UNDERSTANDING THE DIFFUSION OF THE INTERNET: REDESIGNING THE GLOBAL DIFFUSION OF THE INTERNET FRAMEWORK

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ABSTRACT

Since 2001, the Wolcott et al. (2001) framework has been used to measure worldwide diffusion of the Internet. However, the framework is obsolete, and there is a gap in accessible frameworks that allow a better understanding of the Internet's proliferation, especially in this period of extensive digital transformation. The literature review for this study shows advances in Internet diffusion, and in digital technologies and applications over the past two decades. The 2001 framework uses outdated measurements for its six dimensions and does not allow measurement of diffusion relevant to digital evolution in 2020.

The objective is to create a suitable GDI framework for the current stage of the digital economic revolution. The researcher chose to adopt the same qualitative methodological approach as Wolcott et al. (2001), in order to update the existing framework by incorporating more recent determinants related to Internet diffusion, but improved the 2001 methodology by conducting extensive coding using ATLAS.ti.

The key finding of the study was the need for retaining some of the Wolcott et al. (2001) dimensions and levels, while adding one new dimension and revising the levels for each of the seven dimensions. The results of this exercise are presented as the GDI 2020 framework. The lessons learnt from this study can contribute to existing knowledge and enhance the understanding of how the Internet spreads and evolves. Policymakers, regulators and industry decision-makers can use the GDI studies to develop intervention strategies for addressing the digital divide.

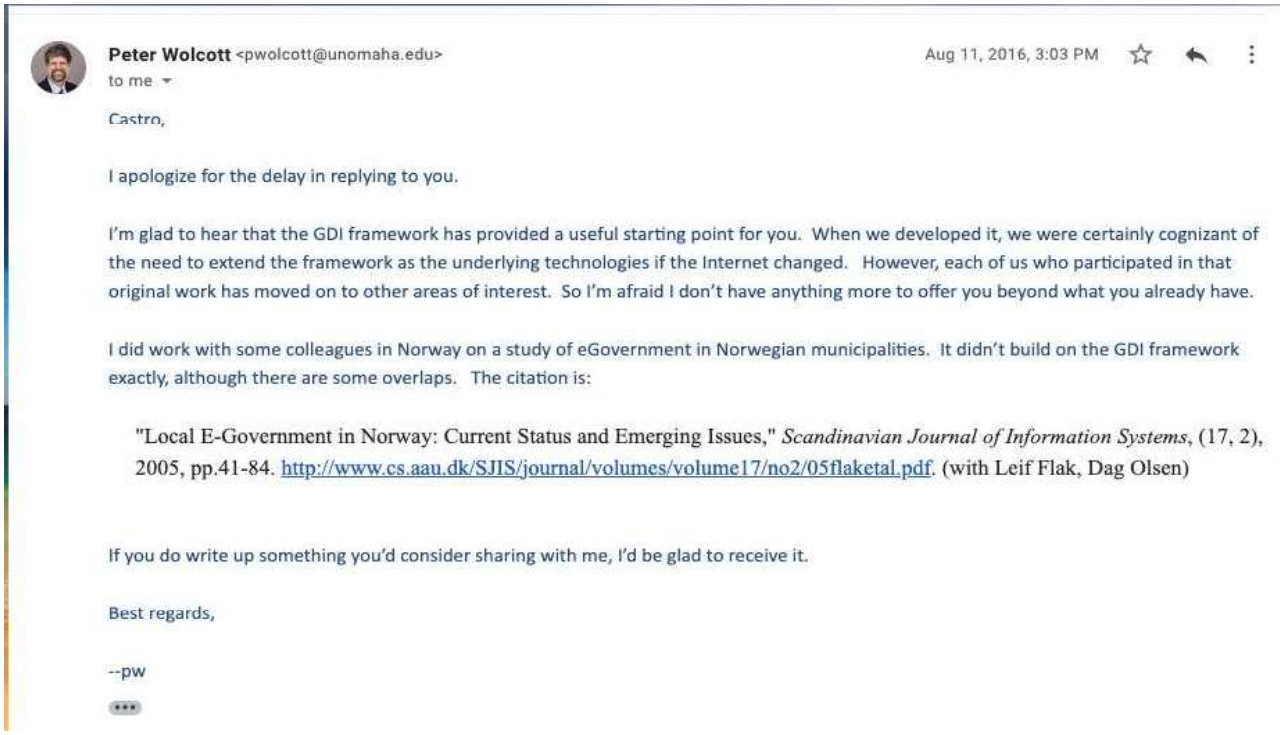
Keywords : Digital, Adoption, Transformation, Revolution, Internet, Diffusion

DEDICATION

To my lovely daughter Lethokuhle Mosina, I dedicate this achievement to you and hope it serves as an inspiration.

ACKNOWLEDGEMENT

I would like to acknowledge the unwavering support of my supervisor, Dr Lucienne Abrahams. I am certain that without her guidance, this task would have not been possible, and may Allah bless her in abundance. I would also like to thank Peter Wolcott for his email encouraging me to enhance the original work of the Wolcott et al. (2001) framework.



Peter Wolcott <pwolcott@unomaha.edu> Aug 11, 2016, 3:03 PM

to me

Castro,

I apologize for the delay in replying to you.

I'm glad to hear that the GDI framework has provided a useful starting point for you. When we developed it, we were certainly cognizant of the need to extend the framework as the underlying technologies if the Internet changed. However, each of us who participated in that original work has moved on to other areas of interest. So I'm afraid I don't have anything more to offer you beyond what you already have.

I did work with some colleagues in Norway on a study of eGovernment in Norwegian municipalities. It didn't build on the GDI framework exactly, although there are some overlaps. The citation is:

"Local E-Government in Norway: Current Status and Emerging Issues," *Scandinavian Journal of Information Systems*, (17, 2), 2005, pp.41-84. http://www.cs.aau.dk/SJIS/journal/volumes/volume17/no2/05flaketal.pdf. (with Leif Flak, Dag Olsen)

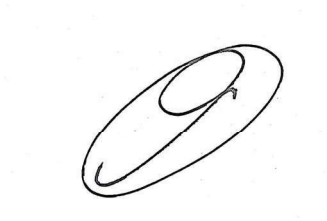
If you do write up something you'd consider sharing with me, I'd be glad to receive it.

Best regards,

--pw

DECLARATION

I declare that this report is my own, unaided work. It is submitted in partial fulfilment of the requirements of the degree of Master of Arts (in the field of ICT Policy and Regulation) at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination to any other University.



Castro Mosina
07 September 2020

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LIST OF ACRONYMS

2G	Second-generation cellular technology
3D	Three Dimensional
3G	Third-generation cellular technology
4G	Fourth-generation cellular technology
5G	Fifth-generation cellular technology
AI	Artificial Intelligence
BRICS	Brazil Russia India China and South Africa
EIU	Economist Intelligent Unit
Gbps	Gigabits per second
GDI	Global Diffusion of the Internet
GDP	Gross Domestic Product
GNI	Gross National Income
GNP	Gross National Product
GPS	Geographic Positioning System
GSMA	Global System for Mobile Communication Association
HDI	Human Development Index
ICT	Information and Communications Technology
IDI	ICT Development Index
IoD	Internet of Drones
IoT	Internet of Things
IP	Internet Protocol
ISEW	Index of Sustainable Economic Welfare
ISP	Internet Service Provider
ITU	International Telecommunication Union
IXP	Internet Exchange Points
LDC	Least Developed Countries
LTE	Long-Term Evolution
Mbps	Megabits per second
NDP	National Development Plan of South Africa
NRI	Network Readiness Index

OECD	Organisational for Economic Co-operation and Development
OTT	Over-The-Top Services
QDAS	Qualitative Data Analysis Software
QoS	Quality of Service
RSA	Republic of South Africa
TAI	Technology Achievement Index
Tbps	Terabits per second
UAV	Unmanned Aerial Vehicles
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNDP	United Nations Development Program
VAT	Value Added Tax
VOD	Video-on-demand
VR	Virtual Reality
WEF	World Economic Forum

CHAPTER ONE: INTRODUCING THE GLOBAL DIFFUSION OF THE INTERNET FRAMEWORK

1.1 INTRODUCTION

The Internet is growing at a faster rate all over the world, but there has been a lack of proper measurement of this growth. “The global diffusion of the Internet has been used to measure the presence of the Internet in countries,” (Wolcott, Press, McHenry, Goodman, & Foster, 2001), and it is still considered a good measuring tool for internet diffusion. This research intends to present a revised GDI framework to close the gap between 2001 and 2020 because there have been many developments in the diffusion of the Internet in the past two decades, the study will retain some of the elements and dimensions of the Wolcott et al. (2001) as they’re considered relevant to the current era of digital revolution. The value to be derived from the revised framework is a framework that is relevant to the current era of broadband Internet and digital economy and society, where the framework can be used to understand the advanced diffusion of the Internet. Some researchers still use the Wolcott et al. (2001) framework, but these studies could be more beneficial if they were based on an up to date framework. The research commences with a review of the Wolcott et al. (2001) framework, intending to add elements and dimensions that are critical to diffusion. The study takes place in the context of digital transformation, bringing into focus newer aspects of diffusion such as broadband, Wi-Fi, cloud computing, Internet of Things, and smart cities. In the scope of the articulation of different studies, the idea of digital transformation can be better understood. (Fountain 2001, 2004: Jaeger & Bertot 2010; Kramer & King 2006; Luna-Reyes & Gil-Garcia, 2011) argue that “information technologies have the potential to transform how government provides its core services to people”. Andersen and Dawes (1991) maintains that "the automation process of government-related services started in the 60s when government automated repetitive and intensive tasks by using mainframe computer and servers”. The digital space has seen some transformation over the years, including recently, the advent of social media.

Wolcott et al. (2001) is one of a few frameworks that assist us to understand specific characteristics of the digital economy. I chose to study and revise the Wolcott et al. (2001) framework, because I am interested in diffusion, rather than readiness, or technology achievement, or ICT development as an index.

Almost two decades ago, Norris (2001) argued that the gaps that exist in Internet usage between those with access and those without access must eventually close with the advancement of technology, when there is greater adoption of the Internet. This view is supported by Leigh and Atkinson (2001), “who argued that as and when the level of diffusion reaches between 80-90%, the level of diffusion will be faster amongst the disadvantaged who would then eventually catch up with the advantaged". The ‘digital divide’ has been defined as “the gap between individuals, households, businesses and geographic areas at different socio-economic levels with regard to both their opportunities to access information and communication technologies (ICTs) and to their use of the internet for a wide variety of activities” (OECD, 2001, p5). When online networking “proliferated and Internet use became much more widespread; ingrained in everyday life and correlated with nuanced usage patterns and access modes”, the subject of debate moved to the topic of 'second-level digital divisions' (Hargittai, 2002; van Dijk, 2006; Strover, 2014) where digital divisions centred more on capability differences and use differences. Stier (2017) argues that the "relationship between regime type and the diffusion of the Internet needs to be understood as a dynamic process, in that the superior, innovative capacity of democracy leads to faster adoption of technologies". He argues that “when digital technologies increase their economic value with economies of scale”, even autocratic rulers see the rationality in encouraging their use to legitimize the performance of their regime (Stier, 2017). There is a general acceptance that Internet diffusion is high "when the government is providing sufficient infrastructure, and the citizens are willing and capable of using it" (Stier, 2017). Governments and stakeholders need to introduce innovative solutions during all stages of technological development to create an environment that is rich in feedback loops (Stier, 2017).

1.2 RESEARCH PROBLEM STATEMENT

The research problem is that, although the Wolcott et al. (2001) framework is more useful than the four other frameworks relevant to understanding the diffusion of the Internet (see Appendix A), it is out of date. Hence, there is a gap in available knowledge of frameworks useful for the understanding of the diffusion of the Internet, particularly in the era of extensive digital transformation. The global diffusion of the Internet (GDI) framework is too limiting as it uses outdated measurements for at least some of its six dimensions, while it excludes aspects that may be important to Internet diffusion in the transition to digital revolution mediated by emerging technologies like Internet of Things, Artificial Intelligence, big data and analytics, blockchain, and robotics and the design of smart cities. The existing framework doesn't allow for measuring diffusion beyond the highest level of the framework. It does not capture the complex social, economic and political and the impact on individuals, business and government. The framework was more appropriate for early adoption and Internet diffusion. An adapted analytical framework is needed for researchers and countries to analyse the diffusion of the Internet in 2020 and beyond.

1.3 PURPOSE STATEMENT

There is a need for a framework to analyse and understand the diffusion of the Internet in South Africa, and more broadly across the globe. The purpose of the study is to revise the existing framework. This was done through (1) reviewing the existing Wolcott et al. (2001) framework to assess strengths and weaknesses (2) revising the Wolcott et al. (2001) framework to include broadband and other contributing components of Internet diffusion in the context of widespread digital transformation across the globe, which were not included in the Wolcott et al. (2001) framework (3) considering the advantages and disadvantages of the revised framework.

1.4 RESEARCH QUESTIONS

Main research question*:*

How should the existing six dimensions and their respective measurements be adjusted to create a suitable GDI framework for the current stage of the digital economic revolution?

Sub-questions:

1. What are the limitations of the existing GDI framework?
2. How can insights on Internet diffusion in a particular country inform a revised framework?
3. What are the advantages and disadvantages of the modified framework?

1.5 RELEVANCE TO SOUTH AFRICA, ACADEMIA, POLICY AND PRACTICE

Given the digital divide in South Africa, where the dimensions and levels of Internet diffusion in 2020 are not fully reported, it would be useful to have a framework that enables us to measure its diffusion more rigorously. Such a framework should be widely applicable, not only to South Africa, but also to other developing nations. It was the initial intention of the study to apply the Wolcott et al. (2001) framework to South Africa but because it was found to be outdated, we used South Africa as an example to show relevance, the context of the study is more theoretical. The framework is relevant for business stakeholders wishing to use and invest in the Internet, policy makers who are discussing how to influence their usage and growth positively (or negatively) and academics who are researching the large-scale deployment of complex integrated technology.

The population of South Africa was estimated to 58.78 million by mid-2019 (StatsSA, 2019a). Black Africans make up 79.4% of the population, the majority. The population of Coloured is estimated to be 8.8%, while the White community is 9.2% and the Indian / Asian population is 2.6%. Women account for just over half of the population (51.3%) and men for 48.7% (StatsSA, 2019a). The Republic is characterized by high unemployment, poverty, low education levels and low income. The GDP for 2019 was estimated at ZAR3,143 trillion (constant 2010 prices, seasonally adjusted and annualised) (StatsSA, 2019b).

The National Development Plan (NDP, 2012) argues that South Africa needs economically dynamic cities that are “more responsive to the needs of all sections of society, the country needs an integrated approach to development”. From the perspective of this study, integrated development should include strategies to generalize diffusion of the Internet, for socio-economic advancement. When we put

together the concept of dynamic cities and the concept of Internet diffusion, this leads us to the potential for evolving smart cities, as well as smart towns and villages in the 'less-favoured' (Abrahams & Pogue, 2012) parts of South Africa.
The framework for the global diffusion of the Internet (Wolcott et al., 2001) is one of a few useful starting points (as discussed in the literature review), though it needs to be reviewed and new aspects that are related to diffusion in the post-2020 period should be added, specifically with respect to digital revolution.

In comparison with the international standards, the NDP (2012) asserts that the South African information infrastructure is inadequate. There is a strong argument that "efficient information infrastructure that promotes economic growth and inclusion requires robust broadband and network backbone" (NDP, 2012).

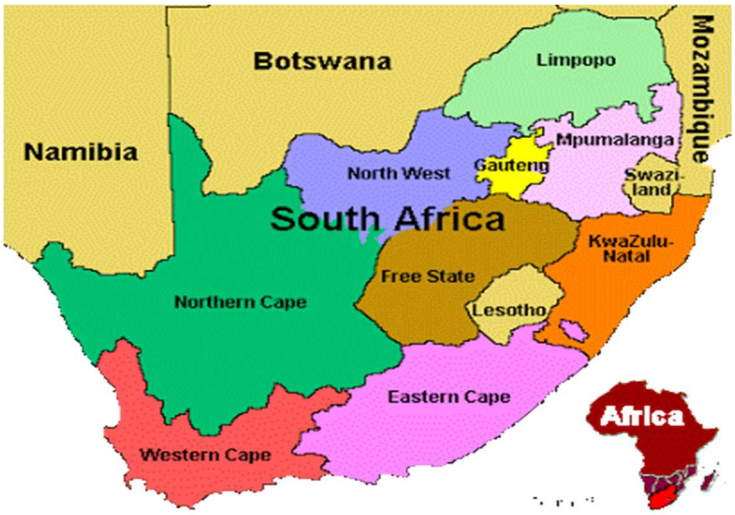

Figure 1: Map of South Africa: provinces

Source: Google Maps

1.6 INTERNET IN SOUTH AFRICA

According to Luiz and Stephan (2012), "South Africa has the highest penetration than any country in Africa in respect of broadband and Internet usage". Statistics South Africa (2019c, pp.56–58) data shows that, in 2018, 89,5% of households had only a mobile phone in their dwelling, while 7,1% had both a mobile phone and a landline, 0,1% had only a landline, and 3,4% had neither.

Household access to the Internet by place of access, was mainly through mobile devices (60,1%), at work (16,2%), at home (10,4%), or at Internet cafes and educational facilities (10,1%). While the data indicates that South Africa fares well in terms of access to the Internet, more refined indicators are needed to assess the intensity of use and the human capacity to make the best of the Internet.

Apăvăloaie (2014) argues that the Internet offers many incentives for growth to underdeveloped areas. Existing economic inequalities can be reduced much more effectively than by traditional means if the internet is used correctly. The benefits must, however, be understood in a global competitiveness context. According (ITU, 2018), “the percentage of individuals using the Internet was estimated at around 51.92%, the fixed broadband subscriptions per 100 inhabitants were estimated at 5.25%, and the mobile broadband subscription per 100 inhabitants was at 59.5%”. The report further shows that households with a computer “were standing at 23.4%, and households with Internet access at home were estimated at 50.6%” (ITU, 2018). South Africa is ranked third in the regional ICT Development Index (IDI) behind Mauritius and Seychelles (ITU, 2018). It is argued that the score of 4.70 is relatively lower than the global average of 4.94, and as such, "this is reflective of a lower level of economic development which affects the broader development of ICT" (ITU, 2018).

Fuksa (2013) argues that "because of the vast functionality and ease of usage, the Internet has become an important communication tool for individuals and organizations”. Salahuddin and Gow (2016) argue that "various governments across the developed and developing countries in the world have begun to recognize the growth potential that the Internet brings to their respective economies, and have developed policies that are enabling this growth in their countries”. Saluhuddin and Gow (2016) further states that " in line with the new growth theories, the growth effect of the modern communication network has brought about different quality, the usage of Internet has accelerated the distribution of ideas, and fostered competition and information”. There has been a “development of new products and business models which has assisted in accelerating macroeconomic growth" (Saluhuddin & Gow, 2016).

The argument is further augmented by the empirical study of Noh and Yoo (2008), who, in their research, "tested Internet adoption, income equality, and economic growth". The empirical study "involved close to 60 countries spanning the period 1995 -2002, and it found that the effect and impact of the Internet on economic growth is negative on countries with high-income inequality as this will inevitably hamper the economic growth of the Internet". The study concludes that since South Africa has all the elements of the high-income level, the same results will be applicable.

Noh and Yoo (2008) make a policy observation, "that as much as the Internet growth in South Africa has been impressive in the African continent, it is relatively low in the context of similar developing economies across the world". The current Internet usage was estimated at around 56.17% (ITU 2018), whereas similar middle-income countries in the world have an uptake of between 70-90% of Internet usage. Holden and Van Klyton (2016) suggest that with the rapid developments of the telecommunications sector in “Africa and the rest of the world”, many countries have come to regard the broadband Internet as being central and the key to economic development initiatives and could be a key driver for profitability. Within the context of Internet governance, (Holden & Van Klyton, 2016) maintain that the narrative in “Africa is about achieving sustainable economic growth and promoting social development through the application of digital technologies". In line with the observations above, it is our considered view that the Internet will be vital in unlocking the challenges that are linked to economic development and drive innovation.

1.7 DELIMITATIONS OF RESEARCH

The delimitations to the research will mainly include the inability on the part of the researcher to test the revised framework with the focus group of experts, to validate the framework. Therefore, the results of this study will reflect the findings mostly from secondary document analysis, noting that there is triangulation of data due to the extensive nature of the document review. The revised framework will provide a platform for future study and further development of the framework.

1.8 CHAPTER OUTLINE

Chapter One provides a contextual overview of the global diffusion of the Internet, and a commentary about the digital divide and the state of the Internet in South Africa. The chapter further briefly discusses the research problem to be explored and the purpose statement and concludes with the delimitations of the study.

Chapter Two examines past studies on the diffusion of the Internet, gives a historical overview of the Wolcott et al. (2001) framework, and informed by the literature sketches the future-orientated framework for country positioning. This chapter also reflects on the analytical conceptual framework that is grounding the research.

Chapter Three then expands on the research problem and the research purpose statement by asking pertinent research questions. The chapter also presents the research methodology, the research paradigm, the methods of data collection, and confirms the ontological orientation of the study.

Chapter Four provides information that was gathered through the secondary data analysis based on the research outlined in Chapter Three. This chapter effectively presents the building blocks of the new dimensions for Internet diffusion.

Chapter Five presents the design of the refreshed and revised GDI framework 2020, based on interpretation, processing and evaluation that emerged from the data in Chapter Four and gives the details of the final dimensions of the Internet diffusion framework.

Chapter Six concludes the study by looking at the advantages and disadvantages of the revised GDI 2020 framework in line with the collected data. The chapter also makes suggestions for future studies that will aim at enhancing the global diffusion of the Internet framework.

1.9 CHAPTER SUMMARY

The chapter looked at the historical context of the Wolcott et al. (2001) framework, which has been widely used to measure the global diffusion of the Internet across the world and observed that the framework has not been refreshed for almost two decades. The chapter also looked at the state of the Internet in South Africa in comparison to other countries in Africa. The chapter also introduced the research problem and the purpose statements.

CHAPTER TWO: LITERATURE REVIEW AND CONCEPTUAL ANALYTICAL FRAMEWORK: DIMENSIONS OF THE GDI

2.1 INTRODUCTION

This chapter looks at various frameworks that are used to measure the diffusion of the Internet around the world. The researcher opted for the Wolcott et al. (2001) framework and the preliminary indications were that the framework needs to be refreshed to accommodate other aspects and dimensions that are critical to measuring the diffusion of the Internet. This chapter examines the strengths and weakness of this 2001 framework and introduces the idea of reworking on the dimensions and levels of the Wolcott et al. (2001) framework. The chapter uses literature published throughout the past two decades to review the 2001 framework.

Eggers (2018) argues that in “today's environment, the assumption that regulations can be slowly and deliberately crafted, and then remain in place, unchanged, for long periods of time has ended”. With the introduction of “new business models and services, such as ridesharing services and initial coin offerings, government agencies are challenged to create or modify regulations, enforce them, and communicate them to the public at an unprecedented pace and while working within legacy frameworks and trying to foster innovation they have to do so” Eggers (2018).

Mutula and Van Brakel (2006) argue that "there are various frameworks and e-readiness assessment tools created by other stakeholders, such as McConnel with Ready, Net. Go, Harvard University with Network Readiness Index tool, the Economist Intelligent Unit with E-readiness Rankings, the United Nations Conference on Trade and Development (UNCTAD)(with its ICT Development Index), the United Nations Development Program (with its Technology Achievement Index)”. The detailed information of the frameworks is included as Appendix A to this research report, and the following represents the summarized description of the various frameworks.

