure coverage, SDN strategy within the mobile operators' core networks, network architecture, and edge computing, which would give guidance on the readiness of the country to adopt and implement 5G technology.

Seventy nine percent of the participants believed that South Africa was ready for the adoption of 5G technology. Participants believed COVID-19 was a turning point for South Africa as education transitioned from face-to-face to remote online learning. Moreover, COVID-19 has impacted medical consultations, with patients

C2 General

and doctors transitioning to virtual consultations enabled by technological advancements.

“During the COVID-19 pandemic, institutions transitioned from face-to-face teaching to online learning, requiring virtual consultations and classes for students. They are now prepared for 5G adoption.” (Participant 1).

The participants emphasised that South Africa already has sufficient 4G coverage due to usage and demand, which 5G can leverage. However, device access is required. The more developed parts of the country are prepared for 5G adoption due to existing 4G eMBB use cases. In addition, the participants believed that South Africa has case studies to support its aggressive deployment of 5G connectivity, despite the dual economy. This is because many citizens, including those without economic activity, perceive technology as a luxury due to affordability challenges.

“South Africa has three operators with 4G penetration above 90 percent, with some reaching 100 percent. The majority of 4G devices have 70 percent penetration, with popular applications like Netflix, Instagram, and Facebook driving usage. Operators are deploying 5G for data in dense metro areas, indicating readiness for potential benefits of 5G.” (Participant 4).

“South Africa is ready for 5G capacity, which can be switched between 4G and 5G using software, as it offers more efficient technology.” (Participant 10).

“The country has ample case studies to support 5G deployment, while the modernized economy, driven by mining, telecoms, and finance, sees it as a competitive advantage. 5G offers global collaboration and potential use cases, making the private and public sectors ready.” (Participant 12).

“*South Africa is a very peculiar country where you kind of have like two countries in one and looking at the digital divide, you have this part of the country which is on par with some of these developed countries, and then you have other part of*

C2 General

the country which is nothing like that. If you're looking at the initial phases of 5G, they start with eMBB because it's more like a continuation from 4G, it is ready especially in the urban areas for that leg." (Participant 13).

Participants believed that South Africa has the infrastructure needed for 5G technology adoption, despite the negative impact of load shedding and vandalism on mobile operator sites. Significant technological and infrastructure investment by mobile operators positions the country at an advantage in this regard.

"South Africa, a first-world country, is prepared to tackle challenges like loadshedding and vandalism using 5G technology, offering smaller cells and radius, demonstrating the country's infrastructure and potential for success." (Participant 5).

"We ready to deploy 5G over 4G in non-stand-alone mode due to its existing infrastructure. With wide network coverage, Vodacom can still use 5G on some sites. Although there will be significant investment costs, South African Telecommunications Network is advanced due to VoLTE, unlike other countries' Circuit Switched Fall Back (CFSB) stages." (Participant 7).

Operator expenses are evidence of the technological investment mobile operators have made as noted by one of the participants. 5G technology benefits mobile operators by lowering the cost per GB and enabling them to create more data. Participants added that mobile operators are selling an evolving mobile broadband product to the market as a result of the advancements they have made so far. High speed and low latency in applications for mission-critical communication that enable 5G technology readiness are the advantages achieved by this service. Equally so, South Africa's readiness for 5G technology is enhanced by spectrum options for 4G and 5G, according to participants.

"5G offers operators a significant cost reduction advantage by reducing the cost per GB. With a millimetre wave range of 26 GHz to 28 GHz, 5G provides up to 800 GHz spectrum on basebands, enabling more data production from a single

C2 General

site. This is the first factor from a cost perspective when considering 5G as a player in the industry. Operators should also consider the population perspective, particularly the advanced Evolve Mobile Broadband offering, considering market demand for data consumption, internet, and mission-critical communications." (Participant 9).

Twenty-one percent of participants believed South Africa was not digitally mature enough to adopt 5G technology, with uptake not being as expected as projected compared to 4G technology. The slow uptake of 5G in the country is attributed to factors like high unemployment, a lack of digital literacy, and infrastructure access, particularly in rural areas, which affect the country's economic scale and geographical landscape, as highlighted by the participants. Furthermore, participants noted that rural areas face significant challenges due to infrastructure and high device costs, hindering citizens' access to 5G technology and its associated benefits.

"South Africa faces unique economic challenges in different provinces, including Gauteng's extensive 5G infrastructure, but rural areas lack the necessary infrastructure for successful 5G implementation. Addressing these challenges is crucial for successful 5G technology implementation." (Participant 2).

"5G's adoption was delayed due to high infrastructure costs and device penetration, as well as the digital divide in communities. Although expected to be more expensive and deployable, adoption may not be as rapid as anticipated." (Participant 3).

"Yes, South Africa is ready for 5G due to its diverse population, including upper, middle, and lower classes. The technology requires fast medium connections without buffering and requires a large transmission network. Urban areas have access to fibre, making it affordable and accessible. The middle class may access 5G due to existing infrastructure, but rural areas, however, may face challenges due to poor coverage." (Participant 8).

C2 General

The participants also raised the issue of lack of access to infrastructure and affordability, which can limit connectivity and contribute to the digital divide. The participants cited that the country's 5G readiness is linked to the upper and middle classes, who have access to fibre infrastructure due to their affordability. Lower-class rural citizens still struggle with access to infrastructure because of a lack of affordability, resulting in difficulties in using 3G and 4G technologies, according to participants.

The view from one participant, however, is that South Africa's readiness for 5G technology adoption is attributed to businesses being prepared, but incoherent policy framework management contributes to the country's lack of readiness for consumers. Thus, participants believe the country is not ready for 5G technology adoption.

"No. 5G is a crucial technology for global connectivity, but the government's regulatory approach may be lacking due to high costs, inadequate infrastructure, and underdeveloped areas with connectivity struggles. Businesses are ahead of the curve and ready for 5G technology. However, some areas have underdeveloped infrastructure and regulation, making it difficult to effectively manage and access these areas." (Participant 14).

4.3.5 *Digital Divide*

The participants were asked what their understanding of 5G technology's potential to bridge the digital divide was and if this was a possibility. The task was also to determine if 5G can contribute towards closing the divide.

Twenty-three percent of participants believed 5G technology could bridge the digital divide through eMBB, uRLLC, and mMTC use cases, highlighting its potential benefits. Participants highlighted 5G's potential to bridge the digital divide by using satellites in space to mitigate the infrastructure challenge, enabling consumers in rural areas to connect across a wider range.

C2 General

“The standardization body has developed a solution using satellite communications with 5G technology to cover a wider footprint, similar to DSTV. This technology allows for 5G connectivity in space, enabling a wider range of applications, as specified in the standards.” (Participant 7).

Although participants believed that more studies are needed on the cost per GB concept model, which reduces data production costs, they viewed this as an enabler to bridge the digital divide. Furthermore, it was believed 5G could leverage existing 4G use cases, making it an advantage for the country to bridge the digital divide.

“5G offers lower data production costs, potentially benefiting governments and operators in terms of business case improvements. This could accelerate programs and engagements, while 4G remains a solid technology for most regular use cases. The cost per GB may also be a factor in the adoption of 5G.” (Participant 9).

Participants believed 5G technology could bridge the digital divide, but infrastructure availability is crucial for its success in rural areas with limited infrastructure. As a result, 5G ecosystem stakeholders must address this issue.

“The digital divide bridge will be bridged, but implementation depends on rural areas’ infrastructure. ISP networks provide point-to-multipoint speeds, but households in rural areas may not adopt 5G technology due to concerns about infrastructure.” (Participant 8).

Forty-seven percent of participants disagreed with 5G technology’s potential to bridge the digital divide due to affordability, economic landscape complexities, transmission fibre limitations, and deployment costs. Some participants believed 4G technology was sufficient and capable of bridging the digital divide. One of the participants was sceptical about 5G’s ability to bridge the digital divide due to the country’s economic complexities, challenges and low maturity in fibre footprint and reach, thus limiting access to 5G technology.

C2 General

“5G benefits are high, but concerns arise due to 4G’s economic landscape and maturation in fibre installation. To fully benefit from 4G, it’s essential to adapt to wireless technologies and learn from the country’s fibre installation maturity.” (Participant 3).

“*South Africa’s unique digital divide is evident in its unique 5G phases, starting with eMBB, extending 4G and preparing urban areas for the 5G leg.*” (Participant 12).

Participants emphasised that 5G technology’s potential to bridge the digital divide is unachievable due to high deployment costs, and lack of infrastructure in some regions as a result of prioritizing metros over rural areas. Participants further believed that FWA is a better alternative to manage the digital divide by providing coverage and infrastructure in rural areas. They also argued that the slow response and lack of digitisation implementation from government contribute to the digital divide, and that 5G should not be seen as a game changer to bridge the digital divide, as that could have been achieved with existing 4G technology.

“A study found that FWA and satellite are better ways to manage the divide between poor or disadvantaged communities compared to 5G technology. 5G is expensive due to its dependence on spectrum and transmission infrastructure, while fibre deployment is more cost-effective. Metros are prioritized due to infrastructure issues and insufficient spectrum availability. Bridging the gap between urban and rural areas remains a challenge due to limited transmission medium and microwave limitations. E-band technology can achieve connectivity, but fibre backhaul capacity is needed.” (Participant 2).

“The South African government has been working on a digital agenda for over ten years, and technology has enabled them to tackle challenges. While 5G has a premium over 4G, 4G is suitable for 99 percent of their needs. However, 5G is not expected to be a transformational eureka moment, as governments and regulators can still manipulate 4G.” (Participant 9).

C2 General

Another pain point that was raised by the participants is the lack of affordability of devices. Participants viewed the affordability of access and devices as the real divide rather than the technology. They shared sentiments that technology is not the solution to bridging the digital divide, but that government and regulatory agencies need to ensure that access in terms of affordable coverage is provided. They also indicated that government and regulatory agencies need to make more of the spectrum available to mobile operators to accelerate the 5G rollout.

"It is low to none for me, and I will go back to those drivers that I mentioned: the drivers of participation are that I must have the money to purchase a device; if I do not have the money to purchase the device, I'll go back to that element around inequality. At this stage, with the cost profiles that we have, the impact is potentially going to be low because, for example, if you take a person in a village, why would they opt for a 5G device when a 3G device is available? Affordability will always remain the actual divide, not the technology." (Participant 4).

"5G is a buzzword promoting bridging the digital divide, but it requires collaboration between regulation and government, as well as spectrum use. Government and regulation must work together to provide better, cheaper coverage at lower costs per megahertz and megabit." (Participant 10).

Two of the participants highlighted the challenges of access to devices and digital literacy as contributing factors of the digital divide. Failure by government and the private sector to address these issues will widen the digital divide gap.

"It goes back to technology. You know the technology can be there readily available for us to use, but if the people are not educated and we must bear in mind that people will not always gladly accept this education. It is something that needs to be done repeatedly until people get the hang of it. I think for this to bridge the digital divide, people must be able to play around with gadgets. So only when people are exposed to these things, can use them, [and] have people to ask about them, only then we can say we're going to bridge the digital divide because if 5G

C2 General

is there and no one is able to use it except people in the cities, it will not do that. It boils down to education; people must be exposed to these things, be able to play with it, understand the benefits of it." (Participant 1).

"The potential for a high-quality product lies in addressing access, providing it at the right price, and implementing support mechanisms. If we continue the wrong path, where access is expensive but accessible to affluent areas, the divide will widen. To address this, it is crucial to ensure that spatially deprived areas and low-income groups can access the product at the right price, thereby diminishing the divide." (Participant 14).

4.4 Results Pertaining to Proposition 2: The implementation of 5G technology is a crucial step towards a more equitable digital future for South African consumers and citizens.

The second proposition was aimed at understanding whether and how 5G can be a catalyst and an enabler of the achievement of digital inclusion for South African consumers and businesses. The questions posed to the participants sought to get an understanding of (1) the impact of the 5G technology on consumers; (2) the impact of the 5G technology on businesses; and (3) the impact of the 5G technology on different industries and sectors.

Themes that emerged from the interviews with the participants were as follows:

i. Customer experience
    a. Consumers
    b. Enterprises
ii. Industry beneficiaries of the 5G technology

4.4.1 *Customer Experience*

Consumers

C2 General

The participants were asked to describe benefits of the 5G technology and whether the benefits have the capability to improve and enhance consumers' lives. Participants indicated that the 5G technology offers higher bandwidth speeds, low latency, enhanced capacity, improved reliability, convenience and seamless applications and uninterrupted connectivity.

"5G technology enables mobile big data transfer, enabling easy access, download, and sharing of content, faster communication, remote access, and improved user experience through faster remote tasks." (Participant 8).

Participants highlighted the importance of remote access to technology, particularly in education, for improving learners' lives, driving digital literacy, and creating jobs. They believed that 5G technology could contribute to achieving UN SDG 4's inclusive and equitable quality education.

"*5G enhances life through social media, mainstream TV, newspapers, schools, and universities. It supports IT services in the Internet of Things, enabling underserved communities to benefit from smart meters and IoT. EMMB offers a wide channel for tele education, transferring digital skills and knowledge, improving employment opportunities for youth and the digitally excluded. Accelerated 5G capacity brings wide channels to the marketplace, ensuring access to the latest skills and opportunities in today's global village."* (Participant 7).

"*Schools and government institutions have free or some form of internet access, and 5G could potentially provide remote learning. OEM "X" investigated this with a mobile operator, developing training for children in remote locations. 5G is a significant factor in supporting learning, as it can facilitate remote learning and enhance educational experiences*." (Participant 10).

"*5G ubiquitous coverage in rural and urban South Africa has the potential to improve education access by enabling eLearning from any household, extending the chance of improving education opportunities.*" (Participant 12).

C2 General

One of the participants, however, noted that 5G can improve e-learning, but the social economy is unbalanced. Disadvantaged learners struggle with food and shelter; this leads them to deprioritising tablets and laptops. While e-learning is important, it loses importance if psychological demands are not addressed.

"*Access to medicines and e-learning is crucial for everyday citizens, especially in remote areas facing social economic challenges. However, if psychological needs aren't met, e-learning becomes secondary, leading to unbalanced social economy. Wealthy institutions embrace e-learning due to students' importance.*" (Participant 14).

Participants believed that the 5G technology would improve access for consumers, particularly in rural areas, thus addressing their economic and social challenges. However, one participant stated that urban areas would benefit the most from 5G, whereas rural areas would benefit from 4G's capabilities and speeds because of their unique socioeconomic needs. The participants' responses indicated that the underserved communities in rural areas would mostly benefit from either 4G or 5G services.

"*Consumers benefit from technology that enables home monitoring, security, and access to live camera feeds. This technology can improve education efficiencies and provide intellectual benefits. In South Africa, SA Connect offers broadband services to rural areas, providing fixed mobile infrastructure for schools and clinics. Implementing 5G in rural areas would provide similar benefits to urban areas."* (Participant 11).

"*From a consumer perspective, 4G connectivity remains viable for affluent high-end markets, and it meets basic connectivity needs in villages. There is no need for 5G deployment in these areas, and the basic connectivity of 4G remains sufficient."* (Participant 4).

One of the participants highlighted that the 5G technology and the SA Broadband project would benefit consumers in urban and rural communities equally,

C2 General

provided it is deployed on a fixed mobile broadband platform. The three 5G use cases (eMBB, uRLLC, and mMTC) offer potential service delivery benefits through IoT, including smart metering. The participant further stated that this enables underserved communities to monitor and use essential services such as water and electricity, transforming their households into smart homes.

