



**The adoption of technology in the Limpopo province
agriculture sector**

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DECLARATION

I Khomotso Kganakga declare that this research report entitled ‘The adoption of technology in the Limpopo province agriculture sector’ is my own unaided work. I have acknowledged, attributed, and referenced all ideas sourced elsewhere. I am hereby submitting it in partial fulfilment of the requirements of the degree of Master of Business Administration at the University of the Witwatersrand, Johannesburg. I have not submitted this report before for any other degree or examination to any other institution.



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ABSTRACT

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Thesis title: The adoption of technology in the Limpopo province agriculture sector

The fourth Industrial revolution technologies offer us an opportunity to increase competitiveness, as well as an opportunity to overcome weaknesses prevalent in the current agricultural system and the persisting limits of intensive agriculture.

The Limpopo province agricultural sector is a major producer of some of South Africa's agricultural commodities and a competitor in the export markets of agriculture produce. This study seeks to explore the usage and adoption of technology in the Limpopo province agriculture sector.

Even though there has been research in the agricultural sector of South Africa in the context of the fourth industrial revolution none has been done in the Limpopo province context. Therefore, this study will attempt to close the knowledge gap by providing more literature on the topic

The research strategy adopted for this study is a qualitative interview research approach. The finding of this research indicates that role players in agricultural sector of Limpopo have embraced the use and adoption of technology within the sector, this adoption of technology has helped the industry to be competitive internationally, however the introduction of technology within the sector has brought about some level of uncertainty regarding job securities for some.

Technology will continue to advance and bring about change in society and its environment, those in business who chose to ignore this fact and continue with obsolete practices are at the risk of finding their own businesses one day. The provincial government too has role to play in advancing awareness and developing policies.

Johannesburg, April 2021

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1 INTRODUCTION TO THE RESEARCH

1.1 Background and context

More generally, this research the adoption of technology in the Limpopo province agriculture sector. However, before getting to the research conceptualisation (Section 1.2), we briefly introduce the terms and concepts that we have used in conceptualising this research in Section 1.1 generally and broadly—while Chapter 2 has a more specific and detailed discussion on the research context. The research conceptualisation section provides for the research problem statement (Section 1.2.1) and consequently the purpose of this research (Section 1.2.2) as well as the research questions (Section 1.2.3). The delimitations and assumptions of the research study are in Section 1.3 while we discuss the significance of the research study in Section 1.4 and provide a preface to the research report in Section 1.5.

1.1.1 The Limpopo Province and Agriculture

The Limpopo province is one of South Africa's nine provinces which is situated in the northern parts of the country, bordering Botswana, Mozambique and Zimbabwe. The province is the fifth largest province by land area, it has a population of 5.7 million residents which amounts to 10% of South Africa's population, its GDP contribution to the country is 7% and while its unemployment rate contributes 9% (LEDA, 2020). The many economic drivers of the province are mining, agriculture and tourism.

The Limpopo province agricultural sector contributes 7.6% towards the national agriculture, with Western Cape and KwaZulu Natal being the major contributors, however according to Dr Matata Mokoale, CEO of the Limpopo Economic Development Agency, the province can be described as the garden of South Africa or the entire African continent due to its richness in fruit and vegetable production (Mokoale, 2020). According to Mokoale (2020) the province's percentage of the national production is:

- 75% - mangoes,
- 65% - papayas,
- 39% - tea,
- 25% - citrus, bananas and litchis,
- 60% - avocados,

- Two thirds of South Africa's tomatoes (Mokoele, 2020),
- 285 000 tons of potatoes annually;
- Macadamia nuts is also said to contribute 54% (Molele, 2016)

Other agricultural commodities produced in the province include coffee, nuts, guavas, sisal, cotton and tobacco, timber, sunflower, maize, wheat cultivation as well as grape (Molele, 2016).

Agro-processing is also a key contributor to the agri-business of the province, in its strategic plan the province's economic development agency noted agro-processing as one of the key drivers in increasing the provinces GDP (LEDA, 2020), companies such as Pioneer foods, McCain, Granor Passi, Kanhym Westfalia and Enterprise foods are key players in this space within the province (Young, 2019)

1.1.2 The Fourth Industrial Revolution (4IR)

The word “revolution” denotes a dramatic and wide-reaching change, according to (Neitzel, 2012, p. 1) the word refers to a “radical, transformative change and has many generic uses describing phenomena from the ‘industrial revolution’ to the ‘sexual revolution’”. (Schwab, 2017, p.12) states that an industrial revolution occurs when “new technologies and world views introduce significant shifts in economic systems and social structures”.