The annual e-readiness rankings reports have been produced by the Economist Intelligence Unit since 2000 and have been mainly used to measure the “world's largest economies in terms of gross domestic product (GDP)”. The ranking model assesses 70 countries' scientific, financial, political, and social capital “and their cumulative impact on their respective knowledge ecosystems”. E-readiness explores the current status of a country's ICT infrastructure and, to a greater extent, investigates the “willingness of its customers, businesses, and governments to use ICT to their advantage”. The supportive environment is created such that digital business and transactions will be able to thrive within the framework of the rankings. The E-readiness is not only concerned about the issues of connectivity but also to a greater extent the ICT literacy of citizenry, and the involvement of government in driving digital technologies. The e-readiness rankings consist of “100 quantitative and qualitative criteria, divided into six separate categories: social, political, economic, connectivity, business environment and technological development”.

The World Economic Forum Network Readiness Index: WEF (2016) confirms that 139 economies were surveyed for the Networked Readiness Index (NRI) ranking, which is composed of “four sub-indexes (the environment of ICT, the readiness of a society to use ICT, the actual usage of ICTs by all the stakeholders and the impact that ICT generates in the economy and society), 10 pillars and 54 indicators” (WEF, 2016). The countries covered in the report account for almost 98% of the world's GDP. Milenkovic, Brajovic, Milenkovic, Vukmirovic, and Jeremic (2016) explain the concept of Network Readiness Index as the “rate at which the implementation of information and communication technology is adopted” and implemented in a particular country with the view to increasing its competitive advantage and boosting its economy. The report provides for a high-level overview of the country's ICT infrastructure. Baller, Dutta and Lanvin (2016) argue that the NRI "presents the nations with a tool that would be used to measure the country's readiness and maturity to realize the benefits of emerging technologies and leverage on the opportunities that come with the digital transformation".

Molla (2008) argues that within the networked economy, the success of the business and the prosperity is heavily reliant on e-readiness, which is seen “as a source of competitive advantage”. Cherchye et al. (2008) explain technological achievement

index as how well the country is doing in terms of "creating and disseminating new and existing technologies to build the human resource capacity" in the development of technology to help the policy-making processes to correctly define strategies aimed at technology development. Technical achievement of a county is related to "the degree to which it is willing to participate in the international knowledge economy" Cherchyre et al. (2008). This can be represented by a combination of suitable indicators. Some of these measures may represent the current level of technological quality potential of a state, while others may provide strong evidence of dynamic and efficient capability. A suitable combination of the two gives a reasonably realistic idea of a country's technical achievement.

The Technology Achievement Index (TAI), initially proposed in 2002 (Desai, Fukuda-Parr, Johansson, & Sagasti, 2002) and subsequently referred to as TAI-02, "is one such composite index that aggregates national technological capabilities and quality in terms of (i) the spread of new technologies, (ii) the spread of old technologies and (iii) the development of human skills". According to (Desai, Fukuda-Parr, Johansson, & Sagasti, 2002), the UNTAI has been limited to only 72 out of more than 200 countries. It is an index that is easy and fairly useful for determining a nation's national technological capacity. The sub-indicators of TAI research are considered to include all relevant aspects of technical achievement in principle. As such, countries can measure "their relative technology-based readiness to compete with their competitors in the international knowledge-based economy" (Desai, Fukuda-Parr, Johansson, & Sagasti, 2002). The TAI "focuses on determining a country's technological performance based on its ability to create and use technology, but NOT on the overall size of its technological development" (Desai, Fukuda-Parr, Johansson, & Sagasti, 2002).

Ghavamifar, Beig, and Montazer (2008) articulates the ICT development index as "a tool that analyses and evaluates the usage of ICT but using indicators of ICT diffusion across countries". According to ITU (2016), "the IDI is described as a composite index that incorporates 11 indicators into one benchmark measure for tracking and comparing developments in ICT between countries over time". The IDI, established by "ITU in 2008, in response to the demand by the ITU member states to create an overall ICT index, was first published in the 2009 version of the document and has

since been published annually" (ITU, 2019). The ITU (2016) report confirms that over 175 economies were done in 2016, which is an improvement from the work that was done in 2015 as this highlights "progress and persistent divide in the global information society".

The "GDI framework consists of six dimensions, each of which describes a measurable feature of the presence of the Internet in a country" (Wolcott et al., 2001). These dimensions collectively cover a range of features, each aspect adding to the overall understanding of Internet diffusion (Wolcott et al., 2001). The framework includes the determinants of each dimension. Knowing how the determinants affect a country's measurements "may contribute to a more accurate understanding of the overall state of diffusion" (Wolcott et al., 2001). Typically, GDI studies include a thorough analysis of dimensions as well as determinants (Wolcott & Goodman, 2000). There is limited researched data to confirm the number of studies conducted to date, suffice a confirmation by (Murthy, Nath & Soleiman, 2015) that the "highly developed countries of the Organisation for Economic Co-operation and Development (OECD) have high levels of Internet diffusion" as opposed to the Sub Saharan African countries, that have primarily lagged behind resulting in the digital divide. ITU (2015), shows that "as in 2013, the average Internet diffusion rate of the Sub Saharan African countries was around 13% with a median rate of 9%, with South Africa leading with the diffusion rate of 46.5%".

Martin, O'Keefe, and Finucan (2016) confirms that "telecommunications service providers are moving quickly, investing in future systems and exploring new business opportunities with other industry sectors as they attempt to find their place in a new ecosystem that requires flexibility to meet changing demands". The new form of businesses "are rapidly developing new technologies and developing innovative products and services that rely on new networking and data services" Martin, O'Keefe, and Finucan (2016).

This is the preferred model based on the confirmation by Ghavamifar, Beig, and Montazer (2008), that "the dimensions of the system complement each other to form a complete array representing a cluster of technologies from infrastructure to end-user application in as much as the concern is about the issue of infrastructure".

A view is taken that this is a framework that could be reworked and refreshed to reflect on the ICT development of countries as of 2020 by adding other aspects that are critical to the diffusion of the Internet.

TABLE 1: Summary of frameworks

INDEX	WHAT IS MEASURED / CONCEPTUAL FRAMEWORK	DIMENSIONS	STRENGTH/WEAKNESS
WEF Network Readiness Index	The rate at which ICT is adopted and implemented in a particular country	The environment of ICT The readiness of a society to use ICT The actual usage of ICT by all stakeholders The impact that ICT generates in the economy and society	Only measure the level of ICT access and usage in a particular country and the overall impact once access has been gained
GDI	The framework measures the presence of Internet in a country	Pervasiveness Geographic dispersion Sectoral absorption Connectivity infrastructure Organisation infrastructure Sophistication of Internet use	This is more of an analytical framework that can be reworked and refreshed to be relevant for the digital revolution
EIU Readiness Ranking – now Inclusive Internet Index (3i)	It measures the country's ICT Infrastructure, the extent of ICT literacy of citizenry and the involvement of government in driving digital technologies	Connectivity and technology infrastructure Business environment Social and cultural environment Legal environment Government policy and vision Consumer and business adoption	The framework is seen as being more high level and concentrated on investment advisory as opposed to advocating for issues of inclusive connectivity
ITU Internet Development Index	It analyses and evaluates the usage of ICT by using indicators of ICT	ICT access ICT use ICT skills	The framework relies on limited data of countries at different levels of development

	diffusion across countries		

2.2 HISTORICAL GLOBAL DIFFUSION OF THE INTERNET (GDI) FRAMEWORK FOR THE ANALYSIS OF COUNTRY POSITIONING

Wolcott et al. (2001), confirm that the model is focused on an "ongoing inductive web analysis in a large representation of countries around the world". The paper by Wolcott is considered to be a significant development of the theory that attempts to explain why the Internet diffuses as it does. Wilson, Daly and Griffiths (1998), Nicholas and Rowlands (2000) maintain that studies of how the Internet affects and changes different countries' "cultural, political and social structures were constrained by the absence of more precise, concise and sophisticated measures than the simple number of Internet hosts in a country".

The GDI "framework allows for a broad overview of diffusion in a country to be determined and addresses the need for a consistent framework to allow for comparison between countries" (Brown et al., 2007). There has been large-scale adoption of the Internet globally, regionally, and in South Africa. Oyelaran-Oyeyinka and Lal (2005) argue that there has been "an exponential growth of the Internet, but the growth and the rate of adoption have not been at the same pace". The observation in terms of the speed of adoption is confirmed by Bloch and Dutta (2009) that around 61% of the "global population still doesn't have access to the Internet". The same studies revealed that the vibrant economies are much better at leveraging information and communication technology as opposed to the developing ones. By 2010 the "GDI framework had been used to assess Internet diffusion in over 40 countries", including several in Africa (Wolcott et al., 2001). However, between 2010 and 2013, the more rapid evolution of the Internet began to occur on the African continent, with significant increases in access to bandwidth, shift to high-speed broadband, and many more Internet-based services are becoming available. This evolution of the Internet in Africa slowly moved beyond what was being measured in the GDI framework, creating a need for a more advanced framework.

The framework is characterized by six dimensions, which presented a rich, and multi-faced view of the diffusion (Akpan-Obong, Thomas, Samake, Niwe, & Mbarika, 2009) at the time of its formulation.

These six dimensions can be categorized “into two general facets (i) the extent to which the Internet is used (connectivity, organizational infrastructure, and sophistication of use) and (ii) range of application (sectoral absorption, geographic dispersion, and pervasiveness)”, (Akpan-Obong, Thomas, Samake, Niwe, & Mbarika, 2009). However, in 2020, this framework requires a significant revision, noting the significant advances that have taken place in Internet diffusion and its consequences since 2001.

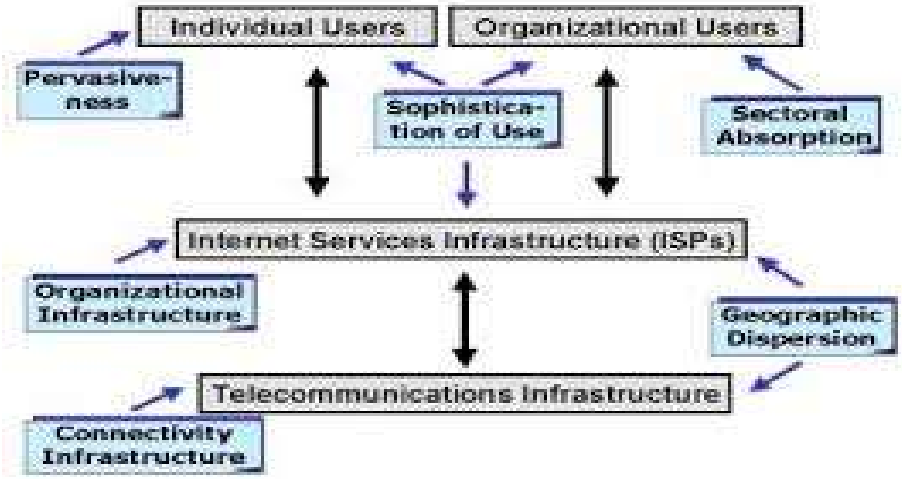

Figure 2: The six dimensions of the 2001 GDI framework

Source: Wolcott et al. (2001)

Economic development has mostly been concerned about the creation of wealth for nations, and before 1970, “it was considered a good proxy for the attributes that are linked to development” (Dang & Pheng, 2015). The performance of the economy has always been measured in terms of the increase in the gross national product, which has since been replaced by gross national income per capita to make a comparison of the wealth of countries. The World Bank defines gross national income as "the amount of value added by all manufacturers living in a nation plus any non-output commodity tax (minus subsidies) plus income received from overseas, such as wages to workers and income from land". Dang and Pheng (2015) made a further observation that "the goal of economic development in its narrowed sense induced the

nations to focus their energies on the rapid growth of national incomes to maximize growth". Gaspar, Marques, and Fuinhas (2017) argue that “gross domestic product being the most commonly used indicator to measure economic growth and sustainable has become insufficient for evaluating the development and are advocating for an alternative indicator known as Index of Sustainable Economic Welfare". They advance an argument that ISEW can be better used to control how countries use "available resources, ecological development, damages to the environment, and income distribution to the citizens".

Dang and Pheng (2015) argue that "the ultimate goal of economic development goes beyond issues of Gross Domestic Product, Gross National Product or Gross National Income per capita and calls for a deeper understanding of other sources of growth that are essential to achieve developmental objectives".

Reyes and Garcia (2014) assert that "access to the government portal via the Internet has largely contributed to the information revolution around the world and has improved how the government offers its services to the people". In a sense, this is a confirmation that the Internet has propelled digital transformation, and it is directly linked to service delivery. The “need for continuous co-evolution between technological innovation, the institutional change” was identified by (Rossel & Finger, 2007) through their common problems solving dynamics that involved several stakeholders, which emphasized that electronic government should make a meaningful contribution to policy and regulation. The International Telecommunication Union estimated in 2013 Internet usage in Africa to be around 16% as compared to 75% in Europe, and the gap in usage is continuing to widen even though the penetration rate has tripled in Africa from 2008-2014(ITU, 2013).

Penard, Poussing, Mukoko, and Piaptie, (2015) argue “that the digital divide is being exacerbated regarding the quality on Internet, in that most users in developed countries have access to broadband at home whereas, in Africa, Internet connection speeds are still extremely low”.

2.3. FUTURE-ORIENTED GDI FRAMEWORK FOR THE ANALYSIS OF COUNTRY POSITIONING

Dimension 1: Connectivity Infrastructure

Infrastructure is the foundation of Internet diffusion. Wolcott et al. (2001) holds that the “connectivity infrastructure is more about evaluation of the degree and robustness of the network's physical structure which involves four components: the aggregate capacity of the domestic backbone, the aggregate bandwidth of the internal IP connections, the number and type of interconnection transfers, the nature, and complexity of the local access approaches used”. It has been found further by Wolcott et al. (2001) that "estimating the aggregate capacity of both domestic backbone and international links has been problematic".

Abramson (2000) found that "some GDI authors have added together with the capacity of all lines found and called that the aggregate capacity similar to the approach taken by TeleGeography". An argument advanced by Abramson (2000) that the approach similar to the TeleGeography is "more appealing for international connections, where it makes sense that each additional line that exits a country adds to the overall traffic volume that can stream in and out of the country at any given time”.

Wilson, Daly and Griffiths (1998) “use the total bandwidth to outside countries”, but Wolcott et al. (2001) believe that such a “domestic backbone approach is quite problematic because the connectivity patterns between backbone components influence overall throughput and performance”.

Wolcott et al. (2001) went on to say that “without domestic internet exchange points; traffic from one Internet Service Provider (ISP) to another within the same country must first” transfer to an external connection point outside the country. The availability “of such exchanges also implies a certain degree of coordination between backbone networks” and the delivery of ancillary services that promote the growth of the entire network (Wolcott et al., 2001).

(ITU, 2018) defines “international bandwidth as the maximum quantity of data rate

transmission from a particular country to the rest of the world, which is mainly an addition to the capacity of international data lines from a state to others". "It is measured in megabits per second, gigabits per second" and most recently in terabits per second, as confirmed by Maher, Alvarado, Lavery and Bayvel (2016) who argue that the "throughput measured in bits per second of lightwave communications system increased from 100Mb/s in 1970 to 10Tb/s today, which represents an increase of 100 000 in transmission speed". The primary use of international bandwidth, according to ITU, is the conveyance of Internet traffic, and more recently, the application is on conveying voice over Internet protocol.

Czernich, Falck, Kretschmer and Woessmann (2011) found in their studies for the Organisation for Economic Cooperation and Development (OECD) countries "that the introduction and diffusion of broadband Internet has a direct contribution to the gross domestic product (GDP) per capita". In that, the studies widely found that with the diffusion of broadband, there "is an increase in economic activity, which leads to a rise in employment" (Czernich, Falck, Kretschmer & Woessmann 2011). Mack and Rey (2014) argue that if firms are to move past utilizing the Internet for participation purposes only, they will need access to high-speed Internet that would be key in enhancing their business operations and making them gain competitive advantage. Ghosh (2017) confirms that there have been significant studies that examined the rate of broadband growth in the last decade, with the view of understanding its impact on economic growth.

The fully-fledged development of broadband is being constrained by the lack of "internationally harmonized spectrum on reasonable terms, which is a prerequisite for a seamless broadband penetration" (Ghosh, 2017). This view is supported by the (ITU 2012a,b) "that advocates for 1340 -1960 MHz of spectrum by 2020 for the mobile traffic of which the average is currently sitting at 200Mhz". Technological change has been the main driver to economic growth, and this drive has mostly been characterized by high-speed Internet connections in the last decade (ITU, 2017). It, therefore, becomes imperative within the broader framework of connectivity infrastructure to measure the penetration rate on broadband.

Connectivity Infrastructure

		Domestic Backbone	International bandwidth	Internet Exchanges	Access Methods	Broadband penetration rate
Level 0	Non-Existent	0Mbps	Tbps			
Level 1	Thin	10Mbps	Tbps			
Level 2	Expanded	100Mbps	Tbps			
Level 3	Broad	1Gbps	Tbps			
Level 4	Extensive	10Gbps	Tbps			

The revised dimension now has the international bandwidth measurements as opposed to international links, in that the intention is to measure the data transmission rates between a particular country and the rest of the world. The broadband penetration rate is also added to the dimension as it is seen as a critical ingredient and driver to competitiveness within the telecommunication infrastructure space (ITU, 2017).

Dimension 2: Organisational Infrastructure: ISPs and Internet of Things service providers

Wolcott et al. (2001) demonstrate that "the assessment of corporate technology is based on the number of Internet Service Providers (ISPs) and their competitive environment. It seeks to determine the robustness of the industry and networks itself and acknowledges that more resources will likely be provided by Internet service providers when there is strong competition". The measure of the “organizational infrastructure is also based on the market conditions, and the argument was that a highly advanced country should have many ISPs and a higher degree of competition in both the telecommunication players and the ISPs” (Wolcott et al., 2001).

The different categories inside the revised organizational infrastructure are as follows: The controlled environment is explained as a situation in which “only a few ISPs are involved, and the competition is carefully controlled by high entry barriers. All ISPs connect via a monopoly telecommunications service provider to the global Internet. Domestic infrastructure delivery is also a monopoly” (Wolcott et al., 2001).

The second subcategory is the competitive environment; where there is competitiveness on “the Internet market and there are plenty of ISPs and low entry

barriers” Wolcott et al. (2001). According to Wolcott et al.(2001) the delivery for international connections “is a monopoly, but domestic infrastructure deployment is open to competition, and vice versa”, cloud service providers are also included in this group. Ouedraogo and Mouratidis (2013) argue that companies and firms that are looking to “achieve both efficiency and cross-cutting in the provisioning of services have been engaging the services of cloud service providers”. Further to the argument is that since “the services that are offered by cloud service providers are now more diversified, the decision making about services and service arrangements would entail striking a balance between benefits in costs and productivity versus drawbacks in risk and liability" (Ouedraogo & Mouratidis, 2013). The fourth subcategory is a robust environment, which is characterized by the “productive service provision infrastructure and there are numerous ISPs and low market entry barriers” Wolcott et al. (2001). Competition is open to international ties & domestic networks and there are programs and mechanisms for cooperation, such as public forums, trade councils, and “emergency response groups” (Wolcott et al., 2001).

In 2020, a major transition occurred in the use of the Internet to the Internet of Things (IoT). According to de Farias et al. (2017), “the Internet of Things envision and advocate for a world of interconnected objects that are capable of being identified, controlled, addressed, and accessible via the Internet”.

Mineraud, Mazhelis, Su, and Tarkoma (2016) argue that "the model of the Internet of Things will see the transformation of the current environment into improved environments, such as smart cities, smart homes, smart grids that will include integrated power and automatic pollution control". Singh and Singh (2015) quoting Gartner, Inc. forecast that "there were 4.9 billion connected things by 2015, and the number is forecast to reach 25 billion by 2020 as the number of devices per person increases".

Organizational Infrastructure: ISPs and IoT service providers

Level 1	Controlled
Level 2	Competitiveness of the market: ISPs and cloud providers
Level 3	Robustness of the infrastructure and cybersecurity regulation
Level 4	Internet of Things service providers

Dimension 3: Geographic dispersion of the Internet

Oyelaran-Oyeyinka and Lal (2005) argue in their study that "the most important factors affecting the adoption of the Internet is telecommunication infrastructure that is represented by the high correlation of telephone density with the Internet". The correct broadband and mobile age have seen an upsurge and increase in penetration of 3G and broadband, which mainly translated into the decrease of telephone density.

It may, therefore, be argued that this dimension measures the levels of Internet connection in a country. Wolcott et al. (2001) point out that beyond having access to networks “throughout the country, there are advantages of having presence points in the area that would include redundant transmission paths and multiple international access points”.

The framework by Wolcott noted two problems in interpreting the geographic dispersion dimension, "the first being that the analyst needs to decide as to what counts as a first-tier political sub-division, in that in most countries, the state, province, or government make up the first tier political sub-division". The second issue is that of the availability of dial-up access, in that, as many users “can get Internet access by making long-distance calls, the cost of making those calls is prohibitive” (Wolcott et al., 2001). According to Wolcott et al. (2001). "an Internet point of presence is taken to mean the physical presence of the Internet service provider in the first tier political sub-division, it is further argued that geographic dispersion also takes into account certain aspect of Internet dispersion that is ascribed to mobile phone operators who provide Internet services through mobile platforms". The updated framework starts with the modest dispersion of Internet presence points situated in the country's various first-tier political subdivisions, and the widely scattered second level, of which 50% of the Internet presence points are located in the country's first-tier political subdivisions. The third level is that of a nationwide presence, wherein “the Internet points-of-presence are found in essentially all first-tier political sub-divisions of the country and accessibility in rural areas is publicly and commonly available” (Wolcott et al., 2001). The fourth level is that of ubiquitous computing, Lyytinen and Yoo (2002) argue that the next big revolution in computing involves ubiquitous computing in which computers will become part of our everyday life and have a significant influence of our environment both social and physical, such that it will facilitate social interactions and situations when it occurs.

This view is supported by Ogiela and Barolli (2017), who confirm that "the development of various information and knowledge management technologies will have a huge impact on the future information and service management activities, with a greater focus on collecting and dissemination of information from different sources".
Ubiquitous computing advocates for more robust and cutting-edge approaches, which “based on ambient technology surroundings like smart cities or collective intelligence, these technologies” are essential in facilitating faster communication between distributed computers and human computers interactions Ogiela and Barolli (2017).

Geographic dispersion of the Internet

Level 1	Moderately dispersed
Level 2	Highly dispersed
Level 2	Nationwide
Level 4	Ubiquitous (everywhere, all the time)

Dimension 4: Sophistication of use

The sophistication of use is primarily characterized by understanding the conventional usage of the Internet to the more sophisticated use, which will ultimately lead to innovation. It is argued by Wolcott et al. (2001) that "in order to really understand a country's Internet capability, it is necessary not only to understand how many people use the services and where, but also how the Internet is used". “A relatively conventional nation uses the Internet as a straightforward substitute for other forms of communication, whereas in a more advanced environment, applications are developed to have a significant impact on business processes and drive innovation” (Wolcott et al., 2001).

The levels of sophistication of use will consist of the following: Conventional use as the first level, the user community is somewhat changing the practices established in response to or adapting to technology. The Web is used as a replacement for an existing process (for instance, email versus post) or as a simple upgrade, at this level, the “Internet has taken hold in a country” (Wolcott et al., 2001).

