Big Data in the Public Interest: Applications, Limitations, and Relevance in the Western Cape Provincial Department of Agriculture

by

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DECLARATION

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own original work, that I am the authorship owner thereof (unless to the extent explicitly otherwise stated) and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Signature: S van Zyl

Date: December 2022

ABSTRACT

The development of mankind has progressed through various distinct phases, through periods such as the Stone Age, Iron Age, and Machine Age – all leading to where we are today – the Information Age. The introduction of the Fourth Industrial Revolution brought about several novel technologies and concepts. One is that of Big Data – a concept often met with equal parts fascination and scepticism. Nevertheless, Big Data and the applications driven by it have seamlessly woven itself into our everyday life, transforming the way in which our information is perceived. Today, Big Data is deemed a currency, enabling its keepers to yield insight like never before.

Over the past decade, Big Data has become a buzzword among private sector organisations worldwide. The shift towards data-driven business has drastically changed the future of private-sector institutions. One may then ask: In the same way businesses use Big Data to pursue profits, can governments utilise Big Data in the public interest? The aim of this study was thus to gain a deeper understanding of the concept of Big Data and explore its value to public sector institutions. Furthermore, this study aimed to explore its relevance and attainability in a South African public sector context. In order to achieve these aims, the study set out to address six research objectives: i) To define Big Data ii) to describe the current applications of Big Data in the public sector, iii) to explore the limitations faced when implementing Big Data-driven technologies in the public sector, iv) to outline the policy and legislative framework affecting the implementation of Big Data-driven technologies within the South African public sector, v) to determine the relevance of Big Data-driven solutions within the context of the Western Cape Provincial Department of Agriculture, and vi) to determine the attainability of implementing Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture.

Following a sequential exploratory mixed-methods design, this study comprised a literature review, legislative and policy framework, case study, document analysis, semi-structured key expert interviews, and a questionnaire. This study was conducted per Stellenbosch University's Policy on Research Ethics and the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments.

This study has produced a theoretical framework depicting not only the various sources of, and uses for, Big Data in the public sector but, more importantly, the various challenges to be expected when implementing public sector Big Data-driven solutions. The study further found

that whilst, in many cases, Big Data-technologies may be relevant to the work of government departments and public sector institutions, the implementation of such technologies is not in all cases attainable. The study then calls for a balanced approach, not implementing Big Data technologies merely for the sake of novelty but rather investigating where these solutions will have the most favourable outcome and the highest chance at success. Technology cannot be blindly put forth as the silver bullet that can solve deeply rooted systemic and cultural issues within government.

OPSOMMING

Die ontwikkeling van die mensdom het deur verskeie afsonderlike fases gevorder, deur periodes soos die Steentydperk, Ystertydperk en Masjientydperk – alles wat gelei het tot waar ons vandag is – die Inligtingstydperk. Die bekendstelling van die Vierde Industriële Revolusie het verskeie nuwe tegnologieë en konsepte meegebring. Een is dié van Groot Data – 'n konsep wat dikwels met gelyke dele fassinasie en skeptisisme ontmoet word. Nietemin, Groot Data en die toepassings wat daardeur gedryf word, het hulself in ons alledaagse lewe ingeweef en die manier waarop ons inligting waargeneem word, verander. Vandag word Groot Data as 'n geldeenheid beskou, wat sy bewaarders in staat stel om insig te gee soos nog nooit tevore nie.

Oor die afgelope dekade het Groot Data 'n modewoord geword in privaatsektororganisasies wêreldwyd. Die verskuiwing na data-gedrewe besigheid het die toekoms van privaatsektor instellings drasties verander. Mens kan dan vra: Op dieselfde manier waarop besighede Groot Data gebruik om wins na te streef, kan regerings Groot Data in die openbare belang gebruik? Die doel van hierdie studie was dus om 'n dieper begrip van die konsep van Groot Data te verkry en die waarde daarvan vir openbare sektor instellings te verken. Verder het hierdie studie ten doel gehad om die relevansie en haalbaarheid daarvan in 'n Suid-Afrikaanse openbare sektorkonteks te verken. Ten einde hierdie doelwitte te bereik, het die studie uiteengesit om ses navorsingsdoelwitte aan te spreek: i) Om Groot Data en sy verwante konsepte te definieer, ii) om die huidige gebruike van Groot Data in die openbare sektor te beskryf, iii) om die uitdagings en beperkings van grootdatagebruik in die openbare sektor te verken, iv) om die beleid en wetgewende raamwerk wat die implementering van Groot Data-tegnologieë binne die Suid-Afrikaanse openbare sektor beïnvloed, te bespreek, v) om die relevansie van Groot Data-gedrewe oplossings vir die Wes-Kaapse Provinsiale Departement van Landbou te bepaal, en vi) om die haalbaarheid van die implementering van Groot Data-gedrewe tegnologieë in die Wes-Kaapse Provinsiale Departement van Landbou te bepaal.

Hierdie studie bevat ses navorsingsdoelwitte om uiteidelik die bogenoemde doel te bereik. Hierdie navorsingsdoelwitte sluit in: i) Om Groot Data en verwante konsepte te definieer, ii) Om die huidige gebruike van Groot Data in die openbaresektor te beskryf, iii) Om die verskeie uitdagings wat die implimentering van Groot Data tegnologieë in die openbaresektor inhou/behels te verken, iv) Om die beleids- en wetgewingsraamwerk onderliggend aan die implimentering van Groot Data tegnologieë in ‘n Suid Afrikaanse konteks te bespreek, v) om die relevansie van Groot Data-gedrewe oplossings tot die Wes Kaapse Provinsiale Departement

van Landbou te bepaal, en vi) om die bereikbaarheid van die implementering van Groot Data-gedrewe tegnologieë in die Wes Kaapse Provinsiale Departement van Landbou te bepaal.

Na aanleiding van 'n opeenvolgende verkennende gemengde-metodes-ontwerp, het hierdie studie uit 'n literatuuroorsig, wetgewende en beleidsraamwerk, gevallestudie, dokumentanalise, semi-gestruktureerde onderhoude en 'n vraelys bestaan. Hierdie studie is uitgevoer volgens die Universiteit Stellenbosch se Beleid oor Navorsingsetiek en die Beskerming van Persoonlike Inligting (POPI) Wet No. 4 van 2013, insluitend die wysigings daarvan.

Hierdie studie het 'n teoretiese raamwerk geskep wat nie net die verskillende bronne en gebruike van Groot Data in die openbare sektor uitbeeld nie, maar, meer belangrik, die verskillende uitdagings wat verwag kan word wanneer openbare sektor Groot Data-gedrewe oplossings geïmplementeer word. Die studie het verder bevind dat hoewel, in baie gevalle, Groot Data-tegnologie relevant kan wees vir die werk van staatsdepartemente en openbare sektor instellings, die implementering van sulke tegnologie nie in alle gevalle haalbaar is nie. Die studie vra dan vir 'n gebalanseerde benadering, nie die implementering van Groot Data-tegnologie bloot ter wille van nuutheid nie, maar eerder om te ondersoek waar hierdie oplossings die mees gunstigste uitkoms en die grootste kans op sukses sal hê. Tegnologie kan nie blindelings voorgehou word as die goue oplossing wat diepgewortelde sistemiese en kulturele kwessies binne die regering kan oplos nie.

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LIST OF ACRONYMS AND ABBREVIATIONS

3D	3 Dimensional
4IR	Fourth Industrial Revolution
ABIS	Automated Biometric Identification System
AI	Artificial Intelligence
AIMS	Agricultural Information Management System
ASD	Agricultural Skills Development
AU	African Union
AUDA	African Union Development Agency
BC	Before Christ
CDC	Centers for Disease Control
Covid-19	Coronavirus Disease 2019
CSIR	Council for Scientific and Industrial Research
DSO	Departmental Strategic Outcome
EA	Enterprise Architecture
ECT	Electronic Communication and Transaction
ESRI	Environmental Systems Research Institute
EU	European Union
GBDE	Government Big Data Ecosystem
GDP	Gross Domestic Product
GDPR	General Data Protection Regulations
GIS	Geographic Information System
GITOC	Government Information Technology Officers Council
GPS	Global Positioning System
GWEA	Government-Wide Enterprise Architecture
HANIS	Home Affairs National Identification System
HET	Higher Education and Training
HIPSSA	Harmonisation of ICT Policies in Sub-Saharan Africa
HRM	Human Resources Management
HTML	Hyper Text Markup Language
ICT	Information and Communication Technology
IoT	Internet of Things
IP	Intellectual Property

ITM	Information Technology Management
ITU	International Telecommunications Union
ITU-T	International Telecommunications Union - Telecommunication Standardisation
J2J	Job-to-Job
KPA	Key Performance Area
LEHD	Longitudinal Employer-Household Dynamics
M&E	Monitoring and Evaluation
MIOS	Minimum Interoperability Standards
MISS	Minimum Information Security Standards
NCOP	National Council of Provinces
NDP	National Development Plan
NEPAD	New Economic Programme for African Development
NO	National Outcome
NPC	National Planning Commission
NPM	New Public Management
NQF	National Qualifications Framework
OASIS	Organisation for the Advancement of Structured Information Standards
OECD	Organisation for Economic Cooperation and Development
PC4IR	Presidential Commission on the Fourth Industrial Revolution
PDF	Portable Document Format
PERO	Provincial Economic Review and Outlook
POPI	Protection of Personal Information
PSEO	Post-Secondary Employment Outcomes
PSP	Provincial Strategic Priority
RICA	Regulation of the Interception of Communications and Provision of Communication-related Information Act
ROI	Return on Investment
SADC	Southern African Development Community
SAIIA	South African Institute of International Affairs
SAPS	South African Police Service
SETA	Sector Education and Training Authority
SITA	State Information Technology Agency
SME	Small and Medium Sized Enterprise

TAM	Technology Acceptance Model
UNECA	United nations Economic commission for Africa
USA	United States of America
VEO	Veteran Employment Outcomes
WCDoA	Western Cape Department of Agriculture
WCDoCS	Western Cape Department of Community Safety

Chapter 1: Introduction

1.1 Background to the Research Question

1.1.1 The Information Age

In an attempt to make sense of the world we live in, we use distinctive indicators or markers of each new age or era to indicate human progress and advancement. Moving from one era to the next, we have endured great change as humankind has progressed through various stages, from the Stone Age and Iron Age to the Machine Age – all leading to our current evolutionary phase – the Information Age.

Big Data and information define the era we are currently living in. Big Data, data characterized by high volume, high variety and high velocity and as further defined in section 2.2, and its related technologies, such as artificial intelligence (AI), machine learning and the Internet of Things (IoT), are not new concepts. These terms have long been used in the world of technology and computing. Moreover, the concept of utilising and analysing vast data sets to make informed decisions has been used long before this process was dubbed “Big Data analytics” as we know it today. This process stretched as far back as 300 Before Christ (BC), during which ancient Egyptians attempted to capture all existing data at the time in the library of Alexandria (Jonker, 2016). Similarly, the ancient Roman Empire is known for using vast sets of census data to administrate their citizens' taxation (Seiner, 2014). However, the magnitude of data sets and the insight-generating capability of data analysis have reached a potential beyond anything ever imagined.

Although it is difficult to say who first coined the term “Big Data”, one of the earliest uses of the term (non-capitalised version) was in 1989 by author Erik Larson, speculating that there are “keepers of big data” responsible for the junk mail he received (Larson, 1989:Online). Some years later, in 1999, the capitalised term “Big Data” appeared in a publication of the Association for Computing Machinery in which the ability to draw valuable insight from Big Data was stressed (Bryson, Kenwright, Cox & Ellsworth, 1999). It is also estimated that around that same year, the term “The Internet of Things” was used for the first time to describe the growing number of interconnected online devices and their ability to communicate with each other (Marr, 2015).

These concepts are not a new or isolated phenomenon but rather part of an information technology (IT) evolution which has been brewing for decades. However, it is evident that the concepts of Big Data, AI, and machine learning, which have previously operated predominantly in the technology world, have now migrated into our everyday life. This is evident in our online activities, whether through, for example, social media, online shopping, or Internet dating.

Big Data's rapid advance to relevance in our day-to-day activities has caught many off guard, clearly distinguishing between those who have the ability to harness its power and those who are being left behind.

1.1.2 Big Data in the Public Sector

Over the past decade, Big Data has become a buzzword in private sector corporations worldwide. This shift towards data-driven business is drastically changing the future of private sector institutions. One may then ask: In the same way businesses use Big Data to pursue profits, can governments utilise a similar approach in the public interest?

Big Data in governance poses new challenges involving complexity, security, privacy, and the need for new technology and human skills (Kim, Trimi & Chung, 2014). Many public policy and governance scholars argue that governments can indeed utilise Big Data to help serve their citizens, and some already are.. However, sceptics remain concerned about whether this transformation is feasible, considering the need for new and costly capabilities, technologies as well as the organizational maturity to apply them effectively.

Furthermore, while this shift towards data-led governance requires technical and structural transformation, it also fundamentally changes the nature of the relationship between government and citizens, introducing a wide range of new ethical and information security considerations and concerns (Morabito, 2015). As citizens are becoming more informed about the role and power of Big Data in everyday life, they are becoming increasingly skeptical of the intentions of those harnessing this power. This fear of being exploited by those in possession of vast amounts of our personal data is not unfounded, as many international examples have raised great concern about our information being everything but personal.

1.1.3 Where Nature Meets Technology

Internationally, the agricultural industry faces great threats such as climate change, increased demands due to urbanisation, water scarcity, and unsustainable land use, all contributing to the most pressing issue – global food insecurity (Walter, 2018). Such complex challenges call for innovative 21st-Century solutions that will ensure the prosperity of this sector itself and, more importantly, promote global food security and sustainable resource use.

These challenges require continuous collaboration across institutions engaged in various scientific disciplines. Such institutions include academic institutions, the agriculture industry, and all levels of government. Access to Big Data is pivotal to understanding the implications of changing environmental factors on production systems and how to formulate policy recommendations and pragmatic new systems approaches. Climate change and the need for water and energy efficiency is driving technological change via "precision agriculture", robotics and biotech. Big Data is converging with these other advances to disrupt the agricultural space. It is not Big Data alone, but Big Data in concert with other innovation that takes the 4IR to a new level. The increasing use of Big Data technologies and automation in the agricultural industry is forging a new role for the farmer and agricultural institutions and governments across the globe.

The Western Cape economy (as with the rest of South Africa and beyond) has suffered a significant shock since 2020. The Coronavirus disease 2019 (COVID-19) pandemic and national lockdown disrupted economic activity and compounded pre-existing constraints such as slow economic growth and high unemployment. South Africa's economic performance for the first half of 2020 was further exacerbated by a sovereign credit rating downgrade by *Standard and Poor* in April 2020 (Swart & Goncalves, 2020).

However, the Western Cape Province, and the country at large, have struggled economically even prior to the economic shock brought on by the COVID-19 pandemic. In 2019, the Western Cape economy grew only by 0.8%, followed by a 0.6% growth in 2020 (Western Cape Provincial Treasury, 2020). Moreover, in 2020, all industries suffered significant losses due to the pandemic and various lockdown restrictions. Interestingly, the agricultural sector was the only sector that positively contributed to Provincial gross domestic product (GDP) growth in the second quarter of 2020 (Western Cape Provincial Treasury, 2020).

In the Western Cape Province of South Africa, the agriculture sector has the potential to act as an enormous economic stimulus and facilitator of much-needed growth, employment creation and foreign exchange and exports.

Agriculture and agri-processed goods in the Western Cape were responsible for 9.9% of the total national exports and 4.4% of national employment in 2019 (Western Cape Provincial Treasury, 2020). This is currently one of the only growing sectors in the province, responsible for the employment of thousands of permanent and temporary workers. However, this industry operates in a volatile environment with many complex challenges. These include unpredictable adverse weather conditions, which have led to the recent drought and numerous disastrous fires, a low-skilled workforce, the widening gap in the dual agricultural economy consisting of well-developed commercial farmers and smaller-scale communal farmers, and the new socio-economic implications of the COVID-19 pandemic.

It is the function of the Provincial Department of Agriculture to provide various development, research, and support services to the entire agricultural community of the Western Cape (Western Cape Government, n.d.a). Thus, serving both sides of the dual agricultural economy – the large scale commercial farmers and the small scale and emerging farmers. This mandate is easier said than done. How can the department ensure that all farmers benefit from Big Data innovation in the industry? More importantly, how can the department minimise the ever-growing chasm between those who can access the power of Big Data and those who cannot?

Considering the department’s key strategic outcomes in light of Big Data technologies raises a question of relevance and attainability. Whilst it may be easy to prove that Big Data and related technologies are relevant to the department and may provide solutions to some of the challenges faced by the agricultural industry of the Western Cape, the challenging follow-up question is this: Does the department have the capacity in terms of resources, funds, skill set, and organisational culture to harness the power of Big Data in serving all members of the province’s agricultural community?

1.2 Problem Statement

Following the above background and introduction, it is understood that Big Data technologies may assist in addressing many governance challenges, including optimising the agricultural industry. However, before over-romanticising technological innovation as a one-size-fits-all solution to government challenges, there is a need for a common understanding of what is meant by the popular term “Big Data”, the applications and technologies which accompany this concept, as well as the type of public sector solutions Big Data-driven innovation could create. There is also a need to understand the challenges in implementing Big Data-related technologies in a public sector setting.

Furthermore, given the realities of governance in a developing country, contextual factors such as financial constraints, a low-skilled labour force, and bureaucratic red tape force one to assess whether Big Data analytics is relevant and attainable in the South African public sector context.

Against the background to the research problem elaborated upon above, the research problem is stated as follows:

Given the sparce research available on Big Data and its value to the public sector, there is a need to explore the applications, limitations and relevance of Big Data in the public sector and, more specifically, within the context of the Western Cape Department of Agriculture (WCDOA).

1.3 Research Questions and Objectives

1.3.1 Primary Research Question and Objective

Stemming from the above, the primary research question of this study is:

To what extent can Big Data add value to the public sector within the context of the Western Cape Department of Agriculture (WCDoA)?

Given this primary research question, the primary research objective is as follows:

To determine the extent to which Big Data can add value to the public sector within the context of the Western Cape Department of Agriculture (WCDOA).

1.3.2 Secondary Research Questions and Objectives

Following the primary research question and objectives, the secondary or sub-research questions are as follow:

1. *What is Big Data?*
2. *What are the current applications of Big Data in the public sector?*
3. *What are the limitations faced when implementing Big Data-driven technologies in the public sector?*
4. *How does the South African policy and legislative framework affect the implementation of Big Data-driven technologies in the South African public sector?*
5. *How relevant are Big Data-driven technologies to the context of the Western Cape Provincial Department of Agriculture?*
6. *How attainable is the implementation of Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture?*
7. *How do the questions above interact and inform the implementation of Big Data in the South African public sector?*

In order to address the respective secondary research questions, the following secondary research objectives form the basis of the study:

i. To define Big Data
ii. To describe the current applications of Big Data in the public sector
iii. To explore the limitations faced when implementing Big Data-driven technologies in the public sector
iv. To outline the policy and legislative framework affecting the implementation of Big Data-driven technologies in the South African public sector
v. To determine the relevance of Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture in 2022
vi. To determine the attainability of implementing Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture in 2022
vii. To develop a conceptual framework that can guide the implementation of Big Data in the South African public sector outlining the sources of Big Data, its characteristics, challenges, processes, applications, and value.

1.4 Research Design and Methodology

Following the research objectives mentioned above, an interpretivist approach was identified as the appropriate research design and methodology for the study. This approach lends itself to a qualitative research design, which rests on the premise that the phenomenon under study is socially constructed and can be viewed from different viewpoints (Cassim, 2021:8). In qualitative research, induction allows for the generation of theory from observations and is oriented to discovering and exploring a phenomenon. Qualitative research thus emphasises meanings and interpretation and attempts to understand various perspectives. Whilst the study is predominantly qualitative in nature, the questionnaire component of the study was quantitative, leading to the statistical analysis of its findings. This means that this study followed an exploratory sequential mixed-methods approach. With this design, qualitative methods are dominant and are applied first in the research process. These qualitative methods are followed by one or more quantitative methods – often in the form of a questionnaire or quantitative data collection. Chapter 4 unpacks the research design and methodology of this study.

1.5 Significance of the Research

It is hoped that this study contributes to knowledge creation in the field of Public Administration. Although recent years have seen an increase in research on Big Data in the public sector internationally, there is little reported on this topic, specifically focusing on the South African public sector context. Therefore, this study aims to produce findings in a way that is orientated toward the developing context of South Africa. This study further consolidates its findings into a conceptual framework that can guide the implementation of Big Data in the South African public sector, outlining the various considerations of Big Data characteristics, sources, limitations, processes, applications and value and how these various components interact with one another.

Furthermore, it is hoped that this study could produce not only academic significance but also some degree of social significance. Given the socio-economic reality of South African public sector institutions, the need for effective and innovative government solutions is now greater than ever.

1.6 Scope and Limitations of the Study

The scope of this study is initially limited to the use of Big Data by public sector organisations and institutions. The scope is thereafter further narrowed to focus on a case study context of the Western Cape Provincial Department of Agriculture. Using a case study limits the study's capacity for generalisation of findings as the case study component of the research will be context specific. Another limitation to note is the relatively low response rate on the questionnaire. The researcher aimed to collect responses from a larger sample size, but the final sample size was n = 22. However, the questionnaire aimed to ascertain qualitative insight into the perception of departmental employees on Big Data and the implementation of such technologies in their jobs. Therefore, the sample size of n = 22 was sufficient for gaining such insight.

Finally, the public sector use of Big Data through various technologies and applications is a relatively new phenomenon in public sector research. Although research regarding this topic exists, there is a limited amount of existing literature available in terms of a South African case study context.

Chapter 4 of this study provides a more detailed discussion of this study's scope and limitations.

1.7 Ethical Considerations

This study adheres to the ethical process of the University of Stellenbosch as set out in its Research Ethics Policy Document, which governs the actions of the researcher, the protection of participants, and the security and confidentiality of both respondents and information. Furthermore, this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments.

Full permission has been granted from the WCDoA to use the organisation's name in the study and access information not in the public domain. Furthermore, all interviewees and questionnaire respondents were given adequate information before participating and requested to provide written agreement to participate in the study. Participants were also informed that they could withdraw from the study at any time if they wished to do so. All participants were offered anonymity, and confidential data was stored securely and discarded appropriately.

1.8 Chapter Overview

Chapter 1: Introduction

This first chapter acts as a brief introduction to the study. In addition, this chapter presents the background and rationale for the study, research question, aim and objectives, research design and methodology, scope, limitations, ethical considerations, and chapter outline.

Chapter 2: A Conceptual Framework on Public Sector Big Data: Components, Characteristics, Applications and Challenges

In this chapter, the researcher summarises and discusses the key knowledge available regarding the topic of study. This literature review includes clear definitions of Big Data and key related concepts, followed by a discussion of the various characteristics of Big Data and its use in the public sector. Furthermore, this chapter outlines the main challenges related to the use of Big Data by public sector institutions. This chapter also presents several existing models on this topic and some contradictory opinions and critiques on using Big Data as a tool for public sector transformation. Finally, this chapter summarises the findings of the literature review into a theoretical conceptual framework.

Chapter 3: Policy and Legislative Framework

The third chapter summarises the relevant legislative and policy framework related to the use of Big Data technologies in the public sector. This chapter follows a funnel approach, starting with international policies and bodies and then discussing relevant South African policies, legislation, and frameworks.

Chapter 4: Research Design Methodology

Chapter 4 includes a detailed discussion of this study's research design and methodology. This includes detailed explanations of the instruments used and the justifications for why they are the most appropriate approaches to answering the various research questions.

Chapter 5: Case Study

The purpose of this chapter is to apply the theoretical knowledge gained in prior chapters and apply it to the context of the case study setting (the Western Cape Provincial Department of Agriculture). This chapter considers the relevance and attainability of implementing Big Data-driven solutions within the department.

Chapter 6: Data Analysis and Interpretation of Findings

Drawing from the key expert interviews and questionnaire responses, this chapter analyses and interprets the available data in an attempt to answer research questions v and vi. Following the analysis and interpretation of the interviews and questionnaire, the researcher synthesizes the literature review findings, legislative framework, and case study to provide an adapted and refined conceptual framework.

Chapter 7: Recommendations and Conclusion

This final chapter summarises and discusses the key findings of this study and how each research objective has been addressed. This is followed by a set of recommendations for future study and a conclusion.

Chapter 2: Public Sector Big Data: Components, Characteristics, Applications and Challenges

This literature review sets out to answer the first three research sub-objectives by defining Big Data and some related concepts, identifying current applications of Big Data in a public sector setting, and exploring various limitations which arise when implementing Big Data-driven technologies in a public sector setting. The literature review further starts looking at the various components and considerations of implementing Big Data in the public sector, which will inform the creation of a conceptual framework as set out by the final research objective (vii).

2.1 Governing During the Fourth Industrial Revolution

Most people have, by the year 2022, heard that we are currently experiencing what is called the "Fourth Industrial Revolution" or "4IR" in short. However, what does this term mean? What are its implications for governments? Moreover, where does Big Data fit into this picture?

The concept of the 4IR was first introduced in the work of Klaus Schwab, World Economic Forum founder and Executive Chairman. His book, titled the *Fourth Industrial Revolution*, unpacks the impact of emerging technologies on nearly all aspects of human development in the 21st century. In this work, Schwab describes the technological innovations driving change and transformation in all industries and parts of society, evolving social norms and political views and affecting economic development and international cooperation (Schwab, 2016). Schwab then titles this phenomenon *The Fourth Industrial Revolution.*

An "Industrial Revolution" marks a period of change in the systems surrounding society and how humans and technology interact. Such change brought about a distinctly new way of perceiving, acting, and being (Philbeck & Davis, 2019). The steam engine marked the start of the First Industrial Revolution, shifting the reliance on animal-, human-, and biomass energy to fossil fuel and the mechanical power enabled by it. The Second Industrial Revolution was characterised by the invention of the internal combustion engine in 1900. This led to rapid industrialisation, utilising oil and electricity to power mass manufacturing. The Third Industrial Revolution saw the advent of computing and robotics. Starting in 1960, the Third Industrial Revolution (also referred to as the "Digital Revolution') was characterised by the implementation of electronics and IT to automate production. However, the capability and ingenuity of automation today far exceed that of the Third Industrial Revolution. Therefore, we have entered the fourth and most recent increment of advancement.

The Fourth Industrial Revolution (hereafter referred to by the common abbreviation 4IR) now involves "smart" computer-generated decision-making and design, machine learning, IoT, and AI – all of which are defined in the following sections of this thesis (pp 13 and 14). This revolution involves a fusion of various technologies blurring the lines between the tangible physical and intangible digital. Consider the overwhelming convergence of emergent technologies like AI, machine learning, IoT, robotics, three-dimensional (3D) printing, nanotechnology, biotechnology, and quantum computing, to name a few. These cyber-physical systems sit at the core of the 4IR. Moreover, parallel to this revolution, we are also experiencing broader socio-economic, geopolitical, and demographic developments, intensifying the disruptive nature of this revolution. Such developments include a growing population, increasing urbanisation, climate change, the rise of biotechnology, globalisation of trade, and changing international regulations and political instability (Schwab, 2016).

One may wonder why a distinction was made between the third and fourth industrial revolutions. With such a short transition period and each being driven by digital technology, why not group these together? Xu, David and Kim (2018) provide three reasons for the distinction: velocity, scope and systems impact. First, today's rate of change (velocity) and innovation has no historical precedent. The scope of the 4IR is evolving exponentially, which is a significant shift from the linear growth of the preceding industrial revolutions. Finally, the 4IR is disrupting nearly every industry, its processes, and systems when looking at systems impact. The concept of the 4IR is often mistakenly used interchangeably with "Industry 4.0". Although related, these concepts are not synonymous. Industry 4.0 is a German initiative that emerged between 2011 and 2015, focusing only on using digital technologies in the manufacturing industry (Schwab, 2016). Industry 4.0 can thus be viewed as an essential component within the larger frame of the 4IR, which spans all sectors of society. Where the first industrial revolutions primarily impacted manufacturing and production, the fourth industrial revolution brought forth many possibilities and challenges for the public sector.

What does this mean for governments across the world? What does governance in the time of the 4IR look like?

While the 4IR poses many challenges to the functioning of governments across the globe in terms of job creation, information security, and privacy and skills requirements, this change also brings about many opportunities for improving government decision-making and service delivery. However, one pivotal building block is needed for the government to unlock the opportunities of the 4IR and adequately combat the inevitable challenges of this revolution. This key to a revolution in how government serves and protects citizens lies in vast sets of information, namely "Big Data", and the capability to harness its power.

2.2 Defining Big Data and Related Concepts

Having established that Big Data acts as the key to unlocking the potential of the 4IR, it is important to define Big Data and the technologies accompanying it. Sections 2.2 to 2.6 aim to address this study's first research objective: *To define Big Data*.

Big Data is often defined in terms of its "three v's". It is thus information of high volume, high velocity, and wide variety, which requires intricate forms of processing to enable decision-making, insight discovery, and process optimisation. Klievink, Romijin, Cunningham, and De Bruijn (2017:267) help make sense of this definition by positing that Big Data should not be considered as technology itself. Instead, "Big Data" is a term used for collections of data that are vast and dynamic and cannot be interpreted by conventional processing technology. Klievink et al. (2017:270) posit that the true power of Big Data can only come to light by utilising advanced technologies, which can combine and analyse such data, revealing insights that have otherwise been undiscoverable.

The World Economic Forum (2012) has declared data a new class of economic asset – thus equal to a currency or form of commodity such as gold. However, available literature on this subject highlights the reality that Big Data itself is powerless without the relevant systems which enable the analysis and interpretation of such information. This process is commonly referred to as **Big Data analytics** and holds the key to true value, insight, and creation. Big Data analytics, therefore, refers to generating insight from Big Data using highly advanced techniques.

Big Data analytics integrate vast amounts of structured and unstructured data (as defined on pp 16), enabling businesses and governments to use sophisticated algorithms to inform their decision-making (Klievink et al., 2017; Pathak, 2021). The **algorithms** derived from Big Data analytics provide detailed instructions for carrying out very specific operations (Technopedia, 2019). Computers read these algorithms as precise instructions for predicting behaviour through analytics, identifying problems such as fraud and abuse, and evaluating policy changes before implementation (Erickson, 2019). The combination of Big Data and analytics are required to understand complex patterns and correlations. Algorithms further enable machines to perform tasks traditionally performed by the human brain, such as understanding and processing language, sound recognition, object identification, and mastering patterns for solving complex problems and performing specific operations (Zandi, Reis, Vayena and Goodman, 2019). This ability is referred to as **AI**, which allows for a "learning" and refinement process called machine learning. **Machine learning** involves utilising large sets of data in adapting algorithms to improve the precision of AI (Zandi et al., 2019). Machine learning allows the real-time analysis of ever-growing data sets to find opportunities for optimisation in everyday life.

Finally, it is important to define "smart" when referring to various new technologies. The term "smart" used as a prefix to describe various technologies and devices stands for "self-monitoring and reporting technology". This prefix refers to the application of data and technology to previously traditional objects and processes to enhance efficiency and convenience (Bowers, 2019). This term is often used as a prefix for modern-day technologies, from "smart" phones and televisions to "smart" cities. These "smart" technologies are part of a digital system of interconnected devices called the **IoT**. In the same way people use the Internet to communicate, physical and virtual objects such as cell phones, fitness devices, coffee machines, or air conditioners use the Internet to communicate with other "smart" objects. This IoT comprises a global heterogeneous network infrastructure enabling advanced services by interconnecting "things" (physical objects and virtual systems) through utilising existing and evolving interoperable information and communication technologies (ICTs) (International Telecommunication Union (ITU), 2005; Scuotto, Ferraris & Bresciani, 2016; Ankosko, 2018). This integration of physical objects and digital systems allows for constant and readily available information (vast data sets) on these complex systems (Chou, 2018).

Having defined the key technologies and concepts surrounding Big Data, one understands that the term "Big Data" refers to much more than the physical data itself. The term "Big Data use" thus refers to the collections of Big Data-driven technologies and applications needed to extract value from the data itself.

In 1991, Mark Weiser, considered the "father of universal computing", declared that the most profound technologies are those so expertly camouflaged that we forget they are even there yet cannot live without them (Weiser, 1991). He describes how these technologies can "weave themselves into the fabric of everyday life until they are indistinguishable from it" (Weiser, 1991:94). Today, almost thirty decades later, amid the 4IR where technology has seamlessly become part of our everyday life, this statement is now more relevant than ever before.

2.3 Generally Acknowledged Characteristics of Big Data

Perhaps the most fundamental concept, which is corroborated by multiple sources of literature, is that of the three key characteristics of Big Data. These characteristics, also referred to as the "3Vs", include volume, velocity, and variety. According to Kim et al. (2014), these characteristics of Big Data make the management and analysis thereof very challenging.

Big Data is nothing if not "Big". Thus, its size is measured as volume. **Volume** is the primary attribute of Big Data and refers to the terabytes or petabytes of data generated by various sources (Kim et al., 2014). One terabyte consists of 1024 gigabytes whereas one petabyte makes up 1024 terabytes – a petabyte of data would thus fill more than 1.5 million CD-ROMs! An example of a corporation that generates and utilises Big Data of startling volumes is the retail group Walmart. According to Forbes (Marr, 2017), Walmart collects and processes approximately 2.5 petabytes of data on its customers and transactions per hour. That equates to 2.5 million gigabytes or roughly 20 million filing cabinets of information per hour. An example of volume in public sector Big Data can be illustrated by means of the South African Department of Home Affairs' migration from the dated Home Affairs National Identification System (HANIS) to the more advanced Automated Biometric Identification System (ABIS). This system migration involves expanding all citizen data (fingerprints, date of birth, identification numbers and identification photos) to include retina scans and baby footprints on the new ABIS (Department of Home Affairs, 2019). One key implication of such a system change is that the existing data set of the department will nearly double in volume. While expanding this data set will enable various new technologies to lead to improved insight and efficiency, the volume of data radically changes how the data are managed, stored, and secured.

The second "V" is **velocity**, which refers to the rate at which information is generated. For many 4IR applications, the speed at which data are generated is as important – if not more – than the volume of the data set. This rapid rate at which data are generated allows organisations to access real-time or near real-time insight into their performance and adjust their strategies in an agile manner. For example, real-time data can be utilised in a public sector context to optimise traffic light control systems to alleviate traffic congestion (Gupta, Gadre & Rawat, 2014). Real-time data can also be used to allow citizens to track the exact status of their passport or visa application or to be proactively warned about an expiring vehicle licence or an upcoming change to a law that might affect them.

The final characteristic, **variety**, relates to the fact that data comes in various forms: structured, semi-structured, and unstructured (Kim et al., 2014). This classification of the forms of Big Data assists in ascertaining how the data needs to be processed. *Structured data* presents itself in a standardised format and highly structured arrangement. Such data sets are stored in databases in which rows and columns are used to store data in a structured way. Structured data are easily accessible and useable as data processing algorithms interact effectively and easily with this form of data as it is retrieved and processed in an arranged and precise manner (Pathak, Pandey & Rautaray, 2018). Public sector-specific examples of structured data include census records, library catalogues, phone directories, and internal databases. *Unstructured data* has no set format in which it is stored. Such data sets are not bound to an explicit layout, structure or model and do not match properly into relational tables as structured data does (Shah, Peristeras & Magnisalis, 2021). Therefore, unstructured data are difficult to transform into a format allowing effective and efficient processing and insight generation. Examples of unstructured data include media files (images, audio, and video), unstructured office documents and reports, and Portable Document Formats (PDFs). Lastly, *semi-structured data* – as the name suggests – consists of structured and unstructured data elements. Semi-structured data are not in the same format as structured data but includes identifiable elements or "tags", which make the data easier to sort and analyse. Such data sets may be irregular, incomplete or have a structure that may change rapidly or unpredictably (Pathak et al., 2018). Semi-structured data are usually managed using Hyper Text Markup Language (HTML), making webpages the most common example of such data (Pathak et al., 2018).