"*5G offers faster download and upload speeds, potentially reaching up to 10 Gbps, enabling seamless streaming, quick downloads, and faster browsing experiences. This low latency enables real-time interactions, making online gaming, video conferencing, and remote control more responsive and immersive. 5G enhances capacity and reliability, benefiting critical applications like autonomous vehicles, remote healthcare monitoring, and industrial automation*." (Participant 6).

Enterprises

The participants were asked to share their views on whether the 5G technology has the ability and capability to reshape future business in South Africa. They were requested to provide views on enterprises and SMEs, to ascertain the real impact and value, if any, of the 5G technology in conducting business in the 4IR era in South Africa.

Most of the participants indicated that the 5G technology has the capability and enables revolutionization of how business operations are conducted to better serve customers by adding process efficiencies to daily operations and reducing operational overheads.

"5G provides reliable connectivity and high throughput speed, enabling faster service to customers. ISP providers can use network slicing to provide varying service quality, allowing flexibility and a customer-centric approach to service and products." (Participant 2).

C2 General

"Fashion gurus require access to clients through various business models, such as online platforms and factory-based designs. However, input costs and exchange of goods are crucial, especially when sourcing raw materials from other countries. Chromium, a mineral in Asia, is a significant concern for laptop manufacturing. 5G technology enables component creation from other countries, enabling customization, assembly, and product completion within that country. These factors impact business models, access, communication, reach, and revenue acquisition." (Participant 14).

Participants indicated that 5G is a facilitator of communication, especially for SMEs. With 5G-capable smartphones, meetings can be conducted anywhere and anytime ensuring business continuity regardless of geographical location at high download and upload rates. Furthermore, one of the participants indicated that 5G technologies enable companies to work remotely, by providing specialist data analysts and cybersecurity capabilities, which are scarce skills in South Africa and can put the country on the competitive map. Remote work enables OPEX savings, travelling expenses, providing convenience through remote collaboration, and benefiting even major corporations operationally in the new ways of working.

"5G enables SMEs to communicate easily, hold remote meetings with high download and upload speeds, thereby save on OPEX costs." (Participant 1).

"SME faces challenges in business costs, but 5G technology can help by eliminating office expenses and enabling remote working and virtual collaboration. It also allows for effective allocation of funds in other business cases. 5G can also optimize farming value chains using smart meters, sensors, and IBM Watson technology, offering higher bandwidth, lower latencies, and connectivity, making it suitable for small farm operations." (Participant 7).

"ISPs can provide indoor coverage solutions for office and manufacturing using 5G's macro-based open spectrum. This ensures better security and densification

C2 General

of Wi-Fi access points, making it suitable for SMEs. Solutions can be plugged into home or office routers." (Participant 10).

"South Africa is increasingly utilizing 5G technology, such as artificial intelligence, to offer specialized data analysts and cybersecurity skills offshore. This enables companies to operate from dormitories and garages, impacting country management and global competition. Unrestricted connectivity allows AI deployment in various spaces, enhancing the country's operations and competitiveness." (Participant 12).

Participants added that 5G access improves small enterprises' management, efficiency, and cost reduction, enabling them to contribute to the telecoms industry and establish specific industries.

"Small businesses can benefit from good internet service, improving efficiency and cost savings. Operators can play a crucial role in the telecommunications sector, with some mobile operators devolving to small players through shared infrastructure. Big companies can create entities for specific sectors, such as remote mines, to better serve their networks. Stable internet ensures enterprise survival and better outcomes for those who participate." (Participant 13).

One of the participants emphasized that 5G can significantly benefit entertainment and media enterprises due to its high-speed, low-latency connections, which enable seamless content streaming, immersive AR/VR experiences, and interactive gaming, thereby transforming the industry and generating revenue.

"5G offers high-speed, low-latency connections for media and entertainment industries, enabling seamless content streaming, immersive AR/VR experiences, interactive gaming, and new forms of media and entertainment, including live event broadcasting and enhanced user engagement." (Participant 6).

C2 General

It was, however, argued by one of the participants that the 5G technology is not a game changer in densely populated urban areas with large enterprises and SMEs, as urban areas would receive priority hotspots and high-capacity use. Instead, 5G should be seen as an alternative for resilience and redundancy.

"5G coverage has significant potential for large enterprises and small and medium-sized enterprises in dense urban areas. It offers an alternative to traditional fixed lines for high-capacity requirements, but its impact on the future of business is uncertain. The low-latency applications suggest a shift in efficiencies, especially in multinationals and the motor industry. Network as a service offers customized solutions, but its impact on high-capacity use cases is less significant. 5G should be seen as a resiliency solution rather than a game changer." (Participant 4).

4.4.2 *Industry Beneficiaries of the 5G Technology*

When the participants were asked about industries that would benefit the most from 5G, they provided multiple responses. The common notions were centred around telecommunication, mining, manufacturing, agriculture and health industries as the major beneficiaries of the 5G technology, and this was mostly associated with 5G benefits such as automation, robotics, IoT, and machine communications that provide efficiencies within these industries.

Thirty-six percent of the shared the view that the telecommunications industry would benefit the most from 5G technology, as it drives innovation and development. Participants highlighted COVID-19 as a stepping stone for this industry as accelerated data traffic growth was experienced, necessitating industry upgrades to prepare for remote living and support new business models. This was due to increased data traffic from consumers working and learning from home.

C2 General

“Telecommunication companies like Vodacom, MTN, and Telkom experienced significant traffic growth and technological utilization during lockdown, becoming the beneficiaries of 5G. This increased dependency on remote work enabled the use of internet connectivity, benefiting various industries like manufacturing, agriculture, retail, and mining.” (Participant 1).

“To be honest, anyone can benefit but mostly telecommunications, first of all because they are the carrier of that technology, they will benefit a lot.” (Participant 8).

Participants believed that the telecommunications industry has evolved into technological organizations, offering various services to customers. 5G technology has improved by enabling faster byte production, reduced data production time, and maximizing data monetisation potential, according to participants. This transformation has enabled the industry to provide more efficient services.

“Top one is the obvious one, it is the Telecoms industry, obviously that is where we have the higher monetization potential.” (Participant 4).

“The first one is telecommunications industry. The telecommunications industry is transforming due to faster byte manufacturing in 5G. Vodacom can now transform from a telecommunications company to a Techno, supporting various services on its platform, because we have evolved the call.” (Participant 7).

Twenty-nine percent of the participants agreed that the mining industry in South Africa is expected to benefit from 5G technology, as it can improve communication services, reduce latency, automate robots, and ensure health and safety compliance. Participants added that the technology also offers massive IoT and private networks for reliable mining operations. It can also transform traditional mines into smart mines, enhancing equipment deployment and modernizing miners.

C2 General

“South Africa’s advanced mining sector offers potential for digitalization, particularly in communication services. 5G technology can improve low latency, real-time information, and efficient robot automation. The industry’s transformation in digitalization and IoT is significant, with 5G providing massive IoT, ensuring connectedness in all aspects of the economy.” (Participant 1).

“I think mining in South Africa could benefit significantly from the widespread availability of 5G technology. This technology could improve equipment deployment through robotics and modernize minors into digitally literate, digitally inclined individuals.” (Participant 12).

Participants highlighted that the mining industry needs digitalisation and the 5G technology to ensure health and safety for its staff. Digitisation of mines can improve operational efficiency, reduce health and safety incidents and fatality, and alert workers to potential safety risks.

“As an OEM involved in mining, we have seen that it involves efficiency, health, and safety, requiring connectivity. In most of these environments, there are already excellent systems in place and while these existing systems collect data and analytics, they lack reliable networks for operations. Private networks provide a reliable solution.” (Participant 10).

“Mining activities require health and safety measures, such as personal detection systems for miners and staff. These systems can be worn by truck drivers or remotely, ensuring safety and monitoring personnel. Digitizing operations can offer numerous advantages, particularly with 5G technology. Mines can be divided into zones, with red zones designated for red employees. Alarms can alert workers of potential safety risks and prompt them to return to their assigned working area if they move onto a different colour zone. These applications are crucial for operational and health and safety efficiencies in the mining industry.” (Participant 11).

C2 General

Thirty-six percent of the participants expressed that the manufacturing industry is also a beneficiary of the 5G technology. Participants indicated that the that 5G technology will significantly enhance manufacturing by reducing manual labour through robotics enablement, automating processes, and predicting maintenance through real-time data analysis, leading to smart factories.

"I think 5G technology will significantly improve manufacturing by enabling robots to be timed, allowing for better production rate and reducing manual labour." (Participant 1).

"5G enables the implementation of smart factories and Industry 4.0 concepts. It connects sensors, machines, and robots, enabling real-time data collection, analysis, and decision-making, resulting in improved efficiency, predictive maintenance, and automation in manufacturing processes." (Participant 6).

Some of the participants indicated that the manufacturing sector needs to undergo a significant transformation with the introduction of smart sensors and 5G technology, which will enable real-time manufacturing process optimization, control, and monitoring, improving operational visibility and operational efficiency.

"Manufacturing for me is key, and the industry must redo plans with 5G in place. Industrial Internet of Things projects leveraging the web can benefit manufacturing, but readiness is crucial." (Participant 13).

"Manufacturing and industrial automation industries in South Africa will be transformed with smart sensors, utilizing 5G for massive machine-type communications." (Participant 7).

One of the participants believed that the 5G technology could improve manufacturing productivity and economies of scale in fashion design by enabling digital design, production, and distribution without fabric costs, thereby reducing operational costs, and increasing access to potential customers both locally and internationally.

C2 General

“I am in manufacturing and on a day-to-day basis I’m boggled down with how I improve manufacturing and productivity within these industries. 5G technology could be beneficial for fashion design, as it will allow for digital design, production, digital fashion show, and distribution before input costs are considered. This approach can lead to increased demand for products without incurring fabric costs. I believe that all industries can benefit from 5G technology in these manufacturing areas.” (Participant 14).

Fourteen percent of the participants were of the view that the agriculture industry is a beneficiary of the 5G technology. They highlighted that the 5G technology will transform the agriculture industry into smart agriculture and smart farming through machine learning and IoT to provide optimisation and efficiencies in soil and plant operations.

“Agriculture is the industry that you will see benefiting from smart agriculture and smart farming, where machine learning is applied over the 5G network. This technology uses smart sensors to capture soil parameters, allowing for optimal planting and yield optimisation using supervised learning, unsupervised learning, and reinforcement learning. This shift will also involve using models and sensors in the atmosphere to predict droughts and plant, accordingly, ensuring food security during periods of drought.” (Participant 7).

One of the participants indicated that 5G technology can significantly benefit farmers by enhancing farm management, reducing input costs, maximizing yields, and accessing new export markets. Despite rising oil and fuel prices, this can ensure long-term financial success for farming enterprises.

“Agriculture will benefit from 5G. The increasing cost of oil and diesel in the Free State province makes it difficult for farmers to sustain large farms. 5G can therefore, help harness drones as a potential solution, providing access to markets and enabling better exportable produce. This could help farmers sustain their operations and reduce input costs.” (Participant 12).

C2 General

Fourteen percent of the participants believed that the health industry is one of the beneficiaries of the 5G technology. 5G revolutionises health care by enabling high-speed, low-latency connections for real-time consultations, telemedicine, patient monitoring, and data exchange and by supporting advanced technologies, thereby improving medical service interaction between patients and medical staff, according to one of the participants. One of the participants also shared similar sentiments in that improvements in machine-learning-driven medicine are transforming health care and telemedicine, enabling remote doctors to operate on patients remotely and offer accurate medical treatment, resulting in reduced travel costs for patients. This technology also affects medical education.

"The healthcare industry can leverage 5G to transform patient care and improve medical services. 5G can revolutionize healthcare by enabling high-speed, low-latency connections for real-time remote consultations, telemedicine, patient monitoring, and data exchange. It supports advanced technologies like robotic surgery, AI-assisted diagnostics, and virtual reality applications for therapy and training." (Participant 6).

"Healthcare and telemedicine are transforming due to the advancements in machine-learning-driven medicine. Remote doctors can operate on patients in different locations, eliminating the need for physical doctors. Sensors on the body can program machine learning algorithms to accurately determine the appropriate medication for treatment. This technology is also impacting medicine education, with applications in medicine education emerging. Traditional brick-and-mortar systems will coexist, but the virtual environment, with enough bandwidth on the 5G EMMB portion, is expected to take off more." (Participant 7).

One of the participants noted that South Africa has some of the best surgeons in the world, and 5G, with its ultra-low latency, can enable South African surgeons to conduct remote surgery for patients on other continents, enhancing the country's global standing in medical surgery.

C2 General

“I think you have potential in medicine as well. South Africa is extremely good with surgeons globally, and that is something that the medicine industry can benefit from. 5G, with its ultra-low latency, is allowing them to provide healthcare.” (Participant 9).

4.5 Results Pertaining to Proposition 3: 5G Will Improve and Enhance Service Delivery in Multiple Sectors in South Africa

The third proposition sought to understand and explore whether 5G will improve and enhance service delivery across all facets of different sectors and industries. This exploration included an understanding of the role of the key stakeholders in the 5G ecosystem and the impact they have on the achievement of service delivery through the 5G technology.

This task focused on understanding the meaning of the 5G technology to its consumers. Themes that emerged from this section were as follows:

a) Benefits of the 5G technology

b) Service delivery

c) Policy and regulatory intervention

d) 5G Acceleration

4.5.1 *Benefits of the 5G technology*

The participants were requested to provide their views on benefits that the 5G technology can introduce. This was to gather an understanding of how 5G benefits can contribute to service delivery in the business and government contexts.

C2 General

The participants highlighted the three 5G technology use cases, namely, eMBB, mMTC and uRLLC, that usher in technological advancements and transformations that can benefit how consumers and businesses can operate efficiently. They added that 5G provides convenience and intelligence in terms of harnessing and monetising data, especially in a sector like mining.

"The focus has been on improving broadband in LTE, 3G, and other technologies. 5G now employs three legs, focusing on broadband improvement, mMTC, IoT, industrial IoT, and uRLLC applications. This modular architecture addresses latency-sensitive applications like driverless cars and transmission latency in IoT. The architecture is modular and enables a more efficient and reliable internet connection." (Participant 13).

"Discussions are ongoing where mobile operators are exploring 5G-based private networks for big data volume in mines, enabling live communication and remote monitoring of operations. This technology enables remote monitoring and access to remote areas for better data management." (Participant 9).

"What we have done in In China and near Rustenburg, is that yellow plant equipment dump trucks are now controlled remotely from an office complex. This improves working conditions and efficiency, as drivers can focus on tasks more effectively and become more motivated. This innovative approach has been shown to improve overall productivity and efficiency in the mining industry." (Participant 11).

One of the participants included the capability of the 5G technology to provide more capacity and the technology's distinct features of being standalone and tapping into sub-6 GHz and above-6 GHz bands, in contrast to the previous mobile generations. This according to the participant, brings about innovation and introduce immense opportunities as, for example, autonomous vehicles and smart cities are now possible.

C2 General

"5G offers two main flavours, non-standalone deployment over existing 4G, which allows signalling to flow over 4G, and complete standalone deployment as the network evolves. It is the first mobile standard to use frequency bands in both sub 6GHz and above 6GHz and can operate in millimetre wave bands. This transformative technology enables autonomous vehicles, smart cities, and industrial revolution era advancements in the mobile domain." (Participant 8).

One of the participants indicated that the main benefit of the 5G technology is its potential to access the abundance of spectrum available because it is able to access the C band with a bandwidth of 800 MHz available for mobile operators to utilise. The participants noted that this ability has never been achieved by 3G and 4G technologies collectively. Other benefits such as the lower cost per GB with the 5G technology and the enablement of IoT, allows people and devices to be connected.