According to (Schwab, 2017) the first profound change to have an impact on humankind was the transition from foraging to farming, which was largely possible by the domestication of animals, this agrarian revolution was the result of fusing animals and human abilities for the purposes of production, transportation and communication.

A series of industrial revolutions occurred after the agrarian revolution, with the first industrial revolution taking place in the 18th century, it was marked by a shift in the reliance of animal power to mechanised power (Ungerer et al., 2018) , this was instigated by the construction of rail roads and the invention of the steam engine (Schwab, 2017). The second industrial revolution spanned the late 19th century till the early 20th century, it was marked by mass production ability, which was as a consequence of the advent of electricity and the assembly lines (Lezoche, Hernandez, Díaz, Panetto, & Kacprzyk, 2020). The third industrial revolution which was propelled by the development of the

semiconductor, mainframe computing, personal computing and the internet (Schwab, 2017) occurred over the last half century (Ungerer et al., 2018), is often referred to as the computer or digital revolution and has unlocked the digital world.

The fourth industrial revolution which is where we now find ourselves, builds on the digital revolution (Ungerer et al., 2018), this convection is supported by:

- **Velocity:** Evolution is at an exponential pace rather than linear, unlike previous industrial revolutions.
- **Breadth and Depth:** Building on the digital revolution, it combines multiple technologies leading to unique paradigm shifts in economy, business, society and individually.
- **System Impact:** The transformation of entire systems (countries, companies, industries and society)

A profound shift across all industries, government and institution is in motion, the emergence of new technology has given rise to new business models, disrupting incumbents and reshaping “how we work, communicate, express, inform and entertain ourselves” (Schwab, 2017, p. 8).

Technologies which are the driving force behind the fourth industrial revolution cover wide-ranging fields such as:

- Artificial intelligence (AI)
- Robotics
- The internet of things (IoT)
- Autonomous vehicles
- 3D printing
- Nanotechnology
- Biotechnology
- Material science
- Energy storage
- Quantum computing

It is the fusion of such technologies across the physical, digital and biological that distinguishes the 4IR apart from its predecessors (Ungerer et al., 2018)

1.1.3 The Fourth Industrial Revolution and Agriculture

The fourth Industrial revolution technologies offer us an opportunity to increase competitiveness, as well as an opportunity to overcome weaknesses prevalent in the current agricultural system and the persisting limits of intensive agriculture (Sung, 2018).

Drought prone countries such as Malawi and South Africa whose crops fail due to drought can benefit from technologies such as precision farming which is now more advanced than before due to its integration with data and sensor technologies (Preez, 2020), Companies such as FruitLook and ThirdEye for instance use satellite technology and unmanned aerial vehicles to measure soil properties, detect crop health and growth, crop nitrogen and evapotranspiration deficits, to assist farmers in decision making on the effective use of inputs such as water, fertilizers and electricity (Preez, 2020).

According to (Uys, 2017) precision farming techniques are new to litchi and avocado producers, they enable farmers to address a range of pre and post planting challenges including:

- Soil Preparation;
- Long-term oxygen management;
- risk mitigation strategies;
- and disease prevention (Uys, 2017).

Precision farming has also enabled a fertilizer company in the Marble Hall area of Limpopo to assist farmers in maximizing macadamia production, through a solution they've developed that combine drone technology, satellite imagery and soil sampling to provide macadamia farmers with price health data for macadamia orchards.

A farm also located in the Marble Hall area of Limpopo Katlego Citrus is a family business which export 80% of its crop to India, Ireland, Taiwan, China, Hong Kong and the United Arab Emirates attribute their success and competitive advantage to the use of technology in their operation (Hartigh, 2016). Through the usage of a smartphone app that they have developed, Katlego Citrus can identify trees and plants infested by pest or diseases, the app allows for real time identification and uses GPS technology to plot out the path travelled by a scout to locate the affected tree and apply the necessary treatment where necessary (Hartigh, 2016).

Indoor or vertical farming and hydroponics do more with less (Preez, 2020), by enabling continuous crop production through controlled environment agriculture technology capable of regulating all environmental factors (Ungerer et al., 2018). According to (Ungerer et al., 2018) vertical eco-farm systems multi-level design offer “eight times more growing area than single-level hydroponic or greenhouse systems or open field systems”.