In recent years, scholars have expanded on the three v's of Big Data by adding two additional characteristics: veracity and value. However, it is only recently that the importance of information quality has been stressed. Lukoianova and Rubin (2014:5) argue that the 3Vs often lead to a "soup" of data that is not objective, truthful or credible, which will subsequently not lead to the insights needed.

According to Pathak et al. (2018:241), **veracity** as a characteristic of Big Data relates to the credibility or trustworthiness of the data set and the need to manage the reliability and predictability of inherently chaotic and imprecise data sets. The well-known saying goes: "not everything that counts can be counted, and not everything that can be counted counts". This quote forms the premise for considering the veracity of Big Data. As the volume, velocity, and variety of Big Data continue to increase, the quality of the data has become pivotal. For Big Data to be useful, it needs to be verified. One must thus establish its veracity by managing uncertainty around the trustworthiness of the data set. The process of improving the veracity of Big Data is highly mathematical. In summary, the uncertainty of numeric or non-textual data can be reduced either by "combining multiple less reliable sources" to create "a more accurate and useful data point" or using "advanced mathematics that embraces uncertainty" (Schroek, Shockly & Smart, 2012:5). Uncertainty management of textual data are more complex since the textual data, in general. Especially social media data are highly uncertain in both their "expression and content" (Lukoianova and Rubin, 2014:5). However, certain forms of data are inherently uncertain to such an extent that no amount of data cleansing can fully correct it. Examples of inherently uncertain data include sentiment and truthfulness in humans, weather conditions, economic factors, and the future. However, despite the level of uncertainty, this data still contain valuable information. It is thus a hallmark of Big Data analysis to acknowledge and embrace uncertainty.

Finally, one can argue for adding a fifth "V" – **Value**. Big Data is characterised by the value of the information extracted from the data. Data have long provided strategic value to organisations. However, with the magnitude of data (Big Data) available today, and our ability to draw insight from such data sets, the value of Big Data has become greater than ever before (Monino, 2021).

These elements are characteristics of Big Data in general. However, one may ask: Are there any other qualities of Big Data related more specifically to the public sector context? Kim et al. (2014:80) posit that the above-mentioned characteristics should be paired with two additional characteristics when looking at public sector Big Data. These include **silo** and **security**. Government departments or institutions typically have their own "silo" of data, with institutions often reluctant to share their data with others (Kim et al., 2014). Furthermore, data security is a critical component of Big Data within the public sector as its collection, storage, and usage require special care. *Silo* and *security* are both characteristics and challenges for government Big Data and will subsequently be discussed with a set of more general Big Data challenges.

2.4 Desouza and Jacob's (2017) Data Continuum

In their research on Big Data in the public sector, Desouza and Jacob (2017:1047) provide a *Data Continuum.* This spectrum indicates the difference between "small data" and "big data" in the public sector, indicating its varying volume, velocity, variety, and complexity levels. The model is graphically depicted in Figure 2.1 below.

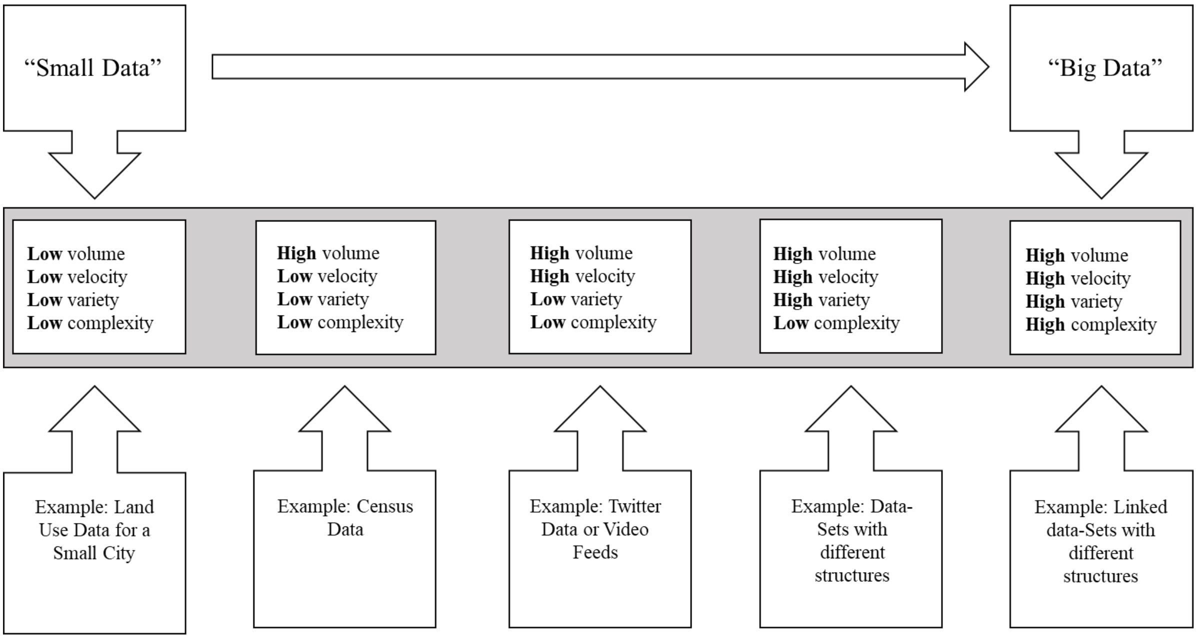

Figure 0.1 - Desouza and Jacob's Data Continuum (Desouza & Jacob, 2017:1047)

Desouza and Jacob (2017:1045) use the same 3Vs characteristics as much of the literature on Big Data does. However, this model introduces a new characteristic of *complexity* as an attribute of public sector data. According to this model, complexity is "the degree to which an organisation's data are drawn from and connected to data in other departments and organisations" (Desouza & Jacob, 2017:1047). This characteristic is very similar to Kim et al.'s (2014:80) characteristic of "silo", measuring the extent to which data originate from and gets shared between various sources (for example, government departments). An example of the high complexity of data in the public sector is the aforementioned ABIS implemented by the South African Department of Home Affairs. This updated system will allow various types of data in various forms to be shared (and used by) multiple other departments and government entities. This set of Big Data is generated at a high velocity, comprises various formats (textual, numeric, image), and can be accessed and used by various departments and public institutions.

2.5 Big Data in Context: Private vs Public Sector

Following the many successes of Big Data analytics in the private sector, similar initiatives have emerged in the public sector. Subsequently, policymakers, public managers, and citizens are increasingly looking toward Big Data as a solution for improved decision-making relating to public policies, programmes, and democratic processes (Desouza & Jacob, 2017).

In older studies, there is a clear distinction between the Big Data mandate of private and public entities. The figure below exemplifies such a distinction made by Kim et al. (2014). However, one must question whether this distinction is as relevant and clean-cut as the authors suggest.

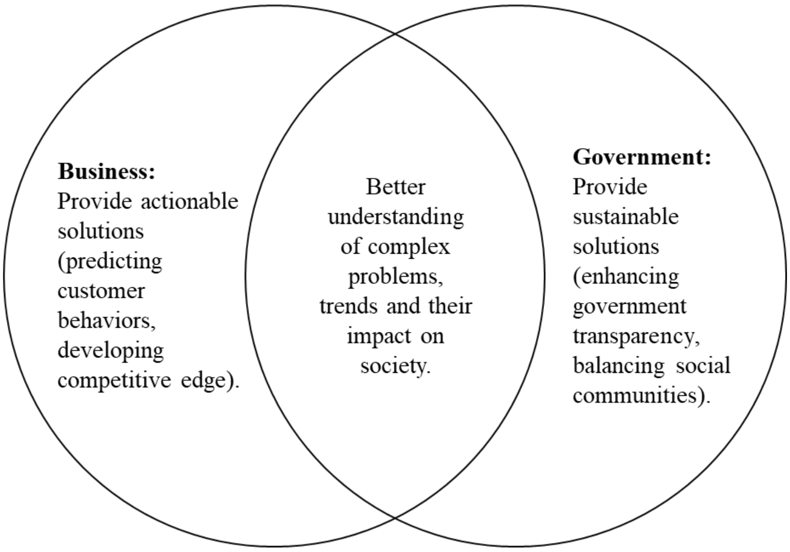

Figure 0.2 - Business and Government Big Data analytics outcomes compared (Kim, Trimi & Chung, 2014:81)

Looking at the above figure through a lens of New Public Management (NPM) or Entrepreneurial Governance, the lines between government and business approaches to Big Data become blurred (Hood, 1991:4). Citizens are then viewed as "customers" to which the government must provide services efficiently, effectively, and economically. Similarly, in an ever-increasingly conscious world, customers expect businesses to provide sustainable services, conduct business transparently and ethically, and participate in positive social change. When it comes to the use of Big Data, Lane (2017:708) suggests that one must look beyond the "public vs private paradigm" toward collaboration and the collective use of Big Data insights across all sectors of society.

Klievink et al. (2016) raise some concern, postulating that although Big Data is implemented in the private sector with great success, public sector use of Big Data seems to be falling behind (these reasons will subsequently be discussed). However, with increased connectivity across the world, several public and developmental institutions have embraced the vision of creating and operating within what is called a "data-ecosystem" or "Government Big Data Ecosystem" (GBDE) in which data from a variety of sources are brought together and used for the benefit of global populations (World Economic Forum, 2012). Shah et al. (2021:9) propose the following definition of GBDEs:

"A socio-technical network of people, processes, technology, infrastructure, data services, base registries (trusted and authoritative source of data) standards & policies, processes, organizations, and resources jointly working to perform data functions such as data collection, integration, analysis, storage, sharing, use, security & protection and archiving to obtain value from big data through its extensive use to ensure better evidence-based policymaking, public services delivery, promote data-driven administration & open government, boost the data economy to benefit citizens, businesses, and government bodies."

A GBDE is thus a complex interaction of numerous interconnected components related to the data itself, the technology used to extract insights, and the various organisational structures and roles involved in the entire data lifestyle from collection to insight application (Demchenko, de Laat & Membrey, 2014:105).

Thus, the true value offsets of Big Data and 4IR technologies will only be unlocked when one looks beyond the public vs private view toward a holistic, multi-dimensional view of multi-sector data and information managed by a diverse Big Data ecosystem of role players.

2.6 The Quadruple Data Helix – Beyond the Public vs Private Paradigm

Lane (2016) refers to the future of public sector Big Bata use as a *Quadruple Data Helix*. This model for the future use of integrated Big Data sets suggests four key contributors, each with its own strengths and ability to reinforce each other's weaknesses. According to Lane (2016), these strands comprise state and city agencies, universities and research centres, private data centres, and federal agencies. Although the Quadruple Data Helix model is based on the United States of America (USA)'s Federal governance structure, it could easily be adapted to a more unitary government structure such as that of the South African government (acknowledging that the South African government structure is unitary with some decentralised tendencies).

As seen in Figure 2.3 below, this model depicts multi-dimensional resource integration for innovative and future-oriented Big Data solutions and ecosystems.

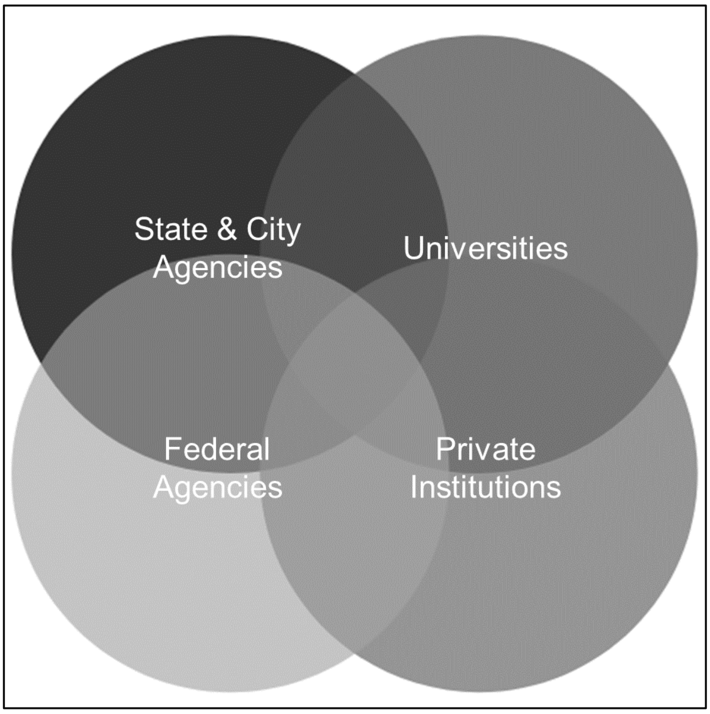

Figure 0.3 - The Quadruple Data Helix Model (Lane, 2016:710)

State and city agencies are critical in formulating key policy questions that drive data collection and organisation (Lane, 2016). Furthermore, these institutions generate data and serve as end-users of the value derived through data analysis. This ultimately allows for the implementation of insights into specific grassroots policies and programmes. In a South African context, the municipal and provincial government will stand in the place of these state and city agencies.

The second strand, universities and research centres, acts as a valuable independent third party that can assist in storing, processing, analysing, and disseminating data. Furthermore, Lane (2016) suggests that universities and schools of public policy can potentially cater to the increasing need for trained human capital in the field of data analysis – both in the public and private sectors.

Private sector institutions own vast amounts of proprietary data (Lane, 2016) as opposed to open data, which can be freely used, shared, and supplemented. Proprietary data are owned and controlled by an individual, group or organisation. This data are often internally generated, which adds to an organisation's competitive advantage. Proprietary data may be secured via copyright, patent, or trade laws. According to Redman (2013), proprietary data – unlike public data such as census information – have four common attributes: it measures social behaviour, is highly granular (detailed), is wide but not too deep, and does not cover the entire population of interest.

Interestingly, such data are often unstructured and under-exploited. Universities and research centres can assist in developing tools that can extrapolate the data's richness whilst preserving its sensitivity. Subsequently, state and city departments should guide this strategic collection and analysis process to answer set policy questions using inferred information (Lane, 2016).

Lane (2016) points out that the federal government (or national government in the South African context) may be slow to respond to data collection and processing changes in this Quadruple Helix model. Therefore, the federal government must draw on the strengths of the other strands of the helix (Lane, 2016). Federal agencies can play a pivotal part in this Quadruple Helix model by providing a source of long-term national frames against which several different sources can be benchmarked (Lane, 2016). Statistics South Africa is an example of such a national statistical agency in South Africa. Furthermore, national agencies ought to act as champions of excellence in ensuring data protection and security by means of policy, legislation, norms, and standards.

Lane presents these four strands as a quadruple helix – each strand affecting and interacting with each of the other. This representation as presented below in figure 2.4 represents the complexity of interaction and departure from the "silo" approach to view Big Data role players. The "Helix" representation represents the interwoven nature of the interaction between the four strands.

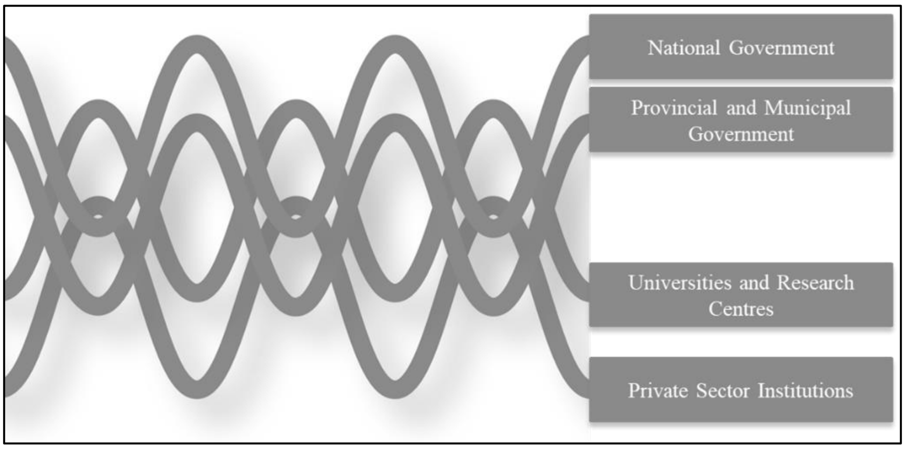

Figure 0.4 - The Quadruple Data Helix Model (Lane, 2016:710)

This Quadruple Helix model strengthens the case for establishing GBDEs, drawing from the strengths of various interdisciplinary inter-sector role players.

2.7 The Case for Big Data Technologies in Government – Opportunities and Examples

Following the many successes of Big Data analytics in the private sector, public service stakeholders have a growing consensus that Big Data applications hold great potential and value for governments and public institutions worldwide (Desouza & Jacob, 2017; Rogge, Agasisti & de Witte, 2017). Subsequently, policymakers and public managers are increasingly utilising Big Data as a tool for improved decision-making related to public policies, programmes, and democratic processes (Desouza & Jacob, 2017; Klievink et al., 2017).

According to Lane, Kendrick and Ellwood (2018), data – if used wisely – have the potential to amplify and accelerate the impact of all public strategies and programmes. The possibilities for applying Big Data-related strategies to public sector operations are boundless. For the purpose of this research study, these possibilities are discussed by means of three subcategories: enhanced democratic processes, improved policy- and decision-making, and effective programme and project management. A discussion of how Big Data technologies can be used in each of these categories addresses the second research objective: *To describe the current application of Big Data in the public sector*.

2.7.1 Enhanced Democratic Processes

According to Theron and Mchunu (2016:17), public participation is an essential "building block" for development, ensuring that citizens can influence, direct, control, and own the processes that will ultimately affect them. Participatory management is vital in ensuring that those affected (beneficiaries) by a certain project or policy should be full partners in the planning process and play an active role in the management thereof (Swanepoel & de Beer, 2016). The importance of citizen participation in public processes is discussed in public administration literature yet nearly always proves much harder to implement in practice than theory may suggest.

The emergence of technologies such as the Internet, Big Data applications, AI, and the increased use of social media platforms by vast numbers of citizens have given rise to a paradigmatic shift regarding the nature of communication and partnerships between government and its citizens. According to Rogge et al. (2017), Big Data technologies have played and will continue to play a pivotal role in strengthening partnerships between the state and its people. On the other hand, traditional technologies only enabled limited possibilities for consulting and informing citizens. Big Data technologies enable a vast number of new opportunities to foster civic participation in what can be deemed a new "online democracy" or "e-democracy" of open government initiatives (Lidén, 2015; Kneuer, 2016; Mishra, 2020). The Organisation for Economic Cooperation and Development (OECD, 2003:11) defines "e-Government" as the process of utilising ICT as a tool to improve governance in terms of the efficiency of public administration processes, public services for citizens, improved policy and decision making, and enhanced trust between government and citizens by enabling citizens to engage in the creation of public policy processes and promoting an open and accountable government.

It is especially social media which performs several valuable functions in democracies, such as informing citizens and enabling them to form and express their opinions, providing a platform for public debate, and serving as a bridge between government and those governed (Kneuer, 2016). Moreover, the media and users of social media exercise scrutiny over government, political parties, and political figures. There is a multitude of examples of e-Government and data-enabled democratic processes. Mishra (2020:1293) describes the example of "MyGov", an ICT-based platform of the government of India where citizens can contribute to public policymaking in various ways. On this platform, citizens (a staggering 1.8 million users) are encouraged to share their views and ideas on various policy issues. According to Mishra (2020), more than 10,000 issues are "posted" per day. The information is then analysed and sent to the relevant departments for consideration in their policymaking processes. This platform provides the government of India with a multitude of information and insight into the views and needs of its people.

A second example of utilising large sets of data from social media to assist government processes lies with the partnership between the American Centers for Disease Control and Prevention (CDC) and the search engine Google. In this joint effort, Google has connected their database of "search items" (items entered into their search engine) such as "flu symptoms" or "cough medication" with the CDC's data on various outbreaks such as H1N1 (swine flu). Thus, by connecting two previously disconnected data sets, analysts could better predict the spread of the virus (Desouza & Jacob, 2017). There are many similar examples in light of the COVID-19 pandemic. Other examples of social media-enabled democracy include Citysourced.com (Morabito, 2015) and the use of Geographic Information Systems (GIS) in various states of the USA (O'Malley, 2015).

2.7.2 Improved Policy- and Decision-Making

Public participation, enabled by technologies such as Internet search queries and social media activity, provides large quantities of data, which can, in turn, lead to valuable insights into the opinions and concerns of the public. This type of information is required to inform the choices of high-level decision-makers regarding the expansion and/or reshaping of public programmes and the setting of new targets (Lane et al., 2018). Improved efficiency and effectiveness enabled by better decision support information allow for more informed and accurate policymaking (Klievink et al., 2017). These large data sets enable accurate profiling of specific demographic groups, which can provide valuable insights in tailoring public services to the specific needs and demands of its intended beneficiaries (Klievink et al., 2017; Rogge et al., 2017).

Existing literature on the use of Big Data in policymaking processes reveals several policy areas that have experienced considerable improvements in outcomes and services due to the implementation of Big Data-related technologies producing effective, targeted solutions to lingering social issues. These policy areas include the management of roads and traffic (Janssen, Charalabidis & Zuiderwijk, 2012; Lv, Duan, Kang, Li & Wang 2015), public security and policing (Meijer & Torenvlied, 2016; Ferguson, 2017; Sanders & Sheptycki, 2017; Shapiro, 2019), detecting fraud (Tang & Karim, 2019), healthcare and other welfare services (Gillingham & Graham, 2017; Stylianou & Talias, 2017; Dash, Shakyawar, Sharm and Kaushik, 2019), environmental policymaking (Faghmous & Kumar, 2014), smart city initiatives (Massobrio & Nesmachnev, 2018; Kandt & Batty, 2021), and education (Wang, 2016; Fischer, Pardos, Baker, Williams, Smyth, Yu, Slater, Baker & Warschauer, 2020).

The USA-based Longitudinal Employer-Household Dynamics (LEHD) programme is a prime example of Big Data which enables policymaking. This programme is run by the Center for Economic Studies of the United States of America (USA) Census Bureau. Combining various data sets from the federal government, all 50 states, and the US Census Bureau, the LEHD programme creates dynamic statistics on employment, earnings, and job flows. These statistics are highly detailed and can be tailored per geographical area, industry, demographics, and level of education. The LEHD programme powers several sub-programmes or “applications” that government and policymakers can utilise in their various tasks. Moreover, this data are publicly available, which means that private sector organisations and academic institutions such as universities can access and utilise this information. Examples of the applications enabled by the LEHD programme include:

- A web-based analysis tool named the *Job-to-Job Flows Explorer* (J2J Explorer). This tool enables comprehensive access to an innovative set of statistics on the flow of workers across employers, industries, and labour markets across the US. The J2J Explorer dashboard provides interactive visualisations, tables, and charts, which compare, aggregate, and analyse the earnings and movement of workers across industries and states. According to the United States Census Bureau J2J dashboard (n.d.), this information has, for example, been used to identify what industries are hiring workers with specific skills, what metro areas have the highest rate of workers relocating to jobs in other areas, and comparing earnings after job flows to earnings for job stayers and a time series analysis on the impacts of educational attainment on employment in the respective states.

- *OnTheMap* is an online mapping and reporting application which shows where employees work in relation to where they live. This information includes various worker characteristics filtered by age, earnings, or industry groups. In addition, the *OnTheMap* application shows workplace and residential distributions by user-defined geographical areas. Use cases of this application include transport and infrastructure planning, emergency planning and disaster management, and economic development planning.

- The *Post-Secondary Employment Outcomes (PSEO) Explorer* provides rich statistics on employment outcomes and earnings of graduates of various post-secondary education institutions across the US. By linking university graduation data with the national employment database, the PSEO tracks graduate flow from a post-secondary institution, degree level, and academic achievements to employment by industry and geographic labour markets.

- Finally, the *Veteran Employment Outcomes* (VEO) *Explorer* allows for comparisons of statistics on Army veterans' labour market outcomes one, five and ten years after discharge. These statistics can be filtered by military occupation, rank, demographics (age, sex, race, ethnicity, education), industry, and employment geography.

The applications mentioned above are all examples of where Big Data sets from various sources are combined to create valuable insight for policymakers. The VEO can, for example, assist in formulating social support and education programmes for low-skilled veterans after being discharged, bettering their chances of attaining employment. The J2J Explorer can assist the US government in anticipating and adequately planning for the influx of citizens to certain areas, allowing for adequate town and transportation planning. Additionally, such an application can assist the government in identifying in need for economic development in specific areas. Finally, the PSEO explorer gives policymakers insight into the skillsets and education background youth need to attain decent employment. This can inform education policies focusing on specific skills that will lead to employment and better economic outcomes for the young working population.

2.7.3 Effective Programme and Project Implementation, Monitoring and Evaluation

Having established the value and potential of Big Data in ensuring improved decision-making and policy development, Big Data also significantly contribute to the management and measurement of performance and efficiency of public organisations, entities, and programmes.

Several studies posit that Big Data has the potential to provide government institutions with highly detailed information regarding the quality and quantity of its outputs and assist in generating targeted measures of these outputs and outcomes (Bertot & Jaeger, 2008; Hofmann, Beverungen, Rackers & Becker, 2013; Klievink et al., 2017; Rogge et al., 2017). In a global survey conducted by Bloomberg Research Services among high-level managers of public sector agencies worldwide, 80 per cent of respondents believed that Big Data-led transformation in the performance management of public sector organisations is underway and essential (Mullich, 2013). The study indicates a belief by managers that the emergence of Big Data in the public sector could result in the use of entirely new management models, including (but not limited to) improved personnel performance measurement tools and overall strengthened Human Resources Management (HRM) practices (Rogge et al., 2017). An example of Big Data-driven performance management can be found in performance dashboards constructed and used by managers and HRM personnel to monitor and guide the performance of employees. Andrews (2012) discusses the importance of (and the distinction between) the internal and external measurement of organisational performance. Big Data and the vast collection and sharing of information can enable internal and external performance measures. Various authors suggest that governments across the world have begun to shift their focus from internal performance management only to now include citizen-centric measurement tools enabled by, among other things, Big Data collected through social media platforms. Social media platforms such as Facebook and Twitter can be used to collect feedback on service quality, participation, and overall citizen satisfaction. Public sector institutions can now use multi-faceted dashboards showing and comparing operational, financial, and citizen-based information to evaluate and compare the performance and efficiency of departments and teams. This will allow agencies to compare and benchmark their performance against others performing similar functions.

Big Data not only assist in measuring the effectiveness of public organisations themselves but also in measuring specific projects and/or programmes run by these departments or units. Project and programme managers require data to determine the effectiveness of different interventions via Monitoring and Evaluation (M&E) strategies. The analysis of Big Data sets on the performance of specific projects and programmes can ensure that resources are focused on improving the quality of activities and outputs and, in doing so, ensure improved operational efficiency and continuous improvement in the satisfaction of recipients' articulated needs.

In their study on citizen-based performance measurement enabled by Big Data technologies, Ho and Coates (2002) found that often, citizens turn out to be highly effective in identifying project and programme faults, which otherwise would have been missed by conventional M&E practices.

There is a multitude of public programmes which make use of Big Data to improve the efficiency and effectiveness of the programme itself. Many excellent examples of Big Data use in informing and directing public programmes resulted from the COVID-19 pandemic. Real-time data reports have helped the government make science-based policy decisions and resource allocations and placed information at citizens' fingertips, enabling everyone to be informed and keep track of COVID statistics in their region. The Worldometer.com website is an example of a Big Data-driven COVID-19 dashboard. The COVID-19 outbreak not only highlighted the possibilities for Big Data in driving effective public health programmes by sharing best practices, lessons learned, and proven approaches but also highlighted the great importance of data sharing between all role players and counties. During this pandemic, the value of data sharing has been highlighted. However, public data sharing involves a risk of personal privacy leakage – a topic discussed in Section 2.8 on the various challenges in government Big Data use.

2.8 Challenges in Implementing Big Data Technologies in the Public Sector

Various challenges are outlined throughout various literature on using Big Data in a general and government context. The third research objective of this study aims *to explore the limitations faced when implementing Big Data-driven technologies in the public sector* and is addressed by means of Sections 2.8 and 2.9 of this literature review. The most general challenges of utilising Big Data are discussed below in Sections 2.8.1 – 2.8.6.

2.8.1 Data Quality, Governance and Management

According to the Center for Digital Government (2015), the success of Big Data analytics largely relies on the quality, governance, and management thereof. Poor quality data can be a result of integrating various data sources. Given the volume and velocity at which this data are gathered, sorting and testing Big Data data sets can be tedious and costly. Not all data have to be of top quality to be useful. However, it has to be able to be sorted into a useable format. It is therefore advisable to first determine the data quality required to achieve the desired outcome before any Big Data-driven project. High-quality data are expensive to produce and manage. Thus, imposing high standards on data quality for a project that does not require high-quality data will be unreasonably costly (The Center for Digital Government, 2015). With this being said, the baseline quality of data needs to be sustained. Furthermore, the challenge comes when data are frequently used and analysed, possibly leading to diluting the data quality (Morabito, 2015). Good management and governance are required to ensure data quality control. These can be particularly challenging in the field of Big Data as there are various variables to consider.

Whilst we have argued to look beyond the public versus private paradigm, data quality has different repercussions in these sectors. In private organisations, low-quality data can be ignored from consideration without compromising the integrity of the analysis or affecting the customer (Morabito, 2015). For example, if a business profiles customers only using the 'clean' data they possess, they will still be able to gauge a useful customer profile and predict future sales. However, the same cannot be said for the education sector; for example, the government cannot base policy decisions on only some useable data sets, particularly if the 'unclean data' relates to one particular area, school district, or a specific demographic profile.

In addition to Big Data quality, public sector decision-makers managing and utilising Big Data must remain aware of the risk of bias in using Big Data (Morabito, 2015). This includes selection bias, confounding bias, and measurement bias. For example, confounding bias will occur if one compares and correlates smoking habits from Facebook or Instagram profiles with youth diabetes statistics. One may erroneously identify a causal relationship between those two factors when other factors are at play, such as unemployment, genetics, or economic status.

2.8.2 Cost and Funding

A crucial element of Big Data analytics is the increase in the availability of low-cost technology. However, according to an extensive survey conducted by the Center for Digital Government (2015), 42 per cent of survey respondents listed cost issues as the biggest challenge to any Big Data project. Upon investigation, the study found that technology such as hardware and software only make up 15 per cent of the total cost of such a project. The remaining 85 per cent consists of a range of highly skilled personnel and support costs.

2.8.3 Leadership and Organisational Culture

According to a Harvard Business Review report on the management revolution brought on by the shift towards Big Data analytics, organisations successfully navigate the Big Data arena because of data and technology and mostly leadership, which sets clear goals, define the meaning of success, and ask appropriate questions (McAfee & Brynjolfsson, 2012). However, Big Data analytics' power and potential do not eliminate the need for clear vision or human insight. In fact, such technologies require even more from leaders to champion the contribution of Big Data to their teams, ensuring that all team members value and own the process. This implies the need for a change management approach to ensure the full buy-in of all employees, especially those dealing with regularly managing data and information systems.

Schein (1985) has described organizational culture as consisting of three parts: assumptions, values and artefacts. Assumptions are the widely held, ingrained and often subconscious beliefs of employees. Values relate to employees' preference of outcomes and the means of achieving them. Finally, Artefacts are the physical representations of a culture often in the form of rituals, slogans, traditions and myths. In essence, organizational culture is thus the widely shared and strongly held assumptions, values and artefacts of a company or organization. Literature on organizational culture in the public sector suggest that public sector organisations often lack the much-needed orientation towards adaptability, change and risk-taking (often referred to as a "developmental culture") (Parker and Bradley, 2000:130). Furthermore, public sector organisations are less driven by outcomes such as productivity and efficiency than public-sector organisations. Instead, public sector organisations are oriented towards a hierarchical culture, prioritizing rules, procedures and stability. Whilst not entirely bad, these values are not conducive to organizational adaptability and embracing of new technologies and ways of working.

Considering the challenge of leadership alignment and employee buy-in, the Technology Acceptance Model (TAM) is a useful mechanism for understanding the variables at play (Davis, 1989). Widely used in the field of information systems research, the TAM provides a vital framework that illustrates how the perceived ease of use and perceived usefulness of an information system/application impact user interaction (Brandon-Jones & Kauppi, 2018).

As Davis (1989) posited, *Perceived Usefulness* (U) can be defined as a prospective user's subjective belief that using a specific application system will enhance their work performance or quality of life. Davis (1989) further defines the *Perceived Ease of Use* (E) as the degree to which the prospective user expects the new application or system to be easy to use. These two factors are influenced by several *external variables*, including social, cultural, and political factors of the environment in which such a new system is to be implemented. A negative institutional culture regarding data-related tasks and the lack of leadership support are both major challenges that negatively impact employees' perceptions of the usefulness and ease of use of information systems. These negative perceptions subsequently negatively impact *Attitude Toward Using* (A), which, in turn, affects the individuals' *Behavioural Intention to Use* the application (B) (Surendran, 2012).

Figure 2.5 below illustrates the TAM and the way in which all the above-mentioned factors ultimately contribute to the application's *actual system use*.

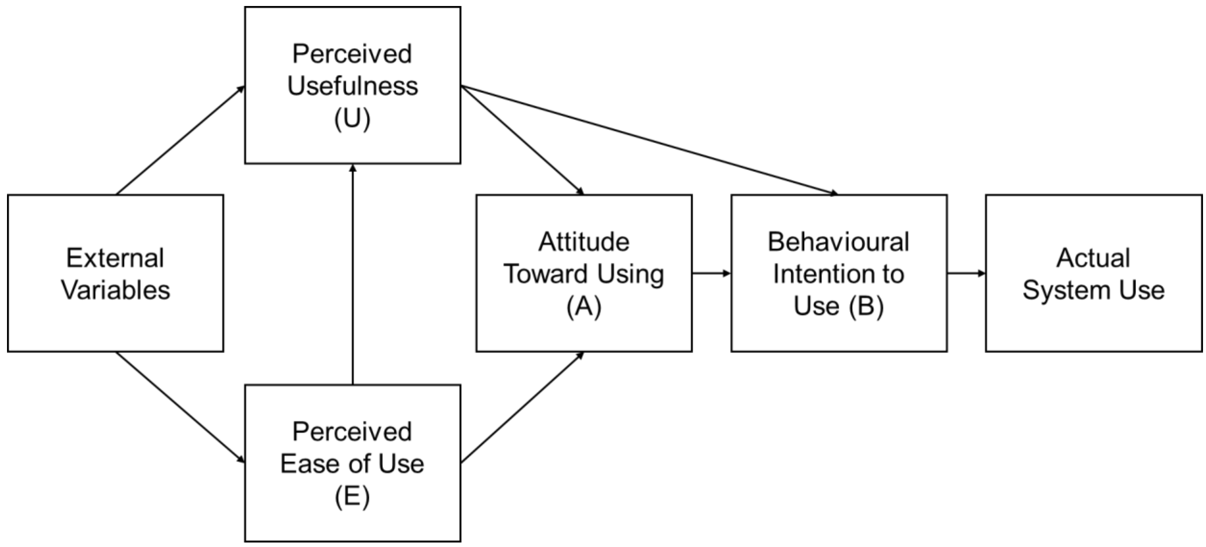

Figure 0.5 - The Technology Acceptance Model (Surendran, 2012:176)

In addition to these general challenges regarding data quality, management, funding, leadership, and culture, the public sector-specific challenges in utilising Big Data are highlighted below.

2.8.4 Silo

As much as it is a characteristic of data within the public sector to operate within silos, this element is a major challenge to successful integrative Big Data analysis. Kim et al. (2014:80) refer to this as a "tower of babel", which keeps data isolated, complicates integration, and often leads to miscommunication. Desouza and Jacob (2017) posit that these silos within which government data operate present unique challenges for the cooperative government as interoperability between various information systems used are often very restricted. Furthermore, coordination between these various silos is a complex and costly process (Morabito, 2015).