"5G is pushed onto the 3.5 C-band, offering a total bandwidth of 800MHz, providing operators with access to new spectrum in large quantities. It is specified on existing bands like low, mid, and 4G bands, as well as the C-band. 5G offers a lower cost per GB and provides the first technology to achieve massive IoT, as everything connected must be connected. This technology is crucial for industries and the concept of massive IoT, as everything connected must be connected." (Participant 10).

4.5.2 *Service Delivery*

The participants were asked about whether the 5G technology can enhance e-government to enable government departments to provide an efficient and satisfactory service to its citizens.

Participants highlighted that 5G technology, when combined with robots, sensors, and machine learning, enhances connectivity, real-time data analysis, resource management, and digital transformation, thereby enhancing service delivery in

C2 General

rural and underprivileged areas. Participants further noted that by leveraging off 5G technology, government could ensure access to essential services, development opportunities, and government engagement for underserved communities.

"Government can leverage off 5G and use robotics, sensors, and machine learning to engage with remote areas and disadvantaged communities, enabling them to reach out and engage with disadvantaged communities." (Participant 3).

"5G technology has the potential to enhance speed and execution in service delivery. For instance, municipalities can now send bills electronically via email or through portals, reducing paper usage and allowing users to pay bills directly from their devices. This shift in communication and payment methods highlights the potential of 5G to improve service delivery." (Participant 5).

Some of the participants expressed that digital transformation of government services can offer convenience and efficiency, enabling efficient implementation of online services for energy, waste disposal, and security in rural areas, whereas smart cities could offer improved security and crime prevention. The participants indicated that focusing on infrastructure and connectivity for 5G technology can improve service delivery and create an inclusive governance structure.

"I think the entire government's services need to go online. They have done a very good job with things like SARS; using self-service is so convenient. But we have got to then roll that out to other services as well, government itself internal with company policies, need to start internally by rolling out services that enable their staff to do that, and ensure that connectivity is there before they can even consider using 5G to enhance service delivery." (Participant 13).

"5G-enabled technology will enhance government operations by delivering real-time information to help cities become smarter and more efficient. This translates into better traffic management and public safety systems, stronger security and streamlined supply chain logistics at shipping ports." (Participant 7).

C2 General

"E-government services could reduce business costs for citizens and government departments, especially in rural areas where travel is costly. This could lead to more efficient energy, waste disposal, and connected gadgets, improving security and crime prevention. The President discussed the potential of smart cities, which could lead to more efficient energy, waste disposal, and improved security in urban areas and primal spots." (Participant 8).

4.5.3 *Policy and regulatory intervention*

Participants were asked to explore interventions required from government and regulatory authorities to accelerate 5G deployment to enable readiness and adoption of the 5G technology, in consideration of the challenges that they had shared. The interventions sought to address the lack of infrastructure, affordability and access to infrastructure and devices that may hinder consumers and businesses from benefiting from the 5G technology.

Participants emphasized the need for thorough preparation, efficient policy-making, and public sector coordination. Participants also highlighted the government's need for proactive implementation, prioritizing industrial development and 5G networks. One of the participants also noted the issue of the government's slow implementation pace, which may be attributed to the age of its officials and their lack of technical expertise. This requires a revision of the appointment process for government officials as well as staff upskilling.

"The government must prioritize coordination, cooperation, and core implementation in industrial development and 5G networks. Agility is crucial for responding to current needs. The Presidency is working with the Department of Communications and Digital Technologies to address policy limitations, as the time frame for policy implementation between 2G and 5G is less than five years. Policies within the department take at least three years to finalize, making it essentially difficult and impossible for the government to adapt to global market changes." (Participant 14).

C2 General

"The government needs to reshuffle and bring younger, fresher talent into the government. The pension-age generation is the generation for whom sitting on things makes sense, and their speed at which things need to happen is crucial. The local broadcaster's transition from analogue to digital to free up 700 MHz spectrum took six times the anticipated period, indicating a significant gap in government. The spectrum, despite being auctioned at an expensive price, served as a period of entry for consumers, reducing barriers to entry and encouraging competition, ultimately benefiting the consumer through reduced competition, and the government needs to rework its policies to ensure consumer benefits." (Participant 3).

One of the participants highlighted that political paradigm shifts are necessary in addressing regulatory frameworks that impede the adoption and deployment of innovative technologies. The participant further added that to facilitate the use of technology, government workers should be trained and equipped with the necessary digital skills.

"The public sector's skills may hinder the adoption of 5G and 4th generation technology, and the government must recruit, retain, and upskill its internal capacity to create an enabling environment. Challenges include finding domain experts in the public sector, as government policy is often vendor-driven, and the government process and inaccessibility to innovation hinder innovation. Three tripartite solutions are needed to enable the adoption of 5G." (Participant 12).

Participants highlighted the importance of collaboration among regulators, government, and operators in establishing sound spectrum and policy rules. This will enable mobile operators, especially small ones, to benefit from Radio Access Network (RAN) active sharing and WOAN models, which encourage innovation, investment, fair competition, and market entry according to participants. They believed that this would enable more spectrum for 5G networks, improve connectivity, and benefit rural regions, bridging the digital divide.

C2 General

“Having a sound spectrum policy is a must. When it comes to rural communities, promoting low-band spectrum (1 GHz) for IMT services would be super helpful. The propagation on low bands is much better than mid bands, therefore making it attractive for the mobile industry as it can reduce the number of sites needed, especially in rural areas.” (Participant 10).

“Telcos must quickly access the auctioned spectrum, and the government must take aggressive initiatives like digital migration to free up more spectrum. A regulatory legal regime is essential for public sector intervention and 5G deployment, ensuring investor accessibility and competition. Legislative measures should also be implemented to create a competitive environment.” (Participant 12).

“The current passive sharing of land and electricity involves companies investing in infrastructure. Technological advancements can improve service quality and reduce capital outlay. Policies and regulation are crucial for RAN sharing, as operators have their own spectrum. A model allowing small players to operate on their own spectrum could lead to social and economic development and job creation.” (Participant 13).

Some of the participants suggested the banning of 2G/3G devices from the market to promote efficiency and technological advancement and refarming spectrum for 5G usage. Participants further suggested that government and regulatory should offer reduced import taxes for 4G and 5G-capable devices and tax incentives to mobile operators and OEMs to accelerate 5G deployment and adoption of 5G technology, promoting industry growth.

“South Africa, part of region 1, requires regulators to comply with the World Radio Conference’s standardization of spectrum every four years. This ensures the availability of spectrum in accordance with the country’s region. The government has been pushing for reduced import taxes on devices and incentivizing higher technologies like 5G and 4G. However, these measures have not yet been

C2 General

implemented. OEMs, government, and institutions are discussing the sunset of older technologies like 2G and 3G due to their inefficiency. 2G is expected to stay longer due to tracking devices and payment points, while 3G may sunset earlier. OEMs are pushing for a ban on introducing 2G-only devices requiring 4G capability, which ICASA is expected to implement. However, import restrictions are uncertain if implemented this year. Blocking devices and declaring imports illegal for 2G-only devices could initiate the sunset of these devices and technology, crucial for industry growth." (Participant 11).

"The government should expedite the removal of 2G devices from the market to address low-cost devices, making it difficult to refarm for 5G. Regulatory policy, which was expected in March 2023, could help with this. Incentives, such as tax breaks or financial incentives, could encourage mobile operators to deploy 5G in profitable areas, aiding in 5G adoption and development. This would help mobile operators deploy 5G faster and contribute to industry growth." (Participant 7).

Participants raised the matter of the government exploring how unemployment and inequality can be addressed, as these aspects converge with technological elements. Participants indicated that government could reduce device costs—by providing financial assistance, collaborating with the private sector, and addressing unemployment and socio-economic factors—to increase affordability and enable wider access to devices and data. Furthermore, government should create a supportive environment for SMEs, by offering training, incentives, and fostering innovation to promote economic growth and a more inclusive society.

"To encourage consumers to use technology and ensure proper coverage, it is essential to provide affordable devices. Fixed wireless technology complements fixed networks, while 5G technology extends connectivity. Ensuring fair subsidies for device access is crucial. The government should act as a strategic partner with the private sector to ensure proper connectivity and consumer service partnerships. Expensive technology can lead to high costs and perpetuate the

C2 General

social divide. Government intervention and private sector collaboration are crucial for equitable access to technology." (Participant 2).

"Device cost is a potential barrier to entry into a network, as it can limit the potential for revenue. Without consumers with devices, there is no money to be made, and SME segments may struggle to access data. Governments should focus on active solutions to address unemployment and equality, focusing on socio-economic factors. A society that can participate in the network will have better affordability of devices and data, ensuring that participants and network users can access the network effectively." (Participant 5).

4.5.4 *5G Acceleration*

To understand how the challenges of the 5G technology and acceleration of 5G deployment can be mitigated and achieved, the participants were asked to provide views on how government and mobile operators can assist with promoting 5G for quicker adoption.

Fifty percent of the participants emphasized the importance of government, private sector, and mobile network operators in promoting and deploying 5G technology, with education also being deemed crucial for promoting awareness and adoption through these partnerships. Some of the participants highlighted the importance of ads, pamphlets, and educational programs for younger generations in communication, aiming to boost awareness, engagement, and technology adoption, promoting a transformational journey.

"I read an article on LinkedIn which alluded to Vodacom partnering with a company to install Wi-Fi devices on taxis, allowing people to access information while commuting. This initiative promotes awareness of advanced technologies like 5G and submarine, enabling people to access information and make informed decisions. Ads and pamphlets could also be placed in the taxis to increase awareness." (Participant 1).

C2 General

“I think Educational programs for the younger generation are crucial for communication, engagement, and promoting technology adoption. By providing early access to these technologies, they can engage with elders, make the community aware, and lead to a transformational journey.” (Participant 2).

Participants emphasized the need for the South African government and telecommunications sector to provide affordable 5G devices to address the digital divide caused by device affordability and digital illiteracy. The availability of affordable 5G devices is a significant factor in promoting digital inclusivity and facilitating the swift adoption of 5G technology. Participants suggested that the private and public sectors should actively educate consumers about 5G technology, promoting digital literacy through early access and educational programs in schools and communities, which can lead to job creation and early access to the technology.

“In an economically mature country, low-cost devices and educational programs are essential for promoting digital era access for all age groups. Partnerships between private and public sectors are crucial for educating consumers about 5G technology. Schools provide early access, while partnerships with communities spread information and help people understand its benefits. By partnering with communities, we can better understand the potential of 5G and its benefits.” (Participant 3)

“The best programme would be one that creates jobs. People will be able to buy better phones if more employment are created.” (Participant 7)

The majority of participants agreed that forming partnerships between the government and private sectors for 5G deployment could boost access, streamline policies, improve service delivery, and accelerate the achievement of ITA goals in underserved areas. Furthermore, participants emphasized the need for concerted efforts and active participation from the private sector and research councils to accelerate broadband connectivity access and achieve the

C2 General

Broadband Policy goal of providing 100 percent universal broadband access to South African citizens.

"Partnering with the government on 5G deployment projects can increase penetration in underserved areas. Private and public partnerships can streamline policy and expedite the process, reducing the time needed to reach the ITA point." (Participant 8).

"What the government should do is try to create partnerships. To look at the ecosystem and to look at technology as an economic driver. The moment you expand the range of that conversation, you start looking at possibilities, which can make everything kick." (Participant 9).

"Collaboration is important for ensuring infrastructure and other services are accessible to all. Companies, as businesses, often have a low return on investment, but a concerted effort between private companies, the government, and public services is necessary. SA Connect aims to do this, but it requires the involvement of the private sector and research councils to tap into both markets and ensure people have access to the necessary resources. Collaboration is essential for achieving a more equitable and efficient infrastructure rollout." (Participant 13).

C2 General

CHAPTER 5. DISCUSSION OF THE FINDINGS

5.1 Introduction

This chapter describes key findings that emerged from Chapter 4 in relation to the literature review conducted in this study. The aim of the study is to explore the 5G technology's potential to bridge the digital divide and socioeconomic impact on consumers. The findings are described and interpreted in accordance with the three research objectives that were provided in Chapter 1. The aim of this chapter is to ascertain and confirm whether findings from the interviews conducted with the participants met the research objectives:

1. Research Objective 1: to investigate the 5G technology's potential to bridge the digital divide in South Africa in accordance with ICT policy/regulatory frameworks
2. Research Objective 2: to investigate the socio-economic impact of 5G on the drive of South African consumers and citizens to embrace digital inclusion; and
3. Research Objective 3: to investigate the 5G technology's potential to assist with service delivery in South Africa.

5.2 Discussion of Objective 1: To Investigate 5G Technology's Potential to Bridge the Digital Divide in South Africa in Accordance with ICT Policy/Regulatory Frameworks

5.2.1 *Technology Evolution*

The mobile industry has revolutionised society over the last 30 years through the development of four or five technology generations, including the 1G, 2G, 3G, and 4G networking technologies (Attaran, 2021). Voice was extensively

C2 General

emphasised in the core circuit-switched network design of older mobile technologies, including 1G, 2G, and 3G technologies (GSMA, 2022). 3G brought higher data transfer speeds and, thus, services such as video calling and mobile TV (Kaur, 2012). Broadband internet access and media downloads and uploads are only a handful of services made possible by the 3G technology. 3G technology also used Wi-Fi networks, although the network's user density had a significant impact on its performance; therefore, users in dense areas would not necessarily benefit fully from this (Chukwuere and Pilatso, 2022).

The major 4G technology, long-term evolution (LTE), is the first network to bypass circuit switching altogether, for data only (Kaur, 2012). The mobile telecommunications requirements of the IoT cannot be met by the current 4G and 4G LTE networks (Attaran, 2021). As an evolutionary technology, 5G accomplishes all the tasks that 4G did, with the potential to do even more on a much larger scale: incredibly high download speeds, higher reliability, and extremely low latency (GSMA, 2022). 5G will first function alongside 4G networks that are currently in place. When it reaches maturity, it should have fully achieved a standalone mode (Rahman et al., 2021). However, although 5G offers superior performance over 4G, the two network generations will likely coexist comfortably until the 2030s (GSMA, 2022). It is evident that the increasing bandwidth requirements and exponential population growth require the evolution of mobile technology to reach higher data speeds, overcome business challenges, and meet growing simultaneous connection demands in this digital era. The growing connection demands result in a positive impact on economic growth and contribute to GDP.

Industry stakeholders have expressed the opinion that 5G is not only the next generation of mobile technology but also a new strategy for converged communication systems that utilise the hardware, software, and spectrum resources more effectively in their networks to enable better and new services and applications for consumers and businesses (OECD, 2019). Accelerating

C2 General

change due to frontier technologies, digitalisation, and innovation affects the speed of technology development. The development of new, more powerful generations of technology can occur rapidly with each technological advancement. Because each generation of technology improves upon the previous one, new technology gets developed more quickly. Incremental innovations are gradual enhancements to already-existing products and procedures. Constant improvements in technological productivity, efficiency, and process accuracy, as well as routine modifications of products to improve quality or lower prices or broaden their range of applications, are distinguishing characteristics of the evolutionary dynamics of any individual technology (Perez, 2004).