The linkage between producer information and consumer through big data and AI enhances the ability to stabilize transactions, smart devices such as intelligent refrigerators are capable of replenishing stock automatically based upon consumption (Sung, 2018)

Other use case for 4IR technologies in the context of agriculture (Ungerer et al., 2018) include:

- Unlocking and optimizing the supply chain,
- Automation,
- Data collection,
- Processing of data,
- Aggregation and distribution of information,
- Unlocking opportunities to finance.

1.1.4 Fourth Industrial Revolution Technology Challenges

The connected world of IoT presents an increase in vulnerabilities in present day systems and will therefore require greater attention to be given to cybersecurity.

The enablement and adoption of the 4th industrial revolution technologies is also subject to many challenges, within the context of South Africa, the following issues were raised as major challenges to enabling the adoption of 4IR technologies within industries, (i) the inaccessibility of fixed broadband to the larger society due to limited penetration and affordability, (ii) reliable and efficient electricity generation, (iii) lack of skills, (iv) cybersecurity and (v) a shift in mindset as some employees continue to resist change (Bayode, van der Poll, & Ramphal), the enormity of this challenges are echoed by (Manda & Ben Dhaou, 2019).

1.2 Research conceptualisation

1.2.1 The research problem statement

Advancement in technological achievement have increased efficiency and speed within the farming sector, agricultural methods such as Hydroponics have enabled farmers to produce crops throughout the year, that would have otherwise been seasonal. The emergence of the fourth industrial revolution provides farmers with an opportunity to exploit these emerging and disruptive technologies by developing new methods of production and new channels of distribution.

According to senior director of food and agricultural global practice at the world bank Juergen Voegelé, technology has revolutionized agriculture at regular intervals and disruptive technologies could help distribute food, wealth and data, reduce hunger and waste, and empower farmers (Voegelé, 2018).

However, the adoption of technology in the South African farming sector seem to be lagging in comparison to other industries such as the Banking sector.

According to a report by the University of Stellenbosch Business School and Western Cape Department of Agriculture (Ungerer et al., 2018), the agricultural sector still need to catch up to other industries in the adoption and application of technologies, the report cites some of the challenges faced to be (i) the import costs of agricultural technology, (ii) Most agricultural equipment in use are analogue (not equipped with digital technology and not networked), (iii) Farmers wanting to use new technologies need to extend their tech-competence, (iv) Telecommunications infrastructure remains inadequate in rural areas, (v) legislation and framework around the usage and collection of data.

1.2.2 The research purpose statement

The purpose of the research is to evaluate the adoption of technology in the Limpopo province agriculture sector. Firstly, we will review literature to determine the knowledge gap and develop a theoretical framework to interpret the research findings. Secondly, we will construct a robust result chain showing the links between inputs, activities, output, outcomes and the impact of the 4th industrial revolution technologies. Thirdly, we propose a research strategy, research design, research procedure and methods appropriate to evaluate the adoption of technology in the Limpopo province agriculture

sector. Fourthly, we will collect and analyse data to determine the usage and impact of technologies in the sector.

1.2.3 The research questions

- 1.2.3.1 What type of technologies are farmers using in their agricultural processes and activities?
- 1.2.3.2 What are the critical factors driving the use and application of technology within the sector?
- 1.2.3.3 Are there any prescribed framework/model available within the sector to follow when adopting technology?
- 1.2.3.4 Is there any legislation governing the use of technologies within the sector?

1.3 Delimitations and assumptions of the research study

This study will only focus on the agriculture sector of Limpopo, the study will not cover the entire province for practical reasons but will specifically focus on the Capricorn district and The Greater Tzaneen local municipality (Mopani district) due to the vast agricultural activities in these areas. Even though there is considerable amount of household agriculture activities in the rural areas of the province, this study will only focus on commercial and small hold farmers.

This research assumes that the sample size and the source location covered by the study is adequate to provide a view on the adoption of technology of technology in the Limpopo province agriculture sector. The views expressed by the participants is considered to be factual, due to the years of active experience in the agriculture sector of the province by the participants as well as the positions currently held by this study participants.

1.4 Significance of the research study

Even though there has been research in the agricultural sector of South Africa in the context of the fourth industrial revolution (Ungerer et al., 2018), none has been done in the Limpopo province context. Therefore, this study will attempt to close the knowledge gap by providing more literature on the topic. Some aspects that contribute to the significance of this study are as follows:

- The research will contribute towards understanding the implication of technology usage in the farming sector in the Limpopo province.