2.8.5 Skillset Requirement

When looking at implementing Big Data-driven technologies in the public sector, government departments and institutions require more skilled employees who understand the complex field of Big Data analytics. These include analysts, data scientists, and chief data officers (The Center for Digital Government, 2015). Various sources highlight this skills shortage in conjunction with governments' inability to offer competitive salaries compared to the private sector (Kim et al., 2014). In many countries, public sector organisations are obliged to recruit at below-market going rates to justify the human resource expense (Morabito, 2015). This ultimately makes it very hard for the government to attract much-needed talent. This leaves the government with three possible solutions. Firstly, the government can choose to outsource Big Data-related projects to leading private sector data companies. Secondly, the government can offer market-relevant salaries to their highly specialised Big Data-related employees. Finally, the government can invest funds to train existing staff in the required data-related skills. Clearly, none of these three options can succeed without increasing costs.

2.8.6 Big Data Ownership, Privacy and Security

With Big Data ownership comes great responsibility and the very call to eliminate government Big Data silos brings about several concerns around shared data ownership, privacy, and security. Governments must view themselves as custodians of citizens' data, granted the responsibility to use it in exchange for effective public services and the promotion of the public good. Governmental Big Data projects, therefore, balance a fine line between collecting and using data for predictive analysis and ensuring citizens' human rights and privacy (Kim et al., 2014). The value of Big Data rests in its ability to connect and identify correlations between disparate sets of information (Desouza & Jacob, 2017). However, Desouza and Jacob (2017) note that it is, in fact, this very advantage that creates concern around privacy as it can lead to insights on individuals that they did not consent to.

The 2019 cybercrime attack on the City of Johannesburg's e-services system is a key example of the vulnerability of public sector data. This event was caused by a group named the *Shadow Kill Hackers,* who disrupted city services by breaching the city's system and demanding 4.0 bitcoin (a cryptocurrency worth an estimated R550 000), threatening to upload sensitive city data should their demands not be met (Modise, 2019). Luckily, the City of Johannesburg detected the breach early and could mitigate the risk by forcing a system shutdown. However, though the breach was appropriately dealt with and its consequences minimised, the incident has impacted the City's ability to deliver its services and forced officials to seek international expert help in investigating the matter (Otieno, 2019). This was an unwanted cost burden for a municipality already under substantial financial strain.

In September 2021, approximately 1 200 files containing contact and banking details of South African citizens who had submitted their personal information to the Department of Justice and Constitutional Development were compromised due to a ransomware attack on the department's IT system (ITWeb, 2021). Ransomware is software designed to restrict access to a computer or system until a sum of money is paid. As a result, all e-Government services provided by the department came to a standstill, including issuing letters of authority, bail services, email, and the departmental website. Furthermore, the department was forced to freeze all monthly child maintenance payments for several days until the issue was resolved. It was expected that the individuals behind the breach sold the personal information obtained (Ilascu, 2021).

Another example of a data security breach occurred in July 2021 when President Cyril Ramaphosa's phone number was listed as one of 14 heads of state among the 50 000 surveillance targets of Israeli-based spyware company NSO Group (Ncwane, 2021). This software, named Pegasus, allows operators to spy on targets by extracting messages, photos, and emails, recording phone calls, and secretly activating microphones and cameras (BBC, 2021). The company involved, NPO, defended the leak by stating that the information is only for use against terrorists and serious criminality by the military, law enforcement, and intelligence agencies with good human rights records. However, this case has one wondering if it is that easy to hack into the devices of heads of state and how easily similar spyware programmes can access private information on citizens.

2.9 Counter Argument: "Tech Goggles"

An interesting counter-argument to governmental Big Data analysis can be found in author and mathematician Ben Green's book named "*The Smart Enough City: Putting Technology in Its Place to Reclaim Our Urban Future*". According to Green (2019:12), there is often a dangerous ideology behind viewing "smart initiatives" that enable Big Data analytics to solve all modern-day challenges. Although Green (2019) does not deny the possibility of utilising Big Data analytics to optimise public service efficiency and convenience, he warns against the phenomenon he refers to as "wearing tech goggles".

These "tech goggles" rest on two premises. Firstly, it assumes that technology provides neutral and optimal solutions to complex social problems. Secondly, it posits technology as a primary instrument of social change. Green (2019:34) argues that those wearing "tech goggles" dangerously perceive all ailments as technical problems and subsequently selectively diagnose and address only the issues that technology can solve. In viewing technology as the most important variable that should be altered, one risks overlooking other critical goals such as political reform and shifting political power (Green, 2019).

Heeks (2006:223-224) corroborates this view in arguing for the consideration of "process before technology". Heeks thus posits that before implementing new technologies, institutions must first focus on improving their processes. Big Data analysis and related technologies are no cure for mismanagement and poor governance. Deep issues with public sector processes must first be addressed before new technologies can be applied to widen the value of any given programme (Heeks, 2006).

Furthermore, the United Nations Digital Economy Report (United Nations, 2019) warns that the digital divide between developed and developing countries is at risk of becoming a chasm. According to the report, network connections are rapidly accelerating in developed nations whilst remaining static in developing countries. The report revealed that at the time of the investigation, 52 per cent of the world's population did not have access to the Internet (United Nations, 2019).

The Big Data that exist today are overwhelmingly made up of information on individuals using different network applications. However, one must remember that insights derived from such Big Data sources only represent the portion of the population with access to and regular Internet use and therefore mostly represent individuals in the already developed world. Therefore, it would be shortsighted to infer insight from Big Data sets to inform projects, which must operate in an environment where very few or none of the beneficiaries formed part of the Big Data "research pool". As much as Big Data initiatives and related technologies have the potential to vastly improve governments across the world, it is crucial to recognise that neatly packaged solutions to complex problems are seldomly possible.

2.10 Summary and Conceptual Framework

In consolidating the findings of the above literature review on public sector Big Data use as a whole, a conceptual framework of all the relevant elements, challenges, and processes is proposed (see Figure 2.6).

Big Data is generated by a variety of sources, including various government entities, universities and research centres, and the private sector. The definition of Big Data is not restricted to size only but relates to the data's volume, velocity, variety, veracity and value. The key characteristic of Big Data is its heterogeneous nature, representing information from various populations and sources that enable modelling through sophisticated statistical techniques. This processing of Big Data is impacted by several challenges that can be sub-categorised as soft "human" challenges, such as leadership alignment, institutional culture, and user buy-in, as well as hard "technical" challenges, including data quality, governance, and integration.

The significance of integrated Big Data lies in its completeness, data correlation, predictability, frequency, interpretability, and level of automated decision-making capabilities through various algorithms, AI, and machine learning. The predictive analytics of Big Data include valuable procedures and techniques to predict future outcomes, enabling improved democratic processes, better decision-making, accurate project planning, effective policy formulation, and the monitoring and evaluation of public programmes and teams. In the framework proposed, various legislative and policy frameworks underpinned the process of transforming Big Data into public value.

Big Data technologies and insights can potentially promote the development of improved farming systems, supported through automation, customisation, staff training, and close collaboration between all stakeholders to align data strategy with departmental needs. Chapters 5 and 6 further unpack these Big Data and agriculture possibilities.

This conceptual framework is used in the following chapters, where key literature review findings are applied to the case study of the agricultural industry of the Western Cape. Therefore, the sources, characteristics, challenges, processes, outcomes, and policies now seen in the conceptual framework are replaced with sector-specific information, forming a possible conceptual framework for Big Data use within the agriculture sector.

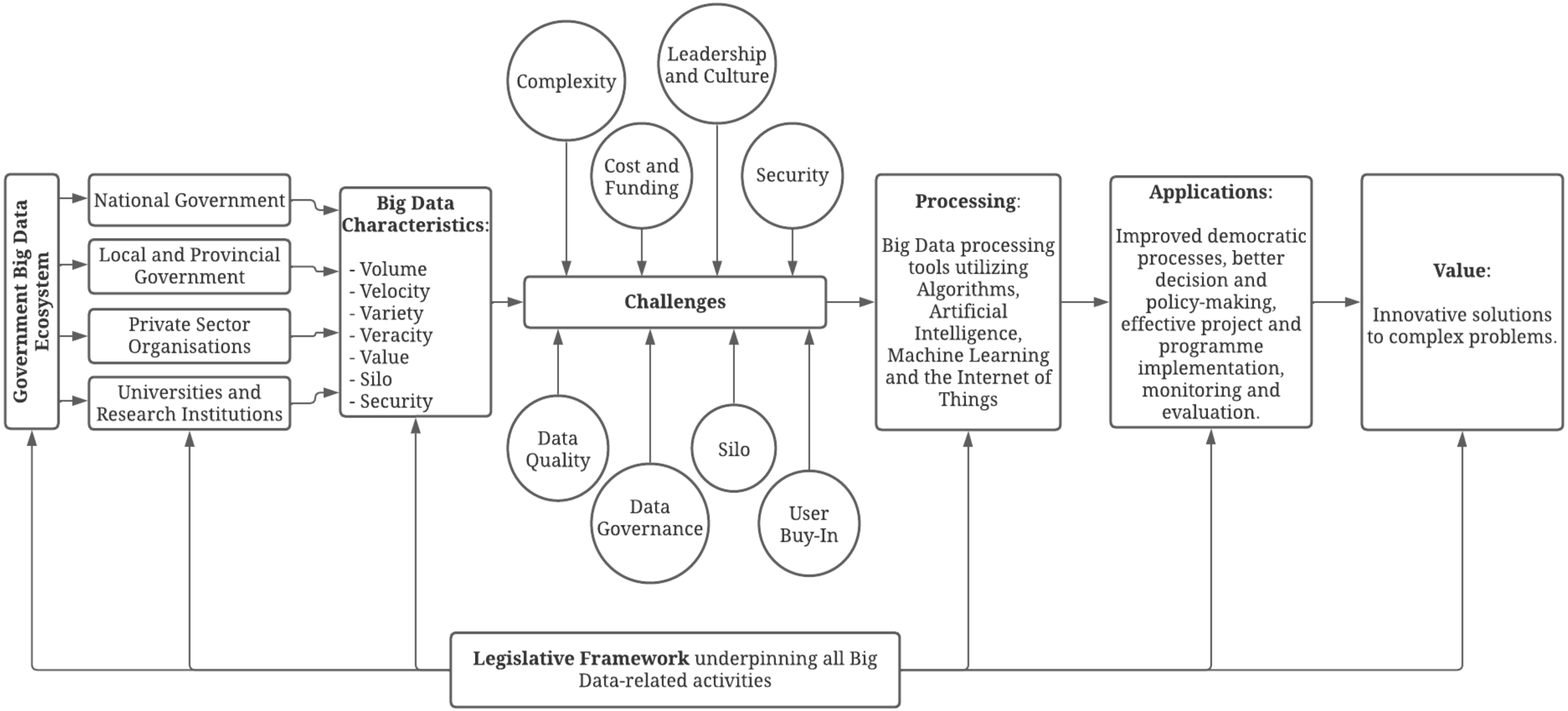

Figure 0.6 - Conceptual framework built from consolidated literature review findings (Author, 2022)

Chapter 3: Legislative and Policy Framework

Following the literature review provided in Chapter 2, and before proceeding to the case study of the Western Cape Provincial Agriculture Department, one needs to explore the relevant legislation and policies that affect the use of Big Data by public sector institutions in South Africa. This chapter addresses the fourth objective of this study: *To outline the policy and legislative framework affecting the implementation of Big Data technologies in the South African public sector*. However, before doing so, there is the need to link the use of Big Data in government and *e-Government*. Whilst there is no one law pertaining to Big Data use by the government, in particular, several laws affect this phenomenon. Therefore, public sector institutions' use of Big Data falls within the ambit of the law dealing with ICTs and e-Government.

3.1 Policy and Regulatory Outline of Public sector Big Data use in South Africa

According to the South African State Information Technology Agency (SITA), ICT systems act as a cornerstone of any modern economy (SITA, 2018). According to Qin, Zhen and Zhang (2021), "ICT" is a collective term for many technologies used in communication and information, which is drastically changing the way people (and government) undertake day-to-day activities. ICT refers to a network of applications and devices to administer and broadcast data to the public. ICT is thus a tool used in gathering and transmitting data electronically between various devices such as computers, tablets, and other smart devices.

However, it is not ICT that this study is concerned with but rather the public sector use of ICT, and Big Data, in particular, to fulfil its duties. Using information technologies in the public sector to bring traditional government services to citizens via the Internet and modern technologies are referred to as *e-Government systems* (OECD, 2009). These systems combine technical and human components and form socio-technical ecosystems of public sector data (Heeks, 2006). Through e-Government, public sector institutions have the opportunity to use ICTs to fundamentally improve the efficiency and quality of public services, ultimately transforming the very nature of government operations.

Several pieces of legislation stipulate how e-Government systems should be managed, enabled, developed, and implemented. However, before examining these, one must first examine the international bodies regulating and directing e-Government and related ICTs.

3.2 International ICT and e-Government Regulatory Bodies

As part of the global community, South Africa forms part of various international ICT and e-Government bodies.

3.2.1 The International Telecommunication Union (ITU) and the European Union (EU) General Data Protection Regulations (GDPR)

The ITU is the United Nations' specialised agency for ICTs. Founded in Paris in 1865 as the *International Telegraph Union*, the ITU was later renamed the *International Telecommunications Union* in 1932. South Africa has been a member of this organisation since 1881. The ITU performs various ICT functions, including allocating global radio spectrum and satellite orbits, developing technical standards ensuring seamless network interconnection, and improving access to ICTs to underserved communities worldwide (ITU, 2022d). Today, every mobile phone call or Internet transaction is enabled by the work of the ITU.

The ITU is currently committed to the following eleven key areas of action (ITU, 2022c):

1. Accessibility
2. AI
3. Broadband
4. Environment and climate change
5. Cybersecurity
6. Digital divide
7. Emergency telecommunications
8. Entrepreneurship and Small and Medium Enterprises (SMEs)
9. Internet
10. Gender equality
11. Youth and academia

The ITU's working committee on Telecommunication Standardisation Sector (ITU-T) consists of global experts in the ICT sector collaborating on developing international standards known as the ITU-T recommendations for global ICT infrastructures (ITU, 2022b). These standards are critical in ensuring the interoperability of all countries' ICT networks and devices.

With regards to the use of Big Data technologies by government entities, the ITU's annual *AI for Good* Global Summit is of particular importance, unpacking various public sector AI initiatives and Big Data-driven solutions to global development issues (ITU, 2022a).

As a partner state, South Africa has access to the various resources and standards developed by the ITU. One such example is the ITU-driven support for *Harmonisation of ICT Policies in Sub-Saharan Africa* (HIPSSA) in collaboration with the Southern African Development Community (SADC) (see Section 3.2.4).

The EU General Data Protection Regulations (GDPR) came into effect in May 2018. Developed as a response to the immergence of Big Data generation and use by corporations across the world, these regulations tighten Europe's already stringent laws on what companies and institutions can do with people's data (EU,2016:119). These regulations give people more control over how and by whom their data is gathered and used and forces Big Data-users to be transparent on how and why they use Big Data. These regulations apply to the entire EU context and thus has implications for any person, organisation or government dealing, or exchanging information, with EU citizens, organisations and or entities.

3.2.2 The Organisation for Economic Cooperation and Development (OECD)

The OECD is an international development organisation that informs and shapes policies that foster prosperity, equality, opportunity, and well-being for all (OECD, 2022). Established in Paris in 1960, the OECD comprises governments, policymakers, academics, and citizens, all working towards establishing evidence-based international standards and policy solutions.

The OECD's *AI principles* promote the use of Big Data-driven AI that is innovative and trustworthy and respects human rights and democratic values. Adopted in May 2019, these standards outline how governments and other actors can shape a human-centric approach to trustworthy Big Data-driven technologies (OECD, 2019). South Africa became part of the OECD in 2007 and is regarded as the "prime mover" for OECD activities, which fall within the objectives of the African Union Development Agency's (AUDA) New Economic Programme for African Development (NEPAD). Despite its membership in the OECD, South Africa is not among the countries that have undertaken a set of recommendations of the OECD Council on AI. These recommendations comprise two sections: 1) principles for responsible stewardship of trustworthy AI and 2) national policies and international cooperation for trustworthy AI.

3.2.3 The Organisation for the Advancement of Structured Information Standards (OASIS) - International Technical Standards for e-Governments

Founded by international IT giant IBM, the Organisation for the Advancement of Structured Information Standards (OASIS) serves as an international platform where individuals, organisations, and governments collaborate to “solve some of the world’s biggest technical challenges through the development of open code and standards”(OASIS, 2021:Online). The OASIS’s technical committee on e-Government is an international not-for-profit consortium which drives the development, standardisation, and adoption of e-Government initiatives (OASIS, 2002). Whilst South Africa does not have a representative serving on this technical committee, the OASIS International Technical Standards for e-Government's findings and policy recommendations are openly available. As a result, they could serve as a basis for e-Government regulations and policymaking by governments across the world.

3.2.4 The South African Development Community (SADC)

South Africa is a member state of the SADC. Established in 1992, this community comprises fifteen southern African member states. The SADC aims “*to promote sustainable and equitable economic growth and socio-economic development through efficient, productive systems, deeper co-operation and integration, good governance and durable peace and security”* among its members (SADC, 2022:Online).

Within the SADC, many targeted committees, institutions, and forums are established to cover various themes of relevance to the above-mentioned mission of the SADC as a whole. These committees conduct research, workshops, and forums in various fields and publish valuable guidelines, protocols, charters, and declarations on their findings. There are four key SADC policies to consider relating to the 4IR and the use of Big Data by public sector institutions.

The first and earliest on the topic is the 2001 *SADC Declaration on Information and Communication Technologies.* This declaration is the SADC’s primary ICT policy, highlighting ICT infrastructure and regulation. In its preamble, this policy states that the member states (including South Africa) recognise that the SADC requires a “coherent regional policy and strategy on ICT that promotes sustainable economic development, technology, and bridges the digital divide within the region and the rest of the world” (SADC, 2001:2). Interestingly, this declaration emphasises the responsibility of member states to ensure that ICT does not further increase the disparities between men and women, rich and poor, and urban and rural populations. The declaration further emphasises the responsibility of its member states to formulate and execute a comprehensive human resources plan in the area of ICT, stating: "*The effective use of ICT presumes a literate population able to use the tools provided by the new technologies"* (SADC, 2001:2).

A second valuable resource published by the SADC is its *HIPSSA Model Laws and Policies* drawn up in collaboration with the ITU between 2008 and 2013. Over this period, the ITU support programme for the HIPSSA assisted the SADC in drawing up several model laws on various relevant matters ranging from data protection, e-transactions, cybercrime, and universal service and access to ICT (ITU, 2014).

The *SADC ICT Sector Infrastructure Development Master Plan* of 2012 sets out a "Digital SADC" vision by 2027. This master plan rests on four pillars of the "Digital SADC 2027", consisting of infrastructure, e-services and applications, research, innovation and industry development, and capacity building and content (see Figure 3.1). The pillars, in turn, rely on two key platforms: 1) confidence and security of networks and services and 2) policy and regulatory harmonisation (SADC, 2012:11).

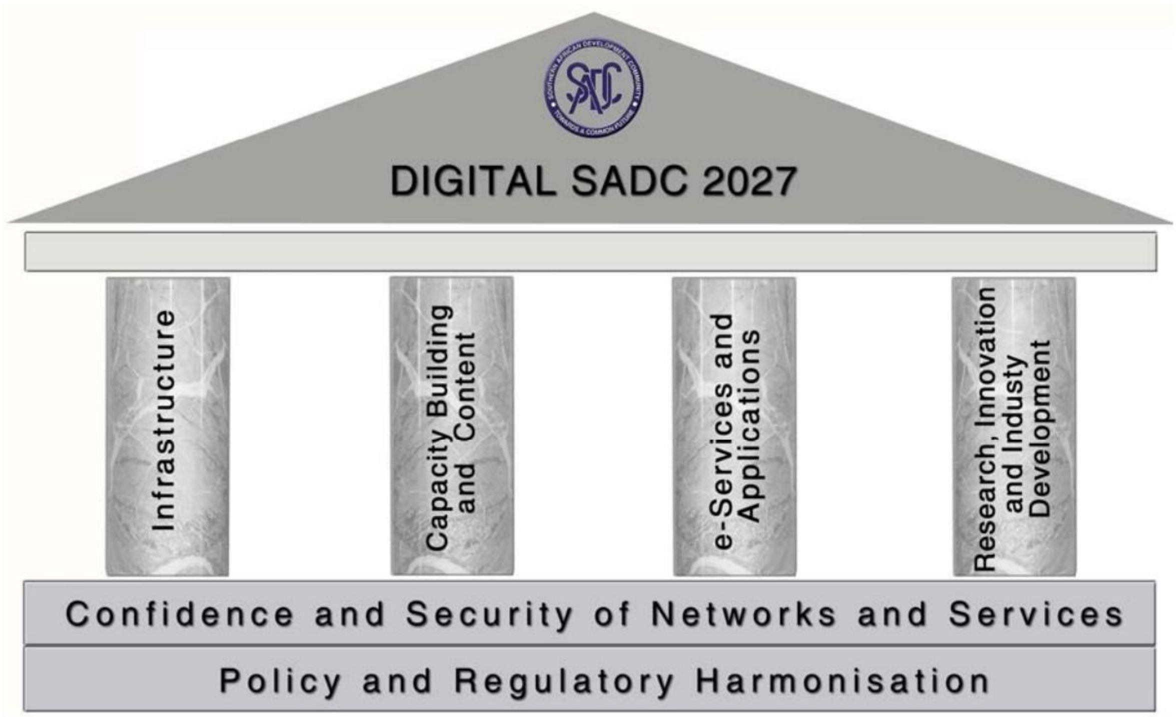

Figure 0.1 - The Four Pillars of the Digital SADC 2027 (SADC, 2012:11)

Finally, in March 2021, the SADC Secretariat's Directorate of Industrial Development and Trade, in partnership with the South African Institute of International Affairs (SAIIA), cohosted a stakeholder webinar on the 4IR and the creation of a SADC Declaration on the 4th Industrial Revolution. Focussing on six pillars: infrastructure and connectivity, affordability, skills, awareness, entrepreneurial development, and local content, this declaration is yet to be published (SAIIA, 2021).

3.2.5 African Union (AU) and the New Economic Programme for African Development (NEPAD)

Launched in 2002 as the successor to the Organisation of African Unity (1963–1999), the African Union (AU) was formed. The AU is guided by its vision of creating *"An Integrated, Prosperous and Peaceful Africa, driven by its own citizens and representing a dynamic force in the global arena"* (AU, 2022:Online). South Africa is one of 55 members of the AU.

The AU's earliest statement on the need to promote ICT security and regulation came to light in 2008 through the *AU Draft Report on a Study of the Harmonisation of Telecommunication and Information Communication Technology Policies and Regulations* (AU, 2008:2). In 2009, AU member states met in an extraordinary sitting in Johannesburg, South Africa, to develop and adopt the Oliver Thambo Declaration. As per the declaration, the AU is tasked with the responsibility to *"jointly develop with the United Nations Economic Commission for Africa (UNECA), under the framework of the African Information Society Initiative, a Convention on cyber legislation based on the continent's needs and which adheres to the legal and regulatory requirements on electronic transactions, cybersecurity, and personal data protection"* (AU, 2009:4. This declaration also proposed that AU member states adopt the proposed Convention by 2012 (Orji, 2018). However, it was only by 2014 that this Convention was drafted. The process underwent numerous technical delays and opposition from various civil society groups and academia. Furthermore, several concerns were that the convention was drafted without sufficient consultation with stakeholders from member states and lacked the needed governance mechanisms to effect its purpose (Orji, 2018).

By June 2014, the AU finally adopted their Convention on Cyber Security and Personal Protection. This Convention acts as a regional cyber security treaty which instructs member states to follow a set of legal, policy, and regulatory measures to promote cybersecurity, ICT governance, and combat cybercrime (Orji, 2018).

The Convention recognises that *"the current state of cybercrime constitutes a real threat to the security of computer networks and the development of the information society in Africa"* and that this state of affairs emphasises the need *"to define broad guidelines of the strategy for the repression of cybercrime in Member States of the AU, taking into account their existing commitments at the sub-regional, regional and international levels"* (AU, 2014:2). This Convention obliges member states to implement the following measures (Orji, 2018):

1. Establish a national cybersecurity framework
2. Promote a culture of cybersecurity
3. Establish national cybersecurity governance structures
4. Protect critical information infrastructure
5. Establish cybercrime offences and procedural measures
6. Promote international cooperation and legal harmonisation

Interestingly, the signing and ratification of the convention by member states have been extremely slow. Many members, including South Africa, have not signed the convention and have developed their own national cybersecurity and ICT governance policies.

3.3 South African Policy and Regulatory Outline

Section 3.2 of this chapter discussed various international ICT and e-Government bodies relevant to implementing Big Data-driven technologies in the South African public sector context. In addition, this section discusses various South African regulations, policies, and legislation. These policies are discussed from the least recent to the most recent date of publication.

3.3.1 The Constitution of the Republic of South Africa (1996)

As a Constitutional Democracy, the Constitution of the Republic of South Africa of 1996 (hereafter referred to as The Constitution) is the country's highest legal authority. It, therefore, makes sense to initiate any legislative framework in the South African context with a review of the topic on hand in terms of the Constitution before proceeding to other pieces of legislation in their order of promulgation.

The topic of Big Data use in the public sector relates to ICT, e-Government, and the privacy of citizen information. Therefore, to find legislation affecting this phenomenon, the researcher must cast a relatively wide net, starting with the Constitution. Interestingly, none of the provisions in The Constitution directly refer to ICT or e-Government. However, there are a handful of applicable sections.

Chapter 2 of the Constitution is arguably the cornerstone of South Africa’s democracy, setting out the South African Bill of Rights. In Section 14(d) of the Bill of Rights, the Constitution sets out the right to privacy of information (Republic of South Africa, 1996). This right is premised on the notion that all persons should be afforded the right to protect their personal information by other individuals or organisations. This right is increasingly prevalent in light of the 4IR and rapid advancement of Big Data technologies and analytics. However, whilst some organisations and applications now can gather and draw highly detailed information on citizens, this does not give them the right to access, use, and share such personal information as they please. The POPI Act No.4 of 2013 affects Section 14(d) of the Constitution (see Section 3.4.7).

The concept of Cooperative Governance is highlighted by Chapter 3 of the Constitution. In this chapter, Section 41(1)(c) states that public sector institutions must provide an effective, transparent, accountable, and coherent government for the Republic as a whole (Republic of South Africa, 1996). This requirement is further expanded in Subsection (h)(iii), stating the responsibility of government entities to inform one another of matters of common interest (Republic of South Africa, 1996). Here, one can link the research topic at hand with the government's responsibility to act effectively, transparently, and accountable manner. Therefore, restricting the government from treating citizens' data in a responsible, transparent manner and for which they can be kept accountable. Furthermore, on the issue of informing each other on matters of common interest, one can interpret that various government entities are constitutionally mandated not to act in silos but to share data and information among departments and units as and when needed as so long as it does not infringe on citizens’ right to privacy.

Finally, Chapter 10 of the Constitution outlines the *Principles of Public Administration*. Section 195(1)(b) of this chapter stipulates that the principle of efficient, economical, and effective use of resources must be promoted (Republic of South Africa, 1996). Here, special mention must be given to the word “must”. It is not an option for government entities to act in a manner which is efficient, economical, and effective in the use of their resources. This is a constitutional requirement. Therefore, if there is evidence that the use of Big Data-driven technologies in the public sector is effective in solving many challenges and becoming increasingly cost-effective, government entities are mandated to look towards using such solutions to improve their work.

3.3.2 State Information Technology Agency Act No 88 of 1998

The State Information Technology Agency Act No. 88 of 1998 provides for the establishment of the State Information Technology Agency (SITA). This body is mandated to provide IT systems, services, and technology to, and/or on behalf of, participating government departments (Republic of South Africa, 1998).

Furthermore, SITA must set standards for the interoperability of information systems and a comprehensive data security environment for departments. SITA thus plays a critical role in supporting the execution of a South African e-Government strategy as seen in their e-Government "House of Values" (see Figure 3.2), which integrates national e-Government values, objectives, and services into a concise framework to guide all other e-Government functions in the South African public sector (Republic of South Africa, 2017a).

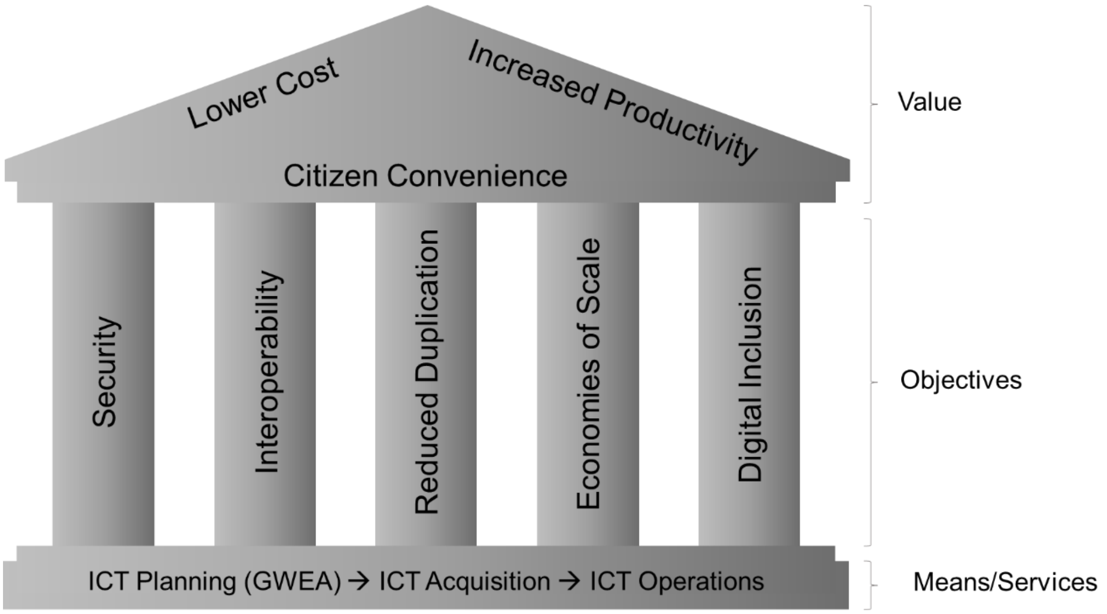

Figure 0.2 - SITA e-Government House of Values (SITA, 2018)

SITA's role includes guiding government entities on how to create and establish secure online e-services whilst supporting the integration of government systems to allow for sharing of data and information and conducting much-needed research to help promote innovation and new technologies in the field of digital governance (SITA, n.d.).

3.3.3 The Public Service Regulations of 2001

The Public Service Regulations of 2001, including its amendments, set out the earliest South African e-Government regulations by addressing three key areas. The first area relates to IT's role in improving the delivery of public services and the productivity and cost-effectiveness of governance. This area highlights the need for a successful electronic government which requires all departments to manage IT effectively and efficiently (Republic of South Africa, 2001). These early e-Government regulations are in line with the Batho Pele Principles of 1997 by stipulating: "*The Batho Pele principle of offering equal access to services, increase in productivity and lowering of cost, shall inform the acquisition, management and use of information technology"* (Republic of South Africa, 2001:66).

The second area that these regulations address is information security, setting out information security principles, compliance principles, and the need for information security vigilance. Furthermore, this section stipulates the Minister of Public Service and Administration's responsibility to issue a handbook called *Minimum Information Security Standards* (MISS) (Republic of South Africa, 2001). All individuals dealing with public service data are thus required to comply with these security standards (Republic of South Africa, 2001). However, the MISS currently in use was drawn up and approved in 1996 and arguably dated, leading to the need for more modernised information security legislation and frameworks. The final area of interest within the Public Service Regulations of 2001 addresses the need for collaboration and interoperability between various government departments. This section mandates the Government Information Technology Officers Council (GITOC) to issue a handbook on Minimum Interoperability Standards (MIOS) to which departments are required to comply, ensuring seamless and integrated service delivery (Republic of South Africa, 2001). The MIOS has been reviewed multiple times, with the most recent version published in November 2017. These standards define the key prerequisites for interoperable e-government and, together with ICT security regulations, form a crucial part of e-government regulations in the South African public sector (Republic of South Africa, 2017a). The MIOS further outline three underlying principles for all e-Government activities: 1) interoperability, 2) openness, and 3) industry support (Republic of South Africa, 2017a).

3.3.4 The Electronic Communication and Transaction (ECT) Act No.25 of 2002

The Electronic Communication and Transaction (ECT) Act facilitates and regulates-government services and electronic communications and transactions between public and private entities, institutions, and citizens (Republic of South Africa, 2002). This act aims to ensure that human resources capacity is developed in the ICT sector to prevent the abuse of information systems and encourage the utilisation and development of national e-Government services. The ECT Act includes sections on critical components related to e-Government and introduces the element of cybercrime and the unauthorised access to, interception of, or interface with data.

Most importantly, Chapter 2(5)(1) of this statute mandates the Minister of Communications and Digital Technologies to develop and execute the National e-Strategy (Republic of South Africa, 2002). Moreover, Section 5(2) stipulates that the Cabinet, upon the approval of the National e-Strategy, "must" declare this strategy as a national priority. Section 5(3), outlining the role of the Minister of Communications and Digital Technologies, stipulates that the minister must not only survey and evaluate the extent to which the national e-strategy's objectives have been met but that the minister is also tasked with conducting research into any new developments relevant to electronic communications and e-Government in the Republic and internationally.

A detailed discussion of the National e-Strategy, which resulted from the stipulations of this Act, will follow in Section 3.3.10.

3.3.5 Government-Wide Enterprise Architecture Framework of 2009

The Government-Wide Enterprise Architecture (GWEA) framework is a broad tool that can be used across all governmental spheres and levels. The GWEA framework of 2009 serves two major purposes. Firstly, it provides a framework for Government Chief Information Officers, Government Information Technology Officers, and Enterprise Architecture (EA) practitioners to establish and manage EA capability within their departments or organisations (Republic of South Africa, 2010). Secondly, this framework assists in developing an EA plan for each government department, agency, or programme. These EA plans are often referred to as an ICT plan or roadmap and ensure full alignment with the department/agency's strategic plan whilst adhering to the broad objectives and principles of set National e-Government principles (Republic of South Africa, 2010). At a departmental level, such an EA plan is essential in ensuring that department performance objectives are met through the optimal enabling of its business processes by means of an efficient ICT environment. The EA plan also provides for the regular review and upgrade of existing information systems, acquiring new systems and utilising new technologies and ICT products that will optimise the performance of the department or unit (Republic of South Africa, 2010). The GWEA framework defines and discusses 14 fundamental principles driving EA. These are categorised according to business, data, application, and technology principles, all of which relate to the issues discussed in the literature review on Big Data technologies preceding this legislative framework. The 14 principles include:

Business architecture principles:

1. Enterprise architecture is aligned with the relevant legal framework
2. Public and private collaboration improves public services
3. Public service design is customer-centric
4. Operations are optimised and simplified
5. Systems are designed to ensure business continuity

Data architecture principles:

6. Sensitive information is secure
7. Data is shared, and duplication is reduced
8. Data are accessible
9. Data definitions are consistent and meaningful

Application architecture principles:

10. Common applications are shared across government
11. Applications are independent of technology infrastructure
12. Common applications are easy to use

Technology architecture principles:

13. Technological diversity is contained (standardisation)
14. Technology components are able to interoperate and exchange information

3.3.6 Public Service Corporate Governance of Information and Communication Technology Policy Framework of 2012

The Department of Public Service and Administration created this framework for the government-wide governance of ICTs. The purpose of this framework is to guide the implementation of a national ICT strategy to address ICT risks based on defined processes and standards. This framework thus institutionalizes the governance of ICT as an integral part of corporate governance within departments. The framework further provides political and executive leadership with a set of principles and practices that must be complied with, together with a suggested implementation approach to be utilized for the corporate governance of ICT within departments (Republic of South Africa, 2012a: v). This framework applies to all spheres of government, organs of state and public enterprises.