Mobile broadband is observed as having evolved over time, ushering in new technologies that have shaped the lives of society and business operations. Findings from the interviews indicate that the evolution from 3G, 4G, and 5G technologies in terms of the differentiating characteristics of speed, capacity, capabilities, and network architecture has brought incremental innovation, technological disruptions, and radical improvements in a positive way. These generations of technologies have leveraged each other as they evolved and introduced enhancements that have thus resulted in increased productivity and efficiencies for consumers and industries. Participant 10 stated that the concept and protocols used for the generation technologies remain the same, despite the improvements and enhancements that have taken place over time. It is thus understood that these mobile technologies will coexist as they are superimposed and introduced to improve and bridge their predecessors' deficiencies and gaps to fulfil evolving and ever-growing capacity and data demands.

5.2.2 *5G Capabilities*

In the 4IR era, 5G is swiftly taking shape as a major enabler of a future technology-driven world. The 5G technology was created to be more effective

C2 General

than its predecessors in addressing the expanding data and connectivity needs of contemporary civilisation (Delport, 2020). 5G is aimed at introducing a major transformation in communication network architectures through its transition to cloud-native networks. This transformation will enable new, unique service capabilities that will drive the development of innovative applications (Solazabal et al., 2018). Although 5G is an extension of the 4G and 4G LTE networks, it comes with an entirely new network architecture and functions such as virtualisation, which offer more than just impressively high data rates (Attaran, 2021). In comparison to 4G and earlier generations, 5G is anticipated to considerably boost mobile network capacity, enabling more users to connect to the network than ever before (Kliks et al., 2018). 5G can enable new and existing technologies, such as artificial intelligence (AI) and the IoT, to have a transformative impact on business processes, thus helping drive productivity and efficiency (ICASA, 2021). It is clear from the participants' responses that they understand 5G technology to be transformative, surpassing previous generations in terms of the capabilities and enhanced and improved services it provides to improve efficiencies for consumers and industries.

The 5G broadband wireless network could mark a paradigm shift because it is the first to be designed with IoT in mind; it is anticipated that there will be billions of linked devices and that various IoT applications will have differing capacity needs (OECD, 2019). However, 5G mobile communication networks would need a significant paradigm shift to meet the rising need for higher data speeds, reduced network latencies, better energy efficiency, and a reliable, omnipresent connection (Akyildiz, 2016). Participant 15 expressed that 5G technology is a paradigm shift and an advancement of other mobile generations through a different architecture and design capable of enabling new use cases. 5G is a development in mobile technology and will improve broadband capabilities across all facets of digital economies and societies since mobile networks may be considered as augmentations of fixed networks (OECD, 2019). It is evident that the key enablers of 5G can unlock an array of new possibilities for various

C2 General

applications and industries because 5G has higher data speeds, coverage, and capacity and lower latency benefits. Participant 8 indicated that through its ultra-low latency, ultra-high speeds, and massive machine-type communications capabilities, 5G takes us a leap forward where humans can connect to “things” and where everything that must be connected must be connected. The era of smart gadgets connected to the IoT offers consumers enhanced productivity at home. Connected devices, such as smartphones, can allow consumers to regulate their homes’ electricity consumption using machine learning, resulting in better control of utility bills. This technology enhances productivity and efficiency in the home, ultimately transforming it into a smart home. It can be deduced from the interview findings that, based on the key enablers of 5G, the technology’s ability to introduce the three use cases and to tap into a wider range of higher and lower frequency bands to enable spectral efficiency indicates enormous capabilities and efficiencies it brings to address the growing consumers’ and industries’ mobile connectivity demands.

5.2.3 *Challenges of the 5G Technology*

Infrastructure

The NDP 2030 plans for a seamless information infrastructure to be available and accessible to everyone by 2030, at a cost and quality that are at least equivalent to those of South Africa’s peers and competitors (NIP 2050 Phase 1, 2022). Bankole et al. (2014) stressed that a sound and efficient telecommunications infrastructure is fundamental for the efficiency of the new technologies and transparency in the socio-institutional component of the 4IR. A survey conducted by the ICASA 5G Council Committee in 2021 indicated that participants from 16 South African industry stakeholders were concerned that the 5G network demands substantial investment deployment of infrastructure to meet its requirements (dense small cells, massive MIMO capacity, and a millimetre wave spectrum). Participant 8 stated that the reason mobile operators are not able to

C2 General

provide sufficient 5G capacity and coverage is mainly the mast space and wind loading constraints that cannot accommodate massive MIMO antennas such as 32T32R and 64T64R, often resulting in operators deploying smaller antennas, such as 8T8R, to work around the limitation. Furthermore, utilities to improve existing 2G, 3G, and 4G infrastructure in South Africa are limited, such that infrastructure sharing will become crucial in ensuring that all operators can deploy 5G networks (ICASA 5G Board Committee, 2021). Participant 15 emphasised that although passive sharing is already in place, regulations and policies that should be implemented expeditiously to enable and support the active radio access network (RAN) sharing model, to which mobile operators are limited because of the exorbitant capital outlay required, are crucial for 5G deployment. The advantages of such sharing models, from which South Africa could benefit, are evident in some of the countries that have implemented them. According to the GSMA (2022), China's data highlight the advantages of 5G network sharing. As of Q1 2021, China Telecom and China Unicom have jointly installed more than 400 000 5G base stations across China under a "co-build, co-share" arrangement. This enabled them to save $12.4 billion in capex and roughly $1.3 billion each year in operating expenses. It is crucial that Africa's regulatory policy and framework follow the same guidelines as those of European nations because Africa is a participant in ITU Region 1. This will allow network equipment and device manufacturers to take advantage of the resulting economies of scale (Ngcaba et al., 2022).

Because of the limited availability of fibre networks in many cities, the deployment of fibre backhaul networks for small cells that can support high data rates and low latency will be one of the major problems faced by operators (ITU, 2018). According to Participant 12, a 5G FWA service could be a cost-effective alternative fibre rollout that enables internet connectivity for consumers and SMEs that are challenged by access to infrastructure. There is, therefore, a need for South Africa to realise the most cost-effective deployment solutions that entail different scenarios for different geographical areas, i.e., informal settlements and

C2 General

dense urban, peri-urban, and rural areas (ICASA 5G Board Committee, 2021). This considers the fact that emerging architectures and higher-frequency bands require a significant increase in the densification of towers and rooftop infrastructure and installation of lower-coverage base stations. Significant investment in passive infrastructure such as base stations, fibre, power supply, and edge data centres are still required (ICASA, 2021). Mobile operators are challenged with expanding the reach of their fibre footprint because of complex geographical landscape limitations in rural areas, difficulties in obtaining wayleave approvals from government authorities and landlord approvals from private property owners, unbinding bylaws pronounced by the government, and interference from other organs of state and local government. These delays can negatively affect the realisation of the 5G technology's benefits. Additionally, a consistent supply of electricity is necessary for IT infrastructure support and successful adoption of new technologies. Eskom, the only electricity supplier in South Africa, has difficulty keeping up with the demand (Du Venage, 2020). As a result, the prolonged and constant loadshedding and battery and generator theft at base stations have affected the network's availability for customers. This affects the mobile operators' NPS and results in increased capex and opex costs due to mobile operators' maintenance of network availability, thus slowing down the 5G deployment.

Cost of deployment

Another major obstacle that mobile operators face is deployment costs. To fulfil demand and throughput requirements, the cost of deploying 5G networks is anticipated to increase. Operators face significant hurdles in presenting the investment case for 5G because of the significant capex investment necessary for deployment (ITU, 2018). Already, the major cost for network implementation and operation is incurred by RANs (GSMA, 2022). Participant 15 highlighted the investment needed by the mobile operators for the densification of new radios, which is required because of the high bands that 5G technology accesses and

C2 General

utilises on the spectrum. This is a barrier that prevents SMEs from gaining a market share because raising the required investment is difficult. This is consistent with a study by Mamushiane et al. (2021), who state that only established mobile network operators can afford the high capex and opex required by the vertically integrated business model. As a result, there is now an infrastructure entry barrier that prevents new operators from entering the telecom industry, creating a monopolistic telecom sector.

According to the participants, energy consumption by 5G equipment and devices is another major factor affecting the adoption of 5G technology, as it has a ripple effect on the mobile operators' opex costs. Compared to earlier network generations, 5G is more energy-inefficient per gigabyte. The difficulty of network energy management is further exacerbated by 5G's massive MIMO and the power needs for cell site densification (GSMA, 2022). Participant 2 indicated that the high power consumption by 5G devices negatively affects the usage of 5G technology, which is deteriorated by the loadshedding crisis and power outages in the country. Participant 10 believed that smart, modernised networks with refarming could reduce 5G's energy consumption risks. Because of rising energy prices and sustainability goals, operators and other ecosystem players will need to put more effort into using renewable energy for network operations. Alternatives such as solar energy systems could provide relief to operators by averting the reliance on Eskom and theft of batteries and generators. This, however, could further increase the cost of deployment for mobile operators as capital would be required to fund the requirements of solar renewable energy.

Affordability

High-speed broadband will be accessible and available in all communities by 2024–2025, resulting in access comparable to that of competitor nations, according to the National Infrastructure Plan 2050 Vision. Free basic data, as will access to water and electricity, will be considered for consumers with low incomes. According to the Competition Commission of South Africa (2019), South

C2 General

Africa currently performs poorly relative to other countries, with data prices generally on the more expensive end. Beyond network deployment, adoption, and usage by customers (consumers and enterprises) are crucial to scaling 5G in Africa and improving the business case for a more widespread 5G rollout. Participant 14 stated that as a result of the high deployment costs facing operators, the potential of the discussion on reduced data rates may not materialise as deployment costs may have to be absorbed by consumers. As a result, ICASA and the Competition Commission should resolve this data dilemma to ensure that the exorbitant data costs are reduced to enable consumers to access the internet and for South Africa to be on par with other countries that offer reasonable and more affordable data rates.

The greatest potential obstacle to consumer 5G adoption and usage in Africa is device cost and availability (GSMA, 2022). Participant 2 highlighted that the low affordability of 5G-enabled devices creates a cycle where low device penetration further pushes up the cost of 5G devices. For mobile operators to generate end-user demand for 5G services during the initial launch, the availability of devices compliant with 5G standards and spectrum will be crucial. Participants 8 and 11 stated that 2G and 3G devices that are still available in the market will hinder the uptake and usage of 5G devices and that the sunsetting of these older-generation devices should be considered as a plausible resolution for this challenge. Manufacturers are now working on technology that will combine 5G, 4G, 3G, and 2G into a single chip, which was anticipated to be ready from 2020 for standards that are universally standardised (ITU, 2018). From the interview findings, it is clear that interventions from the regulator and government are required to remove barriers such as device costs and older-generation devices that are hindering adoption of the 5G technology.

Spectrum

5G must offer spectrum in low, medium, and high bands to achieve IMT 2020's mobile broadband goal, especially for rural regions. This will enable access to

C2 General

high-speed data and improve connectivity (ICASA, 2021). Figure 5 illustrates 5G spectrum requirements based on these frequency ranges and use applications. 5G networks experienced many difficulties because of their ambitious objectives. Beyond what is employed in 3G and 4G systems, the higher capacity and data rates possible by 5G may necessitate the usage of far more spectral resources and spectrally efficient technology (ITU, 2022). Recently, some African nations, particularly South Africa and Nigeria, allocated spectrum to carriers for 5G services. In contrast to the rest of the world, their 5G spectrum assignment is still in its early stages. Another issue is legacy networks' use of priceless spectrum in the low and middle bands, which could postpone the introduction of 5G in the markets concerned. Replanning based on globally harmonised methods will maximise the value of spectrum in areas with fragmented legacy assignments (GSMA, 2022). However, South Africa has yet to even switch over from analogue to digital terrestrial broadcasting, which would free up an important spectrum for rural mobile data coverage, provide people with access to the internet, and accelerate the transition to 5G (Sajum, 2021). Participants 3, 14, and 16 stated the lack of aggressiveness, indecision, and incompetence of the government in accelerating the digital migration. Further delays in concluding the digital migration hinder the release of the much-needed spectrum. Agility, cohesion, and collaboration among government institutions are necessary for achievement of policy frameworks that unlock limitless opportunities that the 5G technology can provide. Figure 5 is an illustration of the 5G spectrum frequency bands for the use cases.

C2 General

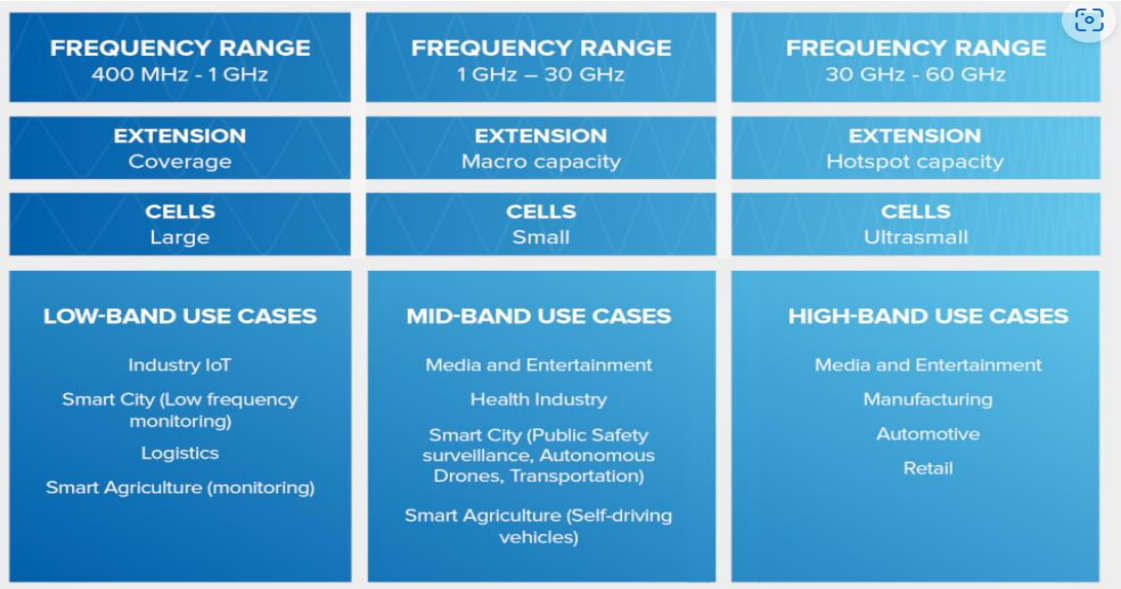


Figure 5: Frequency bands of 5G spectrum use cases (Devopedia, 2020).

Co-ordination among the international community, regional telecommunications organisations, and national regulatory authorities (NRAs) is necessary for the allocation and identification of a globally harmonised spectrum over a variety of frequencies. For NRAs, this is one of the major obstacles to the effective rollout of 5G networks (ITU, 2018). The majority of the participants implied that regulatory agencies and the government should play a crucial role in implementing sound policies to accelerate the release of additional spectrum for technological advancement. To utilise the spectrum that is already accessible more effectively, sharing spectrum should also be considered. Mobile providers have historically received exclusive spectrum allocations from NRAs. To increase the effective use of the already-available spectrum, sharing may be a solution to the expanding requirement (GSMA, 2022). Participant 15 highlighted that a WOAN pooling model would, therefore, be beneficial for the smaller operators that are disadvantaged by the large spectrum investment required, thus enabling connectivity in underserved areas. The narrative is in accordance with the South African Broadband Policy (2013), which states that the market's structural restrictions brought on by the dominance of vertically integrated operators may

C2 General

potentially be addressed under the WOAN regime. The strategy also specifies that WOAN will strengthen service-based competition to better address the country's unmet need for reasonably priced broadband services. South Africa should learn from Mexico's WOAN model, which chose the 700 MHz band for wholesale spectrum due to its crucial role in strategy implementation, cost reduction, and speed of deployment. The model excluded incumbent operators, provided guarantees, subsidies to ensure independence and restricted government role, and a 20-year concession term offering minimal or non-existent spectrum licenses. As a result, ensuring small players' participation and inclusion in the market breaks down barriers, providing connectivity and coverage to rural areas.