The second level is that of transformational use, where using the Web across specific user groups “results in new applications and substantial changes to existing processes and procedures, although such advances may not automatically expand functionality of the software” (Wolcott et al., 2001). The third level is innovative use, where category groups are discriminatory and demanding. Such sections often “use or seek to use the Internet in creative ways that expand the technology's capability and they have an important role to play in driving the state-of-the-art and mutually beneficial and synergistic relationship with developers” (Wolcott et al., 2001).

The fourth level would involve smart cities, smart transport, smart grid, and smart everything. Vanolo (2016) argues that the “idea of smart cities is premised on the assumption that everyday infrastructure and everyday life is optimized and made possible by the technologies and services provided by the information and communication technology companies”. Abellá-García, De-Urbina-Criado, & De-Pablos-Heredero (2015) articulate smart cities as "public, private ecosystem that seeks to provide citizens with the support to the technological infrastructure”. It is clear from the definition that the idea of smart cities has its founding principles on reliable information and communications technology infrastructure, and the sufficient central diffusion of technology will be critical to the success of the smart city.

Sophistication of Use

Level 1	Conventional
Level 2	Transforming
Level 3	Innovating
Level 4	Smart cities, smart transport, smart grid, smart everything

Dimension 5: Sectoral absorption of the Internet

According to Wolcott et al. (2001), the sectoral adoption of the Internet "measures the degree of Internet utilization in four major sectors which are seen as key to development". These measures have been suggested by the United Nations Developing Program Human Development Index. This dimension is also used to assess that the “proportion of all organizations in each sector has a leased line” and uses IP connectivity as the base measure (Wolcott et al., 2001).

The focus is on the following sectors: academic, commercial, agriculture, health, and public sector. Wolcott et al. (2001) further assert, "sectoral absorption paints a significant picture of how the Internet is viewed in different countries and some might be considered as industrial use, but little use in the public sector". It is an observation of Wolcott et al. (2001) that in some instances, the "patterns may be reversed and that the health sector is one of the last to adopt the Internet and as such a country rating at level 4 is indicative of widespread diffusion".

Sectoral absorption of the Internet

Sectoral point total	**Sectoral absorption dimension rating**	
1-3	Level 1	Rare
4-6	Level 2	Moderate
7-9	Level 3	Common
10-12	Level 4	Digital transformation: Business and society

Dimension 6: Pervasiveness of Internet use

Ochara, Van Belle, and Brown (2008) write that "pervasiveness of the measure of Internet use is focused on per capita users and the extent to which non-technicians use the Internet. Many households share Internet accounts, and as such, this limitation of data makes it difficult to establish an accurate number of Internet users per country". It is argued by Wolcott et al. (2001) that "both the pervasiveness and the sectoral absorption measure are similar to traditional diffusion studies in that they simply consider whether the technology has been adopted or not and do not attempt to distinguish between different adoption intensities or different uses".

Wolcott et al. (2001) further hold that pervasiveness "differs from the commonly used Internet growth metrics in that the final measure of omnipresence is not an absolute number but a ranking of that number in one of the five levels".

The ITU (2016) argues that "the increasingly omnipresent, open fast and content-rich Internet has changed the landscape of how people do business and work, the up-take has brought great benefits to people, government and business". The (ITU, 2016) report also noted that “by the end of 2016, half of the world population was using the Internet”. Schneir and Xiong (2016) assert that in a number of regions around “the world, policymakers have defined broadband targets to be met within a specific time frame in order to improve the telecommunications infrastructure, with the European Commission envisaging download rates of 30Mbps by 2020 and 50% of the European households having access to broadband subscription of at least 100Mbps by 2020”.

Several “studies have attempted to understand and describe the economic impact and benefits of the Internet, these studies have mainly focused on developed economies” (McKinsey Global Institute, 2011) and the (World Bank, 2009). The macro-level econometric analysis performed by World Bank (2009) with a focus on developing countries, has reported "a 10% increase in broadband and a 10% increase in wireline Internet penetration are a 1.38% and a 1.12% increase in GDP growth". In trying to understand and quantify the benefits of the Internet further, reference is made to the macroeconomic study (Ericsson, 2013), which mainly used surveyed data of “both developed and developing countries”. The research shows that "doubling broadband speed can increase GDP growth of an economy by 0.3%”.
The study further indicates that in "BRICS countries (later Brazil Russia India China and South Africa), when you introduce a 0.5 Mbps, broadband connection increases household income by USD800 per year, and upgrading that connection from 0.5 to 4 MBPS will raise the household income by USD46 per month”.

The revised framework will look at the following levels to measure pervasiveness of Internet use: Basic or mobile Internet access, advanced mobile Internet access, household, and business broadband access and ultra-broadband access. The revised framework will look to be in alignment with the European Commission in respect of broadband targets, which envisage “that everyone should have access to broadband speeds of at least 100 Mbps upgradeable to Gbps by 2025” (European Commission, 2016).

The pervasiveness of Internet use

Level 1	Basic mobile Internet access
Level 2	Advanced mobile Internet access
Level 3	Household and business broadband access
Level 4	Ultra-broadband access

Dimension 7: Digital Applications

Level 1	Basic social and business applications
Level 2	Business applications
Level 3	Robotics and drones
Level 4	Artificial intelligence

2.4. ANALYTICAL CONCEPTUAL FRAMEWORK

This study will use an adaptation of Wolcott et al. (2001) dimensions to construct a 2020 framework for the diffusion of the Internet relevant to the era of digital transformation. The study will argue from the context that Internet diffusion is directly linked to economic growth and development. The researcher elected to retain some of the elements and dimensions of the Wolcott et al. (2001) framework and refreshed them whilst also adding an additional dimension of Applications.
The review of the literature through analyzing the different framework of measuring the diffusion of the Internet reveals that there are gaps in the available frameworks and even though the researcher opted to use the GDI framework, some if it's elements and dimensions are outdated and needed to be revised to accommodate other important elements of digital transformation. The theorizing of the revised framework is at the global level and it is expected that the revised framework will be useful for country analysis, business and stakeholders and academic researchers.

2.5. CHAPTER SUMMARY

The chapter examined the literature in respect of diffusion of the Internet and Internet readiness by briefly referring to the Wolcott et al. (2001) framework and the other available frameworks as explained in Appendix A. It is in this chapter that the researcher opted to work with the Wolcott et al. (2001) framework and introduce the key concepts and measures relevant to Internet diffusion today based on a review of the applicable literature, and finally considers the relationship of Internet diffusion to digital transformation. The chapter also looked at the analytical conceptual framework.

CHAPTER THREE : RESEARCH DESIGN AND METHODS FOR GDI FRAMEWORK DEVELOPMENT

3.1 INTRODUCTION

This chapter aims to give a detailed account of the researcher's approach to the research problem. The chapter begins by addressing the research questions that are key for this research and then reflects on the research approach to be followed. It is further necessary to note that the methodology design that is so essential in the framework for Internet diffusion will be redesigned.

3.2 RESEARCH APPROACH

3.2.1 Research problem statement

The research problem is that, although the Wolcott et al. (2001) framework is more useful than the four other frameworks relevant to understanding the diffusion of the Internet (see Appendix A), it is out of date. Hence, there is a gap in available knowledge of frameworks useful for the understanding of the diffusion of the Internet, particularly in the era of extensive digital transformation. The global diffusion of the Internet (GDI) framework is too limiting as it uses outdated measurements for at least some of its six dimensions, while it excludes aspects that may be important to Internet diffusion in the transition to smart cities. The existing framework doesn't allow for measuring diffusion beyond the highest level of the framework. The framework was more appropriate for early adoption and Internet diffusion. An adapted analytical framework is needed for researchers and countries to analyse the diffusion of the Internet in 2020 and beyond.

3.2.2 Research purpose statement

There is a need for a framework to analyse and understand the diffusion of the Internet in South Africa, and more broadly. The purpose of the study is to revise the existing framework. This was done through (1) reviewing the existing Wolcott et al. (2001) framework to assess strengths and weaknesses

(2) revising the Wolcott et al. (2001) to include broadband and other contributing components of Internet diffusion in the context of widespread digital transformation across the globe, which were not included in the Wolcott et al. (2001) framework (3) considering the advantages and disadvantages of the revised framework.

3.2.3 Research Questions

Main research question:

3.2.3.1 How should the existing six dimensions and their respective measurements be adjusted to create a suitable GDI framework for the current stage of the digital economic revolution?

Sub-questions:

3.2.3.2 What are the limitations of the existing GDI framework?

3.2.3.3 How can insights on Internet diffusion in a particular country inform the revised framework?

3.2.3.4 What are the advantages and disadvantages of the revised framework?

3.3 Research Methodology

Mouton (2001:55) explains the research design as "the plan in which the researcher intends conducting the research". The design would take into account the relationship between Internet diffusion and digital transformation. Having explained this, the research will be more exploratory and take the basic approach in that the intention is to contribute to the existing academic knowledge.

The Wolcott et al. (2001) framework was mainly based on the qualitative approaches that have been described as a multi-faceted process “that takes place over time in a variety of ways”. Lee (1999) agrees that the usage of qualitative methods does not prohibit the study to specified variables but requires the author to analyse multiple variables within the information technology space. It is against this background that Wolcott et al. (2001) found a “strong justification in viewing adoption as a multi-faceted construct that required a qualitative approach in determining the value of the dimensions within the GDI framework”. Wolcott et al. (2001) further noted that the studies around GDI have mostly been exploratory where there has been “little or no exhaustive research on Internet use”, rather than being limited to the framework and

encouraged researchers to consider all available sources of information; hence there was a bias towards the qualitative research methods. The “qualitative methods of data collection” employed by Wolcott et al. (2001) included the following; “collecting data from existing sources, including other studies, Internet-based methods, collecting Internet service providers' primary data”, obtaining expert opinions using Delphi processes, and interviews with various stakeholders.

Wolcott et al. (2001) argue “that most of the quantitative Internet diffusion studies” have only used adoption as a dependent variable, and most have been various studies that seek to relate to several exogenous factors; thus, the conclusions drawn from the reviews have been limited. The researcher found an excellent reason to adopt the same qualitative methodological approach as Wolcott, as the intention is to revise the existing framework by adding some factors that are relevant to Internet diffusion and the fact that the character of the research problem is technological and about the diffusion of the Internet. Creswell (2013) explains the qualitative approach to research as "exploring and recognizing the importance of individuals or groups raises a specific problem”, and the nature of our research problem is a technological problem. The definition further clarifies that the process includes emerging topics and practices, data usually collected in the environment of participants although surveys and data analysis based on specific general themes will not be performed, and the evaluation of the data collected by the researcher.

As much as many empirical studies deal with data interpretation Patton and Bogdan (2002) and Silverman (2001) argue, "definitions can vary in terms of depth and complexity depending on the method of study and the researcher's ability to separate himself from the understanding of the issues”. Flick (2009) believes that the limitations associated with the quantitative approach to research have been mainly the starting point and reasons for undertaking qualitative research. Babbie (2015: 26) defines the “difference between qualitative and quantitative data in social research as virtually the distinction between numerical and non-numerical data”.

3.3.4 Research paradigm

At the centre of any research “is a research paradigm, which is defined as a shared world view that represents the beliefs and values in a discipline that guides how problems are solved" (Schwandt, 2001). The worldview taken will guide the researcher to ask specific questions and use appropriate approaches to methodology. The study will make use of the qualitative approach to data collection as opposed to the quantitative approach. Creswell (2014) asserts “that the research approaches are more of plans and procedures for research that articulates the steps from broad assumptions to detailed methods of data collection, analysis, and interpretation". Having explained this, the research will be more interpretivism, which is articulated below.

3.3.5 Interpretivist paradigm

The study's ontological focus is interpretivism in the sense of the technical problem being explored by the research. Hudson and Ozanne (1988) suggest that the interpretivist approaches the study with prior conceptual experience but believes that it is not enough to shape a set research design of what is interpreted as fact. This research issue has already been established as a technological problem that is more concerned with the diffusion of the Internet beyond the specified dimensions of the current Wolcott et al. (2001) framework. The chosen research methodology with this paradigm will allow the researcher to collect relevant data in response to the problem of study.

3.4 METHODS OF DATA COLLECTION

To gather data relevant to the research questions, the researcher opted to conduct a document analysis. This is the preferred method in that from the documents analysed; the researcher will be able to gain insight into additional knowledge on the subject being researched. The researcher believes that this is some specialized qualitative research that will use document analysis as a stand-alone method. “Document analysis is defined as a systematic process of reviewing and interpreting documents” in a manner that would enable harnessing an understanding that can develop empirical knowledge (Bowen, 2009). It has often been “observed that document analysis is used in combination or to complement other qualitative research methods with the view of creating a triangulation, the variation of methodologies used to research the same phenomenon” (Bowen, 2009).

Yin (1994) argues that a “qualitative researcher is expected to draw evidence from multiple sources, at least to seek convergence and corroboration”. This researcher has opted to use document analysis as the stand-alone method of data collection in that he is of the firm belief that there is enough data to build a good case for the review of the GDI framework.

Document analysis has been central “to social research since its inception in that documentary products were especially crucial for the ethnographer by providing rich vein analysis" (Hammersley & Atkinson, 1995: 173). “Documentary research is one of the three primary types of social studies with surveys and ethnography and has likely been the most commonly used in the history of sociology and other social sciences, this was the primary method - sometimes even the only one - for leading sociologists” (Ahmed, 2013).

Yin (2011) argues “data serve as the foundation for any research study and in as far as the qualitative study, data is sourced from four field-based activities: interviewing, collecting, observing and examining materials”. It has already been confirmed that the study will mostly be doing secondary document analysis in the area of Internet diffusion. It is the objective of the study to review the existing Wolcott et al. (2001) framework with refreshed dimensions that are seen to be central and essential to Internet diffusion.

Some of the reasons this research will only be concentrated on document review include efficiency; “document analysis is less time consuming and more efficient than other methods as the focus is on data selection, not data collection” (Bowen, 2009). The second reason is availability in that many of the documents are available in the public space, including online and does not often require the permission of the author to access them, which makes document analysis an attractive option for qualitative researchers. The extent to which the researcher can locate the public documents is limited by his “imagination and industriousness” (Merriam, 1998). Documents “analysis is also a very cost-effective method in that data contained in materials have already been gathered; what is left is for the content and quality to be evaluated” (Bowen, 2009). Documents are stable in that the researcher's “presence doesn't alter what is being studied” and as such make documents relevant for repeated reviews

(Merriam, 1998). Essential to the process of document analysis is that document analysis provides a broad range of coverage, covers a longer time-frame and many settings, they also "include exact names, references, and details of events that make documents analysis advantageous in the process" (Yin, 1994).

The procedure that this researcher looked into included finding, selecting, and making sense of various databases of information, and searching extensively for reports and statistics with respect to Internet-related information.

Details of these are found in Table 2 below. When selecting these types of data, the researcher was looking at reflecting on the current six dimensions of the GDI framework, showing what limitations exist and what the substance of the new dimensions should be. The value of these types of data is that they show the importance of Internet evolution and how it has evolved. The most important aspect is to show the limitations of the Wolcott et al. (2001) framework and what should be in the new framework.

3.4.1 Secondary data: Document analysis

Table 2: Documents and reports analysed

Dimension	Type of data	Source of Data
Connectivity infrastructure	• Data centres • Software applications • Base centres • Undersea cables • Landing stations • Last-mile • 3G, 4G, 5G, LTE, Wi-Max • Mobile broadband • Domestic backbone • National backbone • Spectrum • International IP lines • Interconnection exchange • International links	• Operator annual reports • ITU Measuring the information society reports • GSMA reports • The Global Information Technology Report 2016, World Economic Forum • Analyzing ICT Trends and Policies: The Information Economy Report 2017 • South African Broadband Policy • Skills development policies

	• Access methods • Radio and satellite technology • Fibre-optic backbone • Human resources	
Organizational infrastructure: ISPs and Internet of Things service providers, Policymaker, Regulator	• International ISPs • IoT service providers • Public exchanges • ICP, ASP • National telecommunication network • Cloud computing • Cybersecurity • Big data • Virtual reality • Virtualization	• National Integrated ICT Policy White Paper 2016 • World Economic Forum Reports • Laws • Cybercrimes Bill 2017
Geographic dispersion of the Internet.	• Provincial access • Points of presence • Universal service obligations • International IP connections • Quality of network coverage and speed	• ITU reports • World Bank reports • Internet World Statistics • Statistics South Africa
Sectoral absorption of the Internet	• Diffusion in Business, Education, Government, and Health sectors. • Leased lines and Internet servers. • Suppliers and consumers	• Sector reports (education, health, commercial)
Pervasiveness of Internet use	• Rate of internet growth: you need growth to get more pervasiveness • Cost of broadband • Policy Implementation • The ratio of Internet users • Consumer perspectives: Age or gender equality • Mobile subscribers	• Internet World Stats, Economist Intelligence Unit Inclusive Internet Index report • Promotion of Access to Information Act • Electronic Communications and Transaction Act • Electronic Government Policy

	• Internet service providers • Internet bandwidth • Telecommunications revenue • Teledensity • Data communications	• Policy Framework, Minimum Information Security Standards (MISS), Minimum • Interoperability Standards (MIOS) and Policy on Free and Open Source Software (FOSS) • Mobile operator annual reports
Applications	• Mobile money • Mobile applications • Over the top services • Basic social media applications • Business applications • Robotics • Drones • Artificial intelligence • 3D printing	• e-Commerce Strategy • ICT Regulatory Toolkit (ITU) • Net neutrality guidelines • Telecommunications Act • Protection of Personal Information Act, 2013 (POPI) • Financial Advisory and Intermediary Services Act, 2002. • The National Land Transport Amendment Bill, 2015 • Consumer Protection Act, 2008 (CPA) • Market research reports • World Economic Forum reports • World Bank open data
Sophistication of use	• Innovation • Transformation • Smart cities • Smart transport • Smart grid • Smart everything	• National Development Plan • Electronic Communications Act

Babbie (2015) argues, "much of the social research is conducted to explore a topic and start with familiarizing the researcher with the topic". This approach occurs when research is examining a new interest or a relatively new study area, the study is exploring the diffusion on the Internet and advocating for a review of the framework used to determine the diffusion of the Internet. The study has drawn most of its material from the Internet through interrogating electronic journals and research

textbooks. The information was found to be extremely useful as it is continuously updated with advancement within the information and communications landscape.

3.5 FRAMEWORK DESIGN AND DATA ANALYSIS

The study used the Wolcott et al (2001) framework “as the foundation analytical conceptual framework, noting the evolution of the Internet” and emerging technologies and applications in the past 20 years. The study argues that Internet diffusion is linked to digital transformation and that the current framework does not include some of the critical factors that are important to diffusion, which forms the basis of data analysis. For the purpose of this study the focus will be more on framework design and data analysis. The researcher has interpreted, organised, processed and evaluated the data using coding for the limited data analysis in order to create the determinants with which to design the GDI 2020 framework. Kothari (2004) asserts, "the data, after collection, must be processed and evaluated in accordance with the guidelines set out for the purpose when the research plan is being established". The researcher will mainly articulate the strengths and weaknesses of the redesigned framework and further assess the quality of the framework. Marshall and Rossman (1999) articulate “data analysis as a process of order, structure, and meaning for the mass of data collected”. The research will focus on the interpretation of collected data in order to answer research questions, and as such, the theoretical framework has been developed by the researcher and will primarily guide the study's recommendations and conclusions. The researcher used a computer program to help with data collection and data analysis as a result of the volume of data obtained during this research.

The process started with collecting documents in the form of industry reports and academic journals and uploading them on to the program. The documents where then grouped into different family groups and the codes were created afterwards.

3.6 ETHICAL CONCERNS

This research used secondary data only and did not interview any human subjects, therefore no informed consent was required.

3.7 CHAPTER SUMMARY

The chapter began by asking the research questions and developing the approach to respond to those research questions.

The section also looked at the research design, which will mainly guide the researcher as to how to conduct the research and the related data collection methods. It also looked at the framework design and limited data analysis.

CHAPTER FOUR: USING DATA AS THE FOUNDATION FOR BUILDING NEW DIMENSIONS FOR INTERNET DIFFUSION

4.1 INTRODUCTION

The chapter seeks to identify different aspects that are important to understanding the full extent of diffusion of the Internet, a new dimension of applications was added to the six dimensions of the Wolcott framework. The chapter effectively started building on the proposals of the framework that were made in Chapter Two. This chapter further provides feedback on the data collected as per the research approach, as articulated in Chapter Three of this study. The approach followed mainly focused on revisiting the Wolcott et al. (2001) framework to include other contributing components of the diffusion of the Internet.

A total of 89 documents were collected and grouped as per the seven dimensions of the proposed framework. Due to the high volume of the materials obtained during the research, the researcher decided to use the Qualitative Data Analysis Software to assist with the gathering and analysis of data. See Appendix C for the codes created in ATLAS.TI.

4.2 CONNECTIVITY INFRASTRUCTURE

The data presented under this dimension provides a futuristic view of the connectivity infrastructure under the revised framework; the data was collected through reviewing ten documents with the aid of ATLAS.TI computer software. The researcher was then able to generate about 1314 codes linked to 733 quotations. The codes were then arranged into 25 code groups. The codes within the code group or a family named connectivity infrastructure are presented in the structure below, and the emerging codes that were not initially part of the connectivity infrastructure are explained further.

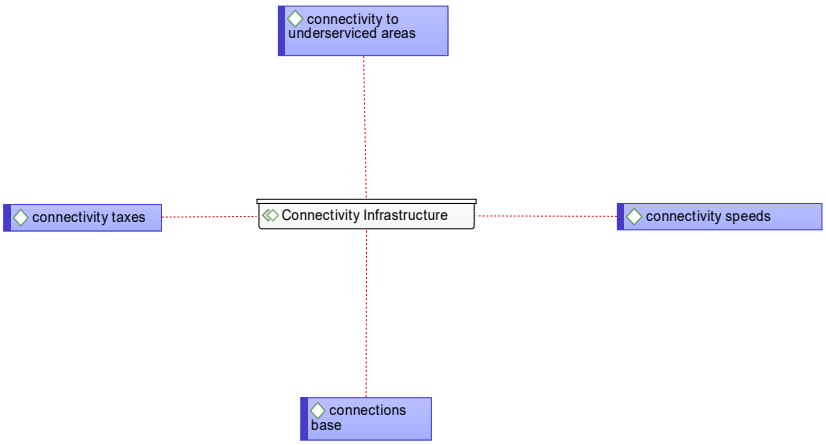

Figure 3: Connectivity Infrastructure

4.2.1 Connectivity speeds

Martin, O'Keefe, and Finucan (2016) argue that many are working hard to develop IMT-2020's fifth-generation mobile networks and expect implementation to start in 2020. IMT-2020 refers to the next stage of development after IMT-Advanced (i.e., 4G / LTE) wireless connectivity. It is more precisely an "ecosystem" than a network offering higher data and transmission speeds, lower latency, supporting billions of users/connected devices, and many applications. OECD (2019) shows that the connectivity speeds of the next-generation wireless technology are" intended to provide download speeds of 20 gigabits per second (Gbps), 10 Gbps upload speeds, and latency of one millisecond (ms)".

"These download speeds are 200 faster and upload speeds are 100 times faster compared to the current Long-Term Evolution (LTE) networks (for instance, 4G), and one-tenth the latency of 4G" (OECD, 2019). The 5G mobile network is seen as an evolutionary network that supports the "introduction of new applications and services at higher speeds with lower latency, improves firm efficiency and innovation through increased download speeds of broadband services, and the use of more effective cloud solutions that rely on low latency and enable greater use of IoT services and applications including mission-critical services that may depend on low latency and ultra-reliable broadband" (OECD, 2019).