3.3.7 National Development Plan (NDP) Vision 2030 of 2012

The National Development Plan (NDP), as prepared by the National Planning Commission (NPC), is acknowledged as the broad strategic framework which forms the basis of all future government planning. Also known as Vision 2030, this plan aims to enable good governance to eliminate poverty and reduce inequality (Republic of South Africa, 2012b). This strategic framework mentions the value of ICT in developing and ensuring the prosperity of South Africa and its people. It states, "2030, ICT will underpin the development of a dynamic and connected information society and a vibrant knowledge economy that is more inclusive and prosperous" (Republic of South Africa, 2012b:190). However, the NDP 2030 does not directly mention e-government as a key enabler of good governance and improved service delivery. Yet, the key elements of the NDP must be considered in developing and executing a national e-Government strategy to ensure that the long-term objectives of the e-Government strategy are aligned to those of the country (Republic of South Africa, 2017).

In 2019, the NPC and Presidential Commission on the Fourth Industrial Revolution (PC4IR) commissioned Research ICT Africa and the University of Cape Town's Nelson Mandela School of Public Governance to review the NDP in South Africa's readiness for the 4IR. Much like this dissertation, this review provides key definitions of the 4IR and related concepts such as Big Data, AI, machine learning, and data ecosystems. The findings highlight the potential benefits of harnessing these technologies within the South African public sector. Yet, it warns against a growing digital divide and the risk of not addressing societal structural and historical inequalities (NPC, 2020). Furthermore, this review call for government 4IR strategies to enable digital inclusion and innovation whilst acknowledging and mitigating the potential harm of the misuse and abuse of such 4IR technologies (NPC, 2020). Finally, this review proposes a citizen-centred policy approach, emphasising the need for human development and digital capacity building as a key strategic enabler of 4IR technologies within the South African landscape (NPC, 2020).

3.3.8 Protection of Personal Information Act No. 4 of 2013

The POPI Act promotes the protection of personal information processed by public and private institutions. It applies to any institution, entity or body that processes and stores personal information (e.g., legal practices, insurance firms, schools, hospitals, banks etc.). This Act was promulgated in November 2013, with its first set of provisions taking effect in April 2014. Other sections allow for making regulations where they are required in the Act. These sections created the framework within which the Act will operate once fully in force. In September 2016, the National Assembly (as mandated by the Act) approved the appointment of members to an Information Regulator that took effect from December 2014. More than six years after the proclamation of the Act and three years after the establishment of the Information Regulator, the remaining provisions (except for two) became operational as of July 2020, followed by a 12-month grace period ending in June 2021.

The POPI Act introduced several key information protection principles and established a set of minimum requirements for processing personal information and data (Republic of South Africa, 2013). The conditions for lawful data processing include:

1. Accountability
2. Processing limitations (consent)
3. Specific purpose
4. Further processing
5. Information quality
6. Openness
7. Security safeguards
8. Consent for direct marketing
9. Data subject participation

The Act further protects specific data and information from destruction, loss, or unlawful disclosure, to regulate how information is protected (Republic of South Africa, 2013). The implementation of e-Government has changed the landscape of information sharing across government departments. Due to this rapid change in information sharing and processing capabilities, it is imperative that all government entities adhere to the requirements of the POPI Act. All government departments must accept their role in the joint effort to ensure that appropriate measures are implemented, preventing unauthorised access to personal information and valuable data, especially when deploying wide-scale Big Data technologies.

3.3.9 The Cybercrimes Bill of 2016

Initially titled "The Cybercrimes and Cybersecurity Bill", the now Cybercrimes Bill aims to address the dangers regarding the security of public data and plays a pivotal role in protecting South Africans against cybercrime. This Bill criminalises the following set of cybercrimes (Republic of South Africa, 2016a):

- Unlawful access to data, programmes, and storage systems
- Unlawful interception of data
- Unlawful acts in respect of software and hardware tools
- Unlawful interference with data, computer programs, storage mediums, and computer systems
- Cyber fraud
- Cyber forgery
- Cyber uttering (passing-off of false data or false computer programmes)
- Malicious communications

This Bill imposes renewed responsibilities for institutions such as banks, electronic service providers, and financial institutions to adhere to stringent security requirements in managing the data of citizens (SAIIA, 2019). Alignment between this Bill and other established data protection statutes such as the Regulation of the Interception of Communications and Provision of Communication-related Information Act (RICA) and the POPI Act is essential in ensuring data security (SAIIA, 2019).

Today, the Cybercrimes Bill differs significantly from its first version (The Cybercrimes and Cybersecurity Bill). Having previously consisted of two sections, 1) cybercrimes and 2) cybersecurity, the cybersecurity section raised concerns around freedom of expression and internet censorship (SAIIA, 2019). Subsequently, in September 2019, sections of this Act were ruled unconstitutional by the Constitutional Court of South Africa and were consequently removed from the Bill. The Cybercrimes Bill was passed by the National Council of Provinces (NCOP) on 1 July 2020 and now awaits the President's assent. Once enacted into law, the Cybercrimes Act will empower the South African Police Service (SAPS) to act against such crimes, enabling cybercrimes specialists to better prosecute such unlawful activity. However, combatting cybercrime is complex and requires a highly specialised strategy and skill set. The ability of the SAPS to prevent and investigate cybercrime remains insubstantial for this task, highlighting the need for capacity building in this domain (Shacksnovis, 2019). Furthermore, the successful implementation and integration of the POPI Act, Cybercrimes Bill, and amended RICA are highly dependent on successful collaboration between private sector institutions and governmental agencies.

3.3.10 National Integrated ICT Policy White Paper of 2016

The National Integrated ICT Policy White Paper serves as an overarching policy framework for the transformation of South Africa into an "inclusive and innovative digital and knowledge society" (Republic of South Africa, 2016b:3). This White Paper includes detailed policy frameworks on highly relevant matters, including the collaboration required in building an inclusive digital society, facilitating innovation and competition, ICTs and matters of convergence, the protection of the Open Internet, and multiple other interventions facilitating the digital transformation of the South African society. This White Paper describes a South African Digital Society wherein the first pillar of this society is the "Digital transformation of the public service" (Republic of South Africa, 2016b:118). This framework states: "*A digital government uses ICTs and digital technologies to make government processes more efficient, strengthen public service delivery and enhance participation by citizens in governance.*"(Republic of South Africa, 2016b:118). Subsequently, the White Paper subdivides a digital government into four programmes:

1. Government to Government programmes (G2G)
2. Government to Citizen programmes (G2C)
3. Citizen to Government programmes (C2G)
4. Government to Business programmes (G2B)

Furthermore, this framework details eight critical principles of e-Government, which include cost-effectiveness, promoting affordable access to public services and information, ease of use, protecting privacy and security, confirmation of digital identities, implementing solutions, and monitoring its impact (Republic of South Africa, 2016b:120-121).

The national ICT policy also mandates the creation of a national e-Government strategy and roadmap based on a diagnostic assessment of the Republic's digital readiness across all spheres of government, including an analysis of various capabilities and a review of all current systems and technologies (Republic of South Africa, 2016b).

3.3.11 National e-Government Strategy and Roadmap of 2017

A key piece of legislation on e-Government in the South African context is the National e-Government Strategy and Roadmap. This strategy aims to digitise government services while transforming South Africa into an inclusive digital society where all citizens can benefit from the opportunities offered by digital and mobile technologies to improve their quality of life (Republic of South Africa, 2017b). The strategy provides a roadmap for improved service delivery and government information and services access. This strategy is an extension of the ECT Act of 2002 (Republic of South Africa, 2002) and the National ICT Policy White Paper of 2016.

The National e-Government strategy outlines a detailed approach to enhancing the Republics' e-Government capabilities, setting out defined e-Government channels and priorities, guided by clear strategic principles, objectives, and security measures.

3.3.12 National Digital and Future Skills Strategy of 2020

The National Digital and Future Skills Strategy of 2020 is the South African government's response to the growing need for fostering a South African workforce that is equipped with the relevant digital skills fit for the 4IR. This strategy addresses the need for mechanisms to foster digital skills development across South Africa at all levels of education and training. Through this strategy, the South African public service recognizes that digital skills are necessary for economic growth and social development across all sectors of society (Republic of South Africa, 2020:8). The strategy posits 8 strategy elements to foster a "Digital Skills Evolution".

The first four strategy elements focus on:

1. **Digital Foundations:** Basic and intermediate digital skills, where the Department of Basic Education, training institutions, TVET institutions and technology hubs are key actors;
2. **Digital Futures and Masters:** Building advanced digital skills, where the Departments of Higher Education and Training, Science and Innovation, universities and training institutions are key actors;
3. **Skills for Industry 4.0 and the world of work:** Where the Departments of Employment and Labour, and Trade, Industry and Competition, as well as industry, trade unions, NEDLAC, SETAs and other institutions are key actors;

4. **Creating Society 4.0 and addressing the digital skills divide:** Where people, social networks and institutions are active.

The other four cross-cutting strategy elements are:

5. Building digital skills awareness;
6. Research and monitoring on digital skills;
7. Co-ordination across government and stakeholder groups;
8. Funding for digital skills

3.4 Summary

Chapter 3 explored the relevant legislation and policies that affect the use of Big Data by public sector institutions in South Africa. This chapter addressed the fourth objective of this study: *To outline the policy and legislative framework affecting the implementation of Big Data technologies in the South African public sector*. This chapter served as the first step in funnelling the study from a generalised view, towards the South African public sector context. The chapter first considered international ICT and e-Government Regulatory Bodies whereafter it shifted to explore various South African e-Government, ICT and cybersecurity regulations and statutes. In looking at these regulations and laws, it is evident that the implementation of Big Data in the South African context, and worldwide, is rapidly becoming more regulated. The protection and ethical use of Big Data is being emphasised by various regulatory bodies and statutes. Subsequently, public sector entities must take special care in ensuring that these regulations and laws are adhered to in every transaction with Big Data.

Chapter 4: Research Design and Methodology

This chapter provides an overview of the research design and methodology used in the study. This discussion covers the research approach (design), methods applied, sampling, data collection, and data analysis. Ethical considerations and measures to ensure the reliability and validity of the findings are also discussed.

The research design and methodology are determined by the nature of the research question and the type of evidence required to address that problem. Thus, before selecting a specific design and methodology, one must consider the nature of the questions asked in this study.

4.1 Primary Research Question and Objective

Stemming from the above, the primary research question of this study is:

To what extent can Big Data add value to the public sector within the context of the Western Cape Department of Agriculture (WCDoA)?

Given this primary research question, the primary research objective is as follows:

To determine the extent to which Big Data can add value to the public sector within the context of the Western Cape Department of Agriculture (WCDOA).

4.2 Secondary Research Questions and Objectives

Following the primary research question and objectives, the secondary or sub-research questions are as follow:

1. *What is Big Data?*
2. *What are the current applications of Big Data in the public sector?*
3. *What are the limitations faced when implementing Big Data-driven technologies in the public sector?*
4. *How does the South African policy and legislative framework affect the implementation of Big Data-driven technologies in the South African public sector?*
5. *How relevant are Big Data-driven technologies to the context of the Western Cape Provincial Department of Agriculture?*
6. *How attainable is the implementation of Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture?*
7. *How do the questions above interact and inform the implementation of Big Data in the South African public sector?*

In order to address the respective secondary research questions, the following secondary research objectives form the basis of the study:

i. To define Big Data
ii. To describe the current applications of Big Data in the public sector
iii. To explore the limitations faced when implementing Big Data-driven technologies in the public sector
iv. To outline the policy and legislative framework affecting the implementation of Big Data-driven technologies in the South African public sector
v. To determine the relevance of Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture
vi. To determine the attainability of implementing Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture
vii. To develop a conceptual framework that can guide the implementation of Big Data in the South African public sector outlining the sources of Big Data, its characteristics, challenges, processes, applications, and value

4.3 Research Design

Research design can be defined as the plan for a study, providing the overall framework for collecting data to answer the research question(s) (Babbie & Mouton, 2018). The research design of a study acts as a strategic framework that serves as a bridge between the research questions and the execution of the research strategy (Terre Blanche, Durrheim & Painter, 2006). MacMillan and Schumacher (2001) posit that the goal of a sound research design is to provide results that are judged to be credible.

Babbie and Mouton (2018) suggest that the first step in determining a research project's appropriate design and methodology lies in defining the nature of the research question(s) as either empirical or non-empirical.

Empirical questions relate to that which is experienced or observed. The term “empirical” is derived from the Greek term for experience, “empereia” (Cassim, 2021). Therefore, empirical questions utilise methods to investigate the world by means of observations and experience. Consequently, non-empirical questions lead to philosophical or conceptual analysis, theory building, and/or literature review.

Following this study's research aim and objectives, an interpretivist approach was identified as the appropriate research design. This approach lends itself to a qualitative research design, which rests on the premise that the phenomenon under study is socially constructed and can be viewed from different viewpoints (Cassim, 2021). Qualitative research is characteristically inductive, subjective, and contextual (Morgan, 2014). In qualitative research, induction allows for the generation of theory from observations and is oriented to discovering and exploring a phenomenon. Qualitative research thus emphasises meanings and interpretation and attempts to understand various perspectives. Finally, this research approach emphasises contextual depth and detail whilst analysing systems holistically. Whilst the study is predominantly qualitative in nature, the small questionnaire component of the study was quantitative, leading to the statistical analysis of its findings. This means that this study followed an exploratory sequential mixed-methods approach. With this design, qualitative methods are dominant and are applied first in the research process. These qualitative methods are then followed by (secondary) quantitative methods, which are often in the form of a questionnaire or other forms of quantitative data collection. Figure 4.1 below illustrates the research design in the context of this study.

The first phase of this study comprises qualitative methods, exploring the concept of Big Data use in the public sector, and highlighting key conceptual themes. The result of this analysis was used to direct the next quantitative phase in the form of a quantitative questionnaire. Here it is important to note that the purpose of this questionnaire was not to create a statistical model or prove a statistical hypothesis but rather to gain insight into the perception of departmental employees against a set of questions based on the TAM as explored in the literature review.

4.4 Research Methodology

The difference between research design and methodology can be distinguished by Babbie and Mouton’s (2018) analogy of constructing a house. Suppose the research design is the plan or blueprint of the house. In that case, the research methodology refers to the systematic, methodological execution of the design, including the various methods and tools to perform the different tasks (Babbie & Mouton, 2018).

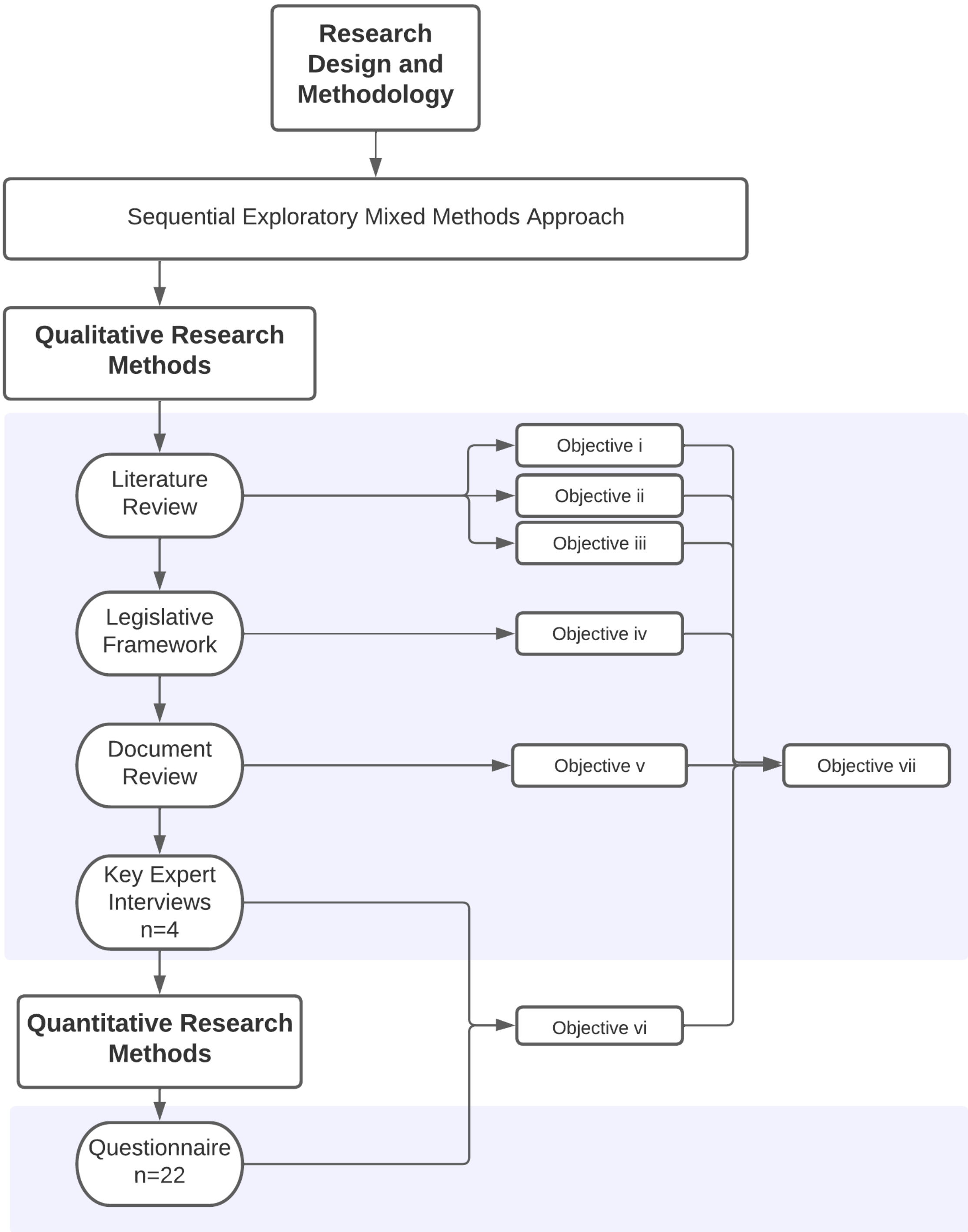

Figure 0.1 - Research Design and Methodology of this Research Study (Author, 2022)

This study's sequential exploratory mixed methods design utilised predominantly qualitative methods, including a literature review, legislative framework, and case study consisting of a document review and key expert interviews. This was followed by a quantitative questionnaire addressing research objective vi (summarised in Figure 4.1). As shown in Figure 4.1, various research methods were utilised in this study. The following subsections will include a discussion of each method employed. Finally, research objectives i to vi together inform the development of the theoretical framework set out by objective vii.

This study aimed to gain a deeper understanding of Big Data use in the public sector. The need for a greater understanding or exploration of this complex phenomenon increased the need for a qualitative-dominant approach.

4.4.1 The Literature Review

An extensive literature review has been conducted on available secondary data that included academic journal articles, conference publications, and relevant reports from credible sources in the field of Big Data technologies applied to a public sector context. The literature review and legislative framework thus address research objectives i, ii, iii, and iv.

Relating a research study to an existing body of knowledge is the cornerstone of all academic research activities. This is done by means of a literature review – a more or less systematic way of collecting and synthesising previous research. The literature review creates a strong foundation for improved knowledge and understanding and facilitates theory development if done thoroughly.

There are three primary advantages of an effective literature review. The first advantage is its ability to integrate findings and perspectives from various studies, allowing it to address research questions with a power that no single study has. Secondly, a well-executed literature review can provide an overview of study areas where research is disparate and interdisciplinary (Snyder, 2019). Finally, the literature review has the potential to synthesise research findings and uncover areas where further research is needed.

When looking at research objectives i – iii (linked to the main research question: *To what extent can Big Data analytics add value to the public sector?)*, the literature review proves to be the best methodological tool to answer these questions. The literature review is useful in this instance as the objectives aim to provide an overview of Big Data use in a public sector context. However, for the literature review to be a sound methodology, proper steps must be followed to ensure that the review is accurate, precise, and trustworthy.

Snyders (2019:334) distinguishes between three main review methodologies: systematic, semi-systematic, and integrative. These three approaches to the literature review are summarised in Table 4.1 below.

Table 0.1 - Snyder's three approaches to the literature review (Snyder, 2019:334)

Approach	Systematic	Semi-systematic	Integrative
Typical Purpose	Synthesise and compare evidence	Overview of the research area and track development over time	Critique and synthesise
Research Question	Specific	Broad	Narrow or broad
Search Strategy	Systematic	May or may not be systematic	Usually not systematic
Sample Characteristics	Quantitative articles	Research articles	Research articles, books and other published texts
Analysis and Evaluation	Quantitative	Qualitative/Quantitative	Qualitative
Examples of Contribution	• Evidence of effect • Inform policy and practice	• State of knowledge • Themes in literature • Historical overview • Theoretical model	• Taxonomy or classification • Theoretical model or framework

The systematic approach involves strict guidelines for a search strategy and selecting articles to review. This approach effectively synthesises the findings of this set collection of studies in terms of a particular question and can provide evidence of an effect. However, this is not the ideal strategy for the study at hand, nor is the integrative approach. The integrative approach is ideal when the research question requires a creative approach to data collection. This approach is applied when the review aims not to cover all published articles on the topic but to combine perspectives to create new theoretical models.

With the systematic approach on one side of the continuum and the integrative approach on the other, perhaps the approach bridging these two is most appropriate for this study. The semi-systematic review is useful to study a broader topic that has been conceptualised differently and studied within various disciplines. This is a good strategy to utilise if one is looking to map theoretical approaches or themes and identify knowledge gaps within the existing literature. In this study, a semi-systematic literature review and the qualitative analysis thereof contribute to a synthesised knowledge of relevant themes and a greater understanding of the topic at large (see Chapter 2).

4.4.2 The Legislative Framework

The legislative framework in this study (see Chapter 3) acted as the first step in funneling the study from Big Data in the public sector in general toward the South African public sector context. This set the scene for the following case study chapter (see Chapter 5).

The purpose of the legislative framework was to consider the various laws and policies affecting the implementation of Dig Data analytics in the South African public sector. The focus of the legislative framework is primarily on national policies and laws.

4.4.3 The Case Study

There are many public sector industries which could be transformed through the implementation of Big Data technologies in different ways. Thus, to narrow the scope of the study, the literature study and legislative review were followed by a case study component focusing solely on the Western Cape Provincial Department of Agriculture.

According to Babbie and Mouton (2018:281), a case study allows for the intensive investigation of the interaction between a unit of analysis and a specific context. The case study component of this research allowed for a deeper understanding of the theoretical components (as unpacked in the broader literature review) against a specific contextual backdrop. In this research, the case study unit of analysis was the Provincial Department of Agriculture. This component enabled the study to be more than a mere theoretical analysis of public sector Big Data use and provide insight into how the theory relates to practice within a specific setting considering multiple contextual variables.

The case study explored two key components: *relevance* and *attainability*, as depicted in Figure 4.2 below:

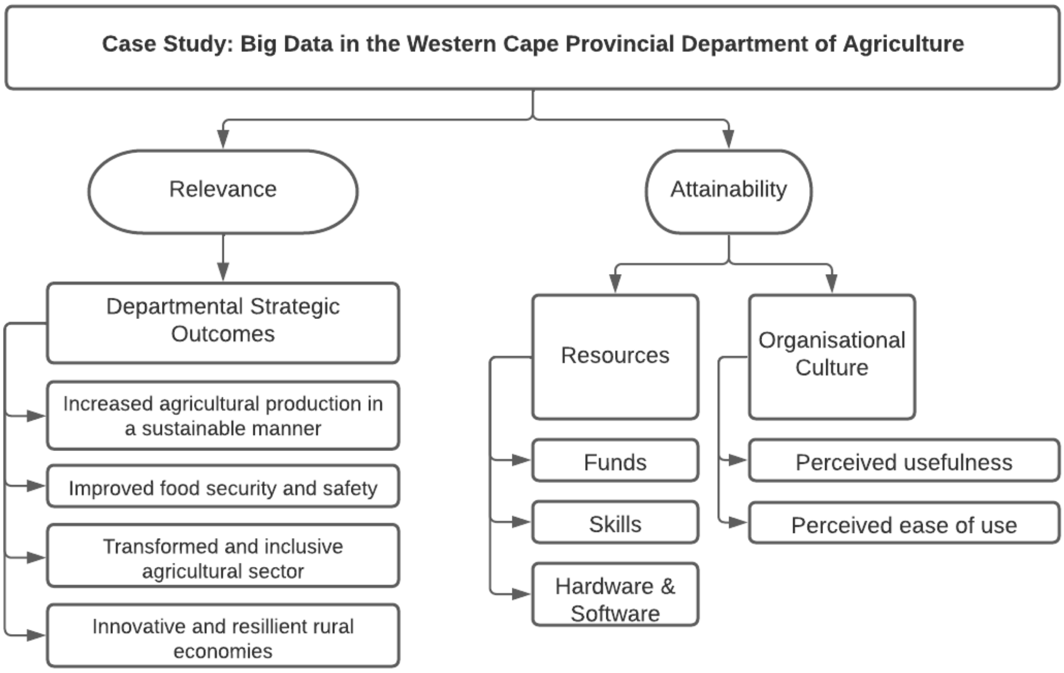

Figure 0.2 - Key components under investigation in the case study (Author, 2022)

This study's case study component included three methodologies: a document analysis, semi-structured key expert interviews, and a small quantitative questionnaire.

- **Document analysis of departmental reports, publications, and strategy documents**

The concept of relevance (objective v) was studied by analysing the value of Big Data in terms of the department's four key strategic outcomes. This was achieved using document analysis of secondary data (departmental publications, documents, and reports). During this process, the researcher analysed a set of departmental reports, publications, and strategy documents to assess how Big Data-driven solutions are (or could possibly be) relevant to the department's work. The researcher chose to measure this exploration of relevance against the Department's four key strategic outcomes, as these outcomes are clearly defined and measurable goals towards which the Department is working.

- **Semi-structured key expert interviews**

The study shifted focus toward the attainability of implementing Big Data technologies within the department. The attainability was examined in terms of the department's available funding, resources (human, hardware, and software), as well as its organisational culture. Information on the department's available funding and other resources was obtained by means of key expert interviews. Key experts included the department's senior strategic and operational heads (see Annexure I for a list of the interviewees' roles).

Interviews are structured conversations consisting of main questions, follow-up questions, and probes (Rubin & Rubin, 2005). The main questions address the key research questions. These questions are worked out in advance to cover the main areas of the research problem. Following the main questions, follow-up questions address any concepts or new themes introduced by the interviewee. Finally, probes help guide the discussion in the desired direction, keeping the conversation on the topic and asking for examples and/or clarification where needed. These questions assist in answering the research questions with the needed depth, detail, and nuance. This study followed a “tree-and-branch” approach to the interview. This approach was useful in answering research questions that can be divided into more or less equal parts (Rubin & Rubin, 2005). The semi-structured interview questions are depicted in the “tree-and-branch” figure in Annexure A (see Figure A1, Annexure A). Annexure B follows with the interview guide and list of semi-structured interview questions.

- **Questionnaire**

Following the semi-structured key expert interviews, a questionnaire was used to gather primary data on the organisational culture within the department (see Annexure C). This organisational culture questionnaire was based on the TAM discussed in the literature review and completed by employees within the department. The nature and analysis of the questionnaire findings were quantitative. Following the dominant qualitative methods, this quantitative questionnaire led this study to be classified as a sequential exploratory mixed-methods approach. Once again, it is important to note that, despite the quantitative questionnaire, the qualitative methods employed in this study remain dominant. Whilst the questionnaire responses underwent basic statistical analysis, the purpose of the questionnaire was for the researcher to render an overall view of departmental employees’ perceived usefulness and ease of use of Big Data technologies. The purpose of the quantitative questionnaire was not to formulate a mathematical theory, establish a correlation or prove a particular hypothesis.

The questionnaire is a valuable research tool for determining the views of a large population group (Brynard, Hanekom & Brynard, 2017:48). This instrument allows for collecting specific primary data that would not exist if it was not for the study at hand (O’Leary, 2014). The questionnaire was the chosen research tool to address the research questions regarding organisational culture and the perception of Big Data analytics amongst the departmental employees. This tool was appropriate for reaching this objective as it allowed gathering information from various respondents. Furthermore, when conducting research that adheres to COVID-19 safety regulations, administering an electronic questionnaire proved to be a safe tool for researchers and respondents alike. However, this tool is not free from disadvantages. Disadvantages include the challenge that the researcher is not at hand to explain any uncertainties the respondents may have. Furthermore, given the electronic nature of the questionnaire in this study, the response rate was low. Finally, the nature of the online questionnaire rests on the premise that the respondents have access to a computer, Internet connectivity, and data to complete and submit their responses. These disadvantages were considered in the questionnaire design, the description preceding the questions, and follow-up communication with respondents to encourage them to complete the questionnaire. Another imperative element to the success of this tool was the support of departmental leadership and their encouragement to their staff members to partake in the study.

4.5 Sampling, Data Collection, And Analysis

This section includes a discussion of the sampling methods used in the study, followed by the collection and analysis of data.

4.5.1 Sampling

The sampling process provided the researcher with a means of selecting a small group (the sample) to study to determine the general characteristics of the population as a whole. The sampling process is used to simplify research, save time, and cut costs, all while determining specific properties of the whole (Brynard, Brynard & Hanekom, 2014:56).

In this study, the Western Cape Provincial Department of Agriculture was the unit of analysis. With an employee population of nearly 400 people, it is clear that a sampling process was required for this study. Interviewing each of these employees would result in a lengthy and expensive study. Furthermore, not all members of this population could make an equally valuable contribution to the study. The questions may be more relevant to some than to others as some employees' nature of their roles has no relation to Big Data technologies. For example, the Departmental Head of Technology and Innovation could contribute much more to funds for new Big Data technologies than an employee responsible for maintaining the departmental fleet.

For the key expert interviews, non-probability sampling methods were followed. The interviews commenced with a purposive sample (also known as "judgement sample") of two individuals, including the departmental Chief Director of Research and Technology Development and the departmental Specialist Data Scientist. Thereafter, the researcher used snowball sampling, asking each of the initial interviewees for one or two references to individuals who could add value to the study. Two new participants were recruited via the initial judgement sample, bringing the ultimate number of interviewees to n = 4.

The questionnaire sample group was determined by the non-probability method, accidental sampling. Thus, all members of the population (employees of the department) did not have an equal chance of being selected to complete the questionnaire. Also known as "grab" or opportunity sampling, this sampling method occurred when the researcher asked interview participants and other members of the departmental leadership to distribute the electronic questionnaire to their colleagues and teams. The questionnaire was distributed throughout the department via various streams. Still, it cannot be said that it was distributed to the entire population and/or that each employee had a similar likelihood of completing the questionnaire. This method thus provided some limitations in terms of ensuring a sample group which varies in age, gender, educational background, tenure, and role. The sample size of the questionnaire was n = 22. This is further discussed in Section 4.6 on the scope and limitations of this study.

4.5.2 Data Collection

Secondary data were utilised in the literature review, legislative framework, and case study chapters. Primary data were collected during the key expert interviews and questionnaires.

4.5.2.1 Key Expert Interviews

The key expert interviews took place virtually, using either MS Teams or Zoom as a platform (depending on the interviewee's preference). These interviews included several pre-determined questions, followed by follow-up questions and probes. The interviews were recorded (with the participant's consent) so the researcher could decode the responses afterwards. Interview recordings and transcripts were backed up and stored on the researcher's computer and on secure cloud storage to ensure the data's security.

4.5.2.2 Questionnaire

The questionnaire was administered electronically. An email containing all the necessary information and consent agreements was sent to participants. This email included a URL/link to the online consent form and questionnaire to be completed and submitted online by the respondents. The questionnaire responses were backed up and stored on the researcher's computer and on secure cloud storage to ensure the data's security.

4.5.3 Data Analysis

Data used in this study underwent mostly qualitative analysis. However, the questionnaire data were analysed quantitatively. The literature review, legislative framework, and case study involved qualitative data analysis. Such data sources included: published academic papers, journal articles, reports, statutes and policies, departmental reports, and publications.

The data collected through the key expert interviews were analysed for any recurring themes, new insights, and agreement and/or disagreement between the various responses.

The questionnaire responses were analysed quantitatively. However, its findings provided qualitative insights on two elements: the employees perceived usefulness of Big Data in their roles and their perceived ease of use towards applying such technologies in their roles. The analysis of this data closely considered the variables of age, gender, tenure, education, and role, as these factors could affect an individual's perception of Big Data use in their workplace.

4.6 Scope And Limitations of the Study

The scope of this study is limited to the use of Big Data by public sector organisations and institutions. However, key elements of private sector Big Data use were briefly touched on compared with public sector Big Data use.

This was followed by the context-specific case study limited to the Western Cape Province of South Africa and its Provincial Department of Agriculture. Relating the topic to a specific case study limited the study's capacity for generalising findings as these findings are context specific. Another limitation to note is the relatively low response rate on the questionnaire. The researcher aimed to collect responses from a larger sample size, but the final sample size was $n = 22$. However, the questionnaire aimed to ascertain qualitative insight into the perception of departmental employees on Big Data and the implementation of such technologies in their jobs. The sample size of $n = 22$ was thus sufficient for gaining such insight. Subsequently, the researcher remained wary of making sweeping judgements or generalisations based on the questionnaire findings. Whilst it did represent the views of departmental employees and did render some insight, the questionnaire findings do not represent the entire department. In addition to the small sample size, because of the non-random sampling method, statistical inference is not possible, and therefore findings cannot be extrapolated beyond that sample. This limitation is distinct from the limitation due to sample size. Once again, whilst the findings are not statistically authoritative, they are suggestive and may give limited insight.

The public sector use of Big Data through various technologies and applications is a relatively new phenomenon in public sector research. Although research regarding this topic exists, there is a limited amount of existing literature available in terms of a South African case study context.

4.7 Ethical Considerations

This study adhered to the ethical process of the University of Stellenbosch as set out in its Research Ethics Policy Document, which governed the actions of the researcher, the protection of participants, and the security and confidentiality of both respondents and information. Furthermore, this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments.

Full permission has been requested from the WCDoA to use the organisation’s name in the study and access information not in the public domain. Furthermore, all interviewees were given adequate information prior to their interviews and were requested to provide agreement to participate in the study (see Annexures D & E). Finally, participants were allowed to leave the study if they wished to continue no longer. All participants offered anonymity, and data were handled confidentially, backed up, and stored securely.

4.8 Summary And Conclusion

This chapter has set out and defended this study’s chosen research design and methodology. It has also elaborated on the sampling procedures, data collection, and analysis processes administered. Finally, this chapter included the ethical considerations involved in the research design and methodology of the study.

Chapter 5: Case Study

Chapters 1 to 3 of this study have addressed the first four research objectives. In these chapters, the researcher has defined the concept of Big Data and its related technologies (objective i), discussed the various applications of Big Data in the public sector (objective ii), described the various limitations of implementing Big Data in the public sector (objective iii), and finally, outlined the legal and policy framework affecting the implementation of Big Data technologies in the South African public sector context (objective iv).

Having addressed objectives i – iv, it is now necessary to funnel the scope of the study to focus on the case study unit of analysis – the WCDoA. In this case study, the final two research objectives are addressed. Firstly, this chapter considers the *relevance* of Big Data-driven solutions to the department in light of its four key departmental strategic outcomes (DSOs) (objective v). Secondly, this chapter unpacks the *attainability* (resources and organisational culture) of implementing Big Data-driven technologies in the department (objective vi).

5.1 The Evolution of Big Data-driven Agriculture

Despite significant growth in food production over the past half-century, one of the most pressing issues today is how to feed an expected population of approximately nine billion by the mid-21st century. It is estimated that food production must increase at least 70% to meet this ever-growing demand (Western Cape Department of Agriculture, 2018). Furthermore, this must happen within the context of climate change and its repercussions.

Agriculture focussed ICTs have grown significantly over the past decade, both in scale and scope. The use of Big Data analysis and related technologies have revolutionised this sector (Food and Agriculture Organisation of the United Nations, 2017). Today, the use of digital technologies – including smartphones, tablets, sensors, drones, and satellites – is widespread in agriculture, providing a range of farming solutions such as remote measurement of soil conditions, improved water management, and livestock and crop monitoring. Precision agriculture has, for instance, provided producers with many types of sensors for recording relevant parameters and different farm-management systems. Digitisation moreover helps improve working conditions on farms and can reduce the environmental impacts of agriculture (for example, by using electronic drones to monitor crops instead of driving fuel-heavy tractors or vehicles). In addition, electronically controlled machinery is becoming highly advanced and enables various cyber-physical systems by networking various devices. This allows farmers to plan more effectively and efficiently, enabling improved crop yields and optimised process inputs and labour reduction.