Security

Because of 5G's speed and the increased number of small cells, breaches are likely to happen more frequently. Additionally, more susceptible hardware will be present. A growth in open-source technologies and designs is also brought on by the 5G technology. Open source accelerates collaboration and creativity, but it also has the potential to introduce security flaws (Attaran, 2021). The support of a vast IoT introduces significant security risks such as spoofing attacks, replay attacks, system capture attacks, and sniffer and tampering attacks, for which protection systems are very challenging to scale owing to the large number of devices (Rahman et al., 2021). Findings from the Participants' interviews indicate that 5G devices are vulnerable to cyber-attacks, which can jeopardise the data privacy and information of consumers and organisations. According to a new survey by Ericsson, businesses still have trouble overcoming obstacles that prevent them from truly utilising the 5G technology. Data security and privacy, a lack of standards, and difficulties with end-to-end implementation were noted as the main obstacles (Ericsson, 2018). From the findings, it is evident that network splicing could guarantee network security to prevent any external breaches that

C2 General

may be harmful to enterprises and consumers. This could be a potential driver for quicker adoption of the 5G technology.

Digital literacy

According to UNESCO (2011), digital literacy is a gatekeeper skill as it enhances and increases employability and is required by most employees during job application evaluations (UNESCO, 2011). The digital divide is not only limited to between those who have internet access and those who do not but is also apparent between those who have digital literacy skills, the ability to produce any form of content online, and financial independence for optimal internet usage and those who do not have them (Violence Prevention Through Urban Upgrading, 2019). Participant 1 stated that although 5G technology is available for usage, digital illiteracy and a lack of education are contributing factors to the low adoption of the 5G technology and to the digital divide. South Africa faces high data charges and lack of digital literacy, limiting internet access for most individuals despite high coverage rates and digital devices (Global Innovation Fund, 2021). This was corroborated by participant 2, who added that once people are given access to the 5G technology, educational programmes will be necessary to upskill communities on how to use the technology. Participant 14 highlighted that the potential of instilling and utilising the 5G technology at early childhood development centres can bridge the digital divide as learners will be digitally literate from a young age.

The NDP's vision for the ICT sector by 2030 focuses on a broadband ecosystem that connects public administration to active citizens, fosters economic growth, and supports nation building. The SA Connect programme aims to close the digital gap, particularly in rural areas, and advance the digital economy. Phase 1 provided 10 Mbps broadband services to 970 government buildings in eight district municipalities, while phase 2 with 42,000 constructions in government buildings, communities, and homes is planned by 2024. It is evident that the SA Connect strategy can benefit from 5G technology that offers higher internet

C2 General

speeds, reduced latency, and reliable connections. Promotion of broadband investment and competition using the 5G technology can boost people's digital readiness. Improvement of public service delivery can, thus, promote digital growth.

5.2.4 *5G Adoption*

The 5G technology is considered to be an enabler that will drive the 4IR through its ability to connect people with their personal and professional habits. When 5G was introduced, 4G had already surpassed 3G in most global locations. By contrast, the 5G era has arrived in Africa at a time when legacy networks continue to support the vast majority of mobile connections. This creates a variety of distinct difficulties that will affect the introduction and uptake of 5G in Africa (GSMA, 2022). Schulz et al. (2018), cited in Cunningham, Levin, and Nyakabawo (2018), defined readiness as 'the ability to capitalise on future production opportunities, mitigate risk and challenges, and be resilient and agile in responding to unknown future shocks'. Seventy one percent of the participants believe that South Africa is ready for the 5G technology's adoption. Participants highlighted that South Africa already has sufficient 4G coverage based on usage and demand, which 5G can leverage but requires access to devices. It was further noted that the more developed parts of the country are ready to adopt 5G because of the eMBB use case that already exists on 4G; therefore, 5G can leverage that capability. In addition, the participants believed that South Africa has case studies to support and motivate why more aggressiveness is required in deploying 5G connectivity across the country. This, however, is despite the dual economy that consists of the bulk of the citizens who are not economically active, and these citizens perceive technology such as 5G as a luxury because of their daily affordability challenges. Equally so, participants believe that the spectrum available that can be applied between 4G and 5G adds to the readiness for the 5G technology's adoption in South Africa.

C2 General

The gradual development of the business case for a more extensive rollout would be made possible by the operators' ability to deploy 5G infrastructure at a sustainable rate in a phased approach. Because there are still considerable returns on investments in 4G networks, operators will only focus on boosting 4G uptake in the near future. This is supported by GSMA (2022), which states that Africa's approach to 5G needs to account for the current connectivity landscape and unique market features that could affect 5G rollout and adoption. In practice, this means phased and targeted 5G deployment in specific locations where customers have a need for 5G capabilities (GSMA, 2022). It is noted, however, that a potential drawback of the phased strategy is that it would reduce local operators' and other ecosystem actors' participation and exacerbate the exclusion and market-entry barriers of small operators. Because of the exclusion mechanisms, the appearance of revolutionary new technologies will not automatically guarantee adoption from branch to branch or on a global scale (Freeman, 1996). This narrative corroborates that of twenty one percent of the participants, who stated that South Africa was not digitally mature enough to adopt the 5G technology. The perception was that the uptake of the 5G technology was not as expected or projected in comparison to the introduction of the 4G technology. The country's cost of economic scale and complex geographical landscape, where high unemployment, a lack of digital literacy, and access to infrastructure affect the population from rural areas, were contributing factors to the slow uptake of 5G, as highlighted by participant 3. The participants further noted that rural areas are affected the most by a lack of infrastructure and the high cost of devices, which inhibit citizens in those areas from accessing and benefiting from the 5G technology.

5.2.5 *Digital Divide*

In 2002, the OECD defined the digital divide as "the gap between individuals, households, businesses, and geographic areas at different socioeconomic levels with regard to their opportunities to access ICTs and use of the internet for a wide

C2 General

variety of activities". Van Dijk et al. (2006) specified that the first level of the digital divide was centred on ICT and internet access. Van Deursen et al. (2014) then identified the second level, which is that even with equal access levels, people do not all possess equal skills and expertise for using digital resources, resulting in varying usage levels. As early as 2004, Selwyn et al. noted increasing awareness of the differences in access and usage of digital resources and the consequences and outcomes in the real world; this would be recognised as the third level of the digital divide.

Lavery et al. (2018) state that economic and geographical gaps are the main causes of the digital divide in South Africa and that they are due to a lack of connectedness to market-driven deployment. Although it is anticipated that the use of digital technology would make it easier and less expensive for people to convey information, quick adoption (particularly as a result of price reductions) has brought up the issue of the so-called "digital divide" (Sebatana & Makhubele, 2021). The majority of the participants believed that communities in rural areas are affected the most by the digital divide, mainly because of lack of access to infrastructure, affordability of devices for accessing technology, and lack of digital literacy. The narrative supported the sentiments of the ICT White Paper (DTPS, 2016), which stated that the main challenges that have underpinned the rural digital divide include an ineffective policy regime, the concentrated broadband infrastructure market, and the high cost of communication.

Prioritisation of 5G deployment in urban areas widens the digital divide further for those in underserved and rural areas. According to Mamushiane et al. (2021), rapid advancements are being made in mobile wireless technology, with 5G now dominating the conversation. The buzz is, unfortunately, growing more quickly than the infrastructure. In South Africa, the 5G footprint is still mostly available in urban areas and is geographically confined. It is evident that the goals of the ICT White Paper (DTPS, 2016), SA Connect, USAASA, and Universal Service policies, which share the same ambition of creating a digitally inclusive society

C2 General

through a transformative ICT framework to close the digital divide, have not been achieved as anticipated. It appears that there is a lack of cohesiveness, co-ordination, and disarray in the execution of these crucial measures, which delays the goal of reducing the digital gap. It can further be deduced that prioritisation of urban areas for 5G deployment hinders an equal digital society. Maintaining the urban prioritisation trajectory may hinder the achievement of the SDG goal of an inclusive society. According to the NDP (2030), South Africans will be guaranteed universal service, that is, affordable, reliable, and secure broadband services that prioritise and cater for underprivileged and rural areas while enhancing economic growth. The NDP vision of universal broadband access, however, will remain a pipedream unless the public and private sectors make rigorous efforts and take initiatives to address the challenges of infrastructure, affordability, poverty, digital literacy, and energy crisis that the country is facing.

The NIP 2050 Phase 1 report states that "low-income communities will be able to afford and have access to high-speed broadband in underserved areas". The unemployment rate, which rose to 32.9 percent in 2023, and the high rates of food and fuel inflation, the growth of debt as a result of the constant rise in repo rates, and the decline in private sector investment have made it more difficult for consumers to afford the high cost of living. According to Stats SA (2023), the poorest families were impacted the most by the rate of inflation where the cost of living climbed by 11.3 percent in the 12 months leading up to April. The rate ranged from 7.8 percent for Decile 5 families to 6.2 percent for the wealthiest Decile 10 households. This suggests that if the socioeconomic issues that make broadband services unaffordable are not resolved by the government, then the possibility of realisation of the NIP 2050 may be further postponed; this will delay the adoption and deployment of the 5G technology and widen the digital divide. The narrative is supported by Van Greunen (2013), who states that the digital divide is not the problem and that the problem is low income, slow socioeconomic development, and the lack of literacy that divides the rich from the poor.

C2 General

Millions of South Africans still do not have access to digital services (e-learning, e-government, and the digital economy), despite businesses and the government aspiring to bridge the digital divide (IITPSA, 2021). The PC4IR Strategic Implementation Plan aims for South Africa to create a technologically advanced, inclusive, and shared economy driven by 4IR, advancing the nation towards social and economic objectives (PC4IR, 2020). Twenty-six percent of the participants believe that the 5G technology is an enabler for bridging the digital divide. Participants 10 and 12 mentioned the effectiveness of 5G in providing bytes to consumers, which decreases the cost per GB through a decrease in data production. According to participant 10, carrier aggregation makes it possible for operators to successfully modernise 5G networks, which is more difficult and expensive for earlier technologies such as 4G. Another use case that is helping in the reduction of the digital divide is 5G through satellite. This will enable more rural and underserved locations to receive complete coverage, guaranteeing that no person is denied connectivity.

According to the IMF's Working Paper on bridging the mobile divide (Alper and Miktus, 2019), 5G technology could help bridge the gap in Sub-Saharan Africa. Densely populated metropolitan areas, always the most lucrative locations for operators, can make a strong argument for investing in 5G. A business case for investing in 5G networks outside of these regions will be more difficult to make, especially in the early stages of 5G adoption (ITU, 2018). Participants 5 and 11 challenged the notion that the 5G technology is a game changer in closing the digital gap. They argued that cost and government failure to provide necessary support mechanisms and regulations, not technology, are the root causes of the digital divide. This, thus, impedes the broadband policy goal, which had aimed for 100 percent adoption by 2020, meaning that all South Africans would have access to broadband services by 2020 (Stats SA, 2017). It, therefore, supports the narrative of 47 percent of participants who do not believe that the 5G technology can bridge the digital divide in South Africa because of the 5G challenges of access, affordability, and digital literacy. Participants further added

C2 General

that based on the duration it has taken for the 4G technology to be adopted in the country, the technology is rightly placed to bridge the digital divide. This narrative is supported by the statistics released by ICASA in 2023, in which urban areas have 100 percent national 4G coverage, while rural areas have 84 percent 4G coverage nationally. It indicates that while the foundational prerequisites for 5G technology deployment are being developed, the 4G technology has the capability to bridge the digital divide based on its ability to leverage the 5G core networks. As a result, this would require more innovation from mobile operators on how to incorporate some of the 5G use cases into the 4G technology to enable the massive benefits that come with the 5G technology.

Interventions on policy frameworks for inscribing adequate and necessary infrastructure provisioning would result in the realisation of a reduced mobile digital divide in terms of knowledge, data privacy, affordability, and cybersecurity (Alper and Miktus, 2019). Mamushiane et al. (2021) suggest a change from single infrastructure ownership to infrastructure sharing as one potential option for supporting digital inclusion, broadband affordability, and service-level differentiation. Through a variety of means, such as reduced capex and opex costs and enhanced competition (by removing the infrastructure barrier that new-entrant operators must overcome), infrastructure sharing can increase broadband affordability.

5.3 Discussion of Objective 2: To Investigate The Socioeconomic Impact of 5G on South African Consumers and Citizens' Drive for Digital Inclusion

5.3.1 *Customer Experience*

Mobile broadband service development is shaped by consumer broadband expectations. Innovative solutions will be needed to address the anticipated

C2 General

increases in traffic (expected to increase 10–100 times between 2020 and 2030), growth in the number of devices and services, and demands for improved affordability and user experience. It is anticipated that by the year 2025, there will be 50 billion internet-connected gadgets (ITU, 2022). According to the 5G Africa Survey's participants, eMBB and FWA would initially dominate 5G use cases in Africa. After the pandemic, which caused changes in numerous social and professional activities, there is an increasing need among consumers for improved connectivity (GSMA, 2022). Participant 14 highlighted that, over and above the potential that will result from having ubiquitous 5G coverage and connectivity in rural and urban areas of South Africa, this means that we will witness things such as access to further education because we can now do e-learning from any household in South Africa.

Interview findings revealed that the 5G technology, as an enabler, will improve access for underserved rural areas, addressing economic and social challenges. Furthermore, 5G can improve life through convenience, seamless connectivity, and reliability. However, Participant 5 was concerned that urban consumers would benefit most from 5G, while rural areas may not benefit because of socio-economic differences. It can be deduced that the 5G technology offers significant benefits to consumers, thus transforming their lives through convenience and convenience-driven innovations. It was noted that the 5G technology revolutionises consumer experiences but may widen and perpetuate the digital divide, benefiting urban areas while excluding rural areas through access and affordability issues.

On the enterprise front, the industry needs to better articulate the capabilities and value proposition of 5G (including FWA, network slicing, edge computing, and IoT technologies) to customers (GSMA, 2022). Findings from the interviews indicated that the 5G technology revolutionises business operations by improving customer service, improving process efficiencies, and reducing overheads. In a post-pandemic future, with 5G at its core, how people live and how organisations

C2 General

work will be reshaped. This includes the possibility of facilitating digital transformation of companies and enhancing connectivity of home and enterprise (GSMA, 2022). 5G will enable businesses to innovate and connect in novel ways, transforming how we work and play and resolving many long-standing issues (PwC, 2020). Participant 1 emphasised 5G's flexibility, efficiency, and remote work, which result in savings on opex expenses and enables flexibility in the ICT sector.

Large enterprises with capital and sound business cases are expected to be early adopters of private 5G networks. Operators now have the chance to test 5G and new business models (GSMA, 2022). This indicates that enterprises will benefit from 5G deployment because of their strategic positioning, but they must make decisions on use cases, activation timing, and choice of usage of either private or public networks. Participant 11 stated that 5G provides a deterministic experience for customers, which can enable enterprises to have defined SLAs that can measure uptime and latency. Larger businesses can benefit from 5G FWA, as it provides a backup line for critical banking activities in case of fibre downtime. This ensures uninterrupted operations and supports critical banking operations, according to the participant. It is clear that the 5G technology offers enterprises flexibility, an enhanced customer experience, cost savings, and a customer-centric approach to implementing various products and services, thereby reducing customer churn and growing revenue.