4.2.2 Connectivity to underserved areas

In advanced economies, some rural areas also await the implementation of basic fixed broadband networks. Farrington et al. (2015) argues that “many others are now experiencing the effects of new digital spatial divisions: their connections are too slow to allow full and effective participation in a digital society where already well-served areas (mainly urban areas) are becoming faster”.

Global System for Mobile Communication Association (GSMA) (2018) shows that in as far as mobile operators are moving towards full coverage of densely populated areas, there is a need to extend the coverage to the unconnected areas, which are mostly rural. This will ensure the industry's long-term survival. This phase would need policy enablers to support the growth of the mobile environment. The policy enablers required are the mechanism for spectrum management and tax reform to improve the accessibility of mobile technology for consumers, especially those in low-income segments. The World Economic Forum (WEF) (2018) indicates that for the developed and developing economies, the inclusive growth doesn't only depend on connectivity but also on providing what they term "forward-looking access," that is internet provision through networks with sufficient capacity, quality, and speed that is able to support more advanced usage.

4.2.3 Connections base

Data from the market reports continue to show that the adoption rate of smartphones is very rapid more especially in Sub Saharan Africa, regardless of the low base, and the challenges that have to do with affordability. The data shows that by the end of 2017, the total number of mobile contacts was 250 million, equal to one-third of the entire base of connections. Through 2025, the adoption rate will be double to hit two-thirds of total links, equivalent to about 690 million installed bases (GSMA, 2018). Forman and van Zeebroeck (2019) found that increasing digitization of innovation processes may increase information flows through locations in geographically disparate organizations.

4.2.4 Connectivity taxes

Aničić, Jelić, and Đurović, (2016) assert that “state and local communities need an active tax policy to contribute to achieving their economic and social goals by finding an appropriate measure that does not jeopardize the economic and market principles and a favourable economic environment”. Many nations have mobile or fixed internet access "connectivity taxes." These taxes drive up users’ prices, which can make the Internet inaccessible for many families and stakeholders alike. This calls for a smart fiscal policy that will enable connectivity for all at an affordable price (WEF, 2018).

4.3 ORGANISATIONAL INFRASTRUCTURE: INTERNET SERVICE PROVIDERS AND INTERNET OF THINGS SERVICE PROVIDERS, POLICYMAKERS AND REGULATOR

The data presented under this dimension mainly focus on the emerging technologies of cloud computing, cybersecurity, and the role that the policymakers need to play in driving the regulatory regime and the advent of the Internet of Things.

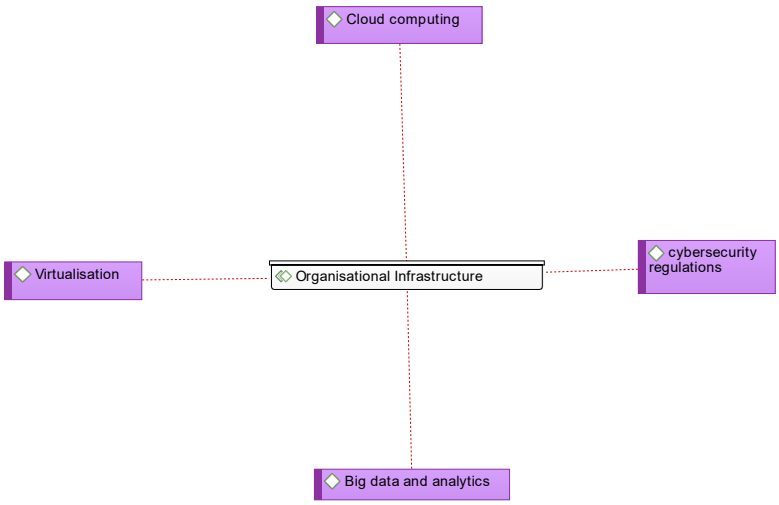

Figure 4: Organisational Infrastructure

4.3.1 Cloud computing providers

Martin, O'Keefe, and Finucan (2016) define cloud computing as an on-demand computing system that enables users to access the Internet's distributed computing resources and information. Based on a centralization principle, this design makes it

possible to pool configurable computing resources (including network servers or storage) as well as applications and services. This centralization brings economies of scale that cloud service providers can exploit to provide multiple users with cheaper computing solutions.

Cloud computing, which is largely marked by a transition in the relationship between networks, enterprises, and culture due to massively “increased processing power, data storage, and lower transfer speeds accompanied by rapid price cuts” (UNCTAD, 2013a). The cloud allows large amounts of data to be collected and analysed. It also decreases small businesses' prices. The Information economy report (UNCTAD, 2017) shows that “adequate, affordable, and reliable connectivity is an essential requirement for individuals and businesses to engage successfully in the digital economy”. Therefore, the development and maintenance of “high-speed, secure, and affordable digital infrastructure must be accelerated as a priority in developing countries” (UNCTAD, 2017). Reducing the differences “in access to and the use of digital technologies between countries is important to maximize progress and offset current and new inequalities not only in income, but also in individual’s economic, cultural, and political involvement and resources” (UNCTAD, 2017). “Improving broadband quality and availability is essential if additional investment” is to be made, and cloud computing, big data, and IoT data centres are used (WEF, 2017).

4.3.2 Cybersecurity regulations

The data shows data more reliance on digital technologies will bring along the cyber threats and security related risks that will need to be mitigated. More efforts would be needed to put together cybersecurity governance structures. Policymakers and regulators will need to develop processes and technologies for implementation by organizations as opposed to devoting resources to only compliance. The data further shows that this “greater reliance on digital technologies will also bring new job opportunities in various sectors, including the production of new goods, services, and cybersecurity” (UNCTAD, 2017).

ITU (2018) indicates that “cybersecurity is a central point for organizations and nations to navigate digital governance effectively”.

Cybersecurity “is needed to protect government infrastructure, create trust and confidence, paving the way for cybersecurity and e-government indices to go hand in hand with a clear and accurate analysis of the level of engagement and growth in the use of ICTs” (ITU, 2018). This view is supported by Markopoulou, Papakonstantinou, and de Hert (2019), who argue that investing and developing greater cybersecurity capability will also “contribute to a better understanding of cybersecurity and a reduction of ability gaps”.

4.3.3 Internet of Things service providers

The Internet of Things (IoT) is recognized as one of the strategic growth areas that will propel business, and as such, it is encouraged that firms continue to build end-to-end capabilities around it, and the role of Internet of Things’ service providers becomes very crucial (RSA, 2016). WEF (2018) data shows impressive growth in connected devices and IoT operates in a continually evolving cyber-physical environment with innovators and developers expanding IoTs’ potential boundaries. Nevertheless, this rapid rate of change often emboldens malicious actors to develop new and increasingly sophisticated methods for exploiting vulnerabilities that are either special to IoT systems or imported with insecure parts, devices, or networks used as part of IoT services.

4.3.4 Virtualisation

Preston (2019) emphasizes that the “trend towards moving virtual workloads to the cloud is fuelled by the efficiency gains which the move brings, especially when companies take full advantage of the design of the cloud”. In addition, “virtualization and cloud can improve businesses long-term operating habits and enhance data security and data protection practices” (Preston, 2019).

The data shows that virtualization becomes a consideration in the organizational infrastructure in that it looks at better utilization of computing resources and minimizes the ICT related risk by centralizing ICT Management. This view is supported by Kochovski, Gec, Stankovski, Bajec, and Drobintsev (2019) who points out that integration of these triumvirate technologies has many expected benefits, such as the introduction of more advanced and efficient artificial intelligence (AI) systems,

improved service performance (quality of service), higher resource utilization, and lower operating costs.

4.3.5 Big data and analytics

Hassani and Gahnouchi (2017) show that web creation, data source aggregation have culminated in a numerical flood of “digitally created and distributed data and today, the business environment is a large space where a large amount of data is introduced every minute”. This innovation “gives rise to a new concept called big data” (Hassani & Gahnouchi, 2017). Gupta, Gupta, Nambiar, and Mohania (2012) described “big data as information that exceeds the processing capacity of conventional database systems”. This means “that the data size is too large, and data values change too quickly and/or do not comply with the rules of traditional database management systems” (Hassani & Gahnouchi, 2017).

Big data brought new technological problems with it and “the required type of analysis must deal with data that is not only large in quantity terms but is also generated in different formats and at high speeds” (Ta et al., 2019). Therefore, “big data analytics is when advanced analytical techniques are applied to big data” (Hazen, Skipper, Boone, & Hill, 2016). Chen, Chiang and Storey (2012) explain data analysis as a method that turns a weight of information into organized information that makes it possible to make decisions. This field applies to “Business Intelligence and Analytics (BI & A) applications that are mainly used in data mining and statistical analysis” (Hassani & Gahnouchi, 2017). Alternatively, for structured data, the same methods used by conventional BI & A software are used, but inadequate for unstructured or semi-structured data.

“Big data brings tremendous promise in the form of exciting innovations, new revenue streams, and even revolutionary lifestyle-threatening disease treatments” (Tao et al., 2019). That is why most organizations “spend a lot of time investing and protecting themselves, and their consumers from privacy concerns, cybersecurity risks, IP registration, and public-related risks, mechanisms/algorithms, and devices used to analyse big data” (Tao et al., 2019).

4.4 GEOGRAPHIC DISPERSION OF THE INTERNET

The data presented in this section reflect on the codes that emerged from the review and flagged the following: Quality of network coverage and speed, International IP Connections, Universal Service Obligation, and the Points of presence.

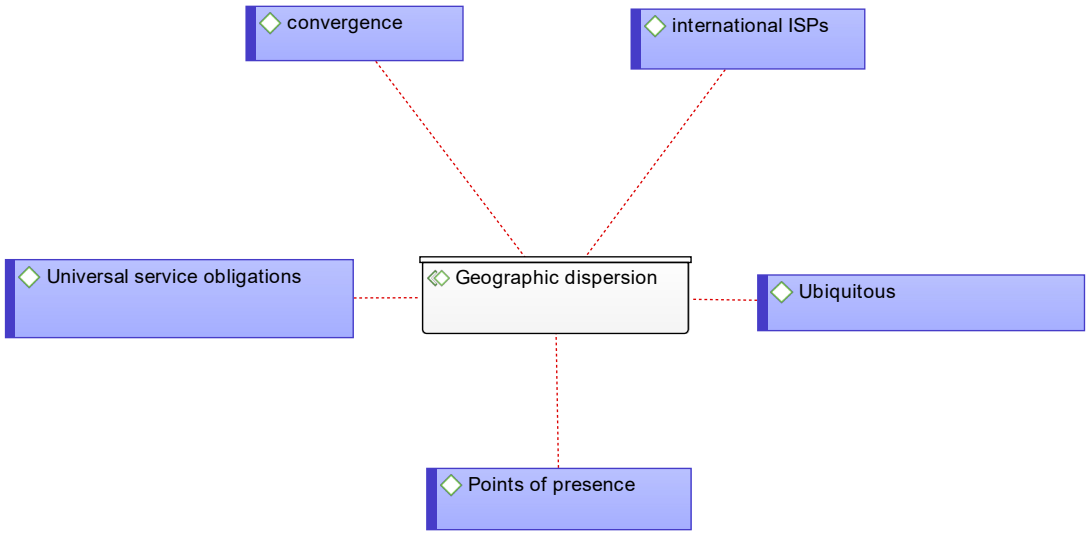

Figure 5: Geographic Dispersion of Internet

4.4.1 International IP connections

“In the light of globalization, the relocation of manufacturing activities, and the development of global value chains, connectivity enhancement” as a way of overcoming obstacles to international trade and increasing productivity is becoming crucial (Arvis & Shepherd, 2015). With the growth of the Internet of Things, there is a need for separate networks to interconnect and exchange traffic with each other. International IP connectivity becomes important in allowing network connectivity and reduction of connection costs, improve network performance.

4.4.2 Ubiquitous

WEF (2012) demonstrated that broadband would have far-reaching effects on smart devices and cloud services and become integral to everyday life and work. Ubiquitous super-broadband, while providing the improved user experience can make almost everything faster and better. Subscribers will not have to wait for videos, images, or other data files to be streamed or downloaded from the network.

The advantages “will also make people's lives much more convenient as ICT technologies are used to build models of e-government and enhance e-commerce, e-learning, and online medical services, and other smart web-based services” (WEF, 2012). Salim and Haque (2015) argue that through today's omnipresent computing devices, smartphones in our pockets constantly track our daily activities, “and more of our everyday things are now connected to the Internet”. This trend is “transforming how we live, function, and communicate with each other” Salim and Haque (2015). This provides not only technical possibilities for smarter communities but also incentives for people to connect.

The evidence examined shows that the “evolving digital economy is characterized by the advent of a platform-based network of virtual products and services that evolves through the pervasive and continuous measurement and data collection of both IoT, input from sensor-laden factory automation systems, and the ubiquitous internet-connected mobile devices” (UNCTAD, 2017). This generates the repositories of "big data" with trends and comparisons that would otherwise remain hidden for processing and study. The findings can be incorporated into applications using “machine learning and automated decision-making to update system elements and even a complete program” (UNCTAD, 2017). Yan and Lee (2019) confirm that mobile Internet's influence “on the daily lives of people around the world continues to grow and more tailored technologies will be established without constraints on location, and seamless flexibility is a fundamental requirement”.

4.4.3 Points of Presence

Network quality, disparities drive “an increasingly important form of digital inequity” (Lldering, 2014). Montenegro and Araral (2020) argue that “Internet users are limited by their failure to benefit from the range of online applications and content in countries with low network quality”. However, most digital diffusion studies on the Internet remains “focused on explaining gaps in penetration and usage, while quality of service remains an underexplored facet and this emphasis makes sense when the policy issue is identified by the unequal distribution of Internet access among a population in the early stages of Internet diffusion” (Montenegro & Araral, 2020).

Nevertheless, as “the Internet approaches global ubiquity over the next decade, policy focus is likely to shift to the divide in value, particularly given its effect on economic growth” (Montenegro & Araral, 2020). “It has been found that a 1% change in latency leads to an increase” in GDP of 0.45% –2.5% (Lidering, 2014).

ITU (2017) shows that the latest ICT development data demonstrate “continued progress in connectivity and ICT use”. The quality of communications has expanded steadily over the “past decade, driven by increases in mobile cellular telephony, and more recently, mobile broadband” (ITU, 2017). “Growth in connectivity for fixed and wireless broadband has facilitated Internet access and use and mobile cellular networks are becoming increasingly ubiquitous and now dominate the delivery of vital telecommunication services” (ITU, 2017). Worldwide, “the number of mobile subscriptions far exceeds the global population, although many people still do not use a mobile phone, especially in developing countries” (ITU, 2017). “Fixed telephone subscriptions have continued to decline, dropping below one billion worldwide, and are low in the least developed countries” (ITU, 2017). Mobile broadband, networks have been proliferating. Worldwide, the number of mobile broadband subscribers now reaches 50 per 100 residents, allowing increased Internet access and online services. That phenomenon was driven by the introduction of new cellular technology, with LTE and higher features being available to most mobile users. The number of fixed-broadband subscribers worldwide has been growing slowly, “although this now exceeds slightly that for fixed telephone lines” (ITU, 2017).

4.4.4 Convergence

Convergence is seen as a critical driver of geographic dispersion by understanding that changes in traditional markets need adjustment of policy solutions to ensure that the dream of the government is realized. It, has therefore, adopted a holistic approach, addressing issues of “both supply and demand to promote universal access to ICTs, and postal sector transformation, and industry growth” (RSA, 2016). It also acknowledges “that policies need to allow for the needs of sectors such as education, justice, health, and welfare in order to support digital technologies in their development goals while acknowledging that integration presents new threats to rights such as privacy and security” (RSA, 2016).

Convergence trend also heralds the launch of many modern, creative digital platforms "such as video-on-demand (VOD) and over-the-top (OTT) services" (RSA, 2016). The networks should allow such services to be delivered at any time. This creates problems with current regulatory regimes for electronic communication networks and web providers that need to be resolved by adequate policies (RSA, 2016).

Smart home applications to become more sophisticated, are now evolving. Through integrating voice recognition software with "IoT devices, IoT devices can be voice-controlled and can also perform various functions such as ordering items or receiving personalized news over the speaker to make life more comfortable at home through improving multi-tasking capabilities and promoting consumer functionality" (Meola, 2016).

Active energy use is advanced through the incorporation of IoT technologies "by remotely controlling all energy devices and scheduling energy use" (Ersue, Romascanu, Schoenwaelder, & Sehgal, 2015). Integration and integration have added value to consumers and the community in different sections (Filho & Brito, 2017).

"Applications in various fields using such technologies have continued with the advent of IoT technology. IoT applications are used in many fields such as smart home, manufacturing, agriculture, building, and home automation, medical and health care, and have the ability to be used in many more areas" (Lim, Kwon, & Lee, 2018). Tools like the smart home platform are already fundamentally changing the way of living in our daily lives. IoT applications can be used for the central control of household devices "by a main hub or controller, such as a smartphone" (Lim, Kwon, & Lee, 2018). "Lighting, heating, and home security systems", and television and computer devices can be controlled remotely (Kang, Krishnaswamy, Peelaers, & Walle, 2017).

Lim, Kwon, and Lee (2018) confirm that "IoT technology is a tool that integrates different technologies from different fields to create new ones and is expected to bring great value to consumers and serve as a key pillar of the forthcoming fourth industrial revolution" by contributing to other emerging fields by such products and services.

4.5 SOPHISTICATION OF INTERNET USE

The data presented under this dimension would look at why individuals and organizations use the Internet and how the use of the Internet ultimately benefits the communities and brings about digital transformation.

We present other issues that are critical to the sophistication of use ranging from innovation ecosystem, smart cities, smart transport, and smart technologies.

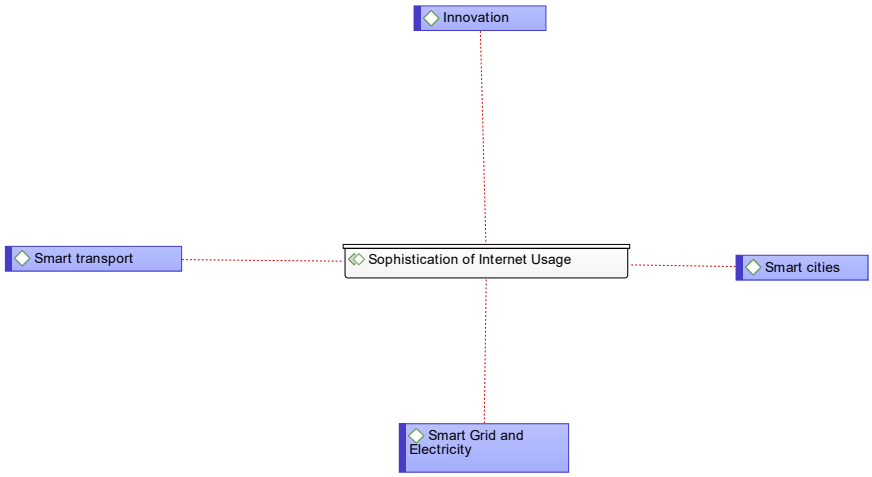

Figure 6: Sophistication of Internet Use

4.5.1 Innovation

Contemporary digital technologies use defined applications that promote social networking and allow global and updated worker-to-work interactions, real-time information delivery, data cloud maintenance, and user-specific multimedia content sharing to improve dialogue and “internet-mediated content management within the enterprise” (Potter & Mcgittigan, 2013). “Accordingly, organizations have recently started to share intra-organizational knowledge, exchange solutions, manage work processes, and cope with rapid changes in customer demand more efficiently” (Hasgall & Ahituv, 2018). This has been “achieved by using various innovative digital means, such as intra-organizational communication networks for employees, data clouds, and digital applications that enables lateral updating, visibility, sharing, and complex organizational knowledge analysis, besides empowering employees” (Hartono & Halim, 2014).

Innovation is seen as a vital enabler of the knowledge economy with technology because for organizations and firms to derive benefit, they will need to be connected, advanced, and secure technology platforms. Infrastructure would need to be upgraded so that it copes with the needs of the emerging technologies. The data reviewed shows that "the availability, speed of the Internet are essential to propel the Internet of Things" and it is imperative that countries and firms need to develop and adopt norms and standards that speak to interoperability and data flows (ITU, 2016).

4.5.2 Smart cities

The data reviewed shows that with the evolution of the Internet of Things, the cities across the world are envisioning the cities of tomorrow, which are connected and are developing smart city projects, and the focus is on the developmental path that is smart. Data shows that more cities turn to the Internet of Things to take advantage of the power of digital technology and promote economic growth. Davis (2010) suggests that a "smart city depends on the implicit assumption of improving and greening urban infrastructure and everyday life by ICT technologies". ITU (2016) adopted the following as the "definition of the sustainable smart city : A smart, sustainable city is a creative city that uses ICTs and other means to improve the quality of life, productivity and competitiveness of urban operations and services, while ensuring that it meets the needs of present and future generations in economic, social, environmental and cultural terms". It is against this background that when we measure the sophistication of Internet usage in the country, we also measure and determine the smart city projects and initiatives. Praharaj and Han (2019) confirm that today innovations "have permeated human lives, buildings, and urban spaces". A host of "smart devices, sensors, GPS tracking facilities, and a host of creative concepts such as smart homes, smart buildings, smart airport cities, smart education, and health are transforming how we live, work and play" (Praharaj & Han 2019).

4.5.3 Smart transport

The data shows that the world is growing and changing at a faster pace, and as such, people need new ways of mobility in a smarter way. The world needs a new way of transportation that will connect people, technology, and infrastructures. The United Nations (2012) argues that society is facing an urban transformation with a growing

world population centred on urban areas and that “by 2050, it is expected that 70% of the population will live in urban areas”. This will pose a challenge to the mobility of people; hence, the smart transport modelling becomes a necessity, and as an when we measure the sophistication of internet use, it will become critical. The digital age has brought about endless technological possibilities that will transform the urban mobility of citizens. Martin, O’Keefe, and Finucan (2016) argue that there are rapid developments and implementations of both vehicle-to-vehicle and vehicle-to-infrastructure technologies.

They predict that by 2020, 75% of cars shipped worldwide will have the capacity to connect to the Internet and that most will be linked through embedded connections, independent of other devices such as a smartphone. Though, due to the lack of other supporting infrastructure and services, many vehicles with capabilities worldwide will not be in use. Then, the implementation of these new technologies must be well planned, including overcoming regulatory issues to unlock these capabilities. Praharaj and Han (2019) show that over the past decade, “smart cities have become increasingly popular in public policy circles and academia”. Nevertheless, the concept's meanings and features remained somewhat inconsistent.

Many issues have been used in literature, “including information and communication technology (ICT), omnipresent connectivity, knowledge and creativity, big data and open data, social capital, business and entrepreneurialism, smart community, and ecological sustainability” (Praharaj & Han, 2019).

4.5.4 Smart grid and electricity

Reka and Dragicevic (2018) assert that the “transformation of the legacy electrical grid into a smart self-healing bidirectional intelligent system paved the way for the future to the smart grid where a new smart grid changes the footprint of its earlier incorporation”. The “advanced technology allows utilities to contribute more to efficient power transportation, carbon-dioxide (CO2) emissions reduction, green energy generation, cost reduction and utility profit maximization” (Reka & Dragicevic, 2018). Using “intelligent meters in residential, industrial and commercial buildings, the provider can learn about their consumption patterns on a daily basis and data from remote

substations or the detection of failures in scheduled areas allow for effective remedial action without delay" (Reka & Dragicevic, 2018).