- It is important to understand factors that drive and deter the adoption of new technologies and methods by those in the sector in order to get an understanding of other forces impacting the sector.
- Government agencies such as the Limpopo Economic Development Agency (LEDA) might benefit from the study as the revitalization of the agricultural and agro-processing sectors remain key to their strategic plan (LEDA, 2020).
- Existing players, new entrants and those considering participating in the sector might find value in the findings of the research for decision making purposes.
- The study could assist in formulating policies around technology usage and data governance within the sector.

1.5 Preface to the research report

To this end, the report has six chapters. Following this introductory chapter, Chapter 2 provides a literature review covering the problem, the past studies, the explanatory framework and the conceptual framework. Chapter 3 discusses the research strategy, design, procedures, reliability and validity measures as well as limitations. Chapter 4 and Chapter presents and discusses the findings, respectively, to interrogating our research questions while Chapter 6 summarises and concludes the research.

2 LITERATURE REVIEW

This chapter has three broad objectives; namely to understand the research problem, to identify the knowledge gap, and to develop a framework for interpreting the research findings. Specifically, in Section 2.1, we detail the research problem. In Section 2.2, we review literature on studies that have attempted a similar study or research. With information arising from Section 2.2, we identify and detail qualitative attributes or quantitative variables that are key to this research in Section 2.3 as well as a framework that we will use to interpret our research findings in Section 2.4.

2.1 Research problem analysis

2.1.1 The revolution

The fourth industrial revolution refers to an era of convergence between information and communication technology, where the physical, biological and the digital world are incorporated through the use of big data (Sung, 2018), it represents “the great tectonic shift of our time” (Ramaphosa, 2020, p.71). It will affect all aspects of life (Sung, 2018), according to (Schwab, 2017, p.10) “the fundamental and global nature of this revolution means it will affect and be influenced by all countries, economies, sectors and people”.

The fourth industrial revolution is transforming production capabilities in all sectors including the agriculture industry (Bonneau, Copigneaux, Probst, & Pedersen, 2017), agriculture is anticipated to evolve into a high-tech industry in which systems are fused with artificial intelligence and big data (Sung, 2018). The widespread use of advanced technologies presents new opportunities in agriculture (Ozdogan, Gacar, & Aktas, 2017). Conceptually agriculture in recent times and in the near future according to (Ozdogan et al., 2017) implies agriculture with water saving; intelligent agriculture; high quality; high efficiency; and non-polluting agriculture, to realize this transformation the digitization of agriculture is the most effective necessary approach (Ozdogan et al., 2017).

2.1.2 Meeting demands of the future

There are four main developments hindering legacy agriculture systems meeting the demands of the future, demographics, scarcity of natural resources, climate change and food wastage (De Clercq, Vats, & Biel, 2018), a concerted effort by governments,

investors and innovative agricultural technologies is required to meet this challenges (De Clercq et al., 2018).

2.1.3 Transforming the agriculture sector

The key to transforming agriculture according to (Bonneau et al., 2017) resides in the collection of data and measurement about the production: soil quality; irrigation levels; weather; presence of insects and pests. Sung (2018) argues that there are three manners by which 4IR technology will have a major impact on agriculture namely through precise optimization; the revision of rural production elements and the overcoming of weather-related problems. Consideration must also be given to the supply chain management in this era of the forth industrial revolution due to the development of new ways of work and business models in farming (A. Braun, Colangelo, & Steckel, 2018). Elements of the fourth industrial revolution should facilitate the integration between the internal and external environment of farming, this integration will enable intelligent agriculture planning and control (A. Braun et al., 2018).