5.3.2 *Industry beneficiaries of the 5G technology*

A paradigm shift in network infrastructure models is currently occurring in the mobile industry, with operators of all sizes progressively considering new network deployment and operational models (GSMA, 2022). 5G is a paradigm shift in the field of handling heavy machine-type communication (MTC) traffic to support the IoT network, in addition to offering much improved performance for conventional phone, data, and video applications (Borkar & Khan, 2020). Higher connection

C2 General

speeds and capacity and lower latency are only a few of the significant advancements 5G networks provide over earlier generations. Because of their improved performance, 5G networks will be able to support new use cases and applications that will have a favourable effect on many different industry sectors (GSMA, 2022).

Expectations for 5G are high, with many believing it will bring about a revolutionary promised land, one that includes improved end-user experiences, new applications, new business models, and new services, all of which will be quickly supported by gigabit speeds, improved network performance, and dependability (ITU, 2020). Thirty percent of the participants believed that the telecommunications industry, as the mobile network carriers, was the main beneficiary of the 5G technology. According to the participants, this industry is the one that innovates, develops, manufactures, and deploys the technology, making it the one that stands to gain the most from a market share and revenue viewpoint. The South African telecom market is expected to grow at a CAGR of 5.32 percent in the next five years because of increased demand due to the COVID-19 pandemic, advancements in technology, and growing data requirements, according to the Mordor Intelligence Report (2023). The same sentiments were shared by Participant 2, who indicated that the COVID-19 pandemic marked a milestone for mobile operators, causing increased internet demand and lockdown and forcing remote work and study. It can be deduced that the COVID-19 pandemic propelled the telecommunications industry to transform and scale up their networks, resulting in quicker byte production, better customer service, and the monetisation of assets. This allowed the industry to gain an advantage over previous technology generations.

Twenty-three percent of the participants agreed that the mining industry is one of the industries that will benefit from the 5G technology. The mining sector still faces a number of difficult problems, such as the unpredictable geopolitical environment and the disruption of the digital economy, which put more pressure

C2 General

on operations because productivity should grow (Deloitte, 2021). However, the industry's current attempts at digitisation have focused on increasing automation. 5G can advance mining connectivity by providing internet access, powering equipment, infrastructure, and the IoT. It enables machine learning, data analytics, fixed asset IoT, and cloud computing, leading to increased automation and operational efficiencies. Participant 10 stated that South Africa's advanced mining sector offers great potential for critical communication services, enabling the automation of robots and real-time information during drilling and excavation. The use of the 5G technology for low latency and critical communication in this sector is tremendous, as it enables low latency and high-quality data. This technology is essential for safe and smart operations in the mining sector. The capability of the 5G technology to transform traditional mines into smart mines was demonstrated by the partnership between MTN and Huawei to launch the first South African smart metal mine in Limpopo. This will illustrate the advancement of the local mining industry's digitalisation transition, highlighting the 5G technology's potential to enhance operations and utilise innovative technologies.

Participant 9 highlighted 5G's convenience, intelligence in data harnessing, and monetisation, particularly in the mining sector. According to participant 10, mining is a crucial industry that focuses on efficiency and health and safety. Connectivity is crucial in these environments, as most of them have excellent systems for data collection and analytics. However, networks are lacking in reliability and resilience, and private networks are essential for operations, according to participant 10. It is thus important for the mining industry to leverage private cellular networks that offer transformational mining operations by automating remote operations, monitoring heavy fixed assets, and automating processes such as autonomous haulers and drill rigs. The industry should take advantage of real-time monitoring for the workplace and equipment, enhancing safety and preventing hazards in mining operations. Participant 11 highlighted the importance of digitalization of mining operations, health and safety efficiencies

C2 General

using 5G enabled applications that have the capabilities of tracking miners' tasks and activities.

Digital technologies are becoming increasingly essential to productivity and effectiveness in the manufacturing industry and along supply chains. By substituting cables with wireless connectivity in factories, 5G may release machines from being tied to a certain place and provide manufacturers with a far higher level of flexibility (PwC, 2020). Maluleke (2020) suggests that tactile manufacturing would be made possible by 5G; this will allow engineers to fine-tune their product in real-time while monitoring its performance in populated regions. This will advance simulation activities that produce consistently accurate outputs and instantaneous, intelligent, and autonomous decisions. Thirty percent of the participants expressed that the manufacturing industry derives value from the 5G technology because higher productivity and efficiency will emerge from more streamlined, technology-driven processes. With the help of 5G's predictive intelligence and quicker, more efficient inspections, the industrial sector is anticipated to progress quickly. The participants highlighted that IoT transforms industry by enabling smart factories; improving production processes, predictive maintenance, and automation; and reducing input cost savings. The notion is supported by Attaran (2021), who mentioned that manufacturing businesses will be able to create smart factories using augmented reality, automation, and AI to solve problems. An important technology for digitisation of the manufacturing industry, 5G improves connectivity, quality, speed, latency, and bandwidth. Participant 16, whose is in the manufacturing industry, believes the 5G technology offers convenience and cost savings for exporting raw materials, allowing assembly in the export country, thereby reducing input costs, and facilitating export of goods.

Fifteen percent of the participants viewed the agriculture industry as another beneficiary of the 5G technology. Agriculture may benefit from connectivity by becoming more data-driven to boost crop production. Additionally, 5G can help

C2 General

farmers monitor crop prices to boost their revenue (ITU, 2022). Participant 12 expressed that the Free State province faces challenges in maintaining large farms because of rising oil, crude oil, and diesel costs. 5G could help farmers gain access to markets and thus produce exportable products. Drones could also be used to support farmers and improve their products, according to participant 12. The farming and agricultural sector will undoubtedly gain most from machine learning being used over the 5G network, which include smart agriculture and smart farming, according to participant 8. It is evident that the 5G technology has the potential to revolutionise agriculture by enabling smart farming through AI-powered machinery and smart irrigation to improve efficiencies in crop management. Improved agriculture-focused applications and livestock management are other benefits that the 5G technology can provide in this industry.

According to the interview findings, fifteen percent of the participants believed that the health industry would also benefit from the 5G technology. Telemedicine and digital health offer potential solutions where the health sector faces challenges in doctor-patient ratio, with skilled specialists concentrated in urbanized cities, while rural areas demand and need more specialists, according to participant 12. URLL's use case can benefit the medical industry by enabling quicker data transmission and remote-assisted medical operations. This enables data-driven decision-making for off-site medical care based on vast amounts of data. PwC (2020) stated that the growing use of 5G, supported by developments in robotics, IoT, and AI, will facilitate the formation of a new, linked healthcare ecosystem in line with the idea of "4P" medicine: predictive, preventative, personalised, and participatory. Using 5G connections, this ecosystem will be able to correctly, easily, affordably, and broadly satisfy demands of patients and providers (PwC, 2020). This corroborates participant 7's statement, that the 5G technology can improve patient care and medical services by enabling remote monitoring, telemedicine, real-time consultations, and data exchange through high-speed, low-latency connections. According to the GSMA, a variety of use-

C2 General

case examples have been tested and commercialised globally: A private 5G network for health care was developed by AT&T to link researchers and patients in the USA (GSMA, 2022).

5.4 Discussion of Objective 3: To Investigate 5G Technology's Potential to Assist with Service Delivery in South Africa

5.4.1 *Benefits of the 5G technology*

A switch to 5G promises to catalyse various benefits, including job creation, income growth, consumer cost and time savings, pollution and greenhouse gas reduction, and quality-adjusted life years gained (Mauro, 2019). 5G is positioned to facilitate socioeconomic changes in a variety of ways, including those that improve well-being, sustainability, and productivity (The Next Generation Mobile Networks Alliance, 2014). Participants emphasised three 5G technology use cases that can usher in technical improvements and a revolution that can improve how effectively consumers and businesses can work. The key functional drives of 5G deployment will unlock a broad range of opportunities, including optimisation of service delivery, decision-making, and end-user experience (Galal, 2021). Participant 8 stated that the 5G technology offers increased capacity and standalone capabilities, enabling access to sub-6 GHz and above-6 GHz frequencies. This innovation fosters autonomous vehicles and smart cities, enabling a wide range of opportunities for businesses and consumers. Maluleke (2020) emphasised that low-income, rural, and urban communities in South Africa will benefit from 5G through connected cars and trucks, public safety, navigation, augmented reality, and ecosystem size. As a result, the 5G technology offers higher speeds, low latency, and higher capacity, thus transforming industries and sectors and expanding internet connectivity for exponential growth.

C2 General

The interview findings indicated that 5G services offer potential benefits towards SDG 4, which advocates for accessible, equitable, quality education, thereby taking the bridging of the digital divide a step closer. According to Maluleke (2020), 5G rewards are online degrees, HD class videos, real-time HD videos and text chats, online study materials, and AI language translation. Public schools will be able to teach current and competitive content with the aid of the 5G network (Maluleke, 2020). Some of the current problems, such as the shortage of textbooks, stationery, or classrooms, can be resolved by e-learning. eMBB improves e-learning in South Africa for low-income, rural, and urban students. Participant 16, however, argued that e-learning is crucial but secondary if psychological needs such as food, shelter, and security for disadvantaged learners are not met, causing an unbalanced social economy. Affluent students embrace e-learning because they have socioeconomic advantages. Furthermore, according to CSIR (2021), the benefits of 5G would be more noticeable in higher-level education (secondary and, especially, tertiary) than in primary and elementary education because 5G cannot replace individual attention in the classroom. It is evident from the contrasting views that while the 5G technology offers educational benefits, the government should address the socioeconomic needs of disadvantaged learners in accordance with Maslow's hierarchy of needs for e-learning adoption. Hybrid learning would thus be a plausible approach to ensuring learner−teacher interaction in early development and primary schools while reaping the benefits of the 5G technology. Huawei in partnership with Rain Click Foundation launched the 5G DigiSchool programme in 2021 in the Mpumalanga province, where 90 out of 100 schools were connected. This was meant to improve the digital literacy and primary school English comprehension to ensure that primary school learners can read and write fluently, with the aim of bridging the digital divide in rural areas. Ericsson and NASDAQ launched the MY5G Ericsson Malaysia Pioneers Programme in January 2023, a customised tertiary program on 5G and digital technologies. The free online curriculum aims to bridge the digital divide between urban and rural

C2 General

communities by providing students with a comprehensive understanding of digital services' applications and functions. The 42-hour program focuses on improving digital literacy, raising awareness of new technologies, and equipping students with knowledge, abilities, and competences to meet skill needs in the rapidly evolving digital world.

According to Rahman (2021), mMTC was designed to enable hundreds of billions of IoT devices to stay connected through mobile networks rather than Wi-Fi or Bluetooth. Wireless flexibility, lower prices, and the viability of applications that are not achievable with present technology are the main benefits of 5G in industry automation (Maluleke, 2020). Participant 12 mentioned that they had implemented mMTC use cases in China and at a mine near Rustenburg where yellow dump truck drivers can now be placed in a remote operation centre, located in an office complex, allowing them to remotely manage the trucks. This improves their concentration, motivation, and efficiency, enhancing their work conditions and overall efficiency. This narrative is supported by PwC (2020), which stated that the most prominent benefit of self-driving trucks for businesses along the supply chain is that these trucks can operate 24/7 without limitations, boosting productivity and enhancing system capacity, potentially boosting efficiency. What is clear from the responses is that the 5G technology can enhance and improve operational efficiencies and revenue growth as a result of increased productivity. Figure 6 illustrates the 5G use cases and the economic benefits the technology provides for consumers and industries.

C2 General

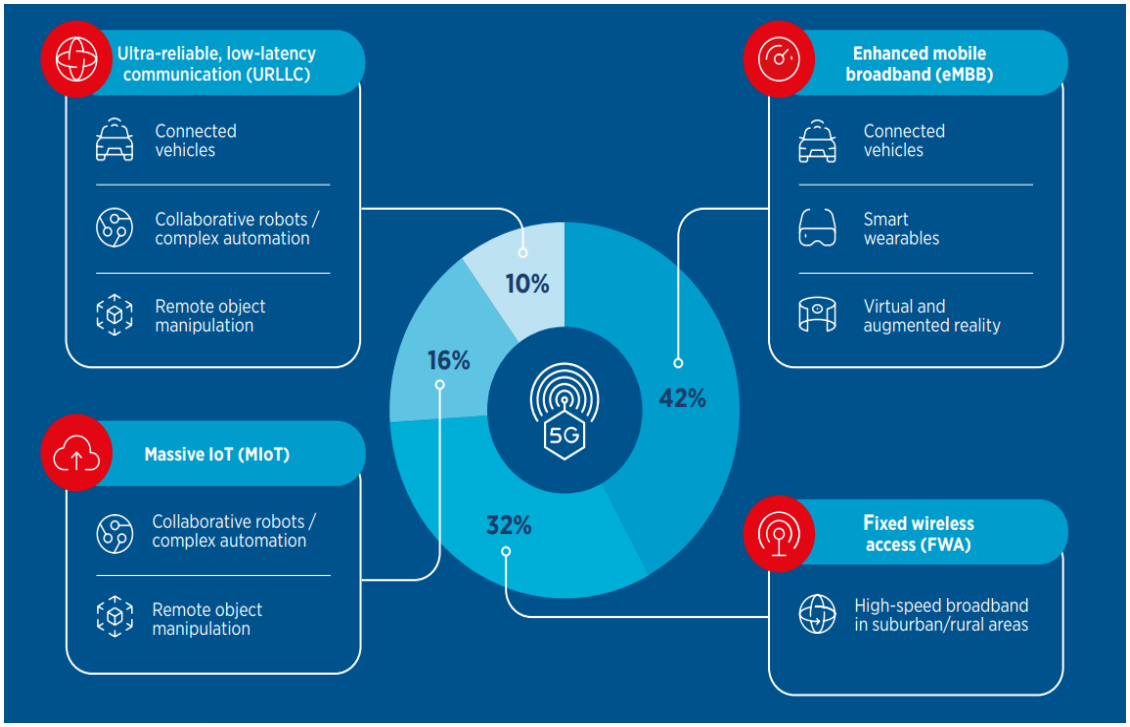


Figure 6: Global economic impact of 5G use cases (GSMA, 2018)

5.4.2 *Service Delivery*

The policy framework for Public Service Corporate Governance of Information and Communication Technology stated that the top priority is to build an ethical, capable, and developing state through e-government for improving service delivery (DPSA, 2022). E-government is an effort by the government to guarantee the highest possible level of service delivery and administration. Performance in serving the public in the current government agencies should go hand in hand with this (Naidoo, 2012). The government can now utilise 5G-powered platforms and apps to provide services without citizens making physical visits to offices. This will benefit both the government and the public by reducing lengthy lines and increasing the speed of service delivery. This will benefit the Home Affairs and Licencing departments by making them more efficient, according to participant 1. The 5G technology can enhance eNaTIS online renewal method, providing quicker, dependable internet connectivity and thus enabling easier system

C2 General

access for users. Furthermore, 5G can enable real-time video conferencing with Traffic Licence customer care agents, enhancing customer service and addressing issues quicker. It can also offer biometric authentication to prevent fraud and identity theft. It is evident that although 5G has the potential to improve efficiency and effectiveness in government departments, which leads to service improvement, the digitalisation of government processes and systems is lacking. Therefore, it is crucial for the government to prioritise and accelerate digitisation and provide uninterrupted connectivity to eliminate manual processes. This will ensure that the benefits of 5G services are realised and will improve service delivery for consumers.