The conventional grids have the power quality and reliability challenges and are no longer servicing the needs of the consumers. There are ongoing technological advancements propelled by the Internet of Things that are modernizing and providing better solutions to managing this challenge. There is a drive towards ensuring the smart metering infrastructure and smart technologies that will modernize conventional power grids. The idea is not to have only electricity running through the network but also information and customer interaction, which will bring smart thinking into the grid. Turjman and Abujubbeh (2018) argue that "electrical power is one of the essential factors for the development of societies by improving life quality and that the conditions in power industry are changing as electricity demand and renewable integration increase". The data emerging shows that the issue of smart grid and electricity will become vital in measuring the level of sophistication in Intern et use in various countries as they are moving towards a low carbon energy sector. The transformation of conventional electricity systems is made possible by smart grids or electricity networks that intelligently incorporate the activities of any linked user from producers and consumers to prosumers. An increasing number of apps deployed on the Internet of Things (IoT) in electricity networks allow connected users to use real-time data to simplify decision-making and help accelerate the energy transition (WEF, 2019).

4.6 SECTORAL ABSORPTION OF THE INTERNET

The data presented under this dimension will mainly focus on the selected codes that are seen to be central to how different sectors absorb the Internet to enhance efficiency and productivity. The selected codes will include connected business, digital government, artificial intelligence and robotics, and 3D printing.

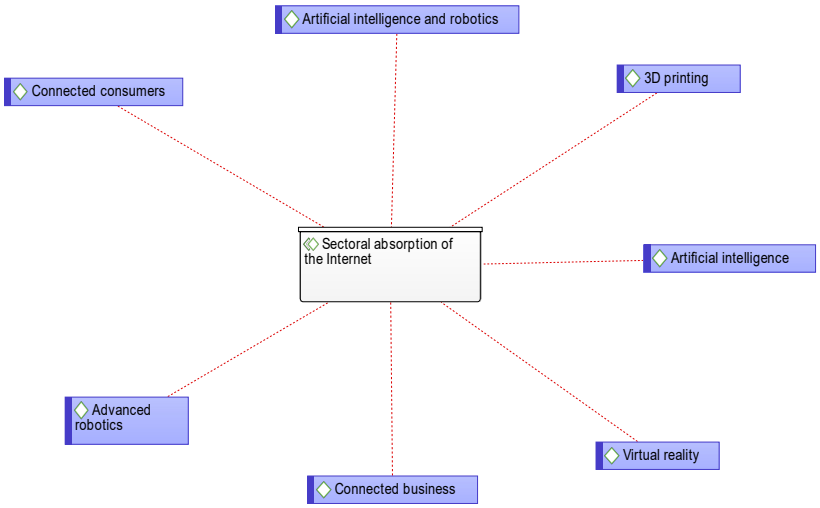

Figure 7: Sectoral Absorption of the Internet

4.6.1 Connected business

The "Internet has created opportunities and challenges that have direct customer relations for existing businesses and start-ups" (Apăvăloaie, 2014). Some intermediaries have emerged with respect to the supply chain, "while others have been replaced and new business models have arisen that have shown companies how to use innovation to gain a competitive advantage and greater profits" (Gay, Charlesworth, & Esen, 2007). Apăvăloaie (2014) argues "it is almost universally accepted that the Internet plays an increasingly higher role in each of our lives".

The issue of Internet adoption has increased the connectivity of business through the broadband internet connection; the data shows that nine out of ten businesses in high-income OECD countries have broadband internet connection as compared to seven "for middle-income countries and four for the lower-income countries" (World Bank, 2016). The idea of a connected business is driven by the growth of digital data and the adoption of technology. There is a massive push and drive for the consumers for organizations to change from silo operations to a more collaborative business model. The trend is pointing to a situation that requires enterprises to build end to end connected business operations. The primary contributors to connected business are the Internet of Things, digital consumer collaboration, and internal partner collaboration in that they drive internal business efficiency (World Bank, 2016).

4.6.2 Digital Government

Janowski (2015) track the “evolution of Digital Government from the Electronic Government in the 1990s, through Government 2.0 in the 2000s, to today's default digital agendas, pointing out that along with progress, the challenges of governance, culture, and leadership have also deepened”. Janowski (2015) provide a “theory of technology co-evolution, organizational networks, and institutional arrangements to explain government transformation, including internal government transformation and the transformation of relations between the government and other social and political actors, through the development of ICT in government”.

The first generational “use of e-government was more of the use of web browsers” and mobile devices to connect, consume government services, and make transactions. Information was exchanged between the citizens and the Government to fulfil the request (World Bank, 2018). The evolution of e-government into the Digital Government has seen data been viewed as a strategic asset that lasts beyond the intended transaction and making the transaction more useful to both citizens and business as the need to re-supply the same information was eliminated. The same information can be reused for different purposes on different platforms and amongst various departments of the government, thus allowing for transaction continuity. This has also underpinned how we create smart cities, and their systems and how technology infrastructure adopts the same behavioural patterns of the consumers (World Bank, 2018). Public problems are becoming more “complex, as are the rapid advances of IT and infrastructure (social media, big data, intelligent cities) and governments are constantly demanding to be able to analyse, adapt and implement new technology and processes” (Wang, Medaglia, & Zheng, 2018).

4.6.3 Connected consumers

The advent of the knowledge economy brought about the interfacing of humans and machines in the process of improving efficiency, where there has been “a transition to a new set of systems that bring together biological and digital components to create unique combinations” (WEF, 2016). The data coming out of the analysis show that the availability of high-density data storage and global digital communications are central in shaping the connected population (WEF, 2016). The other issue that is

related to connected population in the creation of online communities, is that emerging data show that from the education perspective, technology is being consumed in a number of forms which include the digitization of textbooks, and educational and radio programming that is made available to rural areas thus networking students and learners to create online communities (World Bank, 2016).

Organizations are increasingly using omnipresent advertising technologies to connect, locate, classify buyers, promote offers, and collect comprehensive purchasing information. This increased communication creates a new connection between customers and companies through omnipresent technology (Margulis, Boeck, & Laroche 2019). Such developments show the importance of the pervasive technology trend as a powerful tool for enhancing "customer experiences and increasing customer loyalty" (Margulis, Boeck, & Laroche 2019). "Ubiquitous technology gives customers many benefits, such as instant payment and improved customer experience, but it also allows companies to collect valuable data for consumer behaviour analysis" (McBrearty, 2011). In addition, "omnipresent technology changes the relationship between the consumer and the company, transforming it into a customized bond between parties" (Margulis, Boeck, & Laroche 2019). This move "gives consumers every time and place the chance to gain a clear view of goods from customers and to collect information on their attitudes and behaviors" (Margulis, Boeck, Bendavid, & Durif, 2016).

4.6.4 Advanced robotics and artificial intelligence

The data coming out of the analysis shows that the advances in the knowledge economy will bring along advanced robots and artificial intelligence, which will transform the world of work and how we live. The sector that will benefit a lot in terms of advances in robotics is health care in the areas of automation; health care robotics technology that will assist in managing caregiving and performing surgery (WEF, 2017).

The other area that will enhance health service is artificial intelligence within the drug manufacturing industry, in that this is a very complicated space that takes years of training to develop expert skills.

The usage of technology will bring efficiency in navigating complex and challenging tasks. Artificial intelligence will be much more effective in processing big data than the human mind and will be able to consider many parallel project targets (WEF, 2018). AI allows “machines to learn from experience, adapt to new input information, and perform a human-like function” relevant to the proposed intelligence system that is immediately known as AI effectiveness (Singh, Rathore, & Park, 2019). AI offers tools for IoT systems to model smart operations. Using machine learning is known as digital intelligence in IoT applications and provides multiple features such “as predictive analysis, prescriptive analysis, adaptive analysis, and continuous analysis” (Singh, Rathore, & Park, 2019).

“Data processing through AI can ensure better delivery of dimensions of living ability; through cleanliness, health, and conducive environments for people to live and work without pollution and congestion urban challenges” (Allam & Dhunny, 2019). It is further assumed that the built environment will help smart and reactive services electronically both easily and in real-time through this technology. Furthermore, “cities are seen to leverage AI Big Data to attract higher economic returns as their enabling infrastructures such as connectivity, energy and computing capabilities, among others, enable them to support globally competitive jobs” (Davenport & Ronanki, 2018; Kaplan, 2016; Wilson, Daugherty, & Morini-Bianzino, 2017).

In terms of business efficiency and competitiveness, robotic engineering has increasingly changed the world economies. The “market is moving towards optimization and automation; not only for the warehousing and manufacturing sectors but even non-industrial areas such as defence, agriculture, hospitals, offices, and even universities” (Bhardwaj, Avasthi, & Goundar, 2019). Some primary reasons for this new revolution are the “availability of open-source platforms, falling hardware and electronics prices, prompt prototyping, and technology convergence” (Bhardwaj, Avasthi, & Goundar, 2019). The “timing, content, and execution of their interactions should be continuously adjusted to our evolving preferences, needs, and context to foster the adoption of social robots in our daily lives” (Mahieu et al., 2019).

4.6.5 Virtual reality

Garcia, Naranjo, Ortiz, & Garcia, (2019) explains “Virtual Reality (VR) as the development of virtual 3D environments created by computers with the intention of giving the user the impression of being submerged in a different reality”. “Virtual reality technology can provide immersive environments that, in terms of safety and costs, are difficult in a real-life situation and is now accessible to all people and includes several fields of application that can includes industrial process simulation” (Towey, Walker, Austin, Kwong, & Wei, 2018). In the business sector, the primary usage of virtual reality will be on training and recruitment, in that it currently costs a lot of money to hire people and still have to determine their capabilities, with the deployment of virtual reality these capabilities can be tested during the recruitment phase. The other critical intervention will be on the manufacturing space where a digital twin can be created using virtual reality, and virtual reality can also be deployed because of its problem solving and predictive capabilities, with the results being to get the work done a lot faster and less expensively (WEF, 2017).

Information and communication technology (ICT) have changed beyond recognition in the traditional way of living. New discoveries and creative manufacturing techniques made it possible to invent new processes and procedures for various activities to be carried out, which increased efficiency and created new opportunities. By storing huge volumes of data, it allowed human society knowledge to be collected and gathered faster than ever before. In the same period, through the omnipresent cellular wireless telephone networks, through omnipresent internet connectivity, dynamic flexibility, and accessibility, the stored information was available throughout the internet at any time (Davidekova, Mjartan, & Gregus, 2017).

4.6.6 Three-dimension printing/digital fabrication

Three-dimension printing (3DP) processes are different in a number of key ways from traditional manufacturing. First, 3DP is an additive, by adding material to layers, it creates solid objects instead of “removing material to produce the desired form” (Candi & Beltagui, 2019). This feature “offers the potential to reduce waste from raw materials, although energy consumption may be higher than in traditional processes” (Candi & Beltagui, 2019).

Second, “3DP goes straight from the digital model to the physical object, without the need for tooling and allows for short lead times for on-demand production” (Candi & Beltagui, 2019). It “also facilitates distributed production, as resources can be shared” more closely to their point of use through the digital transfer of production designs (Candi & Beltagui, 2019). This provides clear advantages “when demand is low, intermittent, or geographically distributed, such as in supply chains for spare parts” (Candi & Beltagui, 2019). Third, “manufacturing using 3DP is not subject to traditional manufacturing economies of scale as there is no cost penalty associated with low production volume” (Candi & Beltagui, 2019). As a result, it becomes economically viable to manufacture personalized goods on-demand “to meet the needs of individual customers” (Candi & Beltagui, 2019).

3D printing is one technology that is transforming the medical sector in that many countries are performing surgical procedures using 3D printing technology. In fact, the data coming from the analysis shows that 96% of the hearing aids are produced using the 3D printing technology, it is being dubbed the production technology as it saves lives by providing patient-specific solutions where none exist.

3D printing technology can also help disaster areas in that aid organizations can print out the materials that might be needed to assist in disasters. At this level, we will measure the general usage and adaptation of technology in different sectors to resolve various problems (UNCTAD, 2017).

4.7 PERVASIVENESS OF INTERNET USE

The data presented under this dimension will look mainly at the pervasiveness of internet use from an access point of view, in that a number of countries around the world have defined from a policy position the broadband targets to be achieved within a specific timeframe in order to improve the telecommunications infrastructure. The research will explore basic mobile Internet access, advanced mobile Internet access, household & business broadband access, and connected digital society.

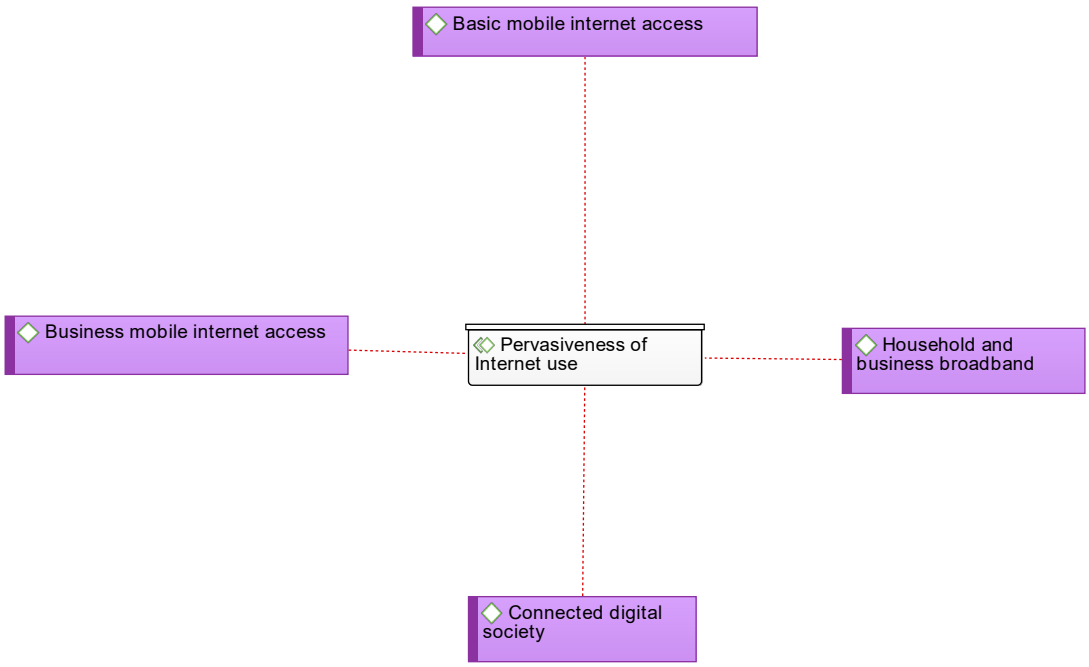

Figure 8: Pervasiveness of Internet Use

4.7.1 Basic mobile Internet access

The effect of "substitution between mobile and fixed telephones" can result in a nation's socio-economic reforms (Lechman, 2016). Hsiao and Chen (2016) examining "the distributional effects of leapfrogging on mobile phones concluded that the relative lack of fixed-line phones in low-income countries could facilitate the growth of mobile alternatives, which could result in more welfare benefits for low-income developing countries and households from some mobile phones than those countries and houses".

The basic mobile Internet access refers to browser-related access through a smart device or a handheld device to the Internet. Broadband Commission (2017) suggests that "the following steps have been successful in getting more people online: (a) giving direct subsidies for vulnerable user groups for the procurement of smartphones" and reducing the cost of Internet use; (b) lowering VAT and ICT hardware import duties; (c) providing free access to the public Internet; (d) developing related online content; and (e) providing ICT education. By the end of 2018, the Internet was used by an estimated "51.2% of the world's population, or 3.9 billion people", according to the latest statistics from ITU (2018). Slow and steady growth "in developed countries has raised the percentage of the worldwide Internet-based population from 51.3%" in 2005

to 80.9% in 2018 (ITU,2018). More sustained growth in developing countries showed an increase from 7.7% in 2005 to 45.3% at the end of 2018 (ITU,2018).

4.7.2 Advanced mobile Internet access

The data coming out of the analysis shows that by 2020 almost a billion more people will be accessing the Internet using mobile devices as a mobile subscribers and at this level of access the study will advocate for maximum download speeds of up to 150Mbps and average download speed of between 20 – 40 Mbps. At this level, the advancement of mobile Internet access will be measured (GSMA, 2017).

4.7.3 Household and business broadband access

“Ultra-fast communication infrastructure deployment typically produces positive direct and indirect effects on economic activities” (Abrardi & Cambini, 2019). The direct impact of providing the new network infrastructure is the “result of increased employment and economic activities” (Abrardi & Cambini, 2019). “Instead, indirect economic benefits are related to productivity gains” resulting from the latest technology being adopted (Abrardi & Cambini, 2019). Productivity is stimulated through “more efficient business processes and innovation acceleration due to larger quantities of better quality data that can be digitally transferred and stored at a lower cost” (Abrardi & Cambini, 2019). Furthermore, “adoption by residential consumers can drive real household income across different channels, such as easier and cheaper access to services, or better distance learning education” (Abrardi & Cambini, 2019). Training, in effect, is a critical skill in achieving “productivity gains” (Abrardi & Cambini, 2019.

This level of access will be looking at bandwidth always available, high-speed and high-quality required by businesses, public institutions, and citizens. It is noted that broadband access is critical to the ongoing evolution of the digital economy, and some countries have set targets in broadband access “in line with the millennium development goals” (ITU, 2017). The proliferation of the fibre to the home network infrastructure will also be explored further. The data coming out of the analysis show that businesses are starting to use high-speed wireless broadband for their connectivity needs as this provides connectivity in far-flung areas without the need to

expand infrastructure and invest in cabling (ITU, 2017). This view is amplified by Stocker and Whalley (2018), who argue that “with the increasing complexity of the network infrastructure and emerging technologies such as IoT, the number of devices connected to the internet, and the demand for bandwidth capabilities is rising continuously”.

“The growing proliferation of innovative business models, the introduction and increasing acceptance of a wide range of heterogeneous application products lead further to a highly dynamic and rapidly evolving value chain that provides services to the customer” (Abrardi & Cambini, 2019). Lastly, “broadband may allow for more flexible working patterns, such as teleworking, and this flexibility may increase labour participation and employment, especially for caregivers, as well as lower pollution and higher living standards” (Abrardi & Cambini, 2019). There may also be expenses. Although “higher productivity could translate into higher salaries”, in response to increased automation, companies could also shed workers (Abrardi & Cambini, 2019). As broadband complements human capital, income gaps “between skilled and non-skilled workers can increase and when broadband raises competition, many companies will lose employees or go entirely out of business” (Abrardi & Cambini, 2019).

4.7.4 Connected digital society

Digital technology has become an “inescapable part of everyday life as things that would have been considered science fiction only a few decades ago, such as modern smartphones, global information networks, or virtual reality, are taken for granted” (Dufva & Dufva, 2019). “Societies are becoming increasingly dependent on digital technologies and infrastructure at the same time” (Dufva & Dufva, 2019). Digital networks and databases are increasingly relying on banking, “electric grid management, health records, and other personal information” (Dufva & Dufva, 2019). The trend is to use digital technologies even more broadly, with a lot of hype surrounding “artificial intelligence and the prospect of an exponentially growing and productive digital economy” (Dufva & Dufva, 2019). “Machine learning, platform thinking, and crowd-based action” were said to be the three primary sources of change in digitalization (McAfee & Brynjolfsson, 2018).

The code of a connected digital society emerged from the National Integrated ICT White Paper and recognizes that achievement “of the universal service and access priorities is not a static target as it will be necessary to continually review definitions and frameworks to ensure that new digital divisions do not emerge as new technologies and services become available” (RSA, 2016). This will include the following interventions: expanded coverage in rural, remote, and underserved areas; digital inclusion and digital literacy programs.

4.8 DIGITAL APPLICATIONS

The advent of “smartphones and new mobile technology has radically revolutionized the telecommunications devices expectations of people” (Tang, 2019). “Mobile applications (apps) are known as smart device mobile operating systems offering advanced computing capabilities and a wide range of functions through application software” (Tang, 2019). “Mobile apps are small software programs designed to run on mobile devices that perform various functions, including, but not limited to, calendar, email, social networking, web browsing, and online gaming” (Tang, 2019). Not only did mobile apps change consumer behaviour “by offering them entertainment platforms, sharing opinions, obtaining information, and making purchasing decisions, they also transformed business, marketing and promotion strategies, building networks with existing customers, and attracting potential customers” (Cheung & To, 2017). Applications are now available on multiple devices.

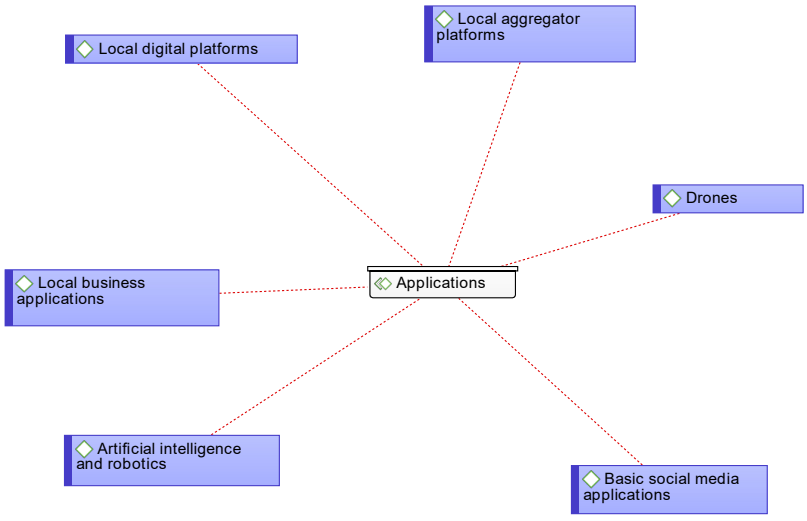

Figure 9: Digital Applications

4.8.1 Basic social applications

With the “rapid development of mobile Internet networks and smart devices, an increasing number of smartphone-based services have emerged to make daily tasks such as shopping, studying, and making transactions more effective” (Hsiao, Shu, & Huang, 2017). Ericsson (2014) estimates that by 2020, users of smartphones “will exceed 6.1 billion people”. These projections show that in many people's lives, smartphones are already becoming a necessity. Data shows that global transformation is such that people are interacting more with information through their connected devices; the proliferation of software and mobile connectivity and is granting access to services to more people around the world. At this level, the study will examine different types of social apps that are available to demonstrate the appreciation of the application economy and the impact that these apps have in improving the lives of the ordinary people.

This also contributed to a boom over the top services like WhatsApp, Facebook, and other related social media applications that have had a tremendous “social impact on the lives of people” and has changed the entertainment landscape (UNCTAD, 2017). As of 2019, "the Google Play store had more than 2 million apps available for download, while the Apple App Store had 1.83 million apps available” (UNCTAD, 2017). Nevertheless, retention rates did not see a similar upward trend. After ten sessions, the global user retention rate stood at 32% in 2019, down from 38% in the previous year. In total, after downloading, a quarter of mobile apps was used only once (Gordon, 2019).

4.8.2 Local business applications

The studies by (Ehrenhard, Wijnhoven, Broek, & Stagno, 2017) show that “mobile applications (apps) provide organizations with new opportunities to create value, such as meeting new demands, increasing efficiency, fostering knowledge sharing, and enhancing competitiveness”. Data shows that the use of local business applications by different sectors of the business, i.e., banking applications, health applications, home appliance applications, and the growing e-commerce applications that are driving the ever-increasing online shopping industry.

These local business applications have had a tremendous impact on the lives of ordinary people, with the success of M-Pesa mobile money in Kenya, which has revolutionized how people use money in that part of the world.