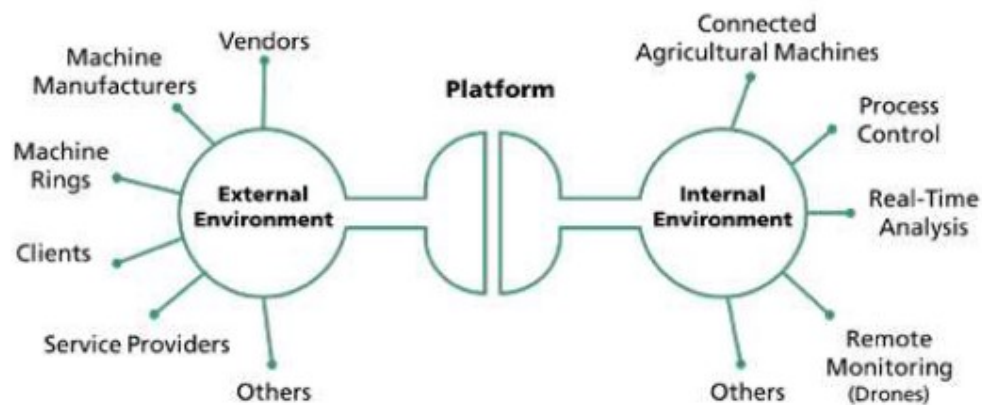


Figure 1: The two environments of agriculture(A. Braun et al., 2018)

Braun et al. (2018) argue that technology does not only present solution to challenges confronted by farmers, but it also serves as an important contributor towards transforming challenges in the supply chain management of agriculture into opportunities. The expected smart supply chain innovation according to (Corallo, Latino, & Menegoli, 2018) is strongly linked to the prospect of modelling networks capable of identifying actors and processes, and “activating inter-company information flows to the benefit of the quality of the product and of company sustainability, effectively embracing the theme of voluntary traceability of supply chain” (Corallo et al., 2018). Food traceability refers to the ability to “trace and then follow the food product during all its transformation phases” (Corallo et al., 2018). Corallo et al. (2018) argue

that there are many factors that have influence over the unpredictable and non-standardized decision-making model of the agri-food industry, factors such as the existence of different business models and environments of production and processing as well as extraordinary climate changes, (Corallo et al., 2018) suggest will look to technologies of the fourth industrial revolution paradigm to address this issues.

2.1.4 An uneven adoption of technology

However according to (Bronson, 2019) not all farmers are enthusiastically involved with digital innovation, Branson (2019) cites a number of studies that found that there was an uneven adoption of digital technologies amongst farmers, the studies revealed that, it is large scale commercial farmers who are adopting these digital tools, and that small scale farmers are not adopting at equal rates. Those studies attributed the an even adoption of technology to cost structures and resource availability for purchasing (Bronson, 2019). Branson (2019, p. 2) also cites another study that found another factor having an impact on the adoption of technology in agriculture was “the level of a farmer’s knowledge about the costs and benefits of digital agricultural tools”. According (Klerkx & Rose, 2020) inclusion and exclusion is not necessarily problematic from a diversity viewpoint, the problem arises however when there is “is no space for diversity and some systems become dominant and hegemonic, this may generate inequalities and injustices which are non-desirable from a human welfare point of view, an animal ethics viewpoint, or an ecosystem integrity and sustainability standpoint” (Klerkx & Rose, 2020).

2.1.5 Social sustainability

According to (Rose, Wheeler, Winter, Lobley, & Chivers, 2020) people, production and the planet are the three tenets that should guide the sustainable intensification of agriculture in the fourth industrial revolution, (Rose et al., 2020) argue that the focus around agriculture 4.0 has mostly ignored incorporating social sustainability into the technological trajectory and has predominantly been framed around benefits to productivity and the environment. The fourth industrial revolution brings many benefits with, however there are also some key challenges that come with it, its disruptive nature has the potential to yield greater inequalities amongst societies (Xu, David, & Kim, 2018). Technologies such as AI and Automation have the potential to substitute labour across the entire economy, this displacement of labour by machine and gaps between capital and labour returns could lead to increase social tensions.

Rose et al. (2020) assert that emergent technologies in the fourth industrial revolution have been presented as “solutions to challenges associated with food production” and that the need to feed an increasing human population has been used as justification for the inevitable digitalisation of all farming systems, Rose et al. (2020) however argue that the marginalization of people (social sustainability) involved in agricultural production result in three consequences:

- Reinforcing dominant narratives of food insecurity,
- Losers of the fourth agricultural revolution,
- Resistance of new technologies (Rose et al., 2020);

To avoid this (Rose et al., 2020) proposed a framework that uses innovation principles and recognises that “innovation occurs within systems comprised of multiple actors”.