This phenomenon, known as ‘AgTech’ or Agriculture 4.0, is particularly noticeable in countries such as the USA, Israel, China, and India, pushing the boundaries of modern-day agriculture. A key case study of agricultural technology and innovation is the Netherlands, a country that, despite its limited arable land, is the sixth largest food exporter in the world (Worldatlas, 2022).

AgTech holds significant promise to increase the productivity and efficiency of the agricultural sector in the following specific categories (AFGRI, 2017): 1) farm management software, 2) precision agriculture and predictive data analytics, 3) sensors that enable farmers to collect data and monitor crop health, weather, and soil quality, 4) software and hardware aimed at better understanding livestock breeding patterns and genetics, 5) robotics and drones, 6) smart irrigation, and 7) new marketplaces where technological platforms connect farmers directly to suppliers or consumers.

Although agriculture still needs to catch up with other industries such as retail and manufacturing, AgTech adoption will inevitably thrive during the 4IR as the global demand for agricultural products is rising. At the same time, AgTech can address the increasing need of consumers, retailers, and participants in the agriculture value-chain to have information on product quality and transparency regarding production activities (Food and Agriculture Organisation of the United Nations, n.d.).

The challenges posed by climate change and global food insecurity will continue to strengthen the case for technological innovation in agriculture. However, these new developments create many further questions. Not every solution that is technologically feasible will become a reality. Therefore, these technologies must at all times be assessed in the context of global social, economic, and political developments and the specific context in which they will be implemented (de Wilde, 2016).

5.2 Introduction to the Western Cape Provincial Department of Agriculture

The Western Cape Province is one of South Africa’s nine provinces. Situated on the country's South-Western coast, this is the fourth largest of the nine provinces, covering 129 370 square kilometres of land (Western Cape Government, n.d.b). As the third most populous province, the Western Cape recorded an estimated 7 million inhabitants in 2020, of which more than two-thirds are based in the metropolitan area of Cape Town (Western Cape Government: Department of the Premier, 2021).

Although the province's climate varies greatly in different areas, the province is synonymous with fertile soil and rich coastal areas, which are extremely fitting for agricultural activities. In 2020, agriculture and agri-processing contributed 8% to the total economic activity in the province (Western Cape Provincial Treasury, 2021). Furthermore, these sectors accounted for 10.4% of employment opportunities in the province (Western Cape Provincial Treasury, 2021). Key agriculture activities in the region involve the production of wine, deciduous fruit, citrus, grain, fynbos, vegetables, ostriches, small and large stock, as well as milk and dairy products (Western Cape Government, n.d.a). Agriculture is not only a key economic sector of the Province but also accounts for approximately 45% of South Africa’s national agricultural exports (Western Cape Government, n.d.a). The agricultural sector of the Western Cape is responsible for more than 90% of national exports of blueberries, bulk wine, pears, bottled wine, and apples (Western Cape Provincial Treasury, 2021). Table 5.1 below depicts the ten biggest agricultural and agri-processing exports of 2019.

Table 0.1 - Biggest WC Agricultural and Agri Processing Exports by Value (WCDoA, 2020:26)

#	Description	Exports 2019 (Rands)	Share 2019	Real Growth 2018 - 2019
1	Table Grapes	6 317 361 525	9.77%	0.35%
2	Oranges	5 801 759 106	8.97%	-19.49%
3	Bottled Wine	5 768 930 571	8.92%	-7.47%
4	Apples	4 559 803 299	7.05%	0.80%
5	Soft Citrus	2 989 020 818	4.62%	10.26%
6	Pears	2 427 512 136	3.75%	-0.12%
7	Lemons & Limes	2 007 515 526	3.10%	6.74%
8	Bulk Wine (>10L containers)	1 837 606 510	2.84%	-22.64%
9	Hake Fillets	1 764 731 844	2.73%	1.36%
10	Cigarettes	1 764 731 844	2.54%	4.69%

According to the Western Cape's 2021 Provincial Economic Review and Outlook (PERO), the period between 2016 and 2020 saw an average annual export growth of -1.2% in the Western Cape (Western Cape Provincial Treasury, 2021:7). This was largely affected by the COVID-19 pandemic, during which export growth in the Western Cape was contracted by 3.5 per cent in 2020 (Western Cape Provincial Treasury, 2021:7). However, due to a considerable growth rate (recovery) of 44.2% in the 2020/2021 financial year, the province's agricultural sector acted as the largest positive contributor to export growth during this period (Western Cape Provincial Treasury, 2021:7).

Situated in the beautiful Boland region of the province, the Western Cape Provincial Department of Agriculture is responsible for the promotion of the agricultural industry of the province. The department provides a wide range of development, research, and support services to the agricultural community in the Western Cape and envisions a *"united, responsive and prosperous agricultural sector in balance with nature"* (Western Cape Government, n.d.a:Online). The department's mission statement is as follows (Western Cape Government, n.d.a:Online):

Unlocking the full potential of agriculture to enhance the economic, ecological and social wealth of all the people of the Western Cape through:

- *Encouraging sound stakeholder engagements;*
- *Promoting the production of affordable, nutritious, safe and accessible food, fibre and agricultural products;*
- *Ensuring sustainable management of natural resources;*
- *Executing cutting-edge and relevant research and technology development;*
- *Developing, retaining and attracting skills and human capital;*
- *Providing a competent and professional extension support service;*
- *Enhancing market access for the entire agricultural sector;*
- *Contributing towards alleviation of poverty and hunger, and*
- *Ensuring transparent and effective governance.*

Under the leadership of Minister Ivan Meyer (Member of the Executive Council), this department employs a staff complement of approximately 400 individuals subdivided into three key directorates: 1) Agricultural Research and Regulatory Services, 2) Agricultural

Development and Support Services, and 3) Business Planning and Strategy. Annexure F depicts the departmental organogram.

The department offers a wide range of services to the agricultural community of the Western Cape Province. These services include:

- Research and technology development services to animal and crop producers in the Western Cape.
- Agricultural advice and guidance to the agricultural community and all users of natural resources.
- Agriculture infrastructure to qualifying farmers.
- Agricultural training, including higher- and further education. Conservation of natural resources.
- Agricultural engineering services.
- Analytical services at our plant pathology and water and soil laboratories.
- Diagnostic and analytical services at our veterinary laboratories.
- Veterinary health services.
- Coordination of rural development in 14 different nodes across the province.

In its study on the future of the Western Cape agricultural sector in the context of the 4IR, the department has identified "megatrends" affecting change in farming activities in the province. All leading to disruption of the sector, these include a growing population, urbanisation, agricultural technology, societal changes, climate change, globalised trade, biotechnology, integrated value chains, and new international regulations. Table 5.2 below summarises these megatrends (Western Cape Department of Agriculture, 2018:13).

Table 0.2 - 4IR megatrends affecting the Western Cape Province's Agricultural Sector (Western Cape Department of Agriculture, 2018:13)

Megatrend	Description
Growing Population	The Western Cape's population will exceed 10 million by 2050
Urbanisation	67% of Western Cape residents live in the City of Cape Town
Climate Change	Changing weather conditions affect water, soil quality, and crop yields
Societal Changes	The need for resource-intensive food products increases
Globalized Trade	Crops are grown in the most suitable locations, processed, and sold internationally
Agriculture Technology	New technologies trigger higher yields and cost reductions
Biotechnology	Genomics and genetic modification help to improve existing crop varieties
Integrated Value Chain	Large producers start integrating vertically to optimise their value chain
International Regulations	Global exports lead to regulatory predicaments between countries

When looking at the province's growing population, effects of climate change, increasing inequality, and rapid technological advances of the 4IR, it is evident that these megatrends are heavily impacting the environment in which the Department operates. In attempting to address the question of relevance to the department, one must consider the literature review findings, use-case scenarios of public sector Big Data and AgTech pioneers, and ultimately, cross reference this information with the department's main success measures – their DSOs. One must thus ask, after everything we have learnt about Big Data-driven technologies, how relevant are these innovations in assisting the department in delivering on their set strategic outcomes? Section 5.3 below addresses this question.

5.3 Determining the Relevance of Big Data to the Western Cape Provincial Department of Agriculture

Whilst the literature review has addressed the relevance of such technologies to the public sector in general, one must follow a more defined approach in investigating this phenomenon at the departmental level. This section addresses research objective v: *To determine the relevance of Big Data-driven technologies within the context of the Western Cape Provincial Department of Agriculture.* The process of addressing this objective should thus be guided by the word "relevance". The notion of relevance is not a simple one, especially not when combined with a novel and a rather abstract concept such as Big Data. Without diving into the semantics of an operational definition of the term, broadly defined, "relevance" considers the manner in which two variables are closely connected or appropriate. The term "relevance" thus indicates an investigation into how Big Data technologies can contribute to the department's functioning in a meaningful, valuable, and/or applicable manner.

In order to assess the relevance of Big Data to the functioning of the department in a measurable manner, this section is guided by the department's key strategic outcomes.

The WCDoA, as with all other state and/or provincial departments, operates within the realm of national strategic priorities. Table 5.3 below provides a summary of the alignment of the WCDoA's strategic objectives (Western Cape Department of Agriculture, 2020a) to the NDP National Outcomes (NO) (Republic of South Africa, 2012) and Western Cape Government's Provincial Strategic Priorities (PSP) (Western Cape Government: Department of the Premier, 2021).

Table 0.3 - Alignment of the WCDoA strategic priorities to the Western Cape Provincial Strategic Priorities and National Development Plan's National Outcomes (Author, 2022)

Alignment on Economic Growth and Employment	
DSO 1	Increased agricultural production in a sustainable manner
PSP 2	Growth and Jobs
NO 4	Decent employment through inclusive growth.
Alignment on Environmental Sustainability	
DSO 1	Increased agricultural production in a sustainable manner
DSO 2	Improved food security and safety
NO 10	Protect and enhance natural assets
NO 7	Vibrant, equitable, sustainable rural communities contributing toward food security
Alignment on Human Capital	
DSO 3	Transformed and inclusive agricultural sector
PSP 3	Empowering people
NO 4	Decent employment through inclusive growth.
NO 5	A skilled and capable workforce to support an inclusive growth path
Alignment on Economic Opportunity	
DSO 4	Innovative and resilient rural economies
PSP 3	Empowering People
PSP 5	Innovation and culture
NO 7	Vibrant, equitable, sustainable rural communities contributing toward food security

The alignment of these four streams (Economic Growth and Employment, Environmental Sustainability, Human Capital, and Economic Opportunity) are discussed in terms of the department's strategic outcomes and the relevance (or lack thereof) of Big Data technologies to each.

5.3.1 Increased Agricultural Production in a Sustainable Manner

The first DSO relates to *increased agricultural production in a sustainable manner*. This outcome is expanded upon by means of four sub-outcomes to be achieved within five years (2020/22–2024/25). These sub-outcomes aim that the sector's provincial export position must be maintained, the value-add of agri-processing in the process must be enhanced, water and land resources must be used sustainably, and the climate change sustainability of the sector must be improved.

Vast information sets generated by remote sensing technologies such as drones, satellites, soil monitors, and infrared sensors can produce a multitude of insights on weather and land conditions. This sort of information can inform and guide farmers in monitoring the productivity of their land, anticipating disasters such as droughts, and planting crops that best suit the specific conditions of their land. Subsequently, such Big Data-informed farming can increase productivity, reduce waste, and assist farmers in monitoring the conditions of their resources. Furthermore, such insight can assist the sector in pre-empting natural disasters, land degradation, and desertification and ultimately enhance the sector's resilience towards climate change and related disasters. The department's Fruitlook application is an example of a Big Data-driven farm management tool. This web-based portal provides the agricultural sector of the province with near real-time data on the growth, moisture, and minerals of crops. Funded by the WCDoA, this application is free of charge to all role players in the sector, informing operations and management decisions relating to irrigation, scheduling, and crop production (Fruitlook, n.d.). Refer to Annexure G for screenshots of this application.

Increased production and resilience against risks will indirectly assist the sector in maintaining its export position. Big Data information sets can also provide valuable insights into market trends and the demand for agricultural goods. Information (Big Data) gathered from a vast number of sources – nationally and internationally – will enable the department to tailor its offering to perfectly cater for demand and anticipate gaps in the market for agricultural goods from the province. This will, in turn, indirectly guide the agri-processing activities to produce goods according to these insights. According to the South African Council for Scientific and Industrial Research (CSIR), Agri processing refers to the subset of the manufacturing sector that processes raw materials and intermediate products derived from the agricultural sector (CSIR, n.d.).

The sub-outcome of an enhanced value-add of agri-processing in the province can be directly influenced by automation, AI, machine learning, and smart production systems. By introducing such technologies to the agri-processing industry of the province, production costs could be minimised through the increase in production efficiency beyond that of conventional processing methods. However, this brings concerns for the labour sector (manual labour that will be replaced with technology) and the employment of agri-workers. This issue is elaborated upon in Section 5.3.3 below.

Table 5.4 below summarises these solutions in terms of their possible effect on the various sub-outcomes of this DSO.

Table 0.4 - Big Data-driven solutions and their possible relevance to the sub-outcomes of DSO 1 (Author, 2022)

DSO 1. Increased Agricultural Production in a Sustainable Manner					
Big Data-driven solution per sub-outcome:	1.1 Maintain export position	1.2 Enhance agri-processing value-add	1.3 Increase sustainable agricultural production	1.4 Optimise sustainable utilisation of water and land resources	1.5 Enhance climate change sustainability
Remote sensing technologies to produce insight on and monitor land conditions and crop productivity	Indirect		Direct	Direct	Direct
Big Data-driven market trend analysis	Direct	Indirect			
Automation, artificial intelligence, and machine learning in agri-processing	Indirect	Direct	Direct		

5.3.2 Improved Food Security and Safety

The second DSO relates to *improved food security and safety*. Under this strategic objective, the department sets out to attain three sub-outcomes: increased access to food produced by communities or households, ensured affordability of food, and the production of food that is safe for consumption (especially animal products).

The first sub-outcome (increased access to food produced by communities or households) relates to primary production by increasing access to community/household-produced food (Western Cape Department of Agriculture, 2020a), thus own production for own consumption via households or community gardens. Here, the example of the Fruitlook application is once again relevant. As described in Section 5.3.1, this application can assist farmers in increasing the productivity of their crops. What is critically important is that the department ensures that applications such as Fruitlook can assist *any* farmer and not just the tech-savvy commercial producers. Thus, it is critical that the application (and future similar applications) is free of charge, requires little data to access, and is easily accessible via the cell phones of subsistence farmers and community gardens who might not have unlimited Internet access or desktop computers. From an operational perspective, the department can utilise Big Data-driven technologies to monitor the performance of community gardens, track best practice initiatives, share information, and provide tailored support.

Those unable to produce their own food are forced to purchase it from others. For this reason, the containment of food price inflation by increased primary production is the second sub-outcome of improved food security and safety. Furthermore, productivity-enhancing applications such as remote sensing technologies can also assist in keeping production costs low and reducing waste, therefore lowering the price of food.

Big Data can also assist with optimising the transport and delivery of agricultural and Agri-processed goods, which is a key contributor to the increase in the price of food. Big Data technologies can ensure seamless deliveries by monitoring and analysing traffic patterns, road conditions and construction, weather, road closures, and distance. With this information, AI considers these multiple factors when calculating routes and the resources required (fuel and maintenance) for delivery from point A to B. Furthermore, through smart processing connected via the IoTs, production equipment is able to "self-communicate" its maintenance needs, informing plant personnel when certain stock needs to be ordered, or machinery parts need to be decommissioned. This can reduce time spent waiting for stock or parts via predictive inventory management and the avoidance of plant failures or mechanical errors. Less time spent on fixing broken machines means more time for production. Efficient production will thus lower the cost of the final product.

The third sub-outcome towards improved food security and safety is to *ensure that animal products are safe for consumption*. When looking at Agri-processed goods, quality is one of the key factors that require particular attention. Meat and dairy products such as milk, yoghurt or cream are examples of perishable temperature-sensitive products requiring highly controlled environmental conditions. Yet again, information obtained via the IoT can assist in monitoring the shelf life and conditions of such perishables. Information is thus shared between the cold storage truck or storage unit, the producer, and the recipient (chain store). This makes it possible to easily replace damaged or expired products and carry out prevention measures to keep products fresh.

Table 5.5 below summarises these solutions in terms of their possible effect on the various sub-outcomes of this DSO.

Table 0.5 - Big Data-driven solutions and their possible relevance to the sub-outcomes of DSO 2 (Author, 2022)

DSO 2. Improved Food Security and Safety			
Big Data-driven solution:	2.1 Increased access to food produced by communities or households	2.2 Ensured affordability of food	2.3 Ensure that food (animal products) is safe for consumption
Access to free farm management and insight application such as fruit look	Direct	Indirect	Indirect
Remote sensing technologies to produce insight on and monitor land conditions and crop productivity		Direct	
Monitoring and analysis of Agri-transport routes		Indirect	
Big Data-driven quality monitoring and control			Direct

5.3.3 Transformed and Inclusive Agricultural Sector

The third DSO relates to *a transformed and inclusive agricultural sector*. Under this strategic objective, the department sets out to attain three sub-outcomes. These include improving the success of agricultural activity among black farmers, increasing relevant skills in the agricultural sector, and improving the participation of youth, women, and people with disabilities in the agricultural economy.

Having explored the rapid increase of Big Data-driven technologies and the 4IR in the agricultural sector worldwide (section 5.1), it is obvious that such a shift will lead to new skill requirements for agri-workers. Subsequently, agricultural training institutes must adjust their curricula to include sought-after Big Data-related skills for roles that have not existed until now. Novel roles include drone operators and technicians, agriculture data scientists and data analysts, and cyber security specialists, to name a few. The WCDoA has a strong education and training focus, hosting one of South Africa's foremost agricultural institutes, Elsenburg College. The department offers training programmes at Higher Education and Training (HET) and Agricultural Skills Development (ASD) levels through this institution.

The transformation of the province's agricultural sector in light of the 4IR should be directed towards empowering minority groups and historically disadvantaged individuals. As per the department's strategic plan for 2021/22-2024/25, to realise this strategic outcome, the success rate of the production of black farmers must improve. According to the strategy document, black farmers must receive increased support through initiatives such as skills development and training programmes, which would allow for the growth of both primary and secondary agricultural production.

With increased awareness and interest in Big Data technologies and the 4IR among youth, the department can attract youth to the agricultural industry. The introduction of new skillset requirements related to Big Data technologies brings about a variety of roles that did not previously form part of the agricultural sector. This allows for a more varied workforce, which can lead to improved participation of youth, women, and people with disabilities. The transformation of the sector using Ag-tech means that the agricultural sector no longer needs to be dominated by primarily white, able-bodied males. For example, with the advent of John Deere's newest fully automated tractors equipped with six pairs of stereo cameras that enable 360-degree obstacle detection and distance calculation, images are passed through a network that classifies each pixel in approximately 100 milliseconds. Its highly sensitive global positioning system (GPS), combined with this continuous stream of images, allows the machine to self-determine whether it continues or stops, continually checking its position relative to an established "geofence" to operate exactly where it is supposed to, within less than an inch of accuracy. Using the John Deere Operations Centre mobile application, the farmer can leave the field whilst monitoring the machine remotely via access to live video, images, and data, allowing the farmer to adjust various conditions on the machine remotely if needed.

During testing alone, John Deere collected more than 50 million images of data (Bedord, 2022). Imagine the extent of "Big Data" once these machines are on the market and utilised globally. With various elements of the agricultural sector, Big Data-driven technologies will make that in order to work in the industry, it is no longer an inherent requirement to be an able-bodied individual spending days on end in a combine harvester, for example. Whilst many elements of agriculture will still require physical labour, more unconventional opportunities are coming to light. The automated tractor is one example of how 4IR technologies open the agricultural sector to a more diverse labour market. Table 5.6 below summarises these solutions in terms of their possible effect on the various sub-outcomes of this DSO.

Table 0.6 - Big Data-driven solutions and their possible relevance to the sub-outcomes of DSO 3 (Author, 2022)

DSO 3. Transformed and Inclusive Agricultural Sector			
Big Data-driven solution:	3.1 Improve the success of agricultural activity among black farmers	3.2 Increase relevant skills in the agricultural sector	3.3 Improve the participation of youth, women, and people with disabilities in the agricultural economy
Accessible Big Data-centred agricultural training at all qualification levels, primarily focusing on black farmers, youth, women, and persons with disabilities	Direct	Direct	Direct
Promoting new and attractive 4IR technologies in agriculture and new agricultural education offering		Indirect	Direct

5.3.4 Innovative and Resilient Rural Economies

With its fourth strategic objective, the department sets out to increase access to economic opportunities for rural communities while creating and enabling an environment for job creation in the sector. Finally, within this outcome, the department sets out to improve the safety and security needs to ensure resilient rural communities.

Instilling innovation and resilience in rural economies begins with education – in this case, future-thinking and sector-relevant education. The department can empower members of rural communities by providing opportunities to learn valuable skills that are in demand by agricultural employers. Yet again, the solution lies with accessible technology-embracing agricultural training at all qualification levels. Failing to pay special attention to upskilling rural communities and agri-workers to be fit for Ag-tech opportunities will lead to numerous negative social and economic consequences for these communities. If agri-workers are not equipped to embrace the change that is already taking place in terms of Ag-tech, their skills will quickly become replaceable by machinery, rendering them without a job.

Output indicators developed for this output include the *number of training and development projects supported and the number of district agri-worker household censuses rolled out* (Western Cape Department of Agriculture, 2020a). The annual Audit Report also refers to the indicator: *Number of referrals of agri-workers and rural community members facilitated*. A key Big Data tool that can assist in realising these indicators is inter-departmental databases and dataflows. For example, in partnering with the provincial Department of Social Development, the WCDoA can create and access a rural communities' network of jobseekers and facilitate employment between rural communities and the agriculture sector.

Big Data technologies can be of particular value to the sub-outcome related to the improvement of safety and security of rural areas. In order to succeed in this outcome, the department needs information. As indicated in their Annual Report for 2020/21, the department runs a number of censuses on district agri-workers and communities. Through these, the department can obtain valuable information about these communities' living-, safety-, and security conditions. Big Data technologies would enable this census data to be viewed in conjunction with data from other departments. Suppose the information is removed from the silos within which they so often remain and shared between departments and teams. In that case, the WCDoA can see a holistic picture of these rural communities by cross-referencing census data, crime statistics per designated areas, the occurrence of fires due to unsafe cooking practices and a multitude of other unsafe living conditions (contaminated water, unsafe electric connections etc.). The WCDoA is succeeding in integrating data sets from various role players to address rural safety and security challenges.

Collaboration between the department's Technical Rural Safety Committee, the Western Cape Department of Community Safety (WCDoCS), the Provincial Inter-Ministerial Committee and SAPS has resulted in various programmes and interventions. The Rural Safety Monitoring Dashboard, developed in 2020/2021, is an excellent example of a Big Data-driven tool shared with and between various departments. This dashboard utilises GISs and acts as an integrated data management portal to capture, verify, monitor, and track incidents of crime reported in rural areas of the province (Western Cape Department of Agriculture, 2020a). According to the Environmental Systems Research Institute (ESRI), the leading international GIS specialist, GIS is a computer-based program that stores, analyses, and interprets geographical data into a single visualisation of geographic patterns and relationships (ESRI, n.d.). The WDoA's ArcGIS Survey 123 mobile app (developed and maintained by ESRI) has been developed as a tool for community development officers in the rural development programme to log crime incidents in rural communities (Western Cape Department of Agriculture, 2020a). Various departments can use this dashboard to track and view safety statistics per district or municipality and plan programmes and interventions according to data-driven crime trends. Furthermore, the department has recently set up a rural safety desk where members of rural communities and the agricultural sector can log enquiries and issues relating to rural safety. This information will feed into and inform the Rural Safety Monitoring Dashboard. Table 5.7 below summarises these solutions in terms of their possible effect on the various sub-outcomes of this DSO.

Table 0.7 - Big Data-driven solutions and their possible relevance to the sub-outcomes of DSO 4 (Author, 2022)

DSO 4. Innovative and Resilient Rural Economies			
Big Data-driven solution:	4.1 Increase access to agricultural and related economic opportunities for rural communities	4.2 Develop an enabling environment for job creation in the agricultural sector	4.3 Improve safety and security in rural areas
Accessible Big Data-centred agricultural training at all qualification levels, especially focusing on black farmers, youth, women, and persons with disabilities	Indirect	Direct	
Jobseekers database linking community members to employment opportunities	Direct	Direct	
Rural Safety Monitoring Dashboard informed by various role players, departments, SAPS and the rural safety desk.			Direct

5.4 Overview of the Relevance of Big Data-driven Technologies to the WCDoA Departmental Strategic Outcomes (DSOs)

Tables 5.4 to 5.7 summarise the discussion of how Big Data-driven technologies can influence (either directly or indirectly) and assist the department in realising its four key DSOs and the sub-outcomes for each. Annexure H provides an overview summary of these DSOs and Big Data solutions. The relevant Big Data-driven solutions discussed are by no means an exhaustive list of all the relevant opportunities. Instead, a select few successfully demonstrate the relevant possibilities strengthening the case for relevance. However, just because a solution is relevant does not mean it can or should be implemented. This is where the discussion on attainability is warranted. The next chapter will look at key elements affecting the implementation of Big Data technologies within the department, rendering a view of the overall attainability of these technological solutions.

Chapter 6: Data Analysis and Interpretation of Findings

The final objective of this study is to consider the attainability of implementing Big Data technologies within the case study setting. Having addressed the objective of determining relevance by means of a document review, this final objective is addressed through two primary data collection methods. The first is a set of four qualitative semi-structured interviews, and the second is a quantitative questionnaire. As discussed in Chapter 4 (Research Design and Methodology) and illustrated in Figure 4.2 the question surrounding attainability is centred around two elements: firstly, attainability in terms of resources (skills, hardware and software, and funds) and secondly, attainability in terms of organisational culture (employees' willingness and openness to adopting new technologies). The first element, attainability in terms of resources, was discussed with four senior management members of the department by means of semi-structured interviews. Data from these interviews are presented in Section 6.1.1. Subsequently, the second element, attainability in terms of organisational culture, is addressed by means of the quantitative questionnaire administered to a sample of departmental employees at various levels. The results of this questionnaire are presented in Section 6.1.2. The insight generated using the interviews and questionnaire provides an overall picture of the degree to which the department can successfully implement Big Data-driven technologies and the various elements that might hinder this technology adoption process.

6.1 Presentation of Results

The following two sections present the data obtained from the semi-structured interviews and questionnaire.

6.1.1 Semi-Structured Interviews with Departmental Employees

Semi-structured interviews were conducted with four senior management members of the department (see Annexure I for a list of roles and Annexure B for the interview guide and guiding questions). This section presents the data emanating from these interviews conducted by the researcher. The data are presented, and the results are discussed to ensure that the participants' identities remain confidential, indistinguishable, and anonymous, thus confirming that the researcher complied with the ethical requirements for conducting the research.

6.1.1.1 Skills

Do you think the skillsets of your employees and colleagues are adequate to accommodate the Fourth Industrial Revolution and Big Data-driven technologies within the Department?

All interview participants were of the opinion that significant upskilling is required within the department to accommodate the department's shift in focus towards the 4IR and Big Data-driven technologies. One participant stated, "*the farming community out there is making more use and is more acquainted with new technologies than we [departmental employees] are*". This participant explained that most departmental employees have an agricultural background and no information systems or programming training. Another participant agreed with this by stating: *"the people [departmental employees] will need considerable upskilling if Big Data starts playing a greater role in our day-to-day work environment"*. This participant highlighted the need for a database specialist within the department. They explained that a large part of the department's IT function is centralised by the department of the Premier's centre for e-innovation – and more specifically, its data office. They further explained that annually, the department provides this data office with their IT needs and that the centre is then responsible for integrating the department's information. However, the participant stated, "*they are limited by funding, and obviously they have to serve the whole range of departments and education; safety and health take priority in just about all cases. So we don't really get a lot of the data office, but that is officially the sort of point where this integration and system developments are supposed to be developed from."* This participant believes an internal data specialist is needed to fulfil this role within the department.

When discussing the Big Data-related skillset of the departmental employees, three of the four interviewees agreed that whilst Big Data exist within the department, very few employees know how to utilise it effectively. One participant stated, "*There is a lot of data out there, but for it to become relevant, your recipient of the data must know what to do with it. So if you can upskill the people, the relevance will increase exponentially. A lot of the data are useful, but I think we are not utilising it optimally at this time, and I think that is through a lack of skills and understanding.*" On what this transformation would look like within the department, one participant stated, "*we are going to see disruption*".

6.1.1.2 Hardware and Software

Is the existing hardware used within the department capable of running complex programmes? Are you currently using Big Data-enabled programmes and software?

All participants mentioned the challenges and constraints that drone technology, in particular, has posed to the hardware and software used within the department.

One participant dealing with technology and the influx of drone-generated data stated, *"Up until now, we have always been able to cope with any kind of data processing that we needed to do as long as we are running at the top end the departments available hardware. What is starting to hamper us now is the size of drone data. That's something that has been pushed very heavily in this sort of 4IR movement – the use of drones. It is the easiest thing on earth to take a drone out and go and fly... But very few people gave any thought to the actual data you generate. How do you store that data, how do you process it, and what do you actually do with it?"* This participant pointed out that multi-spectral data are immense and poses great difficulty to the department to store and process. This participant explained that processing such multi-spectral data on departmental computers can take several days to produce a result. On the matter of drone-captured data, another respondent agreed that *"drone imaging is something that is really going to point out the limitations of our desktop-based systems".* A third participant explained the difference between conventional data collection and dissemination approaches and new Big Data-driven technologies. This participant explained, *"now with a drone, in half an hour, you get 3 000 000 data points, and there is no way that with normal technology you can go and make sense of those 3 000 000 points"*. The participant emphasised that the influx of such Big Data sets is not only about the data itself but about the hardware and programmes that can make sense of it.

Two respondents pointed out that teams generating drone data are currently *"scrambling for server space within the department"* and that the storage limitations within the department have hampered their ability to generate a constant influx of information due to the overheads of storing such vast data sets. According to participants, the department is already starting to utilise cloud storage and computing to mitigate this problem and needs to make use of cloud technologies further, especially when it comes to drone-generated information.

The department utilises the industry standard technology developed by ESRI. On this system, one participant stated, *"There is an overarching database called AIMS (Agricultural Information Management System), and when it was first developed about ten years ago, the intention was to use the system to integrate a lot of our databases to enable managers to integrate the different silos. But unfortunately, it's been managed by non-specialists. You really need a database expert to manage something like that and has the ability to integrate this data. And hopefully, that will come. I think our managers are realising that there is a need for that."*

All participants pointed out that the department often collaborates with third-party service providers to manage complex data-driven programmes and applications. One example of such a partnership is with the Radiant Earth Foundation. According to participants, this NGO assists the department in determining land use automatically by means of remote sensing data. This foundation supports the department's GIS unit, particularly with the cloud storage and managing a constant influx of imagery. On this partnership, a participant commented, *"that's why we are pursuing this relationship with the Radiant Earth Foundation because of this bombardment of fantastic data that you can use to your advantage, but it is just too big for us to handle."* With this data, the GIS unit has created two applications: the *Cape Farm Mapper* and *Sentinel 2 Viewer*. Another example of an application enabled by Big Data is Fruitlook. Fruitlook is based on a model created by a Dutch company, eLeaf. Whilst e-Leaf manages the modelling, data, and user interface, it has appointed a local consulting agency, Blue North, to conduct all matters of training, information dissemination, and customer support. The department is currently fully funding this application, making it freely available to the entire agricultural community of the Province.

6.1.1.3 Funds

Does the department have adequate funding available for investing in Big Data-driven solutions? Do you think the department currently prioritises the allocation of funding toward such technologies?

Two participants outright stated that they do not believe that the allocation of funds for Big Data-driven technologies matches the extent to which these solutions are emphasised and prioritised in departmental strategic documents and plans. One participant elaborated on the process of allocating funds for an additional post to be created for a new role, such as a database manager. According to the interviewee, the process of creating a new post and gaining budgetary approval is laborious and can take several years to finalise. The participant stated that by the time the post is approved and in place, there is a need for 20 more. Therefore, the department is forever trying to catch up on a backlog. The participant concluded by stating that *"there is a lot of talk about the importance of the 4IR and Big Data, but that 'talk' is not always supported by the 'walk' in terms of planning for it, budgeting and funding of it, human resources for it, and all associated aspects of exploiting that [4IR and Big Data] optimally."*

One participant introduces the challenge of competition for funding within the public service. Managers are not always sure they will be able to fund every intervention or programme that is put into plan. This interviewee stated that "*it becomes a competition between the different departments at the provincial level for their cut of the cake that is allocated to the Western Cape*" and then further explains that *"it is very important that we demonstrate the return on investment when it comes to allocated funding*." This participant then highlighted the negative reinforcement loop between 1) the lack of skills and capacity to successfully make a case for a return on investment if more funds are allocated toward new technologies, and 2) the lack of funds to be used to increase departmental capacity and skills in terms of harnessing the power of new technologies.

On the Fruitlook application, in particular, one participant believed that the department should not fund the programme if it could run commercially.

6.1.1.4 Other Themes Emanating from Semi-Structured Interviews

The semi-structured interviews focused on the attainability of implementing Big Data technologies within the department based on three key factors: skills, hardware and software, and funds. However, these semi-structured interviews unearthed several other themes, or challenges, to adopting such technologies within the department. A brief discussion of such themes can thus contribute to viewing the broader picture in terms of possible factors that the researcher has not included as a key factor affecting the attainability element of this study.

The first notable theme is **privacy, security,** and **legal constraints**. All participants mentioned the implications of the POPI Act on sharing departmental and even programme-specific information. All participants mentioned that the department is heavily governed by the POPI Act, making employees aware of *"what is and what is not allowed to be made known and shared on a more public platform*". When asked if the department uses the data generated from the Fruitlook application to inform strategy and programme design, one participant explained that the department does not have access to this information. According to this interviewee, the department was interested in using this information to consult with specific water councils and identify areas requiring maintenance and support. So, although the department funds this application for the province's agricultural sector, the service provider e-Leaf could not make the department privy to such data as it would mean sharing personal information. Another participant brought up the issue of implement-generated information. This participant explained that equipment manufacturers such as John Deere gather vast amounts of information per field via various sensors and meters, such as a combine harvester. However, this information is directed back to the company head office and then to other implements on that same farm, such as sprayers or planters. According to this participant, the information is not properly shared with the farmer or a third party such as the department. If such information could be made freely available, the department could collate an immense amount of data per province region and detect trends and pressure points early. The question, however, remains whether farmers would consent to the department's production data being used and shared. On this point, the participant also stated that this corporatisation of their data means that “farmers get locked into particular equipment supply chains”. If their data are owned by John Deere and not made fully available, they will not purchase another brand of equipment that does not have access to that historical data.

In addition to the legal constraints posed by the POPI Act, another legal consideration was mentioned. One participant explained this challenge by means of using the opening ceremony of the 2021 Tokyo Olympics as an example. During the opening of this event, approximately 2 000 drones performed a coordinated “routine” in what is called the “swarming” of drones. These drones all interacted to create highly complex and precise formations via the IoT. The participant explained, *“This is where agriculture is heading towards. If you remove the operator, you have far greater efficiencies at locust-types of swarms…that can move across a field to take out weeds, monitor pests and plants and so forth.”*. However, this is illegal in South Africa. According to the interviewee, South African Air Law state that an autonomous vehicle is not allowed to operate in South Africa unless it is under the supervision and control of a single individual. A drone “swarm” of 2 000 drones would thus require 2 000 pilots in order to operate within the ambits of South African Air Law.

Stemming from the discussion on the democratisation or “sharing” of data, one participant brought up what that would mean for intellectual property (IP), especially relating to the research conducted by the department. This participant explains that the department may want to protect any market advantage they may generate from their Big Data. “*We are a publicly funded institution, but at the same time, we (the research unit) have to compete for funding and…justify the funding that we are applying for.”* The participant explained that if their information is all in the public domain and democratised, they provide the input whilst other institutions benefit from it and reap the rewards (in terms of scarce funding and grants) of their research output. Keeping its data private would thus enable the department’s research unit to maintain a competitive advantage when applying for research funding and grants.