4.8.3 Local Digital Platforms

The analysed data would broaden digital platforms across markets, reshape business models across a broad spectrum of sectors, from finance and healthcare to media and retail, while establishing fundamentally new divisions of public and private liability. (WEF, 2019). “Digital platforms represent a more sophisticated form of ICT that facilitates interactions between different partners” (Cenamor, Parida, & Wincent, 2019). There are numerous existing and emerging areas where platforms can define and demonstrate the effectiveness of the new public-private liaison. Managing mobility, providing health care, renewing infrastructure, regenerating urban areas, and combating the effects of climate change are the most important. These opportunities can only be fully exploited through strong cross-collaboration aimed at creating sustainable frameworks for all future platforms and ecosystem work, re-emphasizing the value and urgency of public, private partnerships (WEF, 2019).

The leading digital platforms, "from Uber, Lyft, and Didi Chuxing to Airbnb and BlaBlaCar, have already shown how the private sector can provide a modern and invisible type of infrastructure, a new market-driven way of crowd-based public, private collaboration”. The market mechanism is 'switching on' capacity in response to demand spikes, at a fraction of the investment associated with it (WEF, 2019).

4.8.4 Local aggregator platforms

“An aggregator model is an eCommerce form in which a website does not store or store its own goods but collects or aggregates information on several goods and services and aggregates them into a single platform” (Chauhan, 2019). Then, “prices and specifications are easily matched to each customer based on what they're looking for, how much they can spend, what they're filtering out, and what they've been looking for recently” (Chauhan, 2019). The aggregator model enables consumers throughout their shopping experience to be as convenient as possible (Chauhan, 2019). The UNCTAD (2017) shows that “platforms hosted by players like Alibaba, Amazon, Apple,

Facebook, Google, Microsoft, SAP", and others are already at the centre of their business models with big data and AI. The capacity for observation will improve when more significant sections of society are interconnected by IoT, and further advanced AI will become more frequent use. Furthermore, the information distribution cycle from linked factories and clients, cloud data pooling, "big data analytics, and machine-learning algorithms will generate sequences of software changes and system-level strides in productivity and growth" (UNCTAD,2017).

4.8.5 Robotics and Drones

"E-commerce firms are adopting delivery services innovation technologies, not only to reduce costs and time but also to meet customer expectations for the quality of delivery services" (Yoo, Yu, & Jung, 2018). Wu and Lin (2018) shows that "many e-commerce firms and retail companies, such as Amazon, Google, and Wal-Mart, are preparing to offer drone delivery services" among the various innovation methods under consideration. "Drone delivery can bring many advantages over conventional delivery of packages, such as faster delivery times, lower maintenance costs, and environmental friendliness" (Yoo, Yu, & Jung, 2018).

The data coming out of the analysis shows that the advances in the knowledge economy will bring along advanced robots and artificial intelligence, which will transform the world of work and how people will live. The sector that will benefit a lot in terms of advances in robotics is health care in the areas of automation; health care robotics technology that will assist in managing caregiving and assistance in performing surgery. At this level, the study will measure the rate at which robotics technology is applied and the usage of drones for different purposes (UNCTAD, 2017).

Over the past "few years, small-scale unmanned aerial vehicles (UAVs) or drones have demonstrated their promising ability to support different applications, such as monitoring, inspection, package delivery, precision farming, etc" (Tian, Yuan, & Song, 2019). "Given increasing UAVs in low-altitude airspace, linking UAVs to the Internet of Drones (IoDs) is a positive step towards enhancing flying safety as well as the quality of service of UAVs" (Tian, Yuan, & Song, 2019).

Nonetheless, IoDs also pose challenges to “security and privacy issues due to the open-access communication environment”, including encryption risks and identity, location, and flying route's leakage (Tian, Yuan, & Song, 2019).

4.9 CHAPTER SUMMARY

This chapter laid the foundation for framework design and limited data analysis in the next chapter. The researcher grouped the codes that emerged from documents and reports into code groups and classified them accordingly under different dimensions. The chapter also positioned South Africa in terms of the new dimensions.

CHAPTER FIVE: DESIGN OF DIMENSIONS OF THE GLOBAL DIFFUSION OF THE INTERNET FRAMEWORK 2020

5.1 INTRODUCTION

The main objective of the chapter is to design a revised GDI 2020 framework relevant to the global diffusion of the Internet in 2020, with only limited analysis of data, because the chapter provides a detailed design of the framework, based on the interpretation of the data that was presented in Chapter Four. The analysis is only limited to new ideas that were added to the dimensions. In this chapter we have revised and built the refreshed framework which now includes three layers, seven dimensions, four levels for each dimension and many determinants for each level (and therefore for each dimension). Some of the key determinants are briefly discussed under each dimension and level below, and the determinants (codes generated in ATLAS.TI) can also be viewed in Appendix C, where the determinants are related to code groups and dimensions.

5.2 DESIGN OF GDI 2020 FRAMEWORK

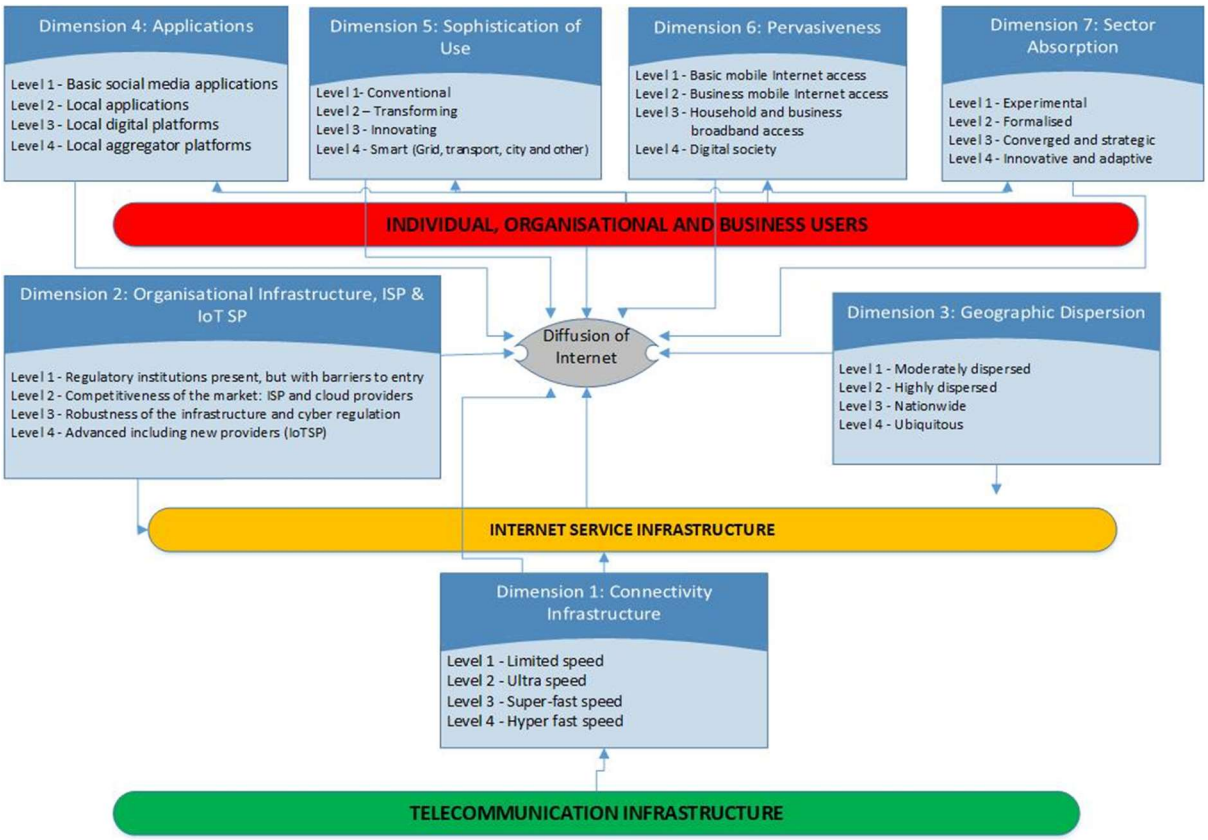

Figure 10: Redesigned GDI Framework 2020

The telecommunication infrastructure, coloured green above, includes only Dimension 1, namely connectivity infrastructure, or the first layer present for global diffusion of the Internet.

5.2.1 Dimension 1: Connectivity Infrastructure

Level 1	Limited speed
Level 2	Superfast speed
Level 3	Ultra-speed
Level 4	Hyper-fast speed

The levels of the dimension have been changed, starting with Level 1 on the revised dimension as opposed to Level 0 on the previous Wolcott framework. The change is a result of the changes in the telecommunication infrastructure wherein, according to data available, there is no level where connectivity is non-existent in one form or another.

The emphasis of the connectivity infrastructure is speed, which has largely informed the revised levels of the connectivity infrastructure dimension. The first level is limited speed, the second is level ultra-speed, the third level is super-fast speed, and the fourth level is hyper-fast speed. The different speeds are explained as follows:

Limited speed (level 1): This level is more about the slow internet connections that cannot support heavy data services, which is best represented by the WEF (2016), which shows that 2G coverage and no fixed-line network, or those using older-generation phones, enjoy limited online access only. Their network connections are not fast enough or secure enough, and their systems are unable to perform many more sophisticated features or uses.

Superfast speed (level 2): This level will be measuring the broadband Internet speed from 30Mbps or more.

Ultrafast speed (level 3): This level will be measuring the broadband Internet speed from 100Mbps or more.

Hyperfast speed (level 4): The data from GSMA (2018) shows that the integrated 4G, 5G, and Wi-Fi hybrid will provide secure, superfast broadband access anytime and anywhere. Ubiquitous broadband Internet speeds of up to 1Gbps provide a consistently high-quality mobile broadband experience that guarantees uninterrupted and smooth Internet access at home, in the office, and on the move. At this level, we will measure the general adoption of 5G and LTE; countries that have adopted this would thus be deemed to have hyperfast connectivity speed.

The second layer present for global diffusion of the Internet is the Internet service infrastructure, coloured yellow in the diagram, which includes Dimension 2 and Dimension 3, namely organisational infrastructure and geographic dispersion.

5.2.2 Dimension 2: Organisational Infrastructure: ISPs and Internet of Things service providers

Level 1	Regulatory institutions present, but with barriers to entry
Level 2	Competitiveness of the market: ISPs and cloud providers
Level 3	Robustness of the organization and cybersecurity regulation
Level 4	Advanced: Internet of Things service providers

Wolcott et al. (2001) show that "the measure of organizational infrastructure is focused on the number and competitive environment of Internet Service Providers (ISPs)". It "assess the robustness of the market and services themselves" and acknowledges that more services will likely be offered by Internet service providers when there is a strong competition (Wolcott et al.,2001). The measure of the organizational infrastructure is also based on the market conditions, and the argument was that a highly advanced country should have many Internet Service Providers and a higher degree of competition in both the telecommunication players and the ISPs.

The revised dimension has now incorporated the Internet service providers and Internet of Things Service providers. The new dimension did not include level 0 because we couldn't find evidence of a country where there is still no internet and in

level 1, according to Wolcott et al. (2001) “there is a single ISP who has the monopoly of Internet service provision market”.

The **entry-level (Level 1)** in this dimension is controlled with barriers to entry wherein there are now a lot of ISPs.

The **second level (Level 2)** of the dimension is the competitiveness of the market, where there are a lot of ISPs, cloud providers, and the Internet market remains very competitive.

The **third (Level 3) level** emphasizes the robustness of the organization where there is still a productive service provider of infrastructure and regulation on cybersecurity. Figure 4 shows data with more reliance on digital technologies; which will bring along the cyber threats and security related risks that will need to be mitigated. More efforts would need to be made to put together cybersecurity governance structures. Policymakers and regulators will need to develop processes and technologies for implementation by organizations as opposed to devoting resources to only compliance. The data further shows that this “greater reliance on digital technologies will also bring new job opportunities in various sectors, including the production of new goods, services, and cybersecurity” (UNCTAD, 2017).

The **fourth level (Level 4)** is about the advanced organizational infrastructure, including new providers of the Internet of Things. However, the data shows impressive growth of connected devices and IoT operates in a continually evolving cyber-physical environment, with innovators and entrepreneurs pushing the boundaries of the potential of IoT. Nevertheless, this rapid rate of change often emboldens malicious actors to develop new and increasingly sophisticated methods for exploiting vulnerabilities that are either special to IoT systems or imported with insecure parts, devices, or networks used as part of IoT services. The “Internet of Things is recognized as one of the strategic growth areas” that will propel business, and as such, it is encouraged that firms continue to build end-to-end capabilities around it, and the role of Internet of Things service providers becomes very crucial (RSA, 2016).

5.2.3 Dimension 3: Geographic dispersion of the Internet

Level 1	Moderately dispersed
Level 2	Highly dispersed
Level 3	Nationwide
Level 4	Ubiquitous (everywhere, all the time)

Oyelaran-Oyeyinka and Lal (2005) argue in their study "the most important factors affecting the adoption of the Internet is telecommunication infrastructure that is represented by the high correlation of telephone density with the Internet".
The correct broadband and mobile age have seen the upsurge and increase in penetration of 3G and broadband, which mainly translated into the decrease of telephone density. It may, therefore, be argued that this dimension measures the levels of Internet connection in a country. The contention is that not only will faster Internet connection attract more users; it will "also boost the development of multimedia on Internet content" (Feng, 2015).

Wolcott et al. (2001) point out that "in addition to having access to the network throughout the country, there are advantages of having locations in the area that would include redundant transmission routes and multiple international access points".

The Wolcott et al. (2001) framework noted two problems in interpreting the geographic dispersion dimension, "the first is that the observer should determine what constitutes as a first-tier political subdivision, in that most countries make up the first-tier political subdivision of the country, region, and parliament". The second issue "is the availability of dial-up access", in that the cost of making those calls are prohibitive as many users can access the Internet by making long-distance calls (Wolcott et al., 2001).

According to Wolcott et al. (2001) "an Internet point of presence is taken to mean the physical presence of the Internet service provider in the first tier political sub-division, it is further argued that geographic dispersion also takes into account certain aspects

of Internet dispersion that are ascribed to mobile phone operators who provide Internet services through mobile platforms". The revised framework starts with the **first level (Level 1)**, which is the moderate dispersion of Internet presence points located in multiple political subdivisions of the country and the **second level (Level 2)**, highly dispersed where 50% of Internet presence points are located in the country's first-tier political subdivisions. The **third level (Level 3)** is that of a nationwide presence, wherein the Internet presence points are found in most of the country's first-tier political subdivisions. Accessibility in rural areas is available to the public. The **fourth level (Level 4)** is that of ubiquitous computing, Lyytinen and Yoo (2002) argue that the next big revolution in computing involves ubiquitous computing in which computers will become part of our everyday life and have a significant influence of our social and physical environment, such that it will facilitate social interactions and situations when it occurs.

Another issue that is connected to ubiquitous computing, as shown by the data in Chapter Four, is convergence, which is see as being key to geographic dispersion. The data shows that the convergence phenomenon heralds the "introduction of a series of new, innovative content services such as video-on-demand (VOD) and over-the-top (OTT) services" (RSA, 2016). The networks should, therefore, allow such services to be "delivered at any given time and this poses challenges to the existing regulatory systems for electronic communications networks and content services that need to be addressed through appropriate policies" (RSA, 2016).

The third layer present for the global diffusion of the Internet is the individual, organisational and business users layer, coloured red above, which includes four dimensions, namely Dimension 4: Digital Applications, Dimension 5: Sophistication of use, Dimension 6: Pervasiveness of Internet usage, and Dimension 7: Sectoral Absorption. Digital applications are a major new dimension that has emerged strongly over the past 20 years and has become the basis for effective Internet usage.

5.2.4 Dimension 4: Digital Applications

Level 1	Basic social media applications
Level 2	Local applications
Level 3	Local digital platforms
Level 4	Local aggregator platforms

This is the new dimension that was added to the revised GDI framework, as this researcher found evidence that suggests that digital applications play a critical role in the general diffusion of the Internet. The dimension will have four levels as follows:

Level 1 Basic social media applications which according to data in Chapter Four, show that global transformation is such that people are interacting more with information through their connected devices, the proliferation of software and mobile connectivity and is granting access to services to more people around the world. At this level, the study will examine a different type of social applications that are available to demonstrate the appreciation of the application economy and the impact that these apps have in improving the lives of the ordinary people. This also led to a boom in over the top services like WhatsApp, Facebook, and other related social media applications that have had a tremendous social impact on the lives of people and has changed the entertainment landscape.

Level 2 Local applications will be looking at different uses of locally developed applications by different sectors of the business, including banking applications, health applications, home appliance applications, and the growing e-commerce applications that are driving the ever-increasing online shopping industry. These local business applications have had a tremendous impact on the lives of ordinary people, with the success of M-Pesa mobile money in Kenya, which has revolutionized how people use money in that part of the world.

Level 3 Local digital platforms will be looking at the network effects that come along with the maturity of local platforms in that from the data analysed in Chapter Four it shows that users drive the demand and create value that drive the demand for economies of scale. The data analysed in Chapter Four shows that new platforms ranging from Uber, Lyft and Didi Chuxing to Airbnb and BlaBlaCar have already shown how the private sector can provide a unique and invisible form of infrastructure, a new type of crowd-based public-private collaboration. In response to demand spikes, the market mechanism switches on capacity at a fraction of the investment associated with high-fixed infrastructure.

Level 4 Local aggregator platforms. This level will be measuring the proliferation of local aggregator platforms by enterprises and confirm how do they utilize digital platforms to create opportunities and benefits for new products.

5.2.5 Dimension 5: Sophistication of use

Level 1	Conventional
Level 2	Transforming
Level 3	Innovating
Level 4	Smart cities, smart transport, smart grid, smart everything

The sophistication of use is primarily characterized by understanding the conventional usage of the Internet to the more sophisticated use, which will ultimately lead to innovation. It is argued by (Wolcott et al., 2001) that "in order to really understand a country's Internet capability, it is necessary not only to understand how many people use the services and where, but also how the Internet is used". The revised dimension has done away with Level 0, which represented non-usage on the Internet except by a small fraction of users who are logging onto foreign services and the minimal usage level wherein the as users struggle to use the Internet with the conventional applications.

The **first level (Level 1)** on the revised dimension is conventional wherein “a relatively conventional nation uses the Internet as a straightforward substitute for other forms of communication, whereas in a more advanced environment, applications are developed to have a significant impact on business processes and drive innovation” (Wolcott et al.,2001).

The **second level (Level 2)** is of transforming Internet use by specific user segments resulting in new applications or substantial changes in processes and practices. The **third level (Level 3)** is innovating, where the user community is highly demanding and apply the Internet to keep on pushing the innovative capabilities of technology; they have a good relationship with developers.

The data in Figure 6 show that innovation is seen as a vital enabler of the knowledge economy together with technology because for organizations and firms to derive benefit, they will need connected, advanced and secure technology platforms. Infrastructure would need to be upgraded so that it copes with the needs of the emerging technologies.
The data reviewed shows “that the availability and speed of the internet are essential to propel the Internet of Things” (ITU, 2016). It is imperative that countries and firms would need to develop, adopt norms and standards that speak to interoperability and data flows (ITU, 2016).

The **fourth level (Level 4)** is that of smart cities, smart transport, smart grid, smart everything and the data reviewed shows that the with the evolution of Internet of Things, the cities across the world are envisioning the cities of tomorrow which are connected and are developing smart city projects, and the focus is on the developmental path that is smart. Data shows that more cities are turning to the Internet of Things to harness the power of digital technology and foster economic growth. Davis (2010) argues that built on the implicit assumption that urban infrastructure and everyday life are streamlined and greened by ICT innovation and firms.

5.2.6 Dimension 6: Pervasiveness of Internet use

Level 1	Basic mobile Internet access
Level 2	Advanced mobile Internet access
Level 3	Household and business broadband access
Level 4	Connected digital society

It is argued by (Wolcott et al., 2001) that “both the pervasiveness and the sectoral absorption measure are similar to traditional diffusion studies in that they simply consider whether the technology has been adopted or not and does not attempt to distinguish between different adoption intensities or different uses”. Wolcott et al. (2001) further maintain that pervasiveness differs from the “Internet growth metrics commonly used in that the final measure of omnipresence is not an absolute number but a ranking of that number in one of the five levels”. Ochara, Van Belle and Brown (2008) write that the "pervasiveness of Internet use measure is based on per capita usage and the degree of use of the Internet by non-technicians. Many households share Internet accounts, and as such, this limitation of data makes it difficult to establish an accurate number of Internet users per country". In this dimension, all the levels have been modified and have done away with Level 0, where the Internet was non-existent in any form in a particular country. The **first level (Level 1)** is basic mobile Internet access, which according to data in Chapter Four, refers to browser-related access through a smart device or a handheld device to the Internet. The UNCTAD (2017) suggests that the following steps have been “successful in bringing more people online: (a) providing direct benefits to disadvantaged user groups for the purchase of telephones and increasing the cost of Internet use; (b) lowering VAT and import duties on ICT equipment; (c) providing free public Internet access; (d) developing related online content apps, (e) providing ICT training to different levels of user groups to enhance their capabilities and facilitate greater use, not only in the work or school environment but also in the home environment”.

The **second level (Level 2)** refers to the advancement of “mobile internet access and the data emerging from the chapter shows that by 2020 almost a billion more people will be accessing the Internet” as mobile subscribers, the research recommends a peak download speed of up to 150Mbps at this level of access and average download speed of between 20 – 40 Mbps (ITU, 2017).

The **third level (Level 3)** refers to household and business broadband access, this level of access will be looking at a bandwidth that is always accessible, and high-speed and high-quality, needed by enterprises, public institutions, and residents. It is noted that broadband access is critical to the ongoing evolution of the digital economy, and several countries have set targets in terms of broadband access in line with the millennium development goals. The data coming out of Chapter Four show that businesses are starting to use high-speed wireless broadband for their connectivity needs as this provides connectivity in far-flung areas without the need to expand infrastructure and invest in cabling.

The **fourth level (Level 4)** refers to a connected digital society, which will be measuring all connected technological aspects, including “advanced robotics, artificial intelligence, and the Internet of Things” (UNCTAD, 2017).

5.2.7 Dimension 7: Sectoral absorption of the Internet

Sectoral absorption dimension rating	
Level 1	Experimental
Level 2	Formalized
Level 3	Converged and strategic
Level 4	Innovative and adaptive

According to Wolcott et al. (2001), the sectoral adoption of the Internet "measures the degree of Internet utilization in four major sectors which are seen as key to development". These measures have been suggested by the United Nations Developing Program Human Development Index. The measures are the health sector, education sector, public sector, and academia.

The levels have been changed from the previous Wolcott framework; this study has done away with Level 0, which referred to non-existent usage of internet in a particular area and previous Level 1, which referred to rare usage. The new levels which are experimental, will look at the purpose of internet use at **Level 1** of the new dimension, bridging the non-existent and rare usage. The **second level (Level 2)** will look at formalized usage of the Internet across the four sectors. The **third level (Level 3)** of converged and strategic examine the convergence of different forms of technology and communications mediums at a higher level. The **fourth level (Level 4)** of innovative and adaptive will broadly be examining how different sectors are taking advantage of technological innovations and adapting them to improve service offerings.

5.3 ADVANTAGES AND DISADVANTAGES OF THE REVISED GDI 2020 FRAMEWORK

In terms of addressing sub-question 3 , I reflect on the advantages and disadvantages of the GDI 2020 framework in comparison to the Wolcott et al. (2001) framework by making a commentary on aspects that stood out during the redesign process of the GDI 2020 framework.

The GDI 2020 frameworks' main advantage compared with Wolcott et al. (2001) includes the fact that the focus of the **connectivity infrastructure** dimension is on speed, which is important in terms of assessing performance quality, as the world prepares and tests for the commercialization of the 5G ecosystem.