Rose et al. (2020) assertion on the consequence of the over-emphasis on emergent technologies as a solution to our food system challenges is also echoed by (Klerkx & Rose, 2020), they argue that the narrative associated with food security could become even more technocentric, this narrative ignores other none technological responses to food security challenges (Klerkx & Rose, 2020) such as that “lack of access to food is rarely caused by a lack of food production, but by unequal distribution and entitlement to the food being produced due to societal inequalities”. Klerkx and Rose (2020) further argue that the dominance of technologies associated with agriculture 4.0 could divert money and attention away currently implementable technologies, also pose a question of integration, how do 4IR technologies interact with other types of technologies not considered part of the revolution. According to (Xu et al., 2018) in era driven by technology the scarcest most valuable resource will neither be ordinary labour nor capital, but it will be those who can create new ideas and innovations.

2.2 Research knowledge gap analysis

Most research around the Fourth Industrial Revolution its technologies, their impact and usage in the context of the agricultural sector have been conducted extensively internationally (see Bonneau et al., 2017; De Clercq et al., 2018; Schwab, 2017; Sung, 2018).

However a few studies have been conducted within South Africa, for example (Ungerer et al., 2018) discusses trends shaping the future of farming, emerging technologies and innovation that could change farming as well as opportunities and challenges that could change the sector brought about by the emergence of 4IR, (Aguera et al., 2020) discusses the digitalisation of agriculture with the focus on general trends of ICT in the agricultural sector as well as challenges facing the sector, while (Preez, 2020) discusses the relevance of the Fourth Industrial Revolution technologies for the agricultural sector in Southern African countries that are drought prone.

None of these studies have contextually examined the Limpopo province's agricultural sector mostly focus on South Africa in its entirety with the exception of (Ungerer et al., 2018) which contextually focuses on the Western Cape. The Limpopo province and the Western Cape province differ socially, demographical and environmentally, there are also differences in agricultural activities conducted in those provinces therefore of (Ungerer et al., 2018) cannot be used to gain insights into state of agriculture of Limpopo province within the context of the Fourth Industrial Revolution technologies.

2.3 Framework(s) for interpreting research findings

According to (Adom et al., 2016) a theoretical framework is “framework based on an existing theory in a field of inquiry that is related and/or reflects the hypothesis of a study. It is a blueprint that is often ‘borrowed’ by the researcher to build his/her own house or research inquiry “

Technology Acceptance Model (TAM) and Theory of Planned Behaviour (TPB) are two theoretical frameworks that serve as the basis of technology adoption within various contexts (Koul & Eydgahi, 2017). According to (Legris, Ingham, & Collette, 2003, p. 3) TAM “examines the mediating role of perceived ease of use and perceived usefulness in their relation between systems characteristics (external variables) and the probability of system use (an indicator of system success)”.

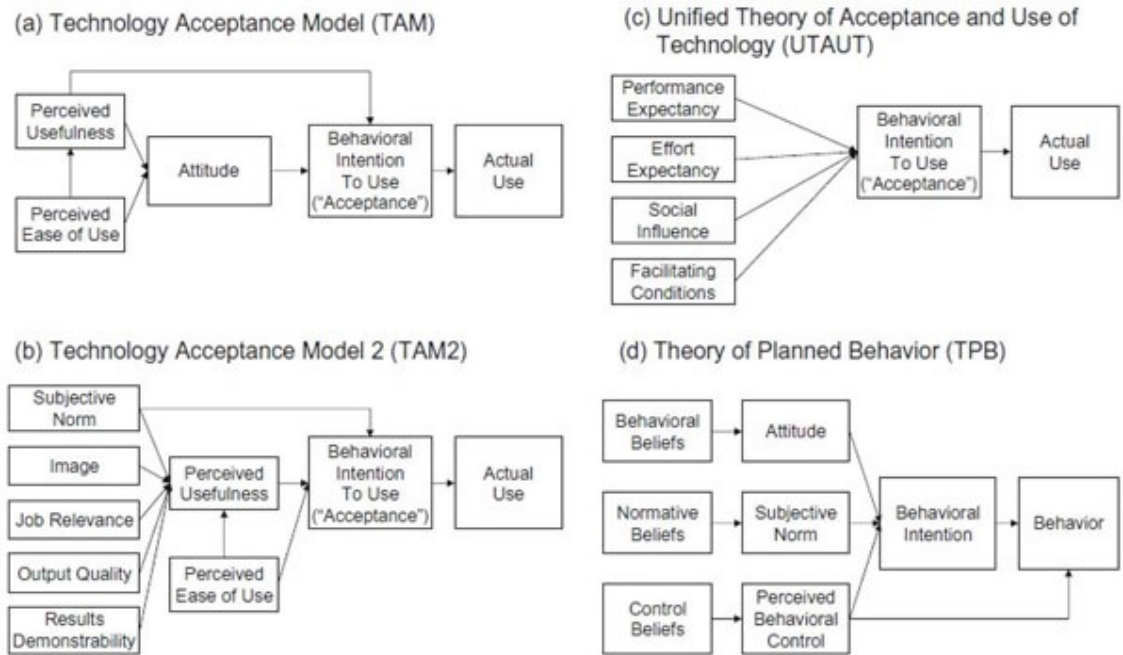


Figure 2: Extensions of the TAM model (Adom et al., 2016).