A second theme raised during interviews is that of the **HRM** implications that such new technologies may bring forth. Introducing new technologies to the department will affect its current system of job descriptions and key performance areas (KPAs). Two participants discussed that the department and public sector as a whole are quite *"rigid"* in terms of their role descriptions and would need to become more flexible to accommodate technologies and functions that did not exist five to ten years ago. One participant stated, *"we are still very old-school when it comes to our structuring of what people may and may not do and should and should not do"*. This also relates to training and ensuring that employees receive role-related training. It has to be related to employees' KPAs. However, one participant pointed out the crux of the matter by explaining that you cannot currently send a technician on an advanced data development course as they will say it is not in their function or department level. This participant explained that *"however, in a few years, every technician may not be able to fulfil their role without that skill because the data they work with and collect will be coming to them via new paths."*

The reality of departments, and even units within the department, operating in **silos** is a further key theme highlighted during the interviews. On this point, respondents emphasised how different units within the department collect and manage their own data and, in rare cases, collaborate with and share data between units. One participant stated that *"they (various units) have their own structures and databases for their own reporting functions."* Once again, participants mentioned the AIMS and Premier's Data Office initiatives aimed at streamlining and joining departmental data sets. However, they have not proven to be very successful.

Finally, one participant also brought forth an **NPM** approach to implementing Big Data-driven solutions within the department. When discussing the management of the Fruitlook application, this participant stated that there is no way that the department could manage the application internally. This participant posited that if a particular function (in this case, Big Data-driven technologies) can be performed by the private sector whilst bringing value to the department, there is no need to train in-house programmers and 4IR specialists. This participant stated that the government should not be in direct competition with the private sector and stated, "*you must keep the public sector as small as is practically possible and rather support the private sector. So, the question is rather, which competencies do you need within the state, and which do you need outside of the state?*

6.1.2 Organisational Culture and Technology Acceptance Questionnaire to Departmental Employees

Questionnaires were electronically sent out to a random sample size of departmental employees, of which 22 responded (see Annexure L for a list of roles and Annexure C for the questionnaire). This section presents the data emanating from the questionnaire conducted by the researcher. The data are presented, and results are discussed to ensure that the identities of participants remain confidential, indistinguishable, and anonymous, thus confirming that the researcher complied with the ethical requirements for conducting the research.

The purpose of the questionnaire was to gather insight into the perception of WCDoA employees on implementing Big Data-driven solutions within their roles and place of work. The main components assessed were: 1) Perceived Usefulness and 2) Perceived Ease of Use. These components stem from the TAM (discussed in Chapter 2, Section 2.8.3 and illustrated in Figure 2.4). This TAM posits that these factors (Perceived Usefulness and Perceived Ease of Use) directly influence an individual's attitude towards using, behavioural intention to use, and actual system use of new technologies in the workplace.

6.1.2.1 Biographical Data

The researcher recognises that various factors could affect an individual's willingness to adopt and embrace new technologies within their place of work. Possible factors include gender, age, highest academic qualification, and tenure.

- **Gender**

Figure 6.1 below graphically depicts the gender composition of questionnaire respondents. All respondents chose to indicate their gender when completing the questionnaire. Of the 22 respondents, 15 (68%) respondents were male, with 7 (32%) respondents female.

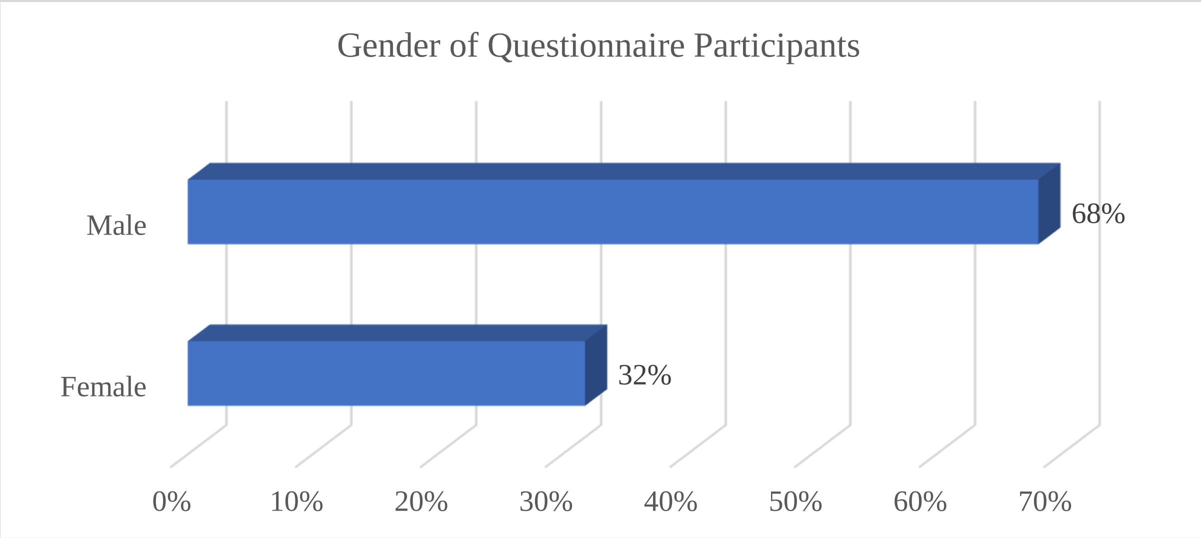

Figure 0.1 - Gender of Questionnaire Respondents

- **Age**

All participants indicated their age. The average age (years) of respondents was 51, with the youngest respondent being 31 and the oldest 63. Figure 6.2 below presents the distribution of respondents per age category. It must be noted that the average participant age was rather high. A sample group with a higher average age may respond differently to a younger group of respondents, especially in terms of technology adoption.

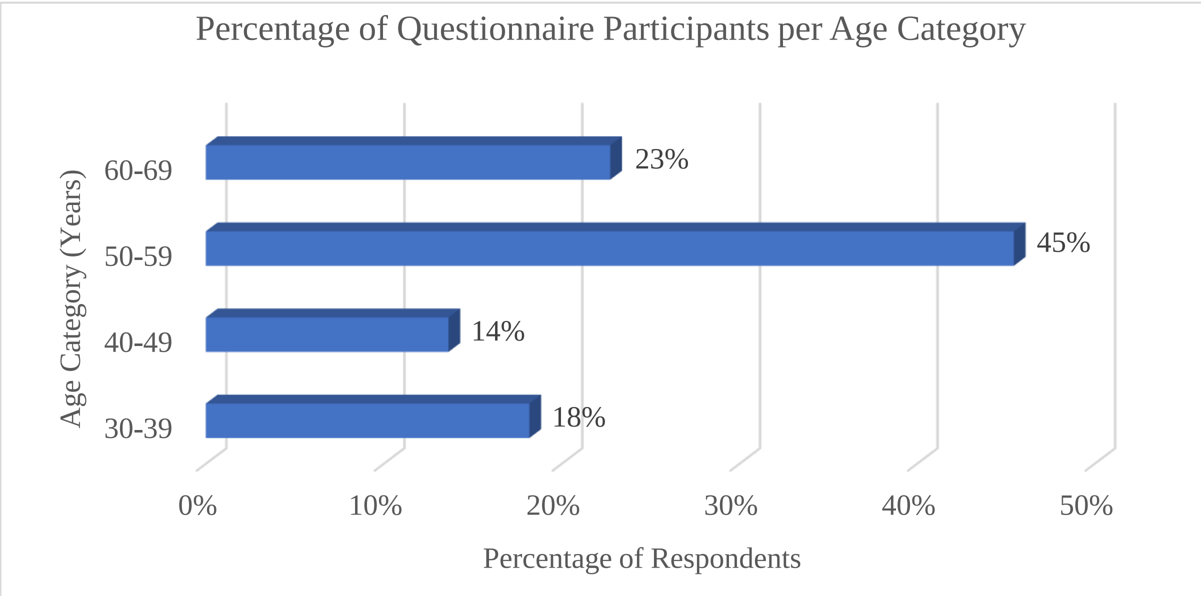

Figure 0.2 - Age Category of Questionnaire Respondents

- **Tenure**

The average tenure of respondents was 14.3 years. The shortest indicated tenure was 1.6 years, with two individuals indicating the longest tenure at 30 years within the department. Figure 6.3 indicates the number of respondents per tenure category.

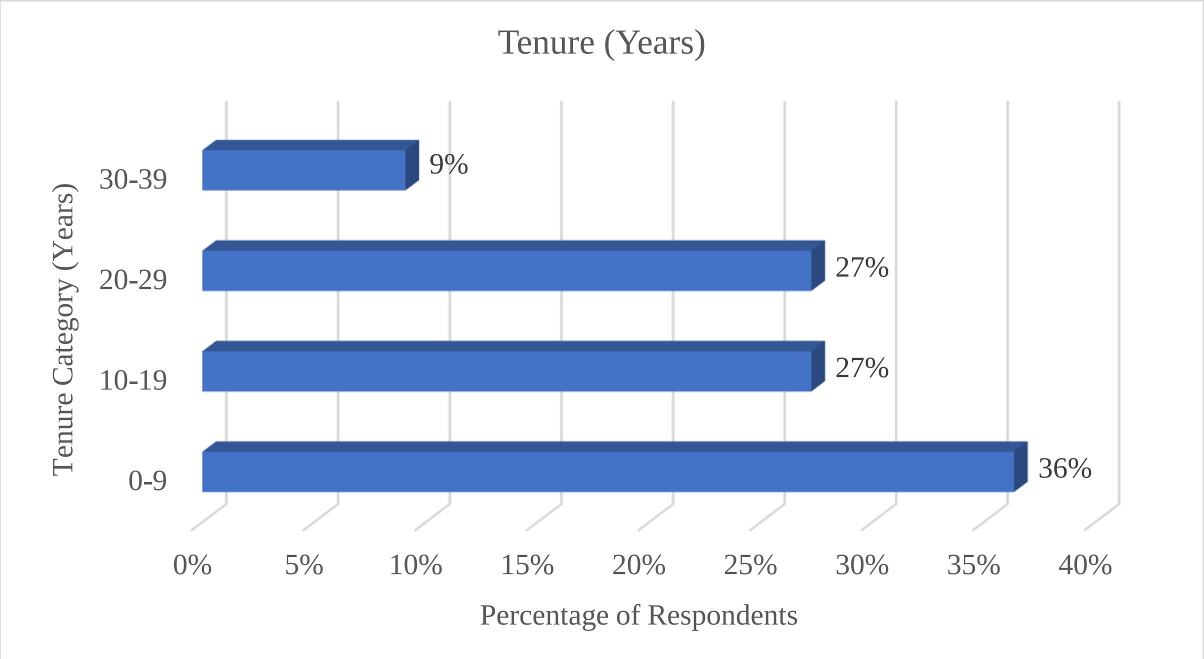

Figure 0.3 - Tenure Category of Questionnaire Respondents

- **Highest Academic Qualification**

All participants indicated their highest academic qualification. Responses included National Diploma (3 respondents;14%), Bachelor's Degree (2 respondents ;9%), Honour's Degree (3 respondents;14%), Master's Degree (9 respondents;41%), and Doctoral Degree (3 respondents;14%). There were no responses for "National Senior Certificate", "Higher

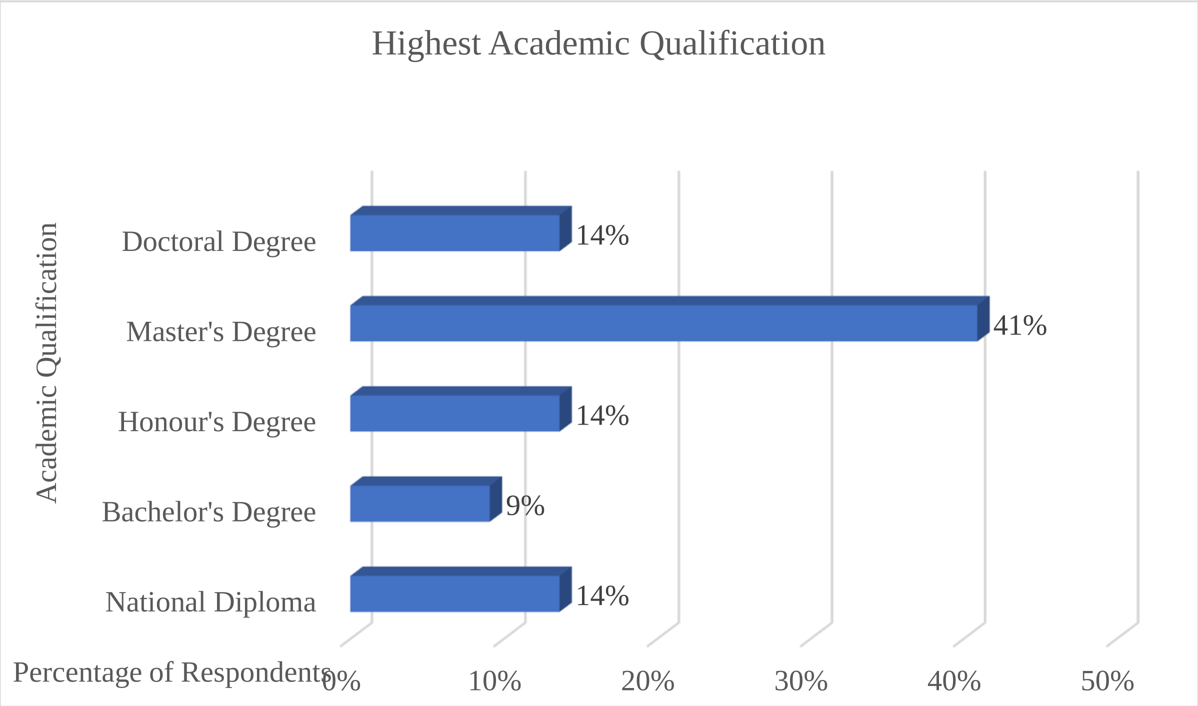

Figure 0.4 - Highest Academic Qualification of Questionnaire Respondents

Certificate", or "Other". Figure 6.4 below presents the distribution of questionnaire respondents in terms of their highest academic qualification.

As shown in Figure 6.5 below, there is no significant association between respondents' highest academic qualifications and average age.

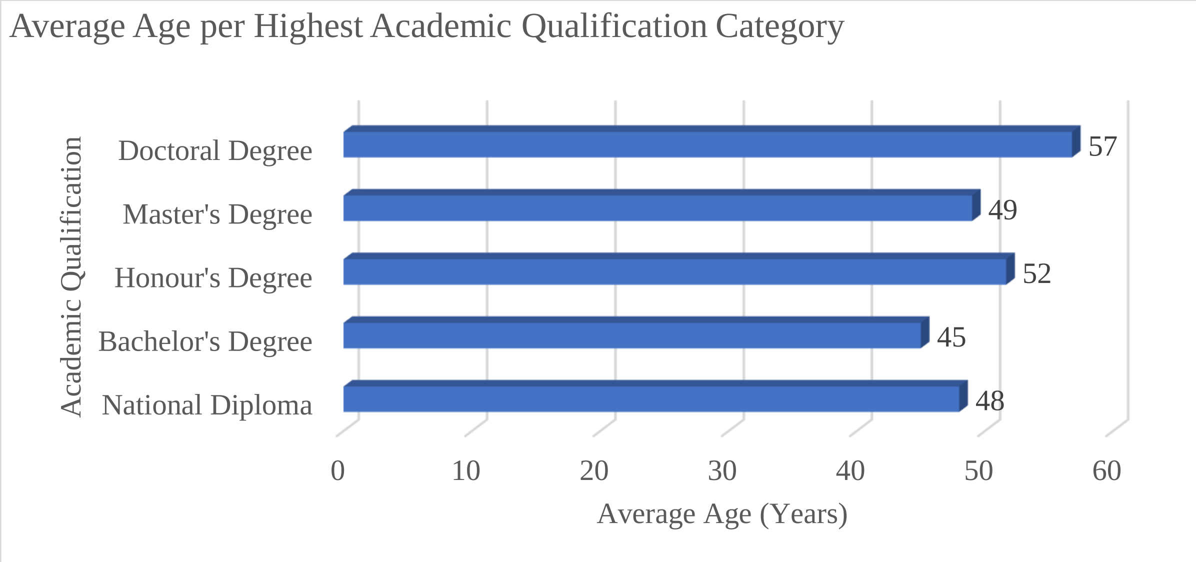

Figure 0.5 - Average Age per Highest Academic Qualification

Finally, in terms of academic qualification and gender, male participants indicated higher academic qualifications (see Figure 6.6). Of all male participants, 86,7% (13 of 15) have a post-graduate degree, whilst only 57,1% (4 of 7) of female participants has a post-graduate degree as their highest academic qualification.

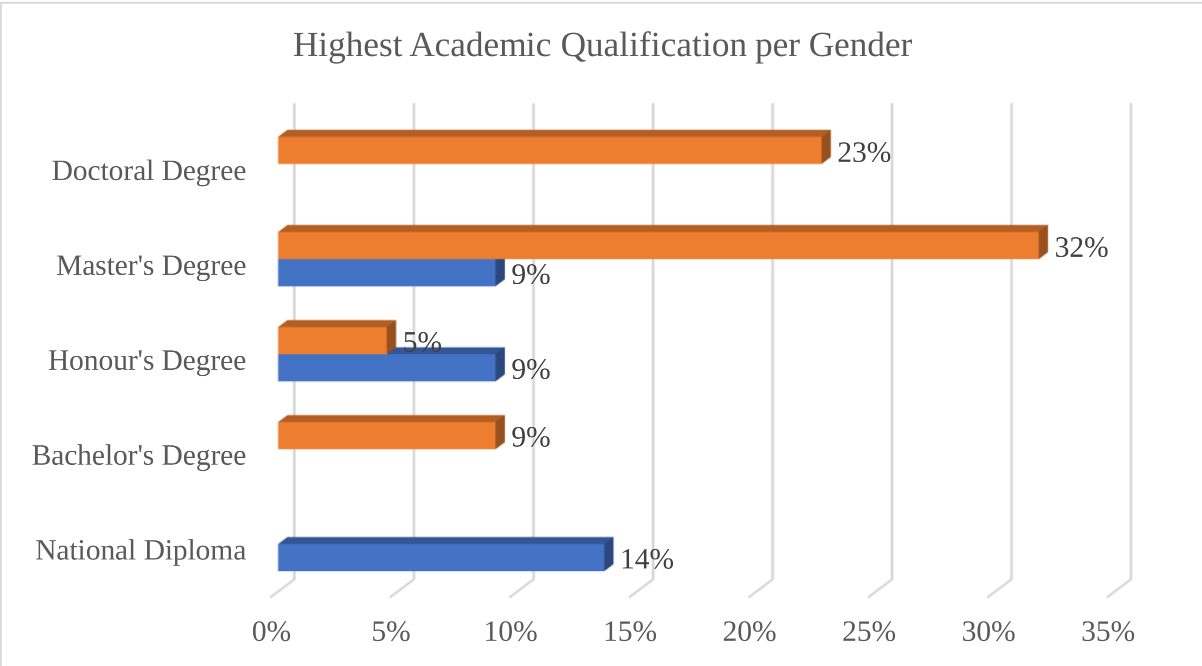

Figure 0.6 - Highest Academic Qualification per Gender

6.1.2.2 Familiarity with "Big Data"

Before asking participants to answer questions regarding their perceived usefulness and perceived ease of use of Big Data technologies, the questionnaire set out to gauge how familiar participants feel with the concept of "Big Data". However, the researcher acknowledges that participants may be more familiar with Big Data than they think. Big Data-enabled technologies are evident in various elements of day-to-day life, and participants may be more familiar with this concept after being exposed to some everyday examples. Therefore, participants were asked to rate their familiarity with the concept "Big Data" twice – once with no information or examples and then a second time after reading a brief definition and a list of everyday applications of Big Data. The list of examples included:

- Targeted advertisements based on your social media profiles, google search queries and general online activity.
- Netflix recommendations based on your personal preferences and watch history.
- Varying Uber rates based on real-time demand, traffic patterns, and location.
- Predictive inventory ordering in large factories and warehouses.
- Smart Agri initiatives such as Fruitlook, utilising drone technologies, sensors, and data from various sources and role players.

The rationale for asking participants to rate their familiarity before and after examples was two-fold. Firstly, the aim was to see if participants were, in fact, more familiar with examples of Big Data use than they would be with the concept itself. Secondly, the researcher wished to provide a brief definition and examples of Big Data technologies before participants were asked to rate their perceptions of its usefulness and ease of use.

Out of all participants, the average familiarity rating (out of 10) before the everyday examples was 6,9 and 7.7 after the examples. There was thus an increase of 0,82 or 8.2% after reading the examples. Figure 6.7 below illustrates this difference in ratings. The highest ranking before examples was 10, with the lowest ranking being 1. The highest ranking after the examples was 10, with the lowest ranking being 3.

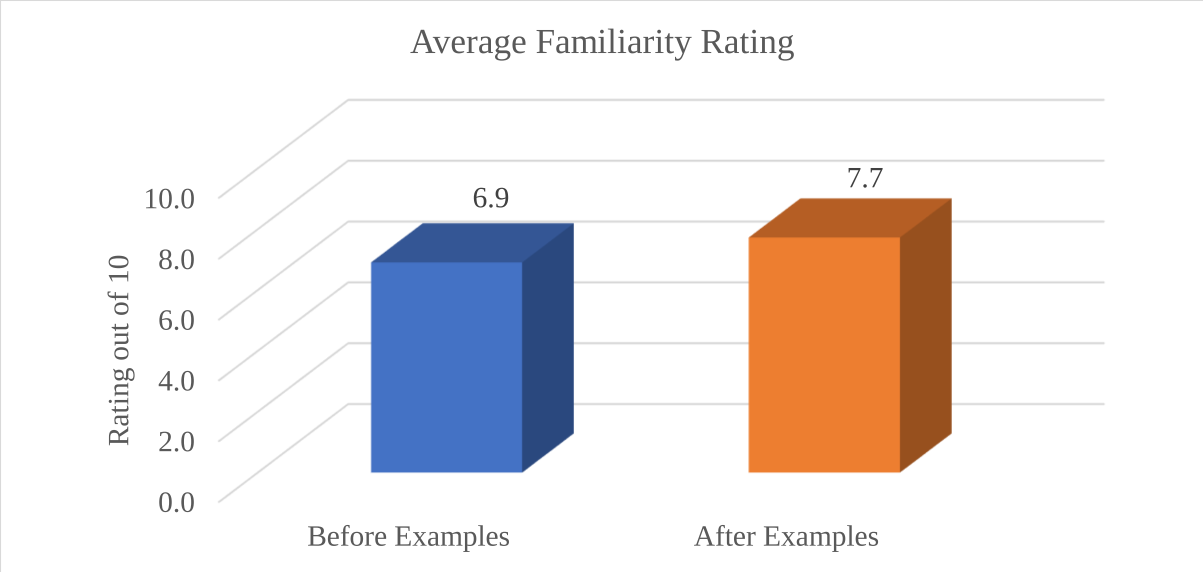

Figure 0.7 - Average Familiarity Rating Before and After Examples

As illustrated in Figure 6.8 below, participants' gender proved to influence their rating of familiarity with the concept "Big Data". On average, male participants rated themselves at an average familiarity of 7,7 out of 10 before reading the examples and 7,9 after, thus causing an increase of 0.26 or 2.6%. On the other hand, female participants rated themselves at an average of 5.3 out of 10 before the examples and 7.3 afterwards. Female respondents' average rating increased by three points, or 30%, after reading the everyday examples of Big Data.

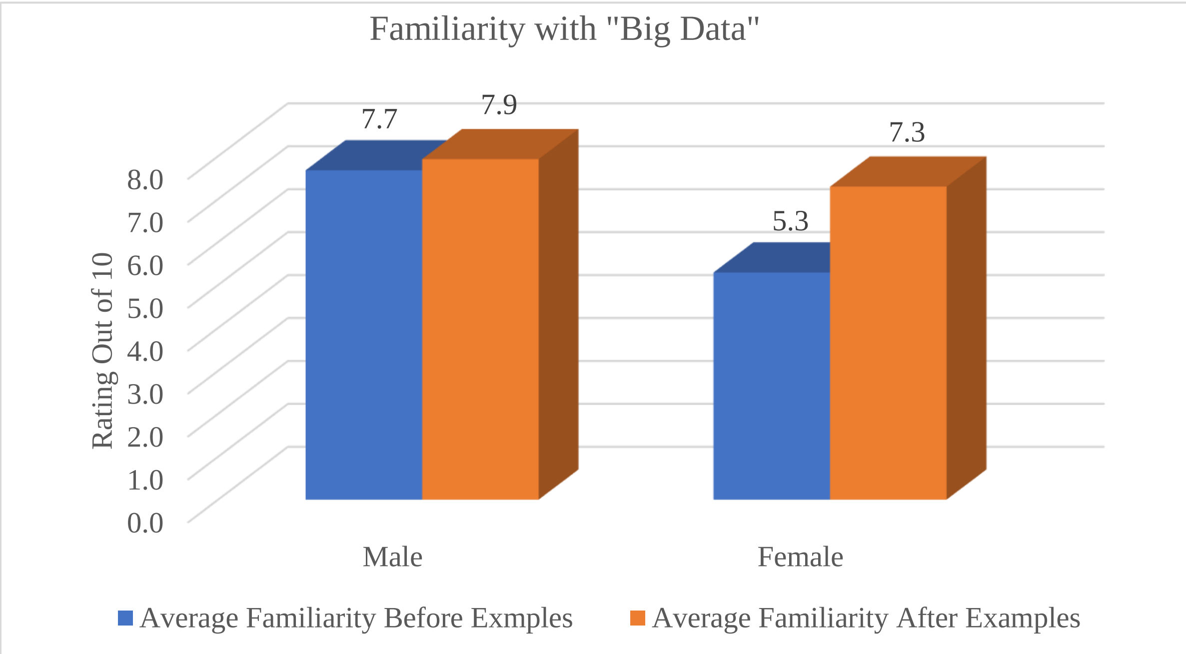

Figure 0.8 - Average Familiarity Rating Before and After Examples per Gender

This phenomenon could be attributed to women's tendency to be less comfortable to "self-promote" or rate their abilities. An extensive study on the gender gap in self-ratings conducted by the National Bureau of Economic Research shows that women subjectively rated their ability and performance less favourably than equally performing men (Exley & Kessler, 2019). Thus, after reading the definition of Big Data accompanied by the examples of its use, female participants possibly felt more comfortable rating their familiarity with the concept. After the examples, the average familiarity rating for female participants was 7.29, a mere 0.64 or 6.4% less than the average male rating. However, the data on average highest academic qualification by gender shows that male participants are more likely to have a postgraduate degree than female participants. It is thus worth investigating whether participants with a higher academic qualification rated their familiarity with "Big Data" differently than participants with a lower academic qualification.

Figure 6.9 summarises respondents' average familiarity rating in terms of two criteria: 1) National Qualification Framework (NQF) level 9 and above and 2) NQF level 8 and below.

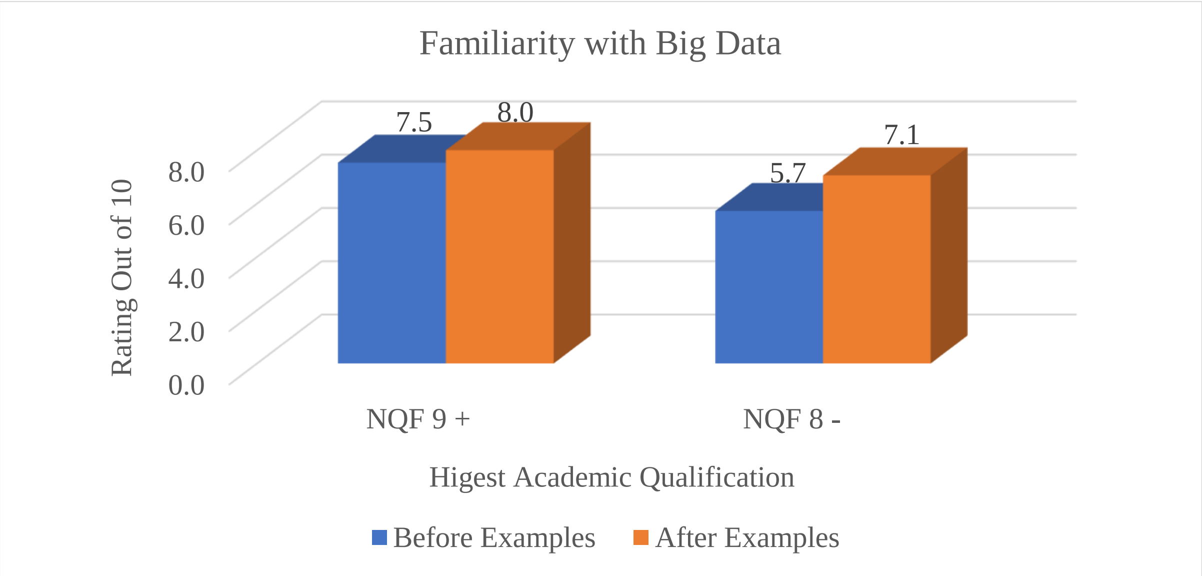

Figure 0.9 - Familiarity with Big Data Before and After Examples per NQF Qualification Level

On average, participants with a highest academic qualification at an NQF level 9 and higher (Master's degree and Doctoral degree) rated themselves as more familiar with the concept of Big Data before and after the examples. This group of participants also showed a smaller increase in familiarity after reading the examples, increasing by only 0,47 points or 4,7%. Participants with a highest academic qualification at an NQF level 8 and below (Honour's degree, Bachelor's degree, and National Diploma) rated themselves as less familiar with Big Data than their colleagues with NQF level 9 and above. This group of respondents' familiarity with the concept increased by 1.34 points or 13.4% after reading the examples. Figure 6.10 below illustrates the respondent's familiarity with Big Data per each qualification level.

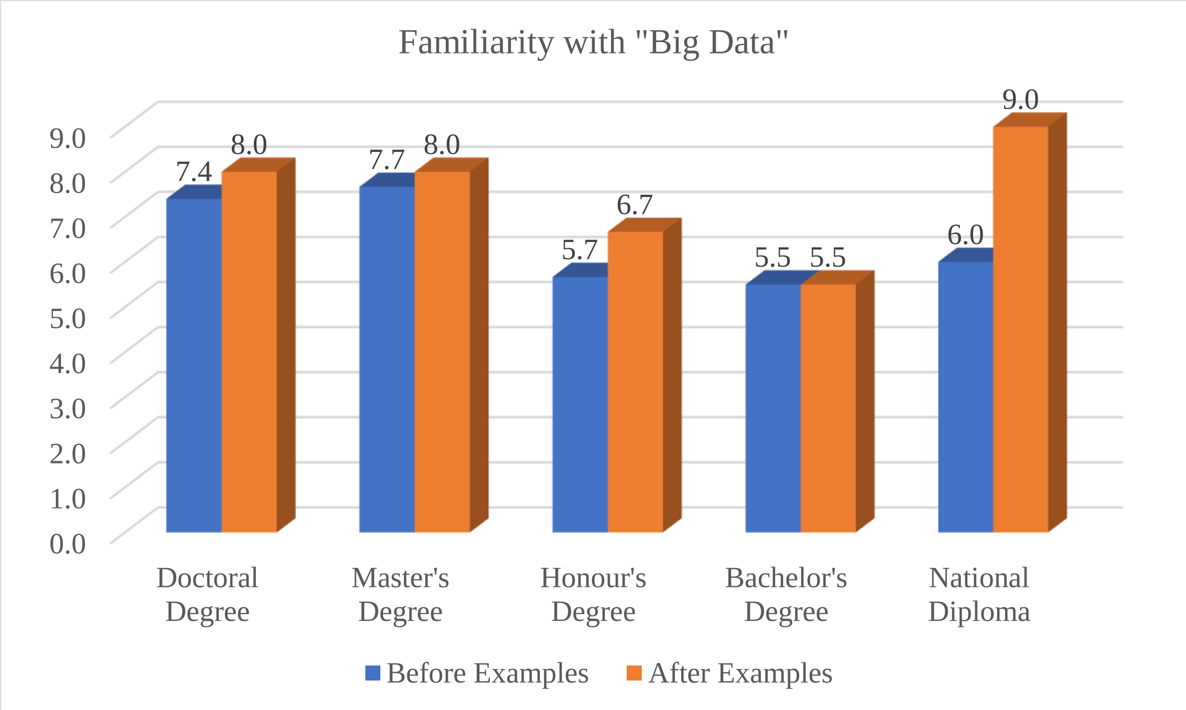

Figure 0.10 - Familiarity with Big Data Before and After Examples per Various Qualifications

Interestingly, the age category did not prove to be a determinant of a participant's familiarity with Big Data. Figure 6.11 below represents the participants' familiarity ratings in terms of four key age categories.

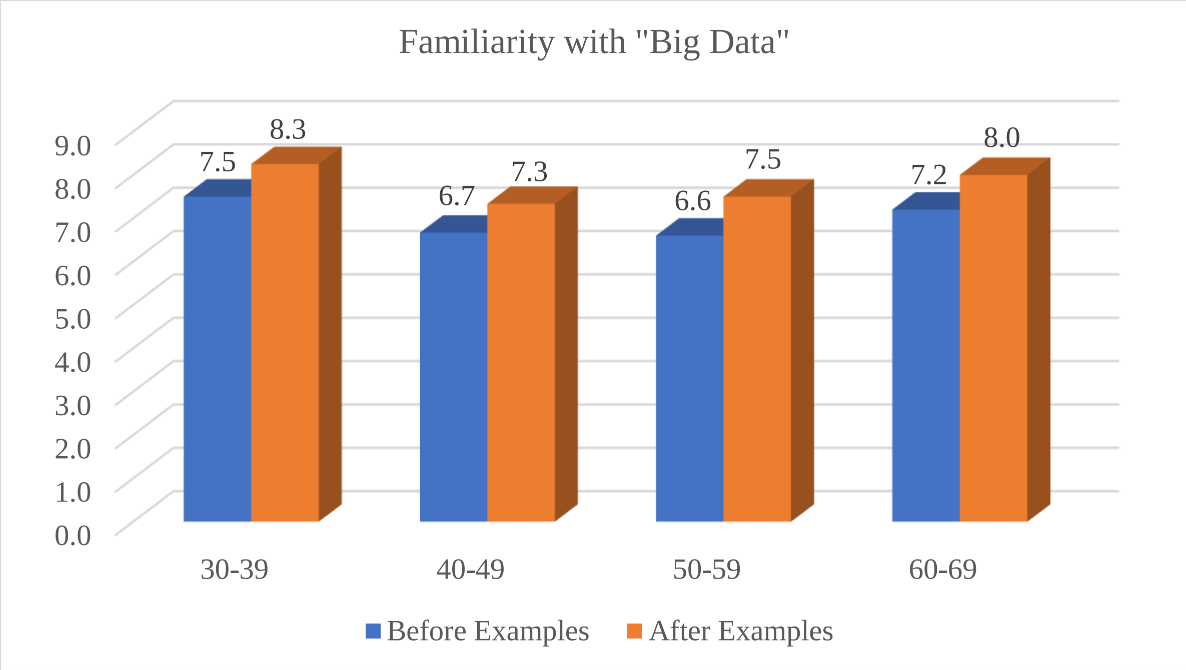

Figure 0.11 - Familiarity with Big Data Before and After Examples per Age Category

6.1.2.3 Perceived Usefulness

As discussed in the literature review, the TAM is a useful mechanism for investigating an organization or group's openness and willingness to adopt new technologies (Davis, 1989). Widely used in the field of information systems research, the TAM provides a vital framework that illustrates how the perceived ease of use and perceived usefulness of an information system/application impact user interaction with that new technology (Brandon-Jones & Kauppi, 2018).