In comparison to Wolcott et al. (2001), under the dimension of **organisational infrastructure**, the GDI 2020 framework has embraced the role of Internet of Things and IoT service providers. The Internet of Things is recognized as one of the strategic growth areas that will propel business, and as such, it is encouraged that firms continue to build end-to-end capabilities around it.

The third advantage, linked with the **geographic dispersion** dimension, is the inclusion of the level ubiquitous. Technological developments have shown that the next big revolution in computing involves ubiquitous computing in which computers

will become part of our everyday life and have an impact in how people and machines interact. This will propel pervasive Internet availability.

The fourth advantage is the incorporation of the **digital applications** dimension, which can assist academic and industry researchers to measure the proliferation of local aggregators and local digital platforms. The use of aggregators is becoming important as many industries are incorporating extensive digital applications in their business models and practices, for example the finance sector is digitising the payments system, a movement from cash to a digital system that uses aggregators.

The fifth advantage of the GDI 2020 framework, under the **sophistication of Internet use** dimension, is the introduction the level of smart everything, with the focus on smart cities, smart transport, smart grid. Data from document review and technological developments show that, with the evolution of the Internet of Things, cities around the world are gravitating towards a connected future.

The sixth advantage of the GDI 2020 framework is seen under the **pervasiveness of Internet use** dimension. Here, I have revised the levels from only looking at ratio of Internet users per capita to focus on the transition from basic mobile access to a household and business broadband access. At the highest level of measurement for this dimension is the connected digital society level, which will measure advancements in respect of advanced robotics, artificial intelligence and Internet of Things initiatives.

One more advantage is linked with the **sectoral absorption of the Internet** dimension, noting that the Wolcott et al. (2001) framework was mainly concerned with the degree of utilisation across four major sectors. The GDI 2020 framework looks at the purpose of Internet usage at the first level, and at the innovative and adaptive use by different sectors to take advantage of technological innovations at the fourth level.

The overall advantage of the GDI 2020 framework is that countries and enterprises can use the data from future GDI studies to develop a global approach for the integration of investments and capabilities in broadband infrastructure with policy and regulatory changes affecting the adoption of network technologies.

This will become a useful framework for businesses that want to invest and do business in particular localities, in that they will have an understanding of the state of Internet and related infrastructure.

Some disadvantages linked with the revised GDI 2020 framework are that because of the rapid pace in technological change, the framework may only be relevant for the next 3-5 years and will need further review. The other disadvantage of fully utilizing the revised GDI 2020 framework is the infrastructural inequalities of different countries. This is confirmed by Chile (2019) who contends that "most communities lack the infrastructure or networks needed to promote and embrace new technologies".

5.4 APPLYING THE GDI 2020 FRAMEWORK TO SOUTH AFRICA

5.4.1 Country positioning in terms of connectivity infrastructure

Based on the new data and dimensions, the positioning of South Africa in the context of this study is at level 3. The data shows that the South African national population coverage for 3G increased form 99.5% in 2018 to 99.7% in 2019 and national population coverage for 4G/LTE increased from 85.7% in 2018 to 92.8% in 2019 (ICASA, 2020). In order to meet the demand for high-usage bandwidth applications, South African operators have invested extensively, increasing capacity by investing in both terrestrial fibre networks and in the provision of mobile LTE networks (Gillwald, Mothobi & Rademan, 2018). ICASA (2020) further shows that South Africa's global ranking for internet speed in 2019 in terms of speed test was at position 96 for fixed broadband (download speed of 26.87 Mbps and upload speed of 19.12 Mbps) and position 60 for mobile broadband (download speed of 31.36 Mbps and upload speed of 9.41 Mbps).

Level 1	Limited speed
Level 2	Superfast speed
Level 3	Ultra-speed
Level 4	Hyper-fast speed

5.4.2 Country positioning in terms of organisational infrastructure

Based on the new data and dimensions, the positioning of South Africa in terms of organisational infrastructure in the context of this study is at level 3, as shown by (ITU, 2018) that South Africa's telecommunications sector provides advanced infrastructures including cloud services provision. ITU (2018) shows that the mobile market consists of four players: Vodacom (65 per cent owned by Vodafone UK), which launched in 1994; MTN, which also launched in 1994; Cell C, majority owned by OGER Telecom of Saudi Arabia, which launched in 2001; and Telkom, the incumbent fixed-service operator, which entered the mobile market in 2010. There is considerable investment from Telkom, Liquid Telecom South Africa, Broadband InfraCo and municipal providers as well as from mobile network operators all aimed at improving network capabilities. The focus in recent years has been on backhaul capacity and on fibre and LTE networks to extend and improve internet service connectivity, while there are many cloud providers including Amazon Web Services and Vodacom Business, which have recently formed a partnership.

The Competition Commission was established by law in 1998, and the electronic communications sector regulator, the Independent Communications Authority of South Africa (ICASA), was established by law in 2000. In terms of the cyber security matters, various pieces of legislation apply, namely (i) the Electronic Communications and Transactions Act, 2002; (ii) the Protection of Personal Information Act, 2013, some sections of which commenced in 2018, while further sections commenced in 2020, and yet further sections will commence in June 2021. The Information Regulator was established by this Act, taking office in 2018, and publishing initial regulations in 2018. The Cybercrimes Bill has been passed in both houses of Parliament, most recently by the National Council of Provinces in July 2020, and is awaiting the President to assent to its commencement (Bhagattjee, Govuza, & Sebanz, 2020). This will require the criminal justice system including the courts to advance their understanding of cybercrime in order to effectively apply this legislation.

Level 1	Regulatory institutions present, but with barriers to entry
Level 2	Competitiveness of the market: ISPs and cloud providers
Level 3	Robustness of the organization and cybersecurity regulation
Level 4	Advanced: Internet of Things service providers

5.4.3 Country positioning in terms of geographic dispersion of the internet

Based on the new data and dimensions the positioning of South Africa in terms of geographic dispersion of the Internet in the context of this study is at level 3. The evidence shows that convergence, which is see as being key to geographic dispersion is connected to ubiquitous computing. Vodacom have continued to invest in infrastructure improvements to expand their network, adding 137 new rural sites in South Africa this year. With an investment of R28.2 billion over the last three years they have focused on promoting digital inclusion by increasing rural coverage. Their network now to extends to over 99.5% of South Africa for 3G users, approximately 99% for urban coverage of 4G users, and 82.9% for rural coverage of 4G users (Vodacom, 2020).

Level 1	Moderately dispersed
Level 2	Highly dispersed
Level 3	Nationwide
Level 4	Ubiquitous (everywhere, all the time)

5.4.4 Country positioning in terms of sophistication of Internet use

Based on the new data and dimensions the positioning of South Africa in terms of sophistication of internet use in the context of this study is at level 2. South African users engage in online shopping, use fintech particularly online insurance services. While there is a basic level of innovation in online services, for example South African online shopping platforms, innovation is too limited to claim that South Africa is operating at level 3. There are some initial discussions on smart cities, but no major transition to smart cities, or smart transport as yet.

Level 1	Conventional
Level 2	Transforming
Level 3	Innovating
Level 4	Smart cities, smart transport, smart grid, smart everything

5.4.5 Country positioning in terms of sectoral absorption of Internet use

Based on the new data and dimensions the positioning of South Africa in terms of sectoral absorption of internet use in the context of this study operates partly at level 1 and at level 2. In the South African context, e-education and e-health are only experimental, with limited connectivity at schools and clinics; while the services sector including banking and finance, travel and tourism, retail and personal services show extensive absorption of Internet use.

Level 1	Experimental
Level 2	Formalized
Level 3	Converged and strategic
Level 4	Innovative and adaptive

5.4.6 Country positioning in terms of pervasiveness of Internet use

Based on the new data and dimensions the positioning of South Africa in terms of pervasiveness of Internet use in the context of this study is at level 3. The data show that households and businesses are starting to use high-speed wireless broadband for their connectivity needs as this provides connectivity in far-flung areas without the need to expand infrastructure and invest in cabling (ITU, 2017). The country is connected to multiple high-speed undersea cables: Seacom, EASSy, WACS and ACE. This has boosted broadband capacity and shifted the bandwidth bottlenecks in South Africa from the international leg to national backbone capacity (Gillwald, Mothobi & Rademan, 2018). Internet penetration in South Africa in January 2020 is at 62% with over 36 million users, 96% of whom are mobile Internet users (Kemp, 2020), noting that 94% of the population are able to access WiMAX/LTE services (BuddeComm, 2019), either at home or at public Wi-Fi hotspots (free or paid).

Level 1	Basic mobile Internet access
Level 2	Advanced mobile Internet access
Level 3	Household and business broadband access
Level 4	Connected digital society

5.4.7 Country positioning in terms of applications

Based on the data and dimensions the positioning of South Africa in terms of applications in the context of this study is at level 4. South Africa shows extensive use of social media (Kemp, 2020); and availability of local digital business applications such as NetFlorist, Spree, and takealot.com. There is extensive use of global digital platforms such as AirBnB and Uber, but the introduction of local digital platforms and aggregator platforms is limited. Telkom (2020) shows that there is a drive to push broadband adoption in the South African consumer market through streaming content and other value-added applications. Telkom is strengthening relationships with its content partners, some local, some international. During 2019, campaigns included bundling data with streaming services such as the local content platform Showmax, a local aggregator platform that buys international film and series content. Telkom Plus, an aggregation platform, provides customers with content and services relating to lifestyle, short-form video and mobile gaming. The platform saw over 100 000 subscriptions in its first two months. The data further shows that in South Africa, Vodacom's digital services business contributed R1.5 billion in revenue through their video on demand, music, gaming, sport and other content services (Vodacom, 2020).

Level 1	Basic social media applications
Level 2	Local applications
Level 3	Local digital platforms
Level 4	Local aggregator platforms

5.5 CHAPTER SUMMARY

The chapter emphasized more on framework design and limited analysis of data. The researcher interpreted, organized, analysed and evaluated the data using coding for data analysis to determine the levels, dimensions and determinants for the GDI 2020 framework. The researcher divided the data into different dimensions of the new framework to make better sense of the information as gathered. The researcher was able to develop new elements of the framework that are included in the GDI 2020 framework. The researcher applied the GDI 2020 framework to South Africa. The chapter also looked at the advantages and disadvantages of the GDI 2020 framework.

CHAPTER SIX: ADVANTAGES OF THE REVISED GDI FRAMEWORK

6.1 INTRODUCTION

This chapter articulates the advantages of the revised GDI 2020 framework, which have been introduced in chapter 5, noting that the framework can be used by any researcher anywhere in the world. This represents an important area of research for South Africa, where measuring and understanding current diffusion of the Internet is important for future policy, regulation and practice. The data interpretation and framework design is used to answer the research questions that were presented in Chapter One and in the methodology chapter of the research report. The main research question of this study is: How should the existing six dimensions and their respective measurements be adjusted to create a suitable GDI framework for the current stage of the digital economic revolution?

The sub-questions are:

1. What are the limitations of the existing GDI framework?
2. How can insights on Internet diffusion in a particular country inform the revised framework?
3. What are the advantages and disadvantages of the modified framework?

6.2 SUMMARY OF INSIGHTS

In addressing sub-question 1, I note that the Wolcott et al. (2001) framework is too limiting as it uses outdated measurements for at least some of its six dimensions, while it excludes aspects that may be important to Internet diffusion in the contemporary digital transition. The existing framework doesn't allow for measuring diffusion beyond 2017. The old levels which started with level 0 were adjusted to all start with level 1, where all four new levels represent advancement in diffusion of the Internet across all dimensions.

In addressing sub-question 2, the researcher examined the current aspects of the global diffusion of the Internet using the perspective of a developing country, namely South Africa, by identifying key elements that need to be integrated into the new GDI

2020 framework. The sub question 3 has been addressed in detail in the previous chapter and was largely looking at the advantages and disadvantages of the revised GDI 2020 framework, the researcher linked an advantage to a dimension of the framework and the impact that it will have in enabling the implementation of the framework.

The research has been able to generate specific layers, dimensions and levels that are important to Internet diffusion and are crucial to updating the Wolcott et al. (2001) framework. The framework design started by unpacking the current form of the Wolcott et al. (2001) framework, attempted to understand its historical context and recognize its shortcomings in the current digital transformation period from about 2016.

6.3 CONCLUSIONS

The value of the revised GDI 2020 framework is that it is a contemporary framework that looked into the limitations of the Wolcott et al. (2001) framework, and integrated new elements relevant to Internet diffusion. The GDI 2020 framework is a useful and powerful tool for policy makers to use in shaping policy for their countries. If regulators use the framework, they will benefit in terms of gaining a superior understanding of the issues of universal access today. If academics and industry use the GDI 2020 framework, they will have a better understanding of the new dimensions, levels, and determinants and the relevance to their particular interests.

In reviewing and refreshing the global diffusion of the 2001 Internet framework, the study took a qualitative approach, and the researcher maintains that the new dimensions and levels are critical to the future determination of Internet diffusion. The lessons learned from this study can add to existing knowledge and enhance the understanding of how the Internet spreads. It can also be useful in guiding for policymakers and industry to develop intervention strategies for ensuring that the digital divide is addressed.

While adjustments to the Wolcott et al. (2001) framework laid the foundation for the creation of a more suitable GDI 2020 framework relevant for a digital economic revolution, further research is needed to keep the framework evolving with the pace of technological developments.

6.4 RECOMMENDATIONS: IMPLICATIONS FOR POLICY, REGULATION AND ACADEMIC RESEARCH

The following recommendations are made for using the revised GDI 2020 framework, noting that each country would only need to conduct one such study every few years:

Policymakers should embrace the idea of using the GDI 2020 framework to inform policy research and policy making. The treatment of broadband networks should be a key consideration in this regard, as policy makers should consider public policy on advanced telecommunication infrastructure, understanding that connectivity is one of the best drivers of technology adoption.

Regulators must also consider using GDI 2020 framework studies to better understand the issue around universal access for social inclusion in a drive to reduce digital divide. As the Internet approaches global ubiquity over the next decade, policy and regulatory attention should shift to tightening the cybersecurity regulations, with attention to cybersecurity now included in the GDI 2020 framework.

Academics and industry should use the GDI 2020 framework to better understand the new dimensions and levels, as it has been noted that it took more than two decades to revise the Wolcott et al. (2001). It is therefore a recommendation of this study that more research work be undertaken to refresh the GDI 2020 framework in five years from now, in order to keep it up to date or on par with the pace of technological developments and further assist in “working towards development of a grounded theory of Internet diffusion” as advocated by Wolcott et al. (2001).

6.5 LIMITATIONS OF THE STUDY

Because of the nature of the research conducted, which was mainly secondary document analysis, the researcher acknowledges that the research report might have gained more from reviewing the updated model with a panel of Internet diffusion experts. It’s also a limitation on the part of the study that more work could not be undertaken more particularly in the layer of telecommunications infrastructure which is the backbone of the Internet diffusion framework models.

The information collected and analysed with ATLAS.ti could not all be included in the document, and there is a chance that some factors could have been omitted. Further, the researcher understands that theories of economic development can be used to relate Internet diffusion to economic growth and development, a perspective that the revised GDI 2020 framework has not been fully tested in a country environment, and this is a limitation.

6.6 AREAS OF FUTURE RESEARCH

The researcher suggests that future research considers canvassing the revised GDI 2020 framework with a panel of experts who are informed about Internet diffusion, as this would add value to the general understanding of Internet diffusion.

Future research could also consider exploring all the dimensions and levels of the revised GDI 2020 framework and applying them in specific country contexts, notably in South Africa, given that only limited information is available about Internet diffusion in South Africa.

This research was conducted on the understanding that economic development is linked to the diffusion of the Internet, therefore the researcher's view is that future studies need to test this link to determine the nature of that relationship, using data collected through the application of the revised GDI 2020 framework.

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APPENDIX A:

FRAMEWORKS FOR UNDERSTANDING SPECIFIC CHARACTERISTICS OF THE DIGITAL ECONOMY

1. Economist Intelligence Unit e-Readiness Rankings

The annual e-readiness rankings reports have been produced by the Economist Intelligence Unit since 2000 and have been used mainly to measure the world's largest economies in terms of GDP. The ranking model evaluates the technological, economic, political and social assets of 70 countries, and their cumulative impact on their respective information economies. E-readiness looks at the current status of a country's information and communications technology (ICT) infrastructure and to a greater extent also examines the ability of its consumers, businesses and governments to use ICT to their benefit.

The ranking allows governments to measure the maturity of their technology initiatives and benchmark with other countries. This information is also helpful to companies that wish to make investments in markets in that they have an insight of the prospects for return on investment in digital initiatives in various economic sectors to assist their decision making.

The supportive environment is created such that digital business and transactions will be able to thrive within the framework of the rankings. E-readiness is not only concerned about the issues of connectivity but also to a greater extent the ICT literacy of citizenry, and also the involvement of government in driving digital technologies. The e-readiness rankings compromise 100 quantitative and qualitative criteria, organised into six distinct categories, namely social, political, economic and of course technological development.

Below is the detailed description of the scoring criteria categories and weights. The e-readiness ranking for **Connectivity and technology infrastructure** is **20%.**

Connectivity measures the extent to which individuals and businesses can access mobile networks and the Internet, and their ability to access digital services through means such as digital identity cards. Effective access uses two primary metrics: penetration and affordability. Penetration of each market's mobile-phone subscriptions, overall Internet users and broadband Internet accounts are ranked as a percentage of the total population. The

Economist Intelligent Unit (EIU) is of the strong opinion that this “basket” of connectivity is the optimal representation of the extent to which voice and data services are accessible to a country’s residents. The affordability of the lowest-priced broadband subscription, measured as a percentage of an average household’s median income, is used as the overall measure of digital service affordability. The penetration of secure Internet servers in the population is also used as a reference indicator of the extent to which reliable digital transactions can be made in each market. International Internet bandwidth is an indicator of the ability of a country’s networks to carry the burgeoning volume of data traffic originating from within and outside of its borders.

Category criteria: Broadband penetration; broadband affordability; mobile-phone penetration; Internet user penetration; international Internet bandwidth; Internet security.

Business environment 15%

In evaluating the general business climate, the Economist Intelligence Unit screens 74 sub-indicators to provide a comprehensive and forward view of each country’s attractiveness as a trading economy and as a destination for business investment from 2009 to 2013. The criteria cover such factors as the strength of the economy, political stability, taxation, competition policy, the labour market, and openness to trade and investment. The aggregate scores of the individual sub-indicators are grouped into nine higher-level indicators, shown below. Updated quarterly as part of the Economist Intelligence Unit’s Country Forecast Service, these rankings have long offered investors an invaluable comparative index for over 60 major economies.

Category criteria: Overall political environment; macroeconomic environment; market opportunities; policy towards private enterprise; foreign investment policy; foreign trade and exchange regimes; tax regime; financing; the labour market

Social and cultural environment 15%

Basic education is a precondition to being able to utilize Internet services, but this category also considers a population’s web-literacy—its experience using the Internet and its receptivity to it—and the technical skills of the workforce. These technical skills are evaluated by both evidence of the familiarity of a country’s population with information technology (IT) applications and the extent to which its schools and governments provide the education infrastructure to engender it. Continued from previous years is an assessment of entrepreneurship, while the scoring of innovation levels in each market (measured by the number of patents and trademarks registered, as well as the level of spending on research

and development, R&D) evaluates how well the society fosters creative business activity that can lead to the creation of intellectual property, new products and industries.

Category criteria: Educational level (measured by school life expectancy and gross enrolment in education); Internet literacy; degree of entrepreneurship; technical skills of workforce; degree of innovation (measured by the generation of patents and trademarks, as well as R&D spending).

Legal environment **10%**

E-business development depends on both a country's overall legal framework and specific laws governing Internet use. This category reflects those legal frameworks that have a direct impact on the use of digital technology to inform, communicate and transact business. Governments need to be forward-thinking in their creation of legal frameworks to cater to Internet commerce. These include legislative approaches to such issues as cybercrime, data privacy and spam. However just as importantly countries need to create a legal atmosphere that works to minimise abuses and non-competitive behaviour, including provisions covering consumer protection and legal jurisdiction. E-ready countries are those that allow businesses and individuals to move nimbly and freely, where there is little bureaucracy to interfere with the registration of a new business or restrict access to information. The commitment of the country to implementing digital identity cards is also considered as a means of determining how a country's population can access digital commerce and digital government services.

Category criteria: Effectiveness of traditional legal framework; laws covering the Internet; level of censorship; ease of registering a new business; electronic ID.

Government policy and vision **15%**

E-ready governments supply their constituents—citizens and organisations—with a clear roadmap for the adoption of technology, and they lead by example in their use of technology to create efficiencies. The Economist Intelligence Unit assesses the activities of governments in this area, and their ability to lead their countries towards a digital future. Are governments employing technology to operate and provide public services with less resource investment? Are they spending on ICT to stimulate similar spending in the greater economy? Are "savings" translated into service gains for citizens? Can more people interact with, and receive information from the government regardless of their own access to technology? This category also analyses, in each country, the availability of digital channels to individuals and businesses for accessing public services, and to citizens for obtaining government information about civic

issues and engaging in consultation with government officials on matters involving the political process.

Category criteria: Government spend on ICT per head; digital development strategy; e-government strategy; online procurement; availability of online public services for citizens and businesses; e-participation (based on the UN e-participation index).

Consumer and business adoption 25%

If connectivity, societal adoption, and legal and policy environments are necessary enabling platforms for e-readiness, then the actual utilisation of digital channels by people and companies is a measure of successful implementation.

The Economist Intelligence Unit looks at the amount that businesses and consumers spend on accessing ICT services, the extent and range of Internet features used by individuals, their online purchasing activity, and the extent to which individuals and businesses use the online public services that have been made available.

Category criteria: Consumer spending on ICT per head; level of e-business development; use of Internet by consumers (assessing both the range of Internet features used by individuals and their online purchasing activity); use of online public services by citizens and businesses.