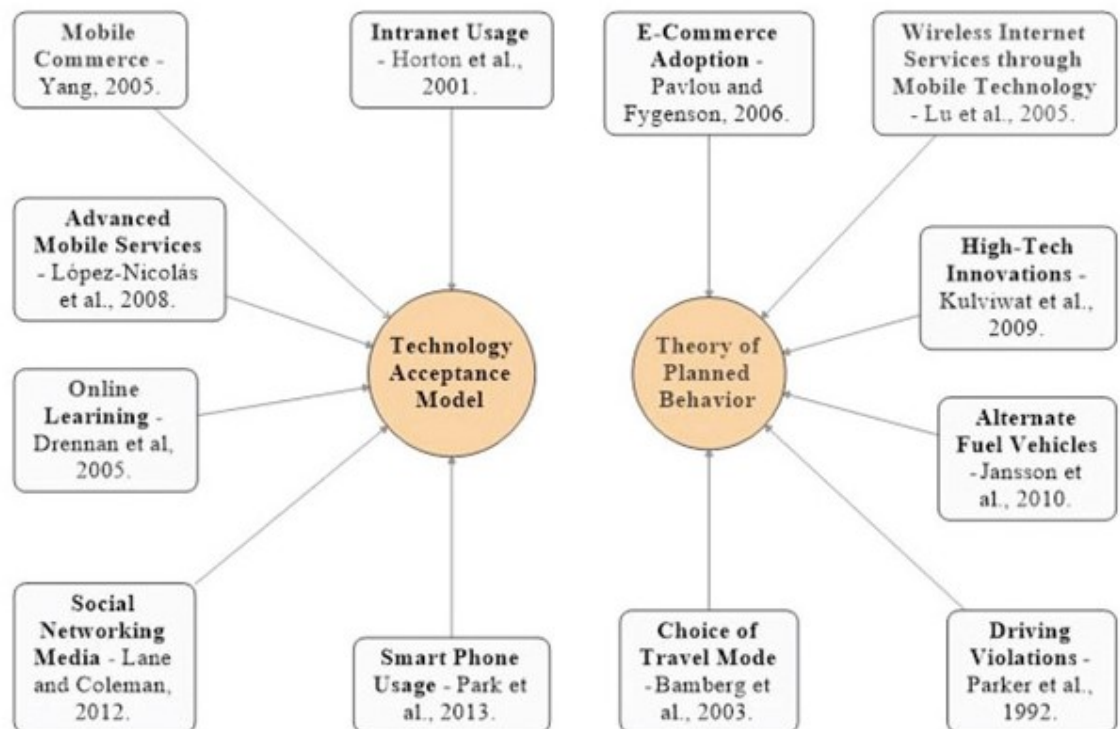


Figure 3: Model depicting various applications of TAM and TPB

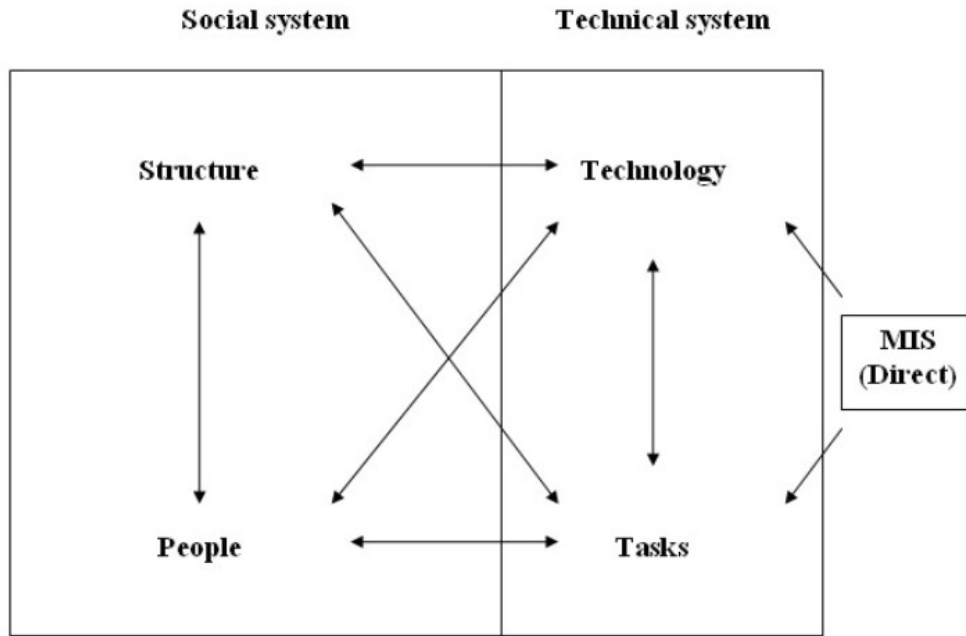
The responsible research and innovation framework was developed for understanding and supporting processes aimed at responsible innovation (Stilgoe, Owen, &