As Davis (1989) posited, *Perceived Usefulness* (U) can be defined as a prospective user's subjective belief that using a specific application system will enhance their work performance or quality of life. In this section of the questionnaire, participants were presented with five statements (as prescribed by the TAM) related to their perceived usefulness of implementing Big Data technologies in their job. Participants were required to rate each statement on a five-point scale ranging from Strongly Agree to Strongly Disagree (see Figure 6.12 below).

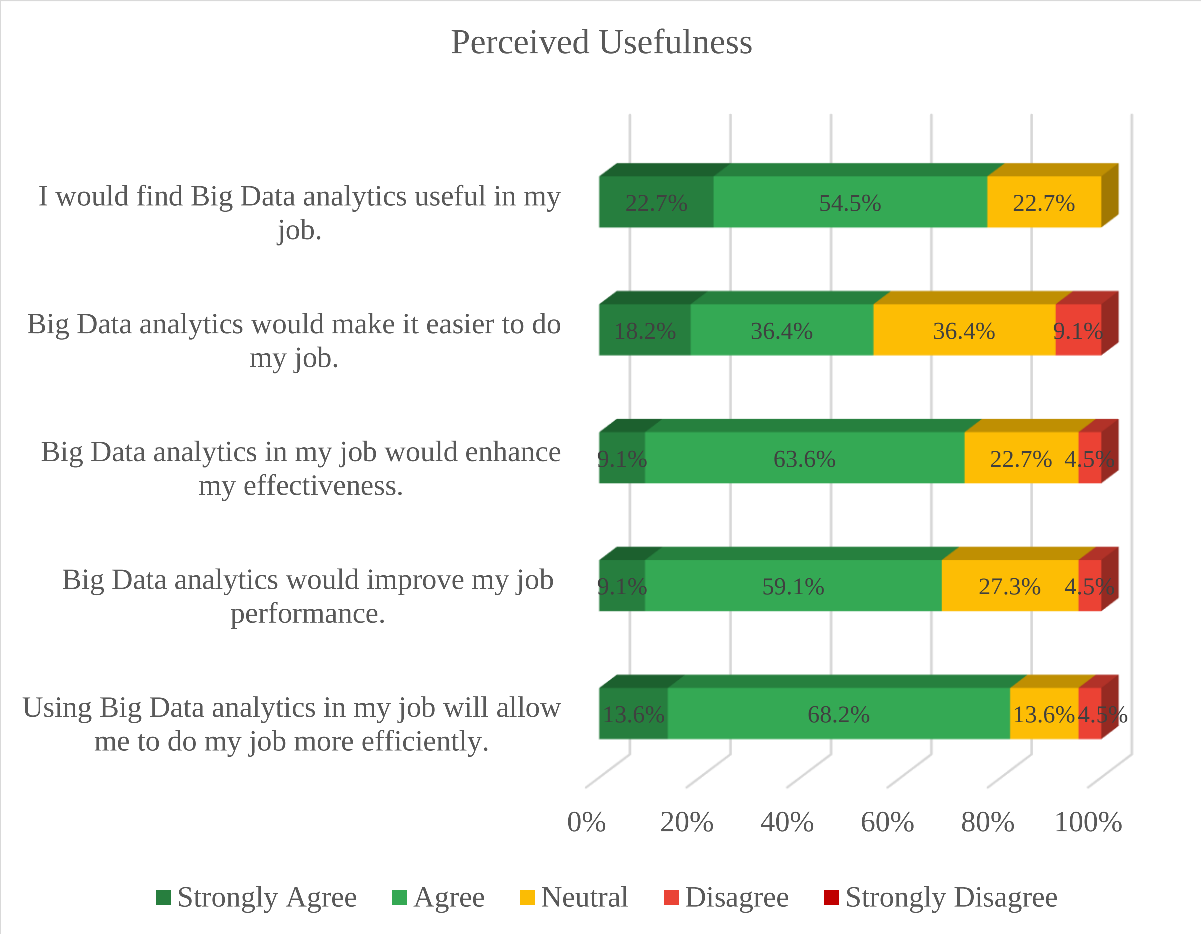

Figure 0.12 - Respondents' Responses Towards Perceived Usefulness Statements

In total, 71% of responses on the Perceived Usefulness statements were positive (Strongly Agree or Agree).

6.1.2.4 Perceived Ease of Use

Davis (1989) defines *Perceived Ease of Use* (E) as the degree to which the prospective user expects the new technology to be easy to use. Participants were presented with five statements (as prescribed by the TAM) related to their perceived ease of use in implementing Big Data technologies in their job. Participants were required to rate each statement on a five-point scale ranging from Strongly Agree to Strongly Disagree (see Figure 6.13 below).

In total, 51% of responses on the Perceived Usefulness statements were positive (Strongly Agree or Agree).

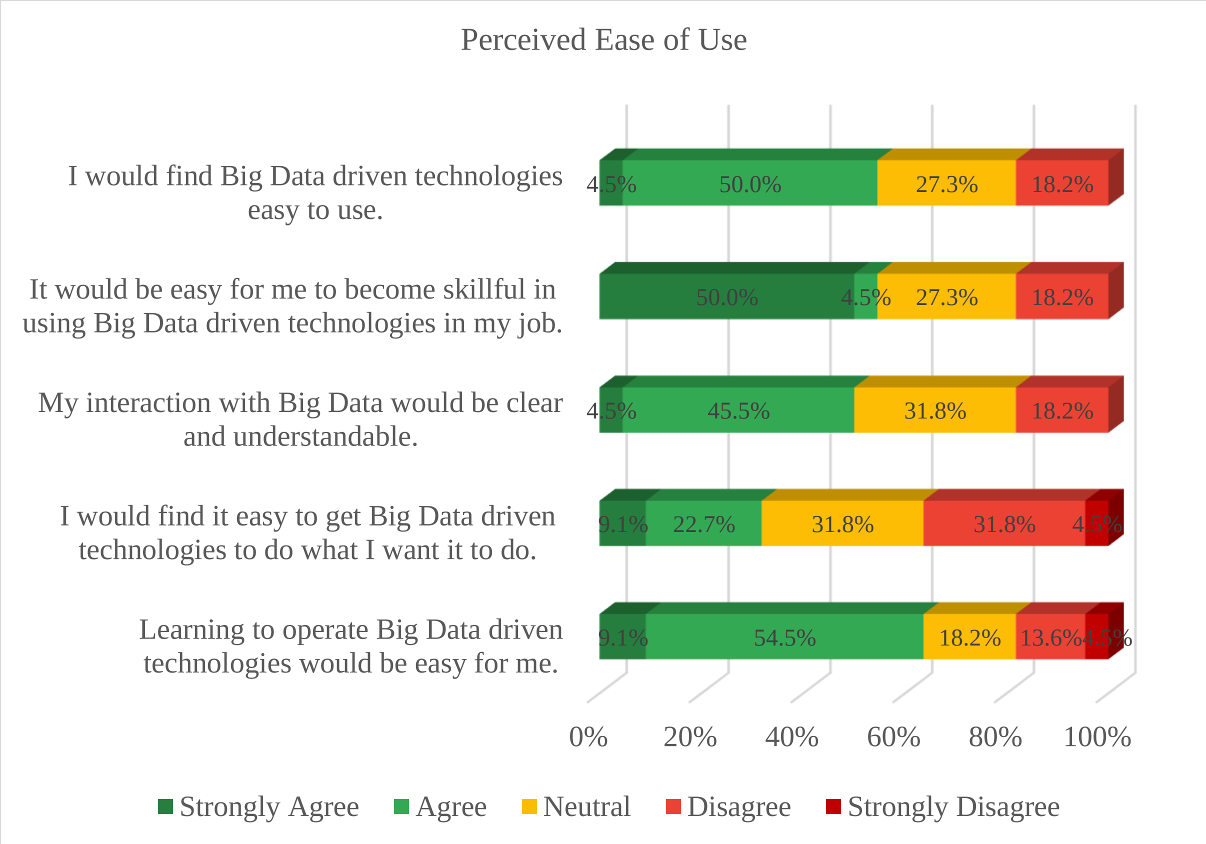

Figure 0.13 - Respondents' Responses Towards Perceived Ease of Use Statements

6.1.2.5 Combination of Perceived Usefulness and Perceived Ease of Use

The true insight of the TAM is gained when comparing respondents' perceived usefulness and perceived ease of use ratings. As mentioned, 71% of responses on the Perceived Usefulness statements were positive (thus, where participants either agree or strongly agree that Big Data Technologies will enhance their work performance and quality). Interestingly, the percentage of positive responses towards the Ease of Use statements was only 51%. Therefore, only 51% of ratings on these statements were positive (thus, where participants either agree or strongly agree that they will be able to master and incorporate Big Data Technologies into their work easily). Figure 6.14 below illustrates these positive response rates. There is thus a 20% difference between the two, indicating that although participants are confident that Big Data technologies could be useful in their jobs, they are considerably less confident in their own ability to master such new technologies.

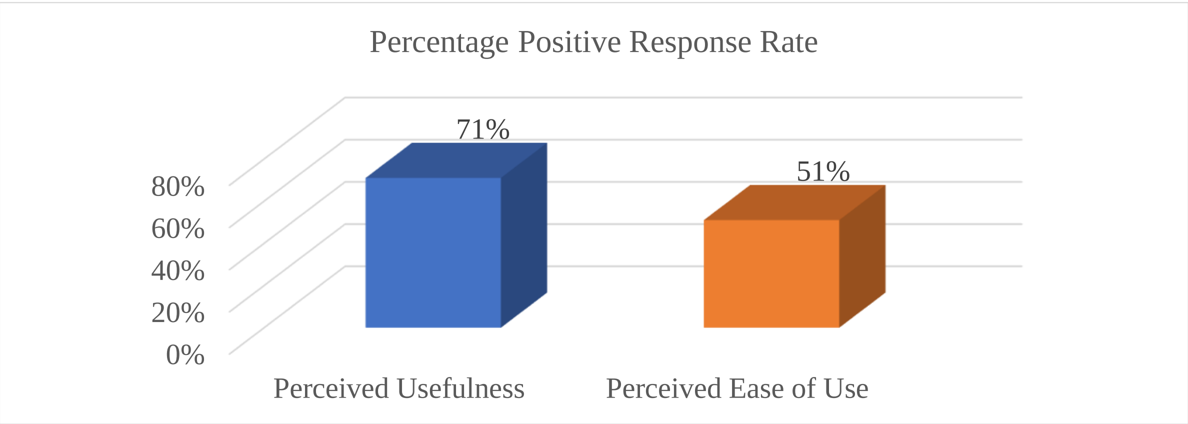

Figure 0.14 - Percentage Positive Response Rate of Respondents' Perceived Usefulness and Perceived Ease of Use

In looking at the positive response rate of perceived usefulness and perceived ease of use, one can now investigate whether any biological information (age, gender, tenure, and highest qualification) impacts the respondents' views on these statements.

The biological variable that showed the largest difference between perceived usefulness and perceived ease of use was gender. As shown in Figure 6.15 below, 67% of male participant responses were positive toward perceived usefulness, whereas 80% of female responses to perceived usefulness were positive. Female responses were thus 13% more positive than their male counterparts. However, whilst male responses to perceived ease of use indicated a positive response percentage of 59%, only 30% of female responses to the ease of use statements were positive. The difference between the perceived usefulness and perceived ease of use was thus

8% for male respondents and 50% for female responses. This shows that whilst both men and women rate the usefulness of Big Data technologies more positively than they rate their own ability to master such technologies, female respondents showed a much greater disparity. It is possible that female respondents, due to the lower rating of their familiarity with the concept of Big Data (see Figure 6.8) are confident in its ability to help them in their jobs but less certain of what that would entail and how they would be required to use these technologies.

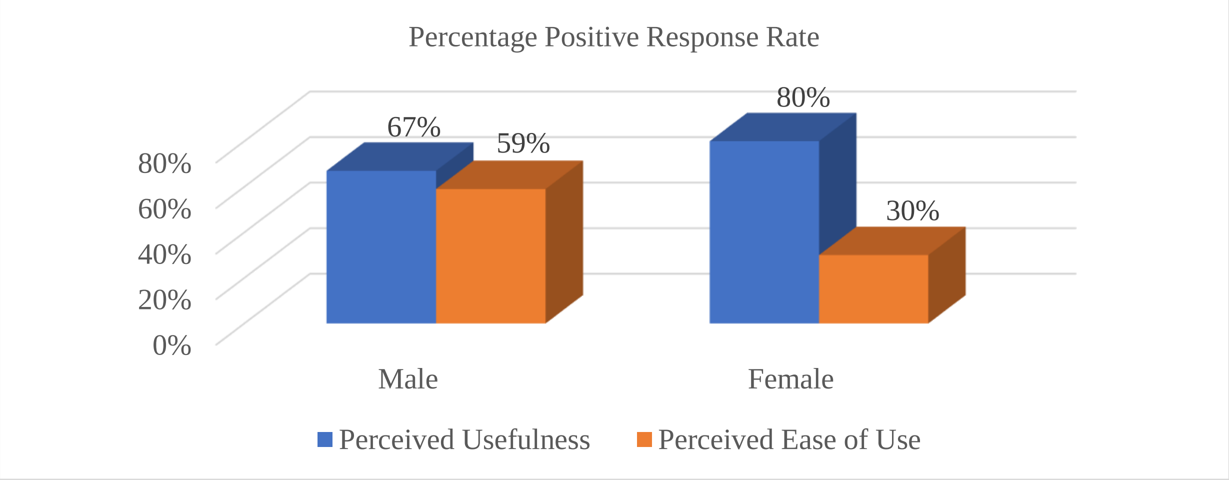

Figure 0.15 - Percentage Positive Response Rate of Male and Female Respondents' Perceived Usefulness and Perceived Ease of Use

Finally, the data indicate that participants from the youngest age category (30 – 39) rated highest on both Perceived Usefulness and Perceived Ease of Use (see Figure 6.16 below).

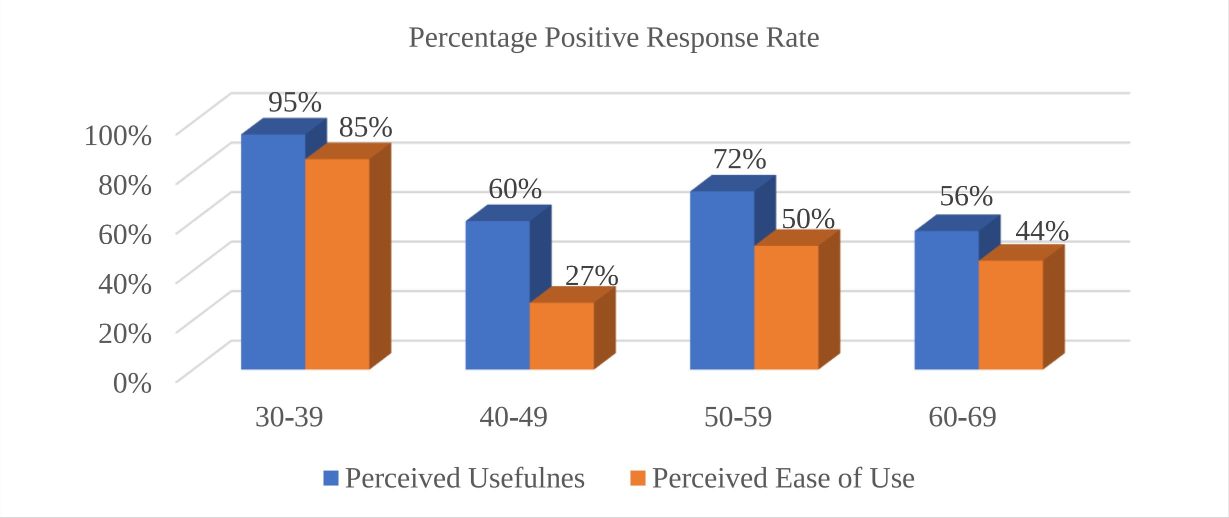

Figure 0.16 - Percentage Positive Response Rate of Different Age Categories' Perceived Usefulness and Perceived Ease of Use

6.2 Interpretation of Findings

The purpose of the semi-structured key expert interviews and questionnaire was to gather the needed insight to address the sixth and final research objective – To determine the attainability of implementing Big Data-driven technologies in the WCDoA. With this objective, the key term "attainability" refers to the extent to which implementing such new technologies is possible or achievable. As identified by means of the literature review, there are a number of constraints in implementing Big Data technologies within the public sector. The literature showed that such constraints include not having the required resources (funding, skillset, hardware and software) or organisational culture to implement Big Data technologies within the public sector workplace. The interviews and questionnaire thus set out to investigate the extent to which these constraints are prevalent in the department and would impair the implementation of Big Data technologies within the WCDoA. This section sets out to interpret and consolidate the interview and questionnaire findings.

6.2.1 Factors Influencing the Attainability of Implementing Big Data Technologies Within the WCDoA

The key expert interviews showed that to successfully implement Big Data technologies within the WCDoA, significant **upskilling** of staff members is required. The department is running the risk of falling behind in terms of the required skills for embracing Big Data and related 4IR technologies as it is not adopting to this change at the same rate as the rest of the agricultural sector. In terms of managing and fully utilising existing departmental data, there is a need for new roles to be created, especially roles related to the proper management of various data sets. Big Data exists within the department and its various collaborators (other departments and private bodies), but this data are grossly underutilised due to a lack of relevant skills among departmental employees. This need to create a new role for a database manager is particularly evident when considering the underutilised AIMS database.

Furthermore, in terms of **hardware and software**, the increasing interest in drone technology has pointed out the department's lack of storage space, especially for sets of multi-spectral data. This shortcoming highlights the need for the department to utilise cloud storage and cloud computation for such vast data sets. Finally, the interviews have highlighted the important role of third-party service providers such as eLeaf in managing and storing large data sets the department would otherwise be unable to manage internally. This aligns with the findings of the literature review on the importance of creating and operating within a Big Data ecosystem that looks beyond the private versus public sector paradigm toward a collaborative approach.

The data shows that obtaining **funding** for new technologies is a constraint to implementing Big Data solutions within the Department. Interview data shows that in order to obtain funding, programmes within the department are required to prove that these technologies would yield a return on investment (ROI). However, such ROI cannot be proved without the needed skills, leading to a negative reinforcement loop, as indicated in Figure 6.17 below.

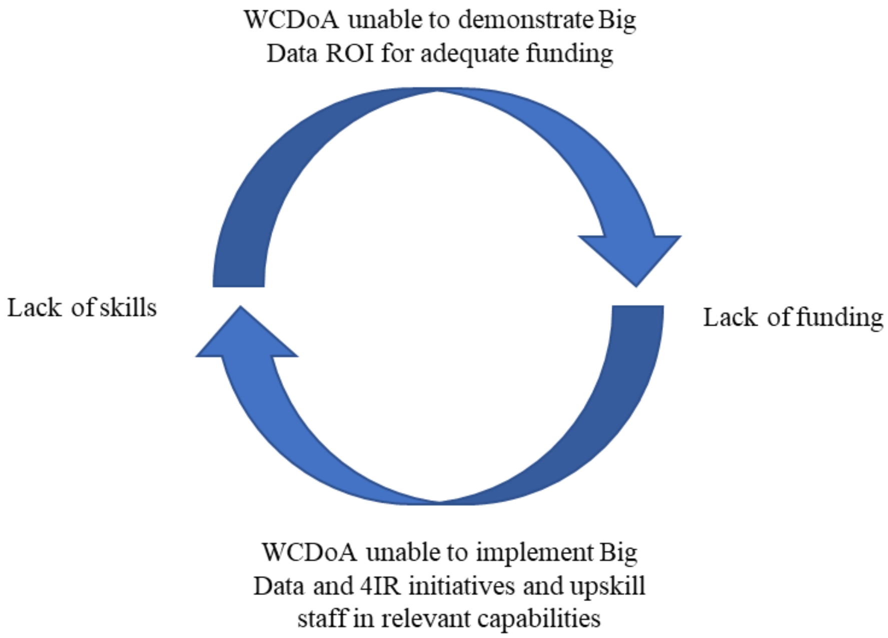

Figure 0.17 - The Lack-of-Skills Lack-of-Funding Negative Reinforcement Loop (Author, 2022)

In terms of **organisational culture** and employee attitude toward implementing Big Data-driven technologies in the workplace, the questionnaire (based on the TAM) provided valuable insights on employee familiarity with Big Data and their Perceived Usefulness and Perceived ease of Use of Big Data technologies. Respondents were asked to rate their familiarity with Big Data before and after reading a set of examples of Big Data uses. On average, employees of the WCDoA rated their own familiarity at 6.91 out of 10 before reading the examples and 7.73 out of 10 after. This shows that respondents had a fairly good understanding of Big Data before seeing the examples. However, reading the examples increased their confidence and familiarity with the topic and resulted in a higher familiarity rating. Of all of the factors that could have affected respondents' views and familiarity with Big Data technologies, gender turned out to be the most significant influence. Prior to seeing the examples of Big Data application, female respondents rated themselves as much less familiar with the concept. The average female rating prior to the examples was 5.29 out of 10, whereas males rated their average familiarity at 7.67% before reading the examples. It is not necessarily the case that female respondents were truly less familiar with the concept but rather less generous with their self-scoring, as discussed in the data presentation section. After reding the examples of Big Data applications, female participants rated their familiarity at an average of 7.29 out of 10, which is not far off from the average male rating after examples, which was 7.93 out of 10.

Relating to the perceived usefulness, this study found that employees of the WCDoA are confident that Big Data technologies could be of valuable use in their daily functions, making them more efficient and effective and improving their overall performance. However, there is some resistance in terms of employees' views on whether they would be able to easily master and manage Big Data-driven technologies (perceived ease of use). This indicates that while the solutions that Big Data may bring sound idyllic to most employees, the reality of learning to operate these new technologies will pose a challenge when implemented within the department. Once again, in terms of gender, female participants rated their perceived ease of use significantly lower than their male colleagues. This does not suggest that female employees would find it more difficult to master these new technologies. It instead suggests that they view the process with more apprehension and uncertainty about their ability to embrace the change. When looking at the questions of perceived usefulness and perceived ease of use in combination with the interview responses as well as the secondary sources (departmental strategic documents), it becomes clear that whilst the relevance of Big Data technologies to the department is clear, employees are uncertain as to what that would practically entail. Departmental strategy documents, key expert interviews, and questionnaire responses indicate that everyone understands the value that Big Data could bring to the department and agricultural sector of the province. Yet, there is very little certainty about how this will be done, which roles will be affected, and how. Thus, if the department wishes to implement a Big Data or 4IR-driven solution within any particular programme or directorate, a clear change management and communication strategy would need to be deployed in order to ensure that all role players are informed and aware of not only the change but also what is expected of them during the process.

Finally, the key expert interviews highlighted a number of additional factors that will affect the attainability of implementing Big Data technologies within the department – all of which resonate with the findings of the literature review. The first set of factors, in this case, limitations, include various **privacy, security and legal constraints**. These include matters relating to the security of information-sharing in terms of the POPI Act and IP, as well as the legal restrictions imposed by South African Air Law on drone "swarming". Another limitation arising from the key expert interviews was the silos in which various departments and programmes within a department operate. Within these silos, departments hold valuable information and insight that is very seldom shared between silos. Thirdly, the **HRM** implications of implementing Big Data technologies within the WCDoA was another restricting factor prevalent in the key expert interviews. The public sector is known for its red tape and bureaucratic HRM processes, which are slow to change and transform. With the introduction of Big Data-related skills and competencies to various posts within the department, these posts' descriptions and KPIs would need to be adjusted. Furthermore, various new posts will have to be created, advertised, budgeted for, and positioned strategically within the department, resulting in a string of HRM processes over various months. These additional themes (security, silo, HRM) all echo the findings of the literature review on the various challenges to be expected when implementing Big Data technologies in public sector institutions.

6.2.2 Presentation of Findings in Terms of an Adapted Conceptual Framework

The findings from the key expert interviews and questionnaire, combined with the case study findings (see Chapter 5), can now be presented in terms of the conceptual framework developed from the literature review (see Chapter 2, Section 2.10, Figure 2.6). The case study and the interview and questionnaire findings corroborate the elements and structure of this initial theoretical conceptual framework (see Figure 2.6). These findings have echoed not only the conclusions of the literature study but also provided practical insight into the complexity of implementing Big Data technologies in public sector institutions. This has enabled the researcher to refine the conceptual framework further to represent the theory and the reality of introducing Big Data technologies to a department such as the WCDoA.

The biggest adaptation the researcher has incorporated into the revised framework is the positioning of the challenges. After analysing the case study findings and interview and questionnaire results, the researcher has learnt that these challenges do not only affect a single point of introducing Big Data technologies to the department or institution. As illustrated in Figure 2.5, these challenges impact a single point in the process. However, the study has shown that various challenges impact various points in the process. Challenges impact elements such as the data ecosystem, processing, or applications, and particular challenges worsen other challenges as described in the skills-funds negative reinforcement loop (see Figure 6.17). Visually, this element of complexity may make for a more chaotic framework. However, this study has shown that the reality is, in fact, much more complex than the initial conceptual framework suggested. Figure 6.18 serves as a revised version of the initial framework, now illustrating the complex interaction between various challenges and stages of the process flow. Whereas the theoretic framework (Figure 2.6) suggested a "Big Data Ecosystem" as an ideal starting point and source of Big Data, the case study findings suggest that this is not the case in practice. Government entities and departments manage and store their data in silos. Whilst some entities occasionally share information, it is not common practice, and information does not flow seamlessly between various parties. Interview results showed that the WCDoA does not freely share information with tertiary education and research institutions for IP reasons. The updated framework shows that information security challenges inhibit data sharing between parties, further exacerbating the silos in which they store and manage their data.

In terms of the characteristics of Big Data, the results have confirmed that the WCDoA is increasingly gathering information that meets the requirements for being classified as "Big Data". Drone-generated and remote sensing information possess all characteristics of Big Data, bringing a multitude of processing and storage challenges. Various challenges come into play with the processing of this information. Limited hardware and software, institutional capabilities (skills), funds, HRM requirements and organisational culture restrict the successful processing of Big Data within the WCDoA. Big Data must be successfully processed to inform and direct various Big Data-driven applications. Examples of such applications and their relevance to the DSOs of the WCDoA are set out in Chapter 5. Such applications include remote sensing technologies, market trend analysis, farm management applications, production quality monitoring and control and initiatives such as the rural safety monitoring dashboard. As with the processing of Big Data, various challenges impact the application of Big Data within the department. These challenges are all factors which ultimately reduce the degree to which implementing Big Data solutions within the department becomes less attainable and more challenging. However, as discussed in Chapter 5, if these applications are implemented successfully, they would greatly influence the department's ability to deliver on its four DSOs. Figure 6.18 concludes with the department's overall strategic vision as the value or desired product of the Big Data implementation process. That is, to unlock the full potential of the agricultural sector to enhance the economic, ecological, and social wealth of the people of the Western Cape.

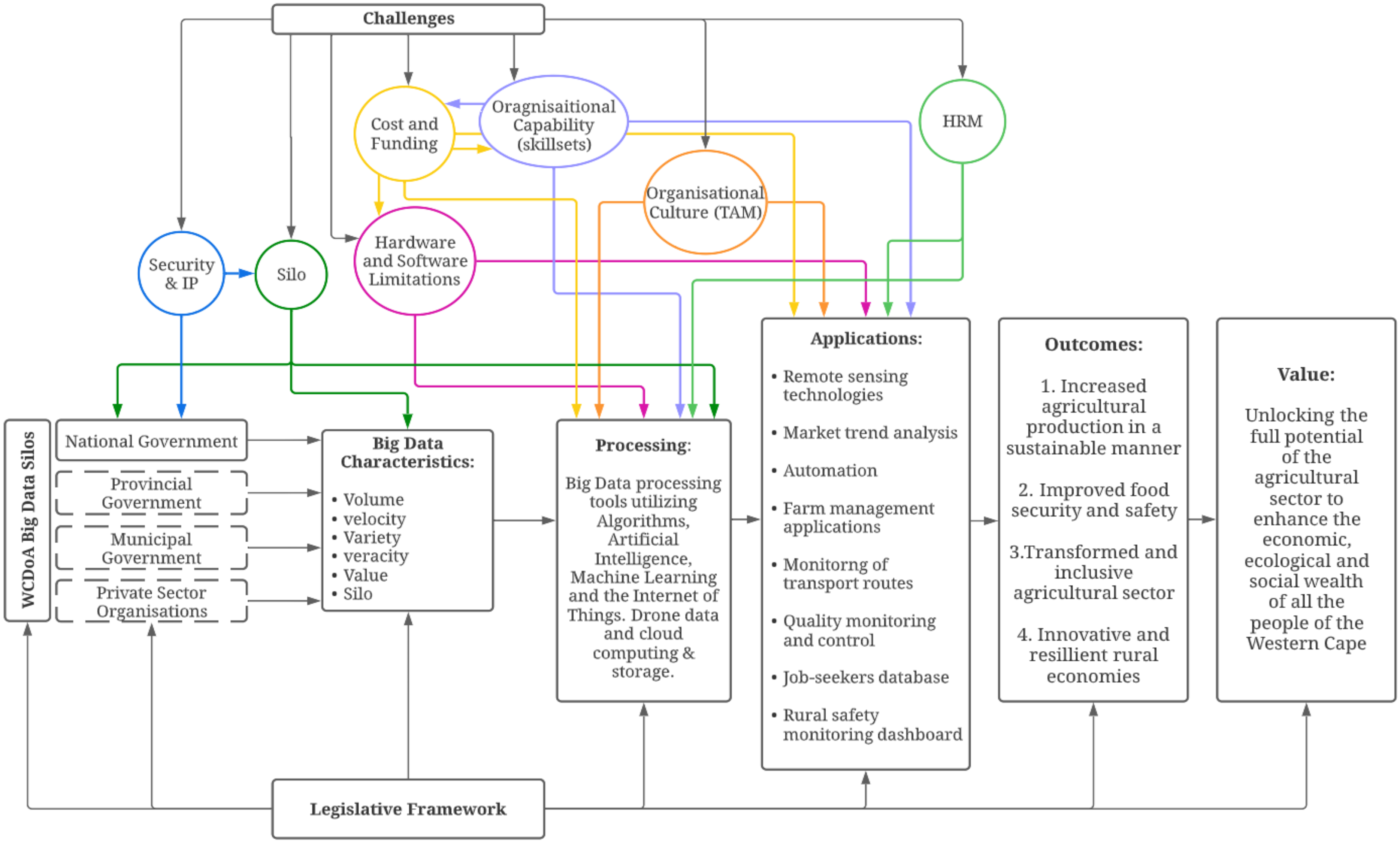

Figure 0.18 - Revised Conceptual Framework Based on Case Study, Interview and Questionnaire Findings

Chapter 7: Summary, Recommendations and Conclusion

Chapter 7 discusses the key points accentuated in the study as extrapolated from the previous six chapters. These chapters comprised a literature review, legislative and policy framework, the research design and methodology, case study, and data presentation and analysis followed by an interpretation of the findings

7.1 Research Question and Objective

Big Data and information define the era we are living in. Having entered the "information age", concepts such as Big Data, AI, machine learning and the IoT have migrated from operating predominantly in the IT world to now being part of everyday life. The rise in prominence of Big Data-driven technologies has enabled endless new possibilities for those who can harness its power, leaving behind those who cannot. The private sector, in particular, has been able to use these technologies to improve the ways in which it serves its customers. This leaves one to wonder whether the government can follow suit and utilise these technologies to improve its offering to citizens. However, what would a Big Data enabled public service look like? Moreover, what new challenges or concerns may arise from it? These considerations led to the main research question and objective discussed in Chapter 1. The researcher also selected the WCDoA as a case study to investigate the relevance and attainability of Big Data technologies to its specific context.

This study aimed to gain a deeper understanding of Big Data and explore its value to public sector institutions. Furthermore, this study aimed to explore its relevance and attainability in a South African public sector context with a specific focus on the Western Cape Provincial Department of Agriculture.

Stemming from the above, the primary research question of this study was:

To what extent can Big Data add value to the public sector within the context of the Western Cape Department of Agriculture (WCDoA)?

Given this primary research question, the primary research objective was:

To determine the extent to which Big Data can add value to the public sector within the context of the Western Cape Department of Agriculture (WCDOA).

7.2 Research Sub-Objectives

In this study, the researcher set out to achieve six research sub-objectives. Each of these objectives and the chapters addressing them are briefly discussed below.

7.2.1 Objective 1: Defining Big Data

The first research objective was addressed through the literature review (see Chapter 2, Sections 2.2 to 2.6). In order to define Big Data, this study identified that Big Data is often defined by its three key characteristics: volume, velocity, and variety. Big Data can thus be defined as immense information sets (volume) that are diverse in their format (variety) and generated at an alarmingly high speed (velocity). In considering various authors' definitions of the phenomenon, the literature review further identified two additional defining characteristics of Big Data: variety and veracity. In addition to its volume, variety, and velocity, Big Data provide immense value when processed and interpreted. However, not all Big Data are of value. Data need to be of high quality and able to be interpreted. This characteristic is known as veracity. Finally, this study found two final defining characteristics unique to Big Data used in and generated by the public sector. These unique characteristics are silo and security. Governmental Big Data are characteristically stored in "silos" within departments, units or entities and are seldomly shared between public sector role players. This is due to a range of reasons, the main one being security issues limiting the extent to which sensitive information is allowed to be shared between multiple parties.

This objective was thus met by defining Big Data as information of high volumes, varying variety, collected at a high velocity which, if of the required quality, can be interpreted to provide immense value to whoever owns it. However, public sector Big Data often operate in silos with complex security limitations restricting its use. In addition to defining Big Data, this section describes that Big Data are nothing but information and are therefore worthless without the necessary processing and interpretation. Therefore, definitions of related technologies were provided. These were: Big Data analytics, algorithms, AI, machine learning, "smart", and IoT. It was clarified that this package of Big Data-driven technologies is included under the umbrella term "Big Data" when referred to in this study.

7.2.2 Objective 2: Describing the Current Applications of Big Data in the Public Sector

The literature review also addressed this research objective (see Chapter 2, Section 2.7).

There are many opportunities for Big Data use in the public sector. There are also many existing examples of ways in which public entities utilise Big Data to deliver on their mandate. In this section, the researcher used existing examples of public sector Big Data use and discussed these opportunities by means of three main categories. These categories included: 1) enhanced democratic processes, 2) improved policy- and decision-making, and 3) effective programme and project implementation, monitoring, and evaluation.

It was found that Big Data technologies can act as a tool for governments to improve public participation, enhance communication channels between citizens and the state or public representatives, and collect valuable insight into citizens' views on policy matters. In this section, examples of e-Government initiatives were used to illustrate how technology can bridge the gap between the government and its people. This led to a discussion of the second category of public sector Big Data use, outlining how Big Data can improve government policy- and decision-making. Here, the review of available literature proved that Big Data could play a pivotal role in informing the choices of high-level decision-makers regarding the expansion and/or reshaping of public programs and setting new targets. In addition, the literature review identified a range of policy areas where Big Data is already being utilised to inform decision-making.

After discussing how Big Data can inform policy- and decision-makers, this section describes the ways in which Big Data can be utilised for effective programme and project implementation, monitoring, and evaluation. The literature suggested various ways in which Big Data has the potential to provide government institutions with highly detailed information regarding the quality and quantity of its outputs and assist in generating targeted measures of these outputs and outcomes. This study found that Big Data can be used to assess the performance of external projects and programmes and improve personnel performance measurement tools, and strengthen HRM practices.

7.2.3 Objective 3: Exploring the Limitations Faced when Implementing Big Data-Driven Technologies in the Public Sector

Having defined Big Data and discussed the various ways in which it can be utilised in the public sector, this study set out to discuss the challenges and limitations of implementing Big Data technologies within a government setting. Six challenge categories were discussed. These include: 1) data quality, governance, and management, 2) cost and funding, 3) leadership and organizational culture, 4) silo, 5) skillset requirements, and 6) big data ownership, privacy, and security.