Table 1: e-Readiness for BRICS countries

	Overall Score	**Connectivity**	**Business Environment**	**Social and Cultural Environment**	**Legal Environment**	**Government policy and vision**	**Consumer and business adoption**
Category weight		20%	15%	15%	10%	15%	25%
South Africa	5.68	4.30	5.94	5.57	7.20	5.95	5.93
Brazil	5.42	4.00	6.47	6.03	6.10	6.00	4.93
China	4.33	2.95	6.32	5.47	5.10	4.75	2.99
India	4.17	2.45	5.89	4.90	5.60	5.25	2.88
Russia	3.98	4.65	5.67	4.90	3.65	2.70	2.76

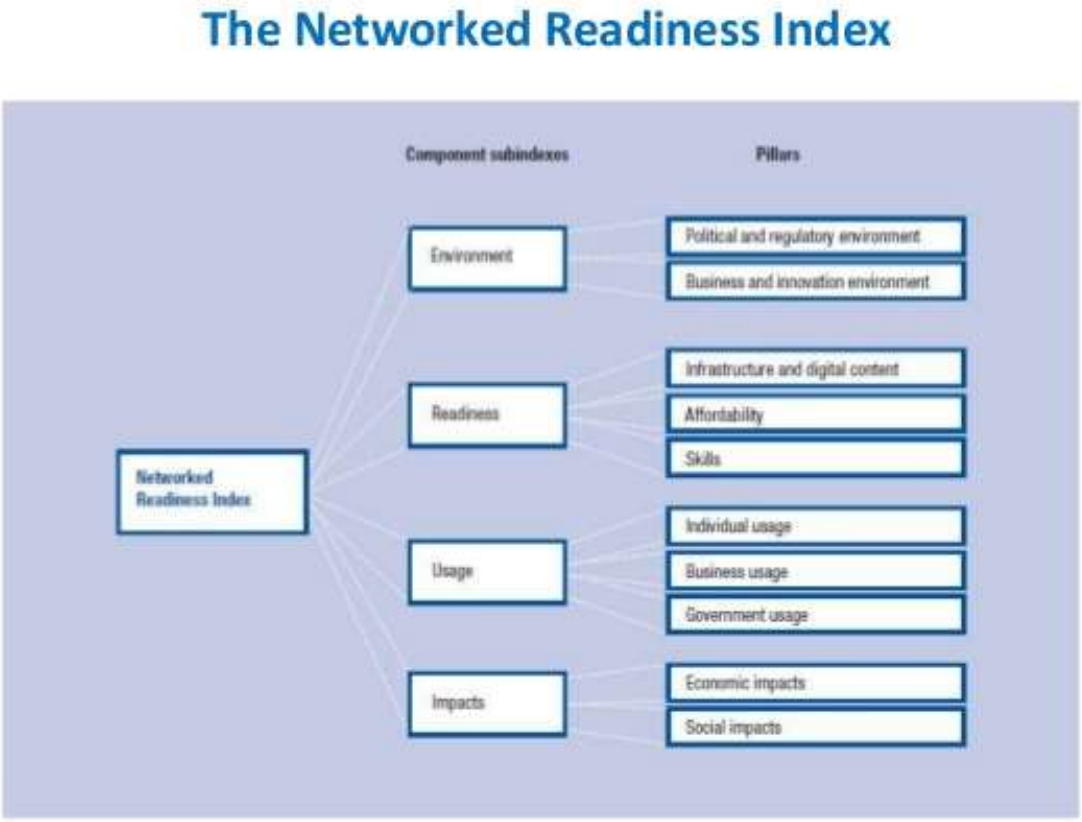
Source: Economist Intelligence Unit, 2009

The e- Readiness though it has some overlaps with other frameworks that are used in assessing the status of the Internet, for the purpose of this study it is seen as being more high level and more concentrated on investment advisory as opposed to advocating for issues of inclusive connectivity.

2. World Economic Forum: Network Readiness Index

The Global Information Technology Report (2016) confirms that over 139 economies were surveyed for the Networked Readiness Index (NRI) ranking, which is composed of four sub-indexes (the environment of ICT, the readiness of a society to use ICT, the actual usage of ICTs by all the stakeholders and the impact that ICT generates in the economy and society), ten pillars and 54 indicators (WEF, 2016), see diagram 2 below. The countries covered in the report account for almost 98% of the world's GDP. Milenkovic, Brajovic, Milenkovic, Vukmirovic and Jeremic (2016) explain the concept of Network Readiness Index as the rate at which the implementation of information and communication technology is adopted and implemented in a particular country with the view to increasing its competitive advantage and boosting its economy. The report provides for a high-level overview of the country's ICT infrastructure. Baller, Dutta and Lanvin (2016) argue that the NRI "present the nations with a tool that would be used to measure the country's readiness and maturity to realise the benefits of emerging technologies and leverage on the opportunities that come with digital transformation". Molla (2008) argue that within the networked economy, the success of the business and the economy is heavily reliant on e-readiness, which is seen as a source of competitive advantage.

Strengths and weaknesses of this framework in relation to the purpose statement for this research, Baller et al. (2016), the level of ICT access and usage in a particular country and the overall impact once access has been gained.



Source: World Economic Forum (2016)

3. United Nations Development Program: Technology Achievement Index

Cherchye et al. (2008) explain the technology achievement index as to how well the country is doing in terms "creating and diffusing new and existing technologies" to build the human resource capacity in the development of technology with the aim of helping the policy-making processes to define strategies aimed at technology development correctly. The technological achievement of a country refers to the level of its technological readiness to participate in the global knowledge-based economy. This can be described through a combination of appropriate indicators. Some of these indicators may describe the existing level of a country's technological ability to perform while others may give strong evidence that the ability is dynamic and productive. An appropriate combination of the two gives a fairly realistic idea about the technology achievement of a country.

The Technology Achievement Index (TAI), originally proposed in 2002 ((Desai, Fukuda-Parr, Johansson, & Sagasti, 2002)) and hereafter referred to as TAI-02, is one such composite index which aggregates national technological capabilities and performance in terms of (i) creation/diffusion of new technologies, (ii) diffusion of old technologies, and (iii) development of human skills. According to Desai, Fukuda-Parr, Johansson, and Sagasti (2002), the UN TAI has only been limited to 72 out of more than 200 countries.

It is a simple and relatively useful index for assessing the national technological capability of a country. The sub-indicators used in the TAI study are considered to cover practically all related aspects of technology achievement. As such, it is a very useful index for countries to assess their relative technology-based readiness in comparison with their competitors for participation in the global knowledge-based economy. The TAI focuses on assessing the technological performance of a country based on its capability in creating and using technology but NOT on the overall size of its technological development. It is for this reason that Finland, a smaller country, finds itself higher in TAI rankings than USA, UK and Germany.

The Index has four dimensions, and each dimension is specified by two sub-indicators. The four dimensions and the corresponding sub-indicators are summarized below:

- Creation of technology is measured by the number of patents granted to residents per capita and by receipts of royalties and license fees from abroad per capita.
- Diffusion of recent innovations, measured by the number of Internet hosts per capita and the share of high-technology and medium-technology exports in total goods exports.
- Diffusion of old innovations, measured by telephones (mainline and cellular) per capita and electricity consumption per capita.
- Human skills, measured by the mean years of schooling in the population aged 15 and older, and the gross tertiary science enrolment ratio.

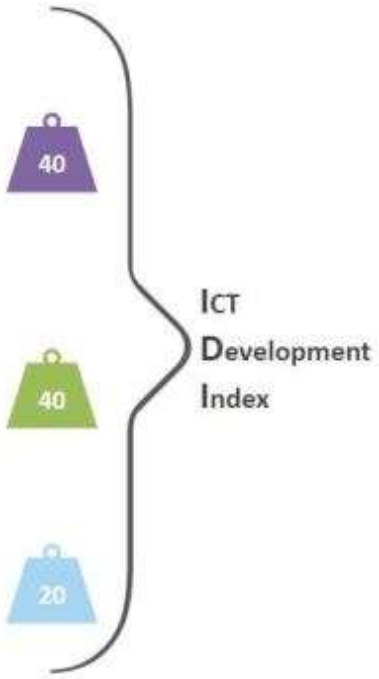
This framework was not chosen because of the limitations that are pointed out by Desai, Fukuda-Parr, Johansson, and Sagasti (2002) which pointed out that more work would still need to be done on this framework in terms of measurements of technological achievements.

4. International Telecommunications Union: ICT Development Index

Ghavamifar, Beig, and Montazer (2008) articulate the ICT development index as "a tool that analyses and evaluates the usage of ICT but using indicators of ICT diffusion across countries". According to ITU (2016), the IDI is explained as a "composite index that combines 11 indicators into one benchmark measure which can be used to monitor and compare developments in ICT between countries and over time." The IDI was developed by ITU in 2008 in response to ITU Member States' request to establish an overall ICT index, which was first presented in the 2009 edition of the Report (ITU, 2009), and has been published annually since then.

The (ITU, 2016) report confirms that over 175 economies were done in 2016, which is an improvement from the work that was done in 2015 as this highlights "progress and persistent divide in global information society".

ICT access	Reference value	(%)
1. Fixed-telephone subscriptions per 100 inhabitants	60	20
2. Mobile-cellular telephone subscriptions per 100 inhabitants	120	20
3. International Internet bandwith (bit/s) per internet user	962'216*	20
4. Percentage of households with a computer	100	20
5. Percentage of households with Internet access	100	20
ICT use	**Reference value**	**(%)**
6. Percentage of Individuals using the Internet	100	33
7. Fixed-broadband subscriptions per 100 inhabitants	60	33
8. Active mobile-broadband subscriptions per 100 inhabitants	100	33
ICT skills	**Reference value**	**(%)**
9. Adult literacy rate	100	33
10. Secondary gross enrolment ratio	100	33
11. Tertiary gross enrolment ratio	100	33



Source: ITU, 2016

The main objectives of the IDI are to measure:

- the level and evolution over time of ICT developments within countries and their experience relative to other countries;
- progress in ICT development in both developed and developing countries;

- the digital divide, i.e. differences between countries in terms of their levels of ICT development; and
- the development potential of ICTs and the extent to which countries can make use of them to enhance growth and development in the context of available capabilities and skills.

This framework is not preferred on the basis that as much as the Index is reflective of the changes that are taking place globally in different countries who are at different levels of ICT development. The framework relies on limited data of countries at a different level of development. (ITU, 2016)

5. Wolcott GDI Framework

This is the preferred framework on the basis confirmed by (Ghavamifar, Beig, & Montazer 2008) that in as much as the consideration is around the issue of infrastructure, the "dimensions of the framework complement each other to form a complete set to reflect a cluster of technologies from infrastructure to end-user application". A view is taken that this is a framework that could be reworked and refreshed to reflect on the ICT development of countries from 2019 into the future, by adding dimensions and levels that are critical to the diffusion of the internet in the current era. The Wolcott framework is not a ranking but an analytical framework.

The GDI framework consists of six dimensions, each of which describes a "measurable feature of the presence of the Internet in a country". These dimensions collectively cover a range of features, each dimension adding to the overall understanding of Internet diffusion (Wolcott et al., 2001). The framework includes the determinants of each dimension. Understanding how the determinants influence the dimensions in a given country can lead to clearer understanding of the overall state of diffusion. GDI studies typically include thorough analyses of both the dimensions and the determinants (Wolcott & Goodman, 2000). There is limited researched data to confirm the number of studies conducted to date, suffice a confirmation by (Murthy, Nath & Soleiman, 2015) that the highly developed countries of the Organisation for Economic Co-operation and Development (OECD) have high level of internet diffusion as opposed to the Sub Saharan African countries, that have primarily lagged behind resulting in the digital divide. According to ITU (2015), "as at 2013, the average Internet Diffusion rate of the Sub Saharan African countries was around 13% with a median rate of 9%, with South Africa leading with the diffusion rate of 46.5%".

The GDI framework consists of six dimensions, as follows (Wolcott et al. 2001):

Dimension 1: Pervasiveness: A function principally of the number of users per capita and the degree to which non-technical users are using the Internet

Level 0	Non-existent: The Internet does not exist in a viable form in this country. No computers with international IP connections are located within the country. There may be some Internet users in the country; however, they obtain a connection via an international telephone call to a foreign ISP.
Level 1	Embryonic: The ratio of users per capita is on the order of magnitude of less than one in a thousand (less than 0.1%).
Level 2	Nascent: The ratio of Internet users per capita is on the order of magnitude of at least one in a thousand (0.1% or greater).
Level 3	Established: The ratio of Internet users per capita is on the order of magnitude of at least one in a hundred (1% or greater).
Level 4	Common: The ratio of Internet users per capita is on the order of magnitude of at least one in 10 (10% or greater).

Dimension 2: Geographic Dispersion: The physical dispersion of the Internet in a Country

Level 0	Non-Existent: The Internet does not exist in a viable form in this country. No computers with international IP connections are located within the country. A country may be using UUCP connections for e-mail and USENET.
Level 1	Single Function: Internet points-of-presence are confined to one major population centre.
Level 2	Moderately dispersed: Internet points-of-presence are located in multiple first-tier political subdivisions of the country.
Level 3	Highly dispersed: Internet points-of-presence are located in at least 50% of the first-tier political subdivisions of the country.
Level 4	Nationwide: Internet points-of-presence are located in essentially all first-tier political sub-divisions of the country. Rural access is publicly and commonly available.

Dimension 3: Sectoral Absorption: The extent to which organisations in the academic, commercial, health, and public sectors have committed to Internet use

Sectoral point total	Sectoral absorption dimension rating	
0	Level 0	Non-existent
1-3	Level 1	Rare
'4-6	Level 2	Moderate
7-9	Level 3	Common
10-12	Level 4	Widely used

Dimension 4: Connectivity Infrastructure: The extent and robustness of the physical structure of the network

		Domestic Backbone	International links	Internet Exchanges	Access Methods
Level 0			None	None	None
Level 1	Thin	<2Mbps	<128Mbps	None	Modem
Level 2	Expanded	<2Mbps 200Mbps	>128Mbps 45Mbps	1	Modem 64 Kbps leased lines
Level 3	Broad	> 200 Mbps - 100 Gbps	> 45 Mbps - 10 Gbps	More than 1; Bilateral or Open	Modem > 64 Kbps leased lines
Level 4	Extensive	>100Gbps	>10Gbps	Many, both bilateral and open	< 90% modem > 64 Kbps leased lines

Dimension 5: Organisational Infrastructure: The robustness of the market and services

Level 0	None: The Internet is not present in the country.
Level 1	Single: A single ISP has a monopoly in the Internet service provision market. This ISP is generally owned or significantly controlled by the government
Level 2	Controlled: There are only a few ISPs, and the market is closely controlled through high barriers to entry. All ISPs connect to the international Internet through a monopoly telecommunications service provider. The provision of domestic infrastructure is also a monopoly.
Level 3	Competitiveness of the market: The Internet market is competitive. There are many ISPs and low barriers to market entry. The provision of international links is a monopoly, but the provision of domestic infrastructure is open to competition, or vice versa.
Level 4	Robustness of the Infrastructure: There is a rich service provision infrastructure. There are many ISPs and low barriers to market entry. International links and domestic infrastructure are open to competition. There are collaborative organizations and arrangements such as public exchanges, industry associations, and emergency response teams.

Dimension 6: Sophistication of Use: An assessment of what leading-edge groups of users are doing

Level 0	None: The Internet is not used, except by a very small fraction of the population that logs into foreign services.
Level 1	Minimal: The user community struggles to employ the Internet in conventional, mainstream applications.
Level 2	Conventional: The user community changes established practices somewhat in response to or in order to accommodate the technology, but few established processes are changed dramatically. The Internet is used as a substitute or straightforward enhancement for an existing process (e.g. e-mail versus post). This is the first level at which we can say that the Internet has taken hold in a country.
Level 3	Transforming: The use of the Internet by certain segments of users results in new applications, or significant changes in existing processes and practices, although these innovations may not necessarily stretch the boundaries of the technology's capabilities.
Level 4	Innovating: Segments of the user community are discriminating and highly demanding. These segments are regularly applying or seeking to apply, the Internet in innovative ways that push the capabilities of the technology. They play a significant role in driving the state-of-the-art and have a mutually beneficial and synergistic relationship with developers.

APPENDIX B

DOCUMENT ANALYSIS GUIDE

Guiding question 1. What needs to change in the dimension and levels pertaining to connectivity infrastructure?
Guiding question 2. What needs to change in the dimension and levels pertaining to organizational infrastructure?
Guiding question 3. What needs to change in the dimension and levels pertaining to geographic dispersion of the Internet?
Guiding question 4. What needs to change in the dimension and levels pertaining to sectoral absorption of the Internet?
Guiding question 5. What needs to change in the dimension and levels pertaining to pervasiveness of Internet use?
Guiding question 6. What needs to change in the dimension and levels pertaining to sophistication of use?
Guiding question 7. What additional dimensions and related levels should be incorporated into the GDI framework?

APPENDIX C

ATLAS.TI DIFFUSION OF INTERNET DIMENSIONS, CODE GROUPS AND CODES/DETERMINANTS

Report created by Castro Mosina on 15 Feb 2020

DIMENSION	CODE GROUP	CODES (DETERMINANTS)
CONNECTIVITY INFRASTRUCTURE	Networking Online services Spectrum Ubiquitous	access methods, connected applications, connected customer, connected devices, connected homes, connected society, connections base, connectivity, connectivity speeds, connectivity taxes, connectivity to underserviced areas, data centres, fibre backbone, high speed, high speed broadband, high speed connections, high speed data coverage, high speed fixed broadband subscriptions, high speed microwave transmission, high speed mobile broadband, high speed transmission, higher access speeds, higher transmission speeds, international connectivity, international ISPs, international links, international private networks, international submarine cable, landing stations, last mile infrastructure, mobile broadband speeds, mobile connectivity, network, network availability, network densification, network deployment, network edge, network expansion, network function virtualization, network infrastructure, network leadership, network licensees, network lock-in, network performance, network providers, network quality, network servers, network service licenses, network slicing, networked presence, quality of network coverage and speed, radio, radio technology, satellite technology, speed of deployment, speed of internet, upload speeds. fixed connectivity, fixed internet connections, fixed line infrastructure, fixed line services, fixed network subscriptions, fixed networks, fixed telecommunications infrastructure, fixed telephone lines, fixed telephone subscriptions, fixed telephony, fixed terrestrial infrastructure, fixed wireless access, fixed-mobile

		substitution, fixed-telephone subscriptions, electronic communications infrastructure, electronic communications networks, electronic data, electronic educational content, electronic numbering, electronic signatures, electronic waste , electronic communications network service licenses, electronic communications services.
GEOGRAPHIC DISPERSION	Spectrum Speed Online platforms Convergence Ubiquitous	1GHz, 10 Mbits/s, 256 kbits/s, 900MHz spectrum, 1800 MHz spectrum, converged ICT, converged ICT applications, converged products, converged services, converged solutions, convergence, international ISPs, international links, network quality, points of presence, quality of network coverage and speed, speed of internet, ubiquitous, ubiquitous 3G coverage, ubiquitous intelligence, ubiquitous linked sensors, ubiquitous super broadband, universal service obligations, online, online accounts, online communication, online e-commerce platforms, online education, online end-to-end services, online labour platforms, online market platforms, online marketing channels, online payment, online payment systems, online platform exchanges, online platforms, online purchases, online resources, online services, online shopping, online sourcing, online stores, online talent platforms, online workers, spectrum, spectrum access, spectrum acquisition, spectrum allocation, spectrum assignment, spectrum auction, spectrum auditing, spectrum availability, spectrum constraints, spectrum cost, spectrum evaluation, spectrum farming, spectrum fees, spectrum licensees, spectrum management, spectrum migration, spectrum monitoring, spectrum planning, spectrum pricing, spectrum re-farming, spectrum scarcity, spectrum sharing, spectrum trading, spectrum usage, spectrum users.
ORGANISATIONAL INFRASTRUCTURE	IoT Big Data Cloud Cyberspace Virtualization	big data, big data and analytics, cloud, cloud based applications, cloud based services, cloud computing, cloud managed services, cloud principles, cloud scalability, cloud service providers, cloud services, cloud solutions, cloud work, cloud workers, cyber extortion, cyber forgery, cyber fraud, cyber intelligence, cyber law, cyber resilience, cyber security, cyber security, cyber

		uttering, cyber-regulations, cyber-resilience, cyber-sovereign, cybersecurity governance structures, cybersecurity regulations, cyberspace, data centres, international ISPs, international private networks, Internet of everything, Internet of Things, Internet service providers, IoT applications, IoT connectivity, IoT devices, IoT enabled services, IoT end to end capabilities, IoT manufacturers, IoT network, IoT solutions, virtual and augmented realities, virtual reality, virtual reality devices, virtualization.
PERVASIVENESS OF INTERNET USE	High capacity networks Digital Access Broadband Digital Speed	access, access costs, access methods, access networks, access to all, access to cellular telephone, access to devices, access to ICTs, access to infrastructure, access to internet, access to mobile phones, access to networks, access to service, access to skills, access to spectrum, bandwidth, basic mobile internet access, broadband costs, broadband rollout, broadband value chain, broadband, broadband access, broadband capacity, broadband connectivity, broadband development, broadband elements, broadband infrastructure, broadband network infrastructure, broadband penetration, broadband policy, broadband pricing, broadband providers, broadband provision, broadband services, broadband spectrum, broadband speed, broadband strategy , broadband subscriptions, broadband technology, entry level mobile broadband subscription, fibre broadband subscriptions, fixed broadband, fixed broadband connections, fixed broadband penetration, fixed broadband prices, fixed broadband services, fixed broadband speeds, fixed broadband subscriptions, fixed broadband uptake, growth in broadband, mobile broadband subscriber, mobile broadband, mobile broadband access, mobile broadband capable connections , mobile broadband growth, mobile broadband infrastructure, mobile broadband networks, mobile broadband penetration, mobile broadband price, mobile broadband services, mobile broadband spectrum, mobile broadband speeds, mobile broadband subscriptions, business mobile Internet access, connected digital society, household and business

		broadband, international bandwidth, international ISPs, Internet bandwidth, Internet based service providers, Internet growth, Internet penetration, Internet service providers, Internet standards, mobile subscribers, digital divide, digital, digital access, digital address, digital age, digital applications, digital automation, digital based economy, digital business, digital capacity challenges, digital communications, digital company, digital connected consumers, digital connectivity, digital content, digital development, digital devices, digital disruption, digital economy, digital economy divide, digital entrepreneurship, digital environment, digital financial services, digital form, digital funds, digital future, digital goods, digital government, digital identifiers, digital identities, digital identity, digital identity programme, digital identity standards, digital inclusion, digital inclusion centre, digital infrastructure, digital labour, digital labour markets, digital labour platforms, digital literacy, digital literacy programmes, digital lives, digital marketing, digital marketing strategies, digital native, digital norms, digital opportunity, digital payments, digital platforms, digital public services, digital readiness, digital service platform, digital services, digital skills, digital social contract, digital society, digital solutions, digital sphere, digital talent, digital technologies, digital technology, digital technology penetration, digital trade, digital transformation, digital transmission, digital value chain, digital visibility, digital world , digitalization, digitally integrated value chain, digitally intermediated services, digitization, digitization of platforms, digitized GDP, high bandwidth, high capacity 4G, high capacity access, high capacity broadband, high capacity data management, high capacity networks, high capacity transmission, high cost of communication, high cost of services, high coverage, high demand spectrum, high density data storage, high growth rates, high quality access, high quality bandwidth, high quality network, high speed, high speed broadband, high speed connections, high speed data coverage, high speed fixed broadband subscriptions, high speed microwave transmission, high speed mobile broadband, high speed transmission, high

		value data segment, higher access speeds, higher bandwidth, higher growth, higher quality of service provision, higher tower density, higher transmission speeds.
SECTORAL ABSORPTION OF INTERNET USE	AI e-services Connected society Robotics Virtual reality	3D printing, advanced robotics, AI divide, artificial intelligence, artificial intelligence and robotics, augmented operators, authenticity online, blockchain, broadband Internet connection, computer simulations, connected business, connected consumers, connected governments, connected people, connected society, connectivity and computing power, crowd-sourcing, data security, digital government, digital inclusion, digital interconnection, digital-physical transformation, digitized textbooks, drones, e-society, e-citizen, e-commerce, e-commerce capacity building, e-commerce payments, e-commerce platforms, e-educations, e-government, e-government platform, e-government services, e-health, e-health solutions, e-literacy, e-market solutions, e-rate, e-readiness, e-services, e-skilling, e-skills, e-solutions, e-wallet, human machine interface, ICT affordability, ICT infrastructure and equipment, ICT4D, online communities, underwater data centres, virtual reality, white spaces, zero rated services.
SOPHISTICATION OF INTERNET USAGE	Innovation Smart	ICT use, innovation, innovation ecosystem, innovative applications, innovative content, innovative digital services, Internet use, smart and connected product development, smart cities, smart devices, smart fiscal policy, smart grid, smart grid and electricity, smart metering, smart transport, smartphone adoption, smartphone connections, smartphone traffic, smartphones, smartphones usage, transformation.
DIGITAL APPLICATIONS	Applications AI Robotics Machine learning	advanced robotics, applications development, artificial intelligence, artificial intelligence and robotics, basic social media applications, blockchain, cloud services, drones, ICT applications, interoperability, local aggregator platforms, local business applications, local digital platforms, machine learning, robotics