According to Sear and Khan (2020), governments can accelerate AI, VR, AR, and IoT adoption with 5G's improved connectivity, accelerating usage and adoption of 5G technology. Participant 3 highlighted that the government can utilise robotics, sensors, and machine learning to engage underserved communities and reach remote areas, enhancing their connectivity and accessibility. Participant 7 stated that 5G-enabled technology enhances government operations by providing real-time information, thus improving cities' smartness, public safety, traffic control, security, and supply chain logistics at shipping ports. This supported the sentiments of Sear and Khan (2020), who stated that 5G can improve traffic management by automating traffic control, enhancing traffic flow, and delivering real-time information on public transportation (Sear & Khan, 2020).

Maluleke (2020) highlighted that the large IoT component of 5G in the health sector, which has various applications that can receive assistance from the network, will provide a great market for wearables, trackers, and sensors. Telemedicine is enabled with the new 5G. According to participant 14, 5G has the potential to significantly improve access to government services, but the Department of Health should consider online services to encourage people to access public health services without visiting a health facility. The participant

C2 General

further highlighted that a public information platform, such as an e-learning platform, can be created to educate people on child immunisation, missile management, and neonatal care. This platform can also enable new mothers to interact with doctors without visiting public health facilities. Electronic scripts can be issued without using smartphones, and local pharmacies can provide medication through QR codes and scanned codes, as stated by participant 14. CSIR (2021) notes that 5G might help with drone-based deliveries of medical samples and medications in both urban and rural areas. For drones to maintain their mutual distance from one another and receive accurate instructions, 5G offers a pervasive communications infrastructure.

Early in the 1990s, cities began referring to themselves as “smart” after establishing ICT infrastructure, adopting e-governance, and aiming to attract high-technology businesses to promote economic growth (DcoG, 2021). The super-fast highway that all other applications use is created by 5G, making it the glue that holds everything smart together (PC4IR Report, 2020). Participant 12 was in support of this view, as he stated that when 5G touches an industry, it transforms the industry into a smart industry where we can measure and complete a number of tasks more quickly than we could before. Furthermore, when one carries out tasks more efficiently, one directly enhances people’s lives. According to DcoG (2021), inclusivity should serve as the foundation for South Africans’ conception of a smart city. In essence, this means that a smart city programme should ultimately increase the well-being of the entire city and benefit all residents of all communities. Some of the participants agreed with this notion and made reference to China and Dubai, which have successfully implemented smart cities with the aid of technologies such as 5G. The participants further added that it is important to note that once a city adopts smart city technology, every aspect of its efficiency increases. It can be deduced that municipalities can transform their electricity and water utilities by achieving efficiencies that eliminate capital-intensive manual tasks, thus saving costs, providing value, and improving customer well-being.

C2 General

5.4.3 *Policy and Regulatory Intervention*

For 5G to succeed in Africa, an enabling policy environment is necessary. In order to promote cost-effective network deployment and the creation of creative use cases to increase demand, governments and regulators must establish an environment that supports investment and innovation (GSMA, 2022). In the future, the government's primary role in the ICT sector will be to facilitate competition and private investment, ensure effective regulation where market failure is apparent, and intervene directly to meet specific social goals (NDP, 2030). A sound regulatory regime is crucial for ensuring practical deployment of the 5G technology, as it is at the core of public sector intervention and legal frameworks, according to participants 10 and 14. Device costs are another barrier for consumers that inhibits universal access. According to Armstrong (2020), operators must play a role to ensure that mobile data prices are re-balanced to achieve digital inclusion through enabling affordability by all citizens. Participant 2 highlighted that operators should ensure fair subsidisation for consumers and customers' device access, but government will have to act as a strategic partner to the private sector, ensuring collaboration and connectivity for consumer service.

The majority of the participants agreed that collaboration between the public and commercial sectors is necessary to achieve equitable spectrum allocation at fair and affordable prices. As many individuals may not be able to afford it, expensive technology might increase expenses for consumers and reinforce social differences. This will support a more inclusive society and guarantee a more equal allocation of spectrum. This could help mobile operators deploy 5G quicker and contribute to the overall growth of the industry. As a result, such incentive initiatives can accelerate the Broadband SA Connect policy's strategic goal of digital development, which is aimed at utilising smart procurement in uneconomic areas as a means of incentivising network infrastructure investment. Participant 8 emphasised the necessity for government incentives to encourage mobile

C2 General

operators and OEMs to reduce imports of 2G and 3G devices. Government and regulatory bodies should play a substantial role in banning these devices, as they hinder 5G adoption and cost reduction.

The processes, assets, and connections that connect policies to programme execution are referred to as policy implementation. Programme execution implies to carry out, perform, fulfil, generate, or finish a specified activity more precisely. Understanding the nature of policy implementation is crucial because, according to international experience, once policies are enacted, they are not always carried out as planned and do not always provide the desired consequences (Mthethwa, 2012). Thorough preparation, improved co-ordination, and quicker policy execution, the government should be more proactive and quicker in implementing plans and policies, as emphasised by participants 14 and 16. For a policy to be implemented expeditiously and effectively, leadership is necessary. Bhuyan (2005) highlights that high-level players and prominent leaders can discuss policy justification and methods and advocate for co-operation and co-ordination for policy implementation. Participant 3 cited cabinet aging and lack of technical advancement and expertise as reasons for the longer implementation time.

Participant 5 added that the government should focus on active solutions to address unemployment and equality, integrating technology and socio-economic elements. A society that participates in technology networks can ensure affordability of devices and data, reducing issues related to device affordability and network accessibility. This approach helps address the issue of unemployment and inequality. This corroborates Van Dijk (2019), who asserts that a typical fallacy in government goals was the belief that granting of internet access will eliminate the issue of the digital divide. It is thus important for government to address socioeconomic challenges such as unemployment and inequality to ensure digital inclusion and technology participation by society. Participant 14 suggested that political paradigm shifts had to overcome regulatory barriers. Policies and regulations are crucial for implementing RAN sharing and

C2 General

spectrum allocation in *multi-operator core networks*, where operators own their own spectrum. A paradigm allows everyone to bring his/her own spectrum while sharing. For achievement of universal access, Armstrong (2020) suggests that the release of the spectrum not earmarked for WOAN should be done immediately by government.

5.4.4 *5G Acceleration*

Governments, agencies, advocacy groups, and digital businesses should work together more to develop digital skills quicker (ITU, 2022). To solve issues that prevent widespread 5G adoption globally and to take full advantage of the benefits 5G will offer across sectors, regulators, industry groups, network operators, service and technology suppliers, and public−private partnership organisations should engage in constant communication (PwC, 2020). Twenty-seven percent of the participants agreed that partnerships between the government, private sector, and mobile network operators were crucial to ensuring that 5G was adopted and deployed at a higher rate. Participant 8 stated that mobile operators can expand the penetration of 5G in underserved areas by collaborating with the government on specific initiatives that call for 5G deployment. Through public−private partnerships, South Africa might accomplish 5G deployment goals while simultaneously simplifying policy. Because it took the country a while to get to the ITA phase, it would be beneficial for the country if the public and private sectors could streamline these processes a little more quickly. Participant 8 emphasised that the government should form partnerships that consider the ecosystem and technology's role as an economic engine and consider options as such discussions broaden. Partnerships between the public and private sectors are crucial for infrastructure deployment, as they tap into both markets and ensure that people have access to necessary resources, according to participant 14. From the interview findings, partnerships and collaboration emerged as dominant drivers for promoting of 5G and ultimately the adoption of the technology. It is evident that the relevant stakeholders, namely government,

C2 General

regulators, and telecommunications actors, should work together to achieve the NDP 2030 vision of a connected society.

The COVID-19 pandemic has underlined the growing significance of digital technology in efficiently responding to disasters and planning for recovery. Moreover, the crisis offers mobile operators the potential to accelerate the continent's digital development, thereby creating resilient digital jobs (GSMA, 2021). The optimum 5G acceleration programme is likely to be one that will generate employment. If more jobs are produced, people will be able to afford better phones, according to participant 7. Education and awareness were expressed by most of the participants as a necessity; this makes it evident that the government, mobile operators, and OEMs should drive 5G technology promotional campaigns and consumers' awareness. This will not only result in increased digital inclusion but also improve digital literacy and potentially accelerate the adoption of 5G-enabled devices. Participant 3 stated that educational programmes should encourage participation in the digital era across all age groups, using digitalised media such as Google equipped with vernacular languages, radio stations, and TV programming at a pace that consumers can understand and decipher information. This will enable everyone to comprehend and be present in the digital age. Furthermore, participant 2 added that community partnerships will be a highly effective means of disseminating 5G information. Participant 3 agreed with the notion and then added that educational initiatives for the younger generation are crucial as they enable them to interact with elders and to explore technology and play with it. The youths can later raise awareness in their communities and schools, making early access to education a revolutionary journey for the rest of the communities. This is an excellent starting point for promoting technology adoption and fostering a more inclusive society. It can be deduced that education and creation of people's awareness of the 5G technology require concerted efforts from the government, mobile operators, OEMs, and communities to upskill, promote, and educate consumers

C2 General

about the benefits of the 5G technology. Such efforts will result in improved digital literacy, which has the potential to create jobs and a digitally inclusive society.

C2 General

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1 Introduction

This study set out to explore the potential of the 5G technology to bridge the digital divide in South Africa and the socioeconomic impact it will have on consumers. This chapter provides conclusions of the research study in relation to the three research propositions proposed in chapter 2. Thereafter, recommendations based on the conclusions are presented. Finally, future research suggestions are provided.

6.2 Conclusions

6.2.1 *Conclusions regarding Proposition 1*

The first research proposition of this study sought to understand how the introduction of 5G will bridge the digital divide in South Africa in accordance with the ICT policy frameworks.

Participants observed that 5G is a cutting-edge and evolutionary technology whose capabilities supersede those of previous mobile generations. Everything 5G touches can be transformed and revolutionised into something “smart” because of the technology’s capability and ability to provide higher user speeds, ultra-low latency, higher capacity, and reliability in the use cases it delivers. Most participants felt positive that The country is ready for deployment of 5G technology and services in urban and affluent areas, where there is sufficient infrastructure and affordability of 5G-enabled devices and equipment. This, however, raises the question of the country’s overall readiness to adopt the 5G

C2 General

technology if certain geographical areas are lagging behind. Installing 5G would perpetuate the digital divide for remote and rural areas left out because of the high cost of 5G deployment, lack of access to infrastructure, and consumers' inability to afford devices and data within these areas. This concern is in line with ITU (2018), which posits that because it will be commercially difficult to roll out 5G networks in rural areas, where demand tends to be lower, these areas risk being left behind, thus widening the digital divide. The study also revealed that South Africa has made strides in the national coverage of the 4G technology, which stood at 98 percent in 2022, that could assist in bridging the digital divide given the country's economic and geographical challenges.

The socioeconomic challenges in the country, however, far exceed advancements and improvements the 5G technology can offer to consumers because of the high unemployment rate; high inflation, which affects energy, food, and fuel costs; lack of access to infrastructure; lack of device affordability; and lack of digital literacy. One participant highlighted that the 5G technology is not a problem, but the level of affordability is the actual divide. This was supported by Van Greunen (2013), who stated that the digital divide is not the problem, but the problem is low income, slow socioeconomic development, and the lack of literacy that divides the rich from the poor. High data prices hinder online usage, impacting consumers and causing financial strain on enterprises that need to remain online for business operations.

Additional spectrum availability required for the 5G technology to enable higher capacity and data rates, as well as security breaches and vulnerability threats related to 5G, were among the challenges identified by the research. These challenges limit not only the capacity to bridge the digital gap but also the country's preparedness for the adoption of the 5G technology. Policy implementation involves processes, assets, and connections of policies to program execution. It involves precise undertaking, performance, fulfilment, generation, or finishing of a specified activity. Understanding of policy

C2 General

implementation is crucial, as this process can sometimes not be carried out as planned and not provide the desired consequences (Mthethwa, 2012). Government and regulatory authorities should remove the socioeconomic obstacles and barriers involved with implementation of the 5G technology if they are to help the 5G technology bridge the digital divide.

The research interview findings revealed that solid and aggressive government policy frameworks are required to address socioeconomic and 5G technology challenges. The NDP 2030 policy, which aims to eradicate poverty and create a connected society by 2030, is an overarching framework that includes the Broadband and ICT White Paper (DTPS, 2016) policies but is yet to achieve the planned outcomes and goals. The researcher noted delays in analogue to digital migration, the SA Connect programme, and WOAN as examples of government's incoherence and failure to execute crucial programmes aimed at bridging the digital divide. The Broadband Policy aims to provide universal broadband access by 2020, while the National Integrated ICT Policy, per the ICT White Paper (DTPS, 2016), aims for a digitally innovative, inclusive society. However, a lack of radical government intervention may hinder these goals. Interventions in policy frameworks for inscribing adequate and necessary infrastructure provisioning would result in the realisation of a reduced digital divide in terms of knowledge, data privacy, affordability of broadband access and devices, and cybersecurity (Alper and Miktus, 2019). The promise of 5G in bridging the digital divide in South Africa remains a pipedream unless policies and regulations are actively enforced and implemented, as set out by the government and regulatory bodies. Therefore, South Africa's digital divide will not be addressed until the NDP 2030 plan addresses unemployment, infrastructure, affordability, digital literacy, and spectrum restrictions for underserved areas. Until radical and rigorous interventions are implemented by the government, 5G will only serve as an enabler and benefit the privileged, while excluding the disadvantaged from the digital society.

C2 General

Although the 5G technology is an evolutionary and innovative technology that can revolutionise how we live and work, the socioeconomic challenges of the country and slow pace of government in implementing policies and executing broadband projects far outweigh 5G's potential to bridge the digital divide. Based on the literature and interview findings, Proposition 1 is debunked.

6.2.2 *Conclusions regarding Proposition 2*

The second research proposition objective was aimed at understanding how implementation of 5G technology can be a crucial step towards a more equitable digital future for South African consumers and citizens.

The present study highlighted the potential of the 5G technology to transform consumers' lives through access improvements, seamless connectivity, and transformation of traditional homes into smart homes. However, 5G only benefits those with internet access and 5G-enabled devices, thus widening the digital divide. Additionally, the 5G technology has transformed education it into e-learning, eliminating the need for stationery, textbooks, and classrooms. The observation was that e-learning benefits affluent schools while leaving disadvantaged learners behind, as ICASA's statistics illustrated a significant drop in public schools connected to the internet since the COVID-19 pandemic. Lack of technology adoption in public schools prolongs e-learning adoption and widens the divide between affluent and public schools; this requires government intervention through the Department of Education.

The present study also sought to provide insights on the impact the 5G technology has on enterprises. The study highlighted that the 5G technology enhances efficiency, business operations, customer service, and innovation and reduces overhead and OPEX, thus boosting revenue growth. 5G will enable businesses to innovate and connect in novel ways, transforming how we work and play and resolving many long-standing issues (PwC, 2020). The 5G technology offers deterministic network capabilities, allowing enterprises to

C2 General

measure uptime and latency through SLAs, and serves as redundancy through 5G FWA service, reducing downtime for critical business operations.

Because of their improved performance, 5G networks will be able to support new use cases and applications that will have a favourable effect on many different industry sectors (GSMA, 2022). The study revealed that 30 percent of participants view the telecommunications industry as the main beneficiary of the 5G technology, as it has achieved improved user experiences, new business models, new applications and services, and network performance for consumers, businesses, and government entities. Government and regulatory support mechanisms are required for the industry to meet customers' data demands and technological advancements towards bridging the digital divide.