The discussion of these challenges was followed by a section in which the researcher discussed the counter-argument against the use of Big Data in the public sector, presenting various arguments as to why public sector Big Data use could be dangerous and/or ineffective. Such arguments include the stance that one cannot view the world through "tech goggles" alone, thinking that technology could solve all society's problems. On the contrary, not all problems can be addressed by means of technology, and in some cases introducing Big Data solutions may even increase the chasm between those who have access to technology and those who do not. This section also warns against the inherent flaws and biases of Big Data and the risks of basing policy solely on information that could be wrongly interpreted.

7.2.4 Objective 4: Outlining the Policy and Legislative Framework Affecting the Implementation of Big Data-Driven Technologies in the South African Public Sector

Chapter 3 of this study discussed the policy and legislative framework affecting the implementation of Big Data technologies in the South African public sector context. In this chapter, the researcher discussed the link between Big Data use and various relevant e-Government, ICT, and information security bodies, regulations, and policies.

This chapter outlined some key bodies, ICT and e-Government frameworks, and regulations. These include the ITU, OECD, OASIS, and its International Technical Standards for e-Government. This discussion was followed by investigating two bodies relevant to the South African context and their policies (or lack thereof) on Big Data-related matters. This discussion covered the SADC, as well as the AU and NEPAD and various relevant policies and/or frameworks such as the ICT Sector Infrastructure Development Master Plan, Declaration on ICTs, model laws and policies, and policies on cybersecurity.

After discussing the entities mentioned above, Chapter 3 outlines the various South African laws and policies relevant to implementing Big Data technologies in the public sector. Starting with the Constitution of the Republic of South Africa, this discussion included key policies and laws such as the State Information Technology Agency Act, National Development Plan, POPI Act, Cybercrimes Bill, and National e-Government Strategy and Roadmap (amongst others).

7.2.5 Objective 5: Determining the Relevance of Big Data-Driven Technologies Within the Context of the Western Cape Provincial Department of Agriculture

The fifth objective of this study was to determine the relevance of Big Data to a case study set in the South African public sector context. The researcher selected the Western Cape Provincial Department of Agriculture as a case study and explored how Big Data solutions could be of value in the context of a South African public sector entity. This objective was addressed in Chapter 5 of this study. In this chapter, the researcher reviewed numerous sources of secondary data. Sources included various departmental reports and publications such as the Provincial Economic Review and Outlook (PERO), Departmental Strategic Plans, Departmental and Provincial Annual Reports and the Provinces Annual Performance Plan.

Before discussing the various ways in which Big Data solutions could be of value to the WCDoA, this chapter first provides an overview of the emergence of Big Data in agriculture, followed by an introduction to the Department as a whole. This was followed by discussing the relevance of Big Data technologies specifically to the four key DSOs. These DSOs included: 1) increased agricultural production in a sustainable manner, 2) improved food security and safety, 3) a transformed and inclusive agricultural sector, and 4) innovative and resilient rural economies. In order to determine the relevance of Big Data to the department, this chapter included a discussion of each of these DSOs and their sub-outcomes that could be achieved or contribute directly or indirectly toward Big Data-driven solutions. Annexure J serves as a summary of the findings.

7.2.6 Objective 6: Determining the Attainability of Implementing Big Data-Driven Technologies Within the Context of the Western Cape Provincial Department of Agriculture

The final research objective of this study was to determine the attainability of implementing Big Data technologies within the WCDoA. This objective was addressed in Chapter 6 of this study by means of the data analysis and interpretation of key expert interviews with management members of the department, as well as a questionnaire completed by departmental employees. In order to successfully determine the extent to which implementing Big Data solutions within the department would be attainable, the researcher structured this chapter around the identified challenges to implementing Big Data in the public sector (as identified in the literature review) and the prevalence of these limitations within the department. The key expert interviews were thus focused on questions regarding the skillset, hardware and software, and funds required to implement such technologies within the department. Four senior management members of the department were interviewed. This was followed by a questionnaire completed by departmental employees regarding their views on Big Data and its 1) perceived usefulness and 2) perceived ease of use within their roles. The interview data showed that all of the elements investigated (skills, hardware, software, and funds) act as limitations that hinder the attainability of implementing Big Data successfully within the department. An analysis of interview data provided insight into these limitations that were not uncovered by the literature review. The data showed the complex interactions between these limitations, as discussed in the negative reinforcement loop between the lack of skills and funding (see Figure 6.17).

The questionnaire data showed that whilst employees may have high regard for the usefulness of Big Data within their roles, they are less clear on what that would entail and less certain of their own abilities to master these new technologies. Thus, Big Data is often talked about and referred to as how the agricultural sector is moving. However, there is a need to clarify the practical implications of implementing it into the functioning of the department.

7.2.7 Objective 7: Developing a conceptual framework that can guide the implementation of Big Data in the South African public sector outlining the sources of Big Data, its characteristics, challenges, processes, applications, and value

The process of obtaining research objectives i to vi allowed for the attainment of the final research objective which was to develop a conceptual framework that can guide the implementation of Big Data in the South African public sector outlining the sources of Big Data, its characteristics, challenges, processes, applications, and value. The literature review and legislative framework allowed for the development of an initial conceptual framework based on the theoretical findings of these chapters. This is illustrated in figure 2.6. However, exploring the use of Big Data within the case-study setting illustrated that the reality of implementing Big Data in the South African public sector is, in fact, more complex than the theory (and subsequently the preliminary framework illustrated in figure 2.5) may suggest. For this reason, the researcher provided a second iteration of this framework in figure 8.18 section 6.2.2. This adapted framework now includes an added level of complexity between the interactions of the various challenges faced when implementing Big Data in the public sector. This adapted framework also accounts for the siloed nature of the various government Big Data sources.

7.3 Research Results

This study aimed to gain a deeper understanding of the concept of Big Data and explore its value to public sector institutions. Furthermore, this study aimed to explore its relevance and attainability in a South African public sector context with a specific focus on the Western Cape Provincial Department of Agriculture. In addressing the seven research objectives, this study produced a holistic picture of what Big Data is, its public sector applications and limitations, and a context-specific view of these findings in terms of a case study setting. Initially, the literature review allowed the researcher to draw a preliminary conceptual framework, integrating the literature review findings on the sources of Big Data in the public sector, its characteristics, challenges, processing technologies, applications, and value, all underpinned by a stringent legislative framework (see Figure 2.5). However, Chapters 5 and 6 then took this theoretical knowledge and explored it further in terms of the case study. Through this exploration of the relevance and attainability of Big Data technologies within the department, the study put the findings of the initial conceptual framework to the test. These chapters called on the researcher to modify this framework in several ways. Firstly, it was found that the Big Data "ecosystem" or sources of various Big Data information sets in practice operate heavily in "silos", requiring a distinction between these sources and a lack of adequate sharing pathways of such data sources. Secondly, data from Chapter 6 showed that the initial representation of challenges at a single point of the framework underrepresents the complexity of these limitations. These challenges impact the process of implementing Big Data within the department at various stages. Furthermore, some of these challenges impact other challenges – further exacerbating the process. This modification is shown in the more complex representation of these challenges as presented in the modified framework (Figure 6.18).

7.4 Recommendations for Further Study

The nature of this study was exploratory, enabling the researcher to gain insight into the concept of "Big Data" and its applications and limitations in the public sector. Throughout this research process, the researcher has identified a variety of opportunities for further, more detailed studies. One of the challenges the researcher faced in conducting this study was the broad nature of the topic. This study primarily focused on exploring Big Data in the public sector by means of research objectives 1 to 4 (literature review and legislative framework). However, the case study of the WCDoA enabled the focus of the study to be funnelled into a detailed look at how the theory relates to practice. It is now recommended that future studies investigate specific elements of Big Data technologies within well-demarcated contexts. This study has highlighted various programmes or initiatives that could warrant an investigation in their own right. For example, future studies could investigate the application of particular technologies such as drone imaging within specific programmes or departmental units such as the Research and Technology Development Services branch of the WCDoA. Future studies could then take a deep dive into the application of specific technologies within demarcated units and the detailed approach that would need to be followed in order for this new technology adoption to be successful. Another possible study could look at the management of the data centre situated within the Premier's Office. This programme received substantial critique from interview participants of this study. In light of the potential value that this data centre could provide if managed correctly, a detailed study on its management and recommendations for strengthening its data-sharing capabilities could prove valuable.

7.5 Conclusion

This study has defined Big Data as information of high volume, variety, and velocity, which can be interpreted to provide immense value to whoever owns it. Big Data has emerged as a key component of the 4IR, acting as the “information” building blocks of technologies such as machine learning, AI, and the IoT. Through these technologies, Big Data has woven itself into our everyday life, often rendering us blissfully unaware of the extent to which it keeps track of and even influences various ways we interact with the world. Big Data can be life-changing, bringing convenience like never before by keeping track of global pandemic outbreaks, collecting information on citizen views and inputs on policy matters, knowing when stock needs to be ordered, or even something as simple as being notified by a manufacturer when your car requires a service. However, the utilisation of Big Data by government institutions is a double-edged sword that should rightfully be met with a healthy dose of scepticism. This study has identified several challenges and concerns to the use of Big Data by public sector institutions. There are not only concerns as to whether public institutions have the capacity to utilise these technologies but also more moral questions regarding the ownership, privacy, and security of citizens’ information and their control over who “owns” their data. Furthermore, this study explored the often restrictive legislative and policy framework public sector entities must adhere to when implementing Big Data technologies.

Big Data and the 4IR have become buzzwords in government publications and strategies, often presented in a rather vague manner rendering the ‘what now’ question. Yes, Big Data could be valuable in enabling governments worldwide to better serve their citizens, but ‘what now’? What do such new technologies actually look like, and what does it mean for public officials and administrators? A balanced approach is required. Not every public official needs to become a data scientist fluent in Big Data or 4IR “talk”. This study has found that the most important requirement of the public sector is an understanding of this phenomenon and the ability to identify *where* and *how* the implementation of these new technologies would produce the most value. Furthermore, this study has found that the public sector is limited by its internal capacity to implement Big Data solutions successfully. On this matter, collaboration with non-governmental stakeholders is imperative, moving beyond the public versus private paradigm toward a collaborative Big Data ecosystem. The premature implementation of Big Data technologies without the required capabilities, collaboration, and clarity of outcomes is highly likely to be costly and ineffective.

Big Data is not a silver bullet to singlehandedly combat all the deeply embedded evils within the public services sector. However, Big Data is information and information, if managed correctly, produces knowledge and insight. This knowledge, and the insight on how to take action with it, can enable a valuable transformation in how government fulfils its many functions in spite of an increasingly complex world.

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ANNEXURE A – TREE AND BRANCH STRUCTURE OF THE SEMI-STRUCTURED INTERVIEW

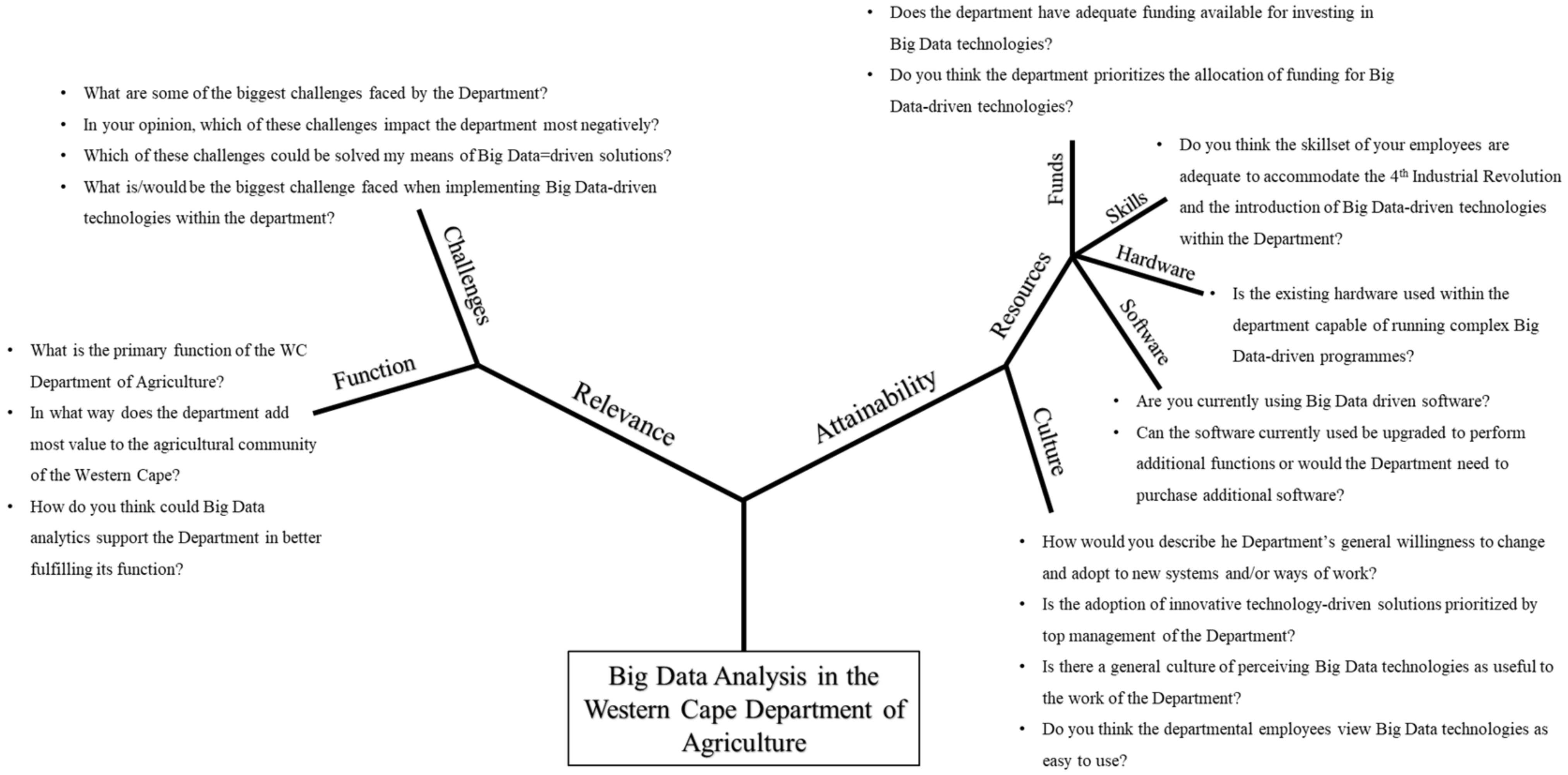

Figure A.1 - Tree and Branch Structure of the Semi-Structured Interviews

ANNEXURE B – SEMI-STRUCTURED INTERVIEW GUIDE & QUESTIONS

Dear Interviewee

Thank you so much for agreeing to be interviewed as part of my MPA research. I am investigating the public sector use of Big Data technologies with the Department as a case study. It is hoped that the findings of my research project can contribute to improving the general understanding of what value Big Data technologies could bring to public sector institutions. I have the permission of the Department to conduct this research. I have several questions that I would like to ask you. I assure you that your responses are completely confidential and anonymous. I will give a general summary of the broad research findings to the Department once my research is complete, but I will not disclose what specific interviewees have said.

You have the right not to participate in this interview and also not to complete the interview if you do not wish to do so. You may withdraw your consent at any time and discontinue participation without penalty. Should you choose to withdraw from the study, the researcher has the right to use any information provided up until the point of the withdrawal.

With your permission, I would like to record this interview in order for me to take thorough notes of your responses. Do I have your permission to record? I am happy to send you a typed copy of my notes tomorrow or at your convenience so that you can verify that the responses I have typed for you are accurate.

This research is conducted in accordance with Stellenbosch University’s Policy on Research Ethics; I can give a copy of this to you, if you like. Furthermore, this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments. Information obtained during this interview will be stored securely and discarded as soon as the study is completed.

Do you have any questions regarding the project before we begin?

The interview will begin with a brief introduction of the researcher, the purpose of the research and the aim of the case study and interview. The researcher will then ask the interviewee to provide a brief introduction of themselves and their role within the department for context.

The following list of questions will guide the discussion according to the specific expertise of the interviewee. If the interviewee is a technological specialist, more time would be spent on questions about the hardware, software and skills component, whereas if the interviewee is a financial manager of the department, more time would be spent on discussing the financial viability and affordability of implementing Big Data technologies within the department.

Guiding Questions

Function of the Department:

1. In your opinion, what is the primary function of the Western Cape Provincial Department of Agriculture?
2. In what way does the Department add value to the agricultural sector of the province?

Challenges faced by the Department:

3. What are some of the biggest challenges faced by the Department?
4. In your opinion, which one of these challenges impacts the department most adversely?
5. What is/would be the biggest challenge faced when implementing Big Data technologies within the Department?

Resources - funds:

6. Does the department have adequate funding available for investing in Big Data-driven solutions?
7. Do you think the Department currently prioritises the allocation of funding toward such technologies?

Resources – skills:

8. Do you think the skillsets of your employees and colleagues are adequate to accommodate the Fourth Industrial Revolution and Big Data-driven technologies within the Department?

Resources – Hardware and Software:

9. Is the existing hardware used within the department capable of running complex programmes?
10. Are you currently using Big Data enabled programmes and software? Can the current software used be upgraded to perform more complex functions, or would it be required for the Department to purchase more advanced functionalities?

Organisational Culture:

11. How would you describe the Department's general willingness to change and adapt to new systems and ways of work?
12. Is the adoption of innovative technology-driven solutions prioritised by top management of the Department?
13. Is there a general culture of perceiving Big Data technologies as useful to the work of the Department?
14. Is there a general culture of perceiving Big Data technologies as easy to use?

ANNEXURE C – QUESTIONNAIRE

Big Data Analytics in the Western Cape Department of Agriculture

Section 1: Introduction

Dear Respondent

As part of my Master's Degree in Public and Development Management, I am conducting a research project investigating the public sector use of Big Data technologies with the Department as a case study. As part of this research, I am administering questionnaires to employees to determine their views on Big Data and its applications within the Department. I am also interviewing senior management members to learn more about the Department's function, challenges and resources and how this may affect the implementation of Big Data-driven technologies within the organisation.

I have been granted the necessary permission from the Department to administer this questionnaire. This questionnaire will include questions regarding your perceptions of Big Data technologies and their application and relevance to your work. There are no anticipated risks to you from participating in the study.

Rights of the Research Participant:

I assure you that your participation and responses are completely private, anonymous and confidential. You have the right not to participate in this study. You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research participant, contact Ms Maléne Fouché [mfouche@sun.ac.za; 021 808 4622] at the Division for Research Development. Should you choose to withdraw from the study, the researcher has the right to use any information provided up until the point of the withdrawal.

Your name is not asked for on the questionnaire, and I will not disclose your responses to anyone. I will be providing the Department with a broad overview of the general research findings at the end of the project, but I will not be disclosing what individual participants' responses are.

I will be using the data obtained from questionnaires and from my interviews to write up my MPA thesis, and thereafter, I hope to publish a paper in an academic journal on the study. Once again, your privacy, anonymity and confidentiality will be completely protected. This research is conducted in accordance with Stellenbosch University's Policy on Research Ethics, and a copy of this can be made available to you upon request. Furthermore, this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including all of its amendments.

Thank you very much for your interest and participation,

Suné van Zyl

Email: sunevz@sun.ac.za

Supervisor: Mrs Naomi Burger (nmb1@spl.sun.ac.za)

Section 2: Consent Form

Please read and acknowledge the following terms of consent:

- ☐ I hereby give my informed consent to participate in the current study conducted by Miss Suné van Zyl as part of her MCom in Public and Development Management research under the supervision of Mrs N Burger (nmb1@spl.sun.ac.za). I also give her my informed consent to ask me my gender, age, tenure, and educational background in her questionnaire, for the purposes of her research. I understand that I do not have to answer these questions if I do not wish to do so.
- ☐ I have read the introduction to this questionnaire and understand that my participation and responses to this questionnaire will be kept private, anonymous and secure.
- ☐ I am aware that this research is conducted in accordance with Stellenbosch University's Policy on Research Ethics. I am also aware of my right to withdraw from this study if I wish to do so at any point. Information I have provided up until the point of my withdrawal can be used by the researcher.
- ☐ I am aware that this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments. I understand that my personal information (age, gender, educational background, and tenure) will be stored securely and discarded as soon as the study is completed.

Section 3: Participant Information

1. Gender:
   - ☐ Male
   - ☐ Female
   - ☐ Non-binary
   - ☐ Prefer not to say

2. Age: ____

3. Job Title: ____

4. Tenure (years with the department): ____

5. Highest Qualification:
   - ☐ National Senior Certificate (Matric)
   - ☐ Higher Certificate
   - ☐ National Diploma
   - ☐ Bachelor's Degree
   - ☐ Honour's Degree
   - ☐ Master's Degree
   - ☐ Doctoral Degree
   - ☐ Other

6. If you selected "other" in the previous question, please specify: ____________________

Section 4: What is "Big Data"?

1. On a scale from 1 to 10, please rate your familiarity with the concept of "Big Data".

	1	2	3	4	5	6	7	8	9	10	
Never heard of it	○	○	○	○	○	○	○	○	○	○	Extremely familiar

Section 5: What is "Big Data"?

Big Data is information often defined in terms of its "three v's" characteristics. It is thus information of high volume, high velocity and high variety, which requires intricate forms of processing to enable decision-making, insight discovery, and process optimisation.

Big Data is a key component of the Fourth Industrial Revolution (4IR) and enables various advanced technologies such as Artificial Intelligence, Machine Learning, and the Internet of Things.

Some examples of Big Data in our everyday life include:

- Targeted advertisements based on your social media profiles, google search queries and general online activity.

- Netflix recommendations based on your personal preferences and watch history.

- Varying Uber rates based on real-time demand, traffic patterns, and location.

- Predictive inventory ordering in large factories and warehouses.

- Smart Agri initiatives such as Fruitlook, utilising drone technologies, sensors, and data from various sources and role players.

1. After reading the short description of Big Data provided above, on a scale from 1 to 10, please rate your familiarity with the concept "Big Data":

	1	2	3	4	5	6	7	8	9	10	
Never heard of it	○	○	○	○	○	○	○	○	○	○	Extremely familiar

Section 6: Perceived Usefulness of Big Data (Based on the Technology Acceptance Model)

1. Using Big Data analytics in my job will allow me to do my job more efficiently.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

2. Using Big Data analytics would improve my job performance.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

3. Using Big Data analytics in my job would enhance my effectiveness.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

4. Using Big Data analytics would make it easier to do my job.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

5. I would find Big Data analytics useful in my job.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

Section 7: Perceived Ease of Use of Big Data (Based on the Technology Acceptance Model)

1. Learning to operate Big Data-driven technologies would be easy for me.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

2. I would find it easy to get Big Data-driven technologies to do what I want them to do.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

3. My interaction with Big Data would be clear and understandable.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

4. It would be easy for me to become skilful in using Big Data-driven technologies in my job.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

5. I would find Big Data-driven technologies easy to use.
   - ☐ Strongly Disagree
   - ☐ Disagree
   - ☐ Neutral
   - ☐ Agree
   - ☐ Strongly Agree

Section 8: Thank you for completing this questionnaire!

Your participation in this study is greatly appreciated. If you have any questions regarding this study or would like to receive a copy of the study once it is completed, feel free to contact me at sunevz@sun.ac.za.

Kind regards,

Suné van Zyl

ANNEXURE D – INTERVIEW PARTICIPANT CONSENT FORM

I, ..., hereby give my informed consent to participate in the current study conducted by Miss Suné van Zyl as part of her MCom in Public and Development Management research under the supervision of Mrs N Burger (nmb1@spl.sun.ac.za). I also give her my informed consent to conduct a recorded interview with me, for the purposes of her research.

Miss Van Zyl has explained her research project to me and has assured me that my participation and responses to her questions will be kept private, anonymous, and secure. She has also given me an electronic statement containing details of her research project.

I am aware that this research is conducted according to Stellenbosch University's Policy on Research Ethics. I am also aware of my right to withdraw from this study if I wish to do so at any point. Information I have provided up until the point of my withdrawal can be used by the researcher.

I am aware that this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments. I understand that my personal information (age, gender, educational background, and tenure) will be stored securely and discarded as soon as the study is completed.

Signature: Date:

ANNEXURE E – QUESTIONNAIRE PARTICIPANT CONSENT FORM

I, ..., hereby give my informed consent to participate in the current study conducted by Miss Suné van Zyl as part of her MCom in Public and Development Management research under the supervision of Mrs N Burger (nmb1@spl.sun.ac.za). I also give her my informed consent to ask me my gender, age, tenure, and educational background in her questionnaire, for the purposes of her research. I understand that I do not have to answer these questions if I do not wish to do so.

I have read the introduction to this questionnaire and understand that my participation and responses to this questionnaire will be kept private, anonymous, and secure.

I am aware that this research is conducted in accordance with Stellenbosch University's Policy on Research Ethics. I am also aware of my right to withdraw from this study if I wish to do so at any point. Information I have provided up until the point of my withdrawal can be used by the researcher.

I am aware that this study is conducted in accordance with the Protection of Personal Information (POPI) Act No. 4 of 2013, including its amendments. I understand that my personal information (age, gender, educational background, and tenure) will be stored securely and discarded as soon as the study is completed.

Signature: Date:

ANNEXURE F – ORGANOGRAM OF THE WESTERN CAPE PROVINCIAL DEPARTMENT OF AGRICULTURE

Figure F.1 - Organogram of the Western Cape Provincial Department of Agriculture

ANNEXURE G – EXAMPLE OF FRUITLOOK APPLICATION

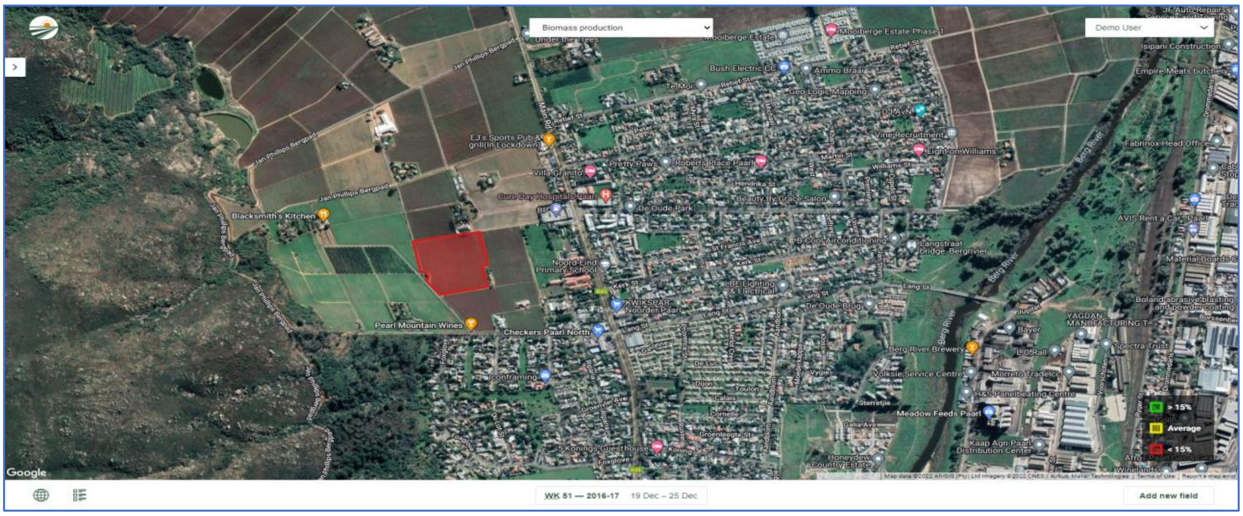

Figure G.1 - Screenshot of Fruitlook Dashboard Depicting Demarcated Field

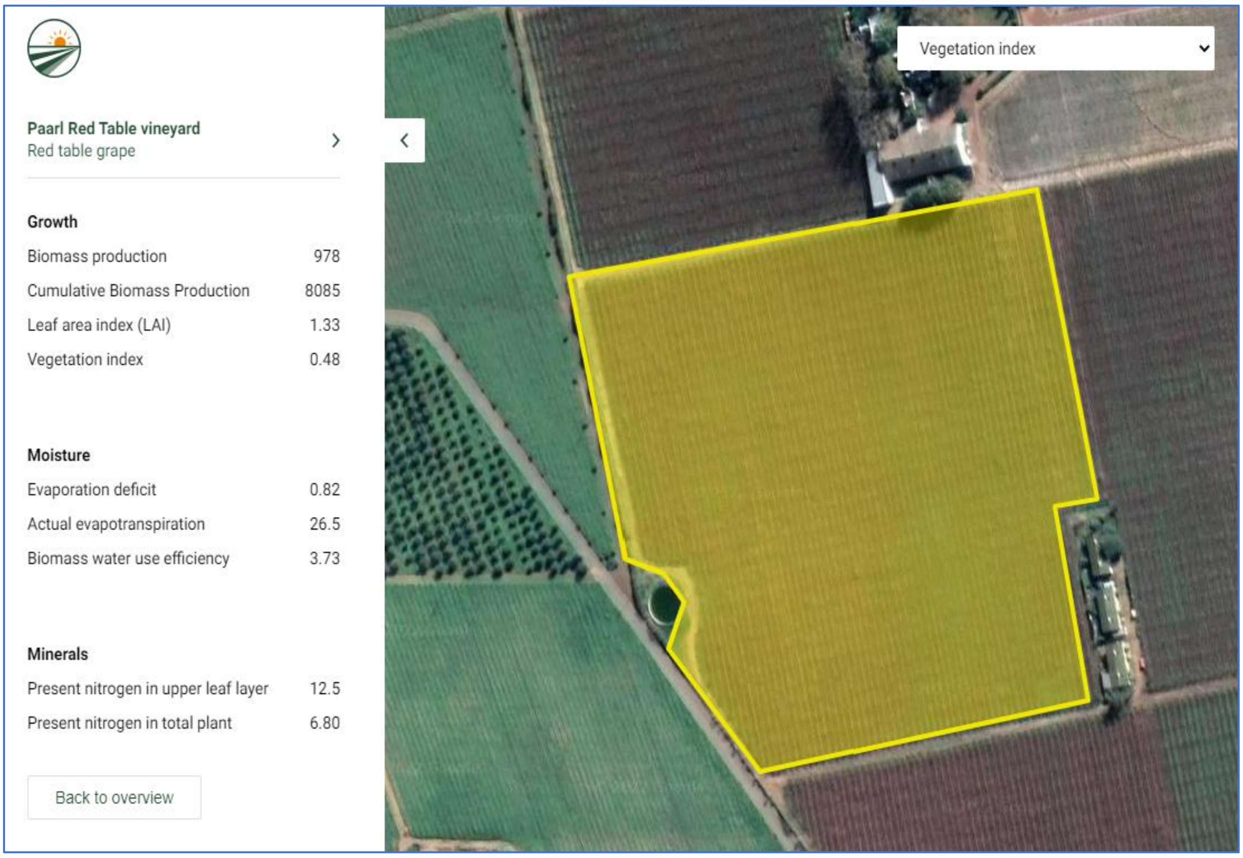

Figure G.2 - Screenshot of Fruitlook Application Depicting Demarcated Field in terms of Relevant Indicators on Biomass Production, Leaf Area Index, and Vegetation Index

ANNEXURE H – SUMMARY OF BIG DATA SOLUTIONS RELEVANT TO DEPARTMENTAL STRATEGIC OUTCOMES AND SUB-OUTCOMES

Table H.0.1 – Summary of Big Data Solutions Relevant to Departmental Strategic Outcomes and Sub-Outcomes

Departmental Strategic Outcome:	**DSO 1. Increased agricultural production in a sustainable manner**					**DSO 2. Improved food security and safety**			**DSO 3. Transformed and inclusive agricultural sector**			**DSO 4. Innovative and resilient rural economies**		
Solution per Sub-Outcomes:	1.1 Maintain export position	1.2 Enhance agri-processing value-add	1.3 Increase sustainable agricultural production	1.4 Optimise sustainable utilisation of water and land resources	1.5 Enhance climate change sustainability	2.1 Increased access to food produced by communities or households	2.2 Ensured affordability of food	2.3 Ensure that food is safe for consumption	3.1 Improve success of agricultural activity among black farmers	3.2 Increase relevant skills within the agricultural sector	3.3 Improve participation of youth, women, and people with disabilities in the agricultural economy	4.1 Increase access to agricultural and economic opportunities for rural communities	4.2 Develop an enabling environment for job creation in the agricultural sector	4.3 Improve safety and security in rural areas
Remote sensing technologies to produce insight on and monitor land conditions and crop productivity	I		D	D	D		I							
Big Data-driven market trend analysis	D	I												
Automation, artificial intelligence, and machine learning in agri-processing	I	D												
Access to free farm management and insight application such as Fruitlook						D	I	I	D					

Departmental Strategic Outcome:	**DSO 1. Increased agricultural production in a sustainable manner**					**DSO 2. Improved food security and safety**			**DSO 3. Transformed and inclusive agricultural sector**			**DSO 4. Innovative and resilient rural economies**		
Solution per Sub-Outcomes:	1.1 Maintain export position	1.2 Enhance agri-processing value-add	1.3 Increase sustainable agricultural production	1.4 Optimise sustainable utilisation of water and land resources	1.5 Enhance climate change sustainability	2.1 Increased access to food produced by communities or households	2.2 Ensured affordability of food	2.3 Ensure that food is safe for consumption	3.1 Improve success of agricultural activity among black farmers	3.2 Increase relevant skills within the agricultural sector	3.3 Improve participation of youth, women, and people with disabilities in the agricultural economy	4.1 Increase access to agricultural and economic opportunities for rural communities	4.2 Develop an enabling environment for job creation in the agricultural sector	4.3 Improve safety and security in rural areas
Monitoring and analysis of Agri-transport routes							I							
Big Data-driven quality monitoring and control								D						
Accessible Big Data-centred agricultural training at all qualification levels, especially focusing on black farmers, youth, women, and persons with disabilities									D	D	D	I	D	
Promoting new and attractive 4IR technologies in agriculture										I	D			
Jobseekers database linking community members to employment opportunities											D	D	D	

Departmental Strategic Outcome:	**DSO 1. Increased agricultural production in a sustainable manner**					**DSO 2. Improved food security and safety**			**DSO 3. Transformed and inclusive agricultural sector**			**DSO 4. Innovative and resilient rural economies**		
Solution per Sub-Outcomes:	1.1 Maintain export position	1.2 Enhance agri-processing value-add	1.3 Increase sustainable agricultural production	1.4 Optimise sustainable utilisation of water and land resources	1.5 Enhance climate change sustainability	2.1 Increased access to food produced by communities or households	2.2 Ensured affordability of food	2.3 Ensure that food is safe for consumption	3.1 Improve success of agricultural activity among black farmers	3.2 Increase relevant skills within the agricultural sector	3.3 Improve participation of youth, women, and people with disabilities in the agricultural economy	4.1 Increase access to agricultural and economic opportunities for rural communities	4.2 Develop an enabling environment for job creation in the agricultural sector	4.3 Improve safety and security in rural areas
Rural Safety Monitoring Dashboard informed by various role players, departments, SAPS and the Rural Safety Desk.														D

*key:

D = Direct Impact

I = Indirect Impact

ANNEXURE I – ROLES OF INTERVIEW PARTICIPANTS

Table I.1 - Roles of Interview Participants

Participant Number	**Role**
1	Scientific Manager: Animal Science Directorate and Acting Chief Director: Research and Technology Development Services
2	Director: Business Planning and Strategy
3	GIS Team Leader and Specialist Scientist: Research and Technology Development Services
4	Chief Engineer

ANNEXURE J – ROLES OF QUESTIONNAIRE RESPONDENTS

Table J.1 - Roles of Questionnaire Respondents

Respondents Number	Role
1	Scientific Manager: Animal Science Directorate
2	Scientist
3	Senior Scientist
4	Assistant Director: Innovation, Technology Design and Transfer
5	Researcher
6	Specialist Scientist
7	Director: Business Planning and Strategy
8	Senior Agricultural Economist
9	Chief Financial Officer
10	Information Developer
11	Office Manager
12	Agricultural Economist
13	GIS Technologist
14	Manager
15	Chief Director: Veterinary Services
16	Deputy Director: Export Control
17	Lecturer
18	Lecturer
19	Project Manager
20	Chief Engineer
21	Deputy Director
22	Scientific Technician