Mining was also observed as the second-highest industry to benefit from the 5G technology through increased automation, advanced communication, and operational efficiencies required for effective operations of mines. The study found that mining in South Africa, a globally advanced country in the sector, can transform into smart mining through usage of the 5G technology for quick internet access, IoT, data analytics, machine learning, cloud computing, equipment powering, and data monetisation. Low-latency and high-quality data offer significant benefits for the industry.

Maluleke (2020) suggests that tactile manufacturing would be made possible by 5G, allowing engineers to fine-tune their product in real-time while monitoring the product's performance in populated regions. This ability will advance simulation activities that produce consistently accurate outputs and instantaneous, intelligent, and autonomous decisions. The study revealed that the 5G technology, combined with IoT, can transform manufacturing industries into smart factories, improving process efficiencies and reducing maintenance and input costs. This technology also promotes the digitisation of mines, further enhancing the efficiency of mining processes.

C2 General

Agriculture may benefit from connectivity by becoming more data-driven to boost crop production. Additionally, connectivity can help farmers monitor crop prices to boost their revenue (ITU, 2022). Findings from the study indicated that the 5G technology can transform agriculture through machine learning and usage of drones and AI, enabling efficient crop production, livestock management, and monitoring for farmers in smart farming and smart agriculture.

The research interview findings highlighted the 5G technology's potential to transform the health industry through telemedicine and digital healthcare, thus enhancing its efficiency and accessibility. The health industry can greatly benefit from 5G technology for telemedicine and digital health care. Its uRLL use case can enable remote assisted medical procedures and data-driven decision-making for off-site medical care, thus enhancing government health. The study found that the 5G technology can enhance remote doctor care and medical services by reducing travel time and costs for patients, particularly in rural areas, through low-latency and high-speed connections. Using 5G connections, this ecosystem will be able to correctly, easily, affordably, and broadly satisfy the demands of patients and providers (PwC, 2020).

The literature and interview findings indicate the ability of the 5G technology to reshape consumers' lives, businesses, and industries through the 5G use cases of eMBB, mMTC, and uRLLC in line with the IMT 2020 vision. These present study's findings, therefore, validate and confirm Proposition 2, the implementation of 5G technology is a crucial step towards a more equitable digital future for South African consumers and citizens.

6.2.3 *Conclusions regarding Proposition 3*

The third research proposition sought to understand and explore whether 5G will improve and enhance service delivery across all facets of different sectors and industries.

C2 General

The key functional drivers of 5G will unlock a broad range of opportunities, including optimisation of service delivery, decision-making, and end-user experience (Galal, 2021). The research interview findings highlighted the potential of the 5G technology to enhance consumer and business operations and foster innovation through smart cities, autonomous vehicles, e-learning, telemedicine, and connected and smart homes because of the technology's increased capacity and standalone capabilities. Furthermore, the 5G technology can enhance government services through e-government for consumers. E-government is the government's effort to guarantee the highest possible level of service delivery and administration. Performance in serving the public in the current government agencies should go hand in hand with this (Naidoo, 2012). Participants mentioned frustrations with manual operations, long queues, and incompetent government staff; the 5G technology could eliminate these issues and improve efficiency. Uses of eNaTIS system for licence renewals, consumption of health services, and utilisation of municipal utilities are examples of services that can be enhanced and of improved efficiencies of services rendered to consumers through the 5G technology.

The research interview findings, however, highlighted the need for the government to digitalise departments' processes and upskill staff for efficient service delivery. Inconsistent internet connectivity in government departments leads to offline systems, thus necessitating infrastructure investment by the government to ensure the 5G technology's benefits. Government challenges indicate a lack of policy framework adoption and implementation, as the government should set a leading example by implementing policies within its departments first.

The potential of 5G to enhance service delivery for consumers is enormous, and e-government can provide government and local authorities operational and administrative efficiencies, thereby saving consumers time, money, and convenience. The literature review and research interview findings confirm

C2 General

Proposition 3, that 5G will improve and enhance service delivery in multiple sectors in South Africa.

6.3 Recommendations

5G is a catalyst and enabler for achievement of digital inclusion for South African consumers and businesses. The technology has the potential to offer enormous benefits to consumers and industries, but the socioeconomic challenges will hinder any potential of this technology to bridge the digital divide. The following recommendations are proposed with the aim of accelerating the adoption of the 5G technology:

Department of Cooperative Governance; National Treasury; and Department of Planning, Monitoring and Evaluation

i. The COVID-19 pandemic has led to increased inflation and unemployment rates in South Africa, exacerbated by high food, energy, and fuel costs. To address this, the DcoG, National Treasury, and Reserve Bank must implement sustainable changes in interest rates and taxes. The government and private sector should collaborate to create employment opportunities and provide technological infrastructure for 5G adoption.
ii. The DPME should implement policy frameworks and government plans using specific, measurable, attainable, realistic and time bound (SMART) performance measurement principles, enforce consequential performance management, and hold those responsible accountable for non-delivery and non-performance. The NDP 2030, Broadband Policy, and NIC Plan require urgent and radical approaches to policy implementation to achieve objectives. Technical expertise and qualifications are essential in technology implementation, and the government must have skilled resources to reduce the long policy implementation durations.

C2 General

Department of Basic Education

i. Education plays a crucial role in the eradication of unemployment; it is, therefore, important for the government to be aggressive in the adoption of e-learning, especially in public schools, which have regressed to the traditional face-to-face ways of teaching. All public and rural schools should be equipped with internet infrastructure, gadgets, and a curriculum that incorporates digital technology subjects. These initiatives will empower learners from primary to high school with the digital skills required for readiness for the 21st-century jobs, thereby improving digital literacy.
ii. The department should form partnerships and collaborate with NGOs, the private sector, and ICASA to come up with innovative digital technology-focused programmes that will enhance education.

Department of Communications and Digital Technologies

i. The Department of Communications and Digital Technologies (DCDT) and ICASA should accelerate the digitalisation of all its departments within realistic timelines to ensure improved efficiencies and service delivery to consumers. As the custodian and champion of 4IR through the PC4IR Strategic Implementation Plan, the government should lead by example in terms of digital transformation within its entities.
ii. For DCDT, in collaboration with Department of Public Works and Infrastructure (DPWI), investing in infrastructure and IT systems for government buildings is of paramount importance to ensure uninterrupted and stable service to consumers, especially in essential service departments such as Home Affairs, the licensing department, municipalities, SAPS, SASSA, clinics, and hospitals.
iii. DCDT in collaboration with DPWI and mobile operators should consider increasing the free Wi-Fi hot spot areas to enable free internet access for

C2 General

the less disadvantaged consumers who are unable to afford and access broadband infrastructure.

iv. The SA Connect policy should be reviewed to include 5G as a service in the second phase of the project rollout to ensure that the 42 000 government buildings, households and communities are 5G enabled and ready.

v. Digital literacy training and upskilling of government staff and civil servants are also essential to the adoption of the 5G technology and enhancement of operational efficiencies in service delivery.

vi. Collaboration and partnerships with mobile operators, OEMs, and NGOs were strong sentiments shared by participants in the study. It is, therefore, of utmost importance for the DCDT to work with 5G stakeholders to ensure the following:

- The 5G FWA service, which is a cost-effective solution, should be adopted and deployed in rural and remote areas to enable 5G coverage and connectivity for consumers; this is a step closer towards achieving the Broadband Policy's universal broadband goal and reduction of the digital divide. The government should also consider 5G FWA as a redundancy service for their buildings to maintain network availability and to eradicate the "system offline" syndrome often experienced by consumers when they visit government buildings. This will enable the government to monitor non-performing civil servants, who often use this reason to avoid working.
- DCDT and ICASA should incentivise mobile operators and OEMs through tax breaks for the sunsetting of 2G and 3G devices on the market, to accelerate the adoption of 5G-enabled devices. They should also explore subsidisation and direct funding models to accelerate 5G network deployment, renewable energy and 5G enabled devices. The government can learn from South Korea,

C2 General

China, and Saudi Arabia, who have collaborated to make investment initiatives available to mobile operators through funding models.

Regulatory

To accelerate 5G deployment and promote healthy competition in the telecommunications industry, the following recommendations are made for regulatory authorities to implement in collaboration with the DCDT ministry:

i. ICASA must expedite the additional spectrum release in accordance with ITU standards to increase the pace of 5G deployment and provide new services that will further transform industries and consumers. ICASA and DCDT should accelerate the long-awaited analogue-to-digital migration to release the much-needed spectrum.
ii. ICASA and DCDT should re-evaluate WOAN to allow for the involvement of smaller telecom companies to access the spectrum; these companies may enhance coverage in remote and rural locations that are not a top priority for mobile operators. WOAN will boost broadband connectivity towards achieving the Broadband Policy goal of providing 100 percent universal broadband access to South African citizens. This has a potential to contribute towards bridging the digital divide quicker by reducing the dominance of vertically integrated operators, thereby increasing healthy and fair competition.
iii. The researcher suggests that ICASA explore the development of and publish special 5G-specific rules and legislation in the ECA to regulate licenses, spectrum, and security issues related to the 5G technology. The United Kingdom can be used as a benchmark based on its success rate, as it already has rules and legislation to manage the 5G ecosystem.
iv. ICASA should consider network sharing agreements, especially active RAN and spectrum sharing. Enactment of these agreements will

C2 General

enable mobile operators to accelerate 5G deployment and reduce investment required to deploy 5G. The agreements should enforce timelines for when mobile operators should achieve 5G deployment milestones.

Mobile Operators and OEMs

Mobile operators and OEMs play a crucial role in the designing, manufacture, building, deployment, and maintenance of 5G networks. They also provide a crucial role towards bridging the digital divide, achieving the government policy frameworks and plans, and ultimately meeting the SDG goals. The following recommendations are made for the mobile operators and OEMs to accelerate 5G deployment:

i. Mobile operators and OEMs should prioritise 5G over satellite and 5G FWA services as alternative broadband solutions to accelerate 5G deployment in areas with limited coverage and insufficient infrastructure. Mobile operators that own the fibre infrastructure should consider that prioritisation of long-haul fibre routes for rural areas ensures infrastructure availability for 5G, thus bridging the first level of the digital divide and enhancing access.
ii. Mobile operators should offer affordable 5G devices to consumers through innovative funding models to increase device penetration for accelerated 5G deployment and the consumption of 5G products and services. South Africa faces high data costs, and collaboration between operators, the government, and ICASA is crucial to reducing affordability challenges and bridging the digital divide.
iii. Mobile operators must contribute to inclusive society goals by promoting 5G technology awareness, collaborating with NGOs and communities. Digital literacy programs and initiatives empower consumers to understand 5G products and services, increasing revenue growth and market share for mobile operators. This will contribute towards the bridging

C2 General

of the third level of the digital divide, which is increased awareness regarding differences in access and usage of digital resources.

6.4 Suggestions for Further Research

The present study highlighted an in-depth understanding, informed by experts, of the potential and capabilities of 5G to bridge the digital divide in South Africa. In addition, it aimed to understand how South Africa can leverage the IMT-2020 vision through the 5G use cases to drive societal and industrial changes.

It is suggested that future research looks at (1) how mobile network operators will deploy 5G technology and roll out the spectrum to enable 5G on their networks; (2) the impact of 5G technology on the digital economy; and (3) how cybersecurity will keep 5G equipment and devices secure.

The researcher also suggests future research to look at how innovative policies can foster lasting digital transformation and connection, and how these policies can be measured to ensure that government and regulatory authorities are held accountable for non-implementation and deadline breaches.

C2 General

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C2 General

APPENDIX A: Participation information sheet

Dear Sir / Madam,

My name is Sebongile Dumako and I am a Masters student in Digital Business at the University of the Witwatersrand, Johannesburg. As part of my studies, I have to undertake a research project, and I am investigating the potential of 5G in closing the digital divide in South Africa under the supervision of Mr Ashraf Patel. The aim of this research project is to find out the socio-economic impact of 5G it will have on the South African citizens and how it will bridge the digital divide.

As part of this project, I would like to invite you to take part in an interview. This activity will involve a question-and-answer session and will take around 40 minutes. With your permission, I would also like to audio record the interview using a digital device. This recording will be stored in a secure storage platform and only the researcher will have access to this recording. It will be deleted after 1 year.

There will be no personal costs to you if you participate in this project, you will not receive any direct benefits from participation but there are no disadvantages or penalties if you do not choose to participate or if you withdraw from the study. You may withdraw at any time or not answer any question if you do not want to. The interview will be completely confidential and anonymous as I will not be asking for your name or any identifying information, and the information you give to me will be held securely and not disclosed to anyone else. I will be using a pseudonym (false name) to represent your participation in my final research report. If you experience any distress or discomfort at any point in this process, we will stop the interview or resume another time.

If you have any questions during or afterwards about this research, feel free to contact me on the details listed below. This study will be written up as a research report which will be available online through the university library website. If you

C2 General

wish to receive a summary of this report, I will be happy to send it to you (optional). The data collected from this research project will be stored in an authorised secure storage platform and will be kept for 1 year. With your permission the data collected from this research project may be used by other researchers in an anonymized format. If you have any concerns or complaints regarding the ethical procedures of this study, you are welcome to contact the University Human Research Ethics Committee (Non-Medical), telephone +27(0) 11 717 1408, email hrecnon-medical@wits.ac.za

Yours sincerely,

Researcher:

Sebongile Dumako, 1817381@wits.students.ac.za, 082 444 3325

Supervisor:

Mr Ashraf Patel, baobabknowledge@gmail.com, 011 717 3980

C2 General

Appendix B: Interview guide

Item	Questions
1.	What is your understanding of 5G technology?
2.	What is the technical difference between 3G, 4G and 5G?
3.	Is South Africa ready for 5G and why?
4.	What interventions do you think government and the regulatory can implement to accelerate 5G deployment?
5.	What does 5G mean for South African consumers and how should operators educate consumers?
6.	Which South African industries will benefit the most from 5G?
7.	How do you think 5G can reshape future business at various levels (small, medium, and macro enterprises)
8.	What do you understand about the 5G technology's potential to bridge the digital divide in South Africa?
9.	What type of services can be offered by 5G technology to improve the socio-economic impact of South African consumers and citizens?
10.	How will 5G enhance e-Government in SA? What are the key features of 5G that will enhance service delivery in South Africa?
11.	What are the 5G disadvantages?
12.	How will the disadvantaged and poorer communities without smartphone devices have access and benefit from 5G technology? What kind of programs are required to promote 5G?

C2 General

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APPENDIX C: Ethics clearance approval

Graduate School of Business Administration
University of the Witwatersrand, Johannesburg

Wits Business School Ethics Committee
Constituted under the University Human Research Ethics Committee (Non-Medical)

Ethics Clearance Certificate

Ethics protocol number: WBS/DB1817381/211
This certificate is only valid with a legitimate ethics protocol number and signed by the Researcher (below).

This certificate is only valid if accompanied by formal permission from the relevant stakeholder(s).

Project title	The potential of 5G to bridge the digital divide in South Africa
Investigator / Researcher	Ms Sebongile Dumako
Nature of Project	MM (Digital Business)
Decision of the Committee	Approved, provided stakeholders and participants are guaranteed confidentialty.
Issue Date of Certificate	2023-01-18
Expiry date	Date of submission of the project / research report
Chairperson	Prof Anthony Stacey ☎ +27 11 717 3587 +27 82 880 4531 ✉ anthony.stacey@wits.ac.za

Declaration by Researcher

One copy must be signed by the Researcher and returned to the Chairperson of the Wits Business School Ethics Committee.

I fully understand the conditions under which I am authorized to carry out the abovementioned research and I guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I undertake to resubmit the protocol to the Committee.

Signature

20 January 2023
Date:

C2 General