Macnaghten, 2013). Branson (2019, p. 1) states that According to responsible research and innovation (RRI) calls for “interrogations of the decisions taken by designers of technologies not just about what they are capable of doing but, normatively, about what the technologies ought to do and for whom”. According to (Eastwood, Klerkx, Ayre, & Rue, 2019, p. 4) RRI “extends the TA concept to ethical issues of responsibility and broader processes for including public perspectives”.

The socio-technical perspective is based on the idea that an organization consist of two components; technical (equipment, tools, techniques and processes) and social (people and relationships among them) (Hadid, Mansouri, & Gallea, 2016). According to (Trist, 1981) the social-technical concept arose in conjunction with the first several field projects undertaken by the Tavistock Institute in the British coal mining industry”.

The socio-technical perspective views the technical and the social as interdependent parts of system by which the design and performance of an organization can be understood and improved, “any organizational system maximizes performance only if the interdependency of the subsystems is explicitly recognized” (Cartelli, 2007). The foundation of the socio-technical theory is the joint optimization of both the technical and the social (Cartelli, 2007), “thus improving one side will require improving the other side” (Hadid et al., 2016) in order to achieve superior results by ensuring that the technical and social are working in harmony (Cartelli, 2007), “emphasising the technical side of a system by investing more in its practices and neglecting the social system (by investing less in its practices), or vice versa, will not lead to the optimal performance” (Hadid et al., 2016).

Moreover, “Implications of the digital-driven revolution could be reasonably understood by assessing the implications of digital transformation on skills, jobs, work systems, and broader society. Moreover, the influence of the environment, e.g., prevailing economic condition, labour market, and the regulatory framework need to be understood to better prepare governments and their citizenry for digital transformation” (Manda & Ben Dhaou, 2019, p. 2).



This study primarily adopts socio-technical perspective and the technology Acceptance Model (TAM) to understand the adoption of technology in the Limpopo province agriculture sector and how the adoption of technology in within that sector can be impacted by the socio-economic context.

2.4 Summary and conclusion

2.4.1 Summary of literature reviewed

The emergence of the Fourth Industrial Revolution will no doubt have an impact on all societies and all aspects of life (Schwab, 2017), the agricultural sector too will not be left behind by the train that is the fourth industrial revolution (Bonneau et al., 2017), we must be mindful and responsible in adopting as well as in the application of these emergent technologies (Rose et al., 2020) and not further perpetuate an unequal society (Bronson, 2019).

3 RESEARCH STRATEGY, DESIGN, PROCEDURE AND METHODS

In Section 1.2.3, we have posed two questions that this research report intends to answer—that is, ‘What type of technologies are farmers using in their agricultural processes and activities?’, ‘What are the critical factors driving farmers towards the application of technology?’, and ... We have since reviewed literature and developed an interpretative as well as conceptual framework that will guide the choices of techniques we will use. This chapter identifies and describes research approach, design as well as procedure and methods that we employ in this research to collect, process, and analyse empirical evidence. Broadly, it has three objectives; namely, to identify and describe the research strategy (Section 3.1), the research design (Section 3.2), as well as the procedure and methods (Section 3.3). The chapter also describes the reliability and validity measures (Section 3.4) that this research applies to make it credible as well as the technical and administrative limitations of the choices we make (Section 3.5).

3.1 Research strategy

Generally a strategy is a plan of action to achieve a goal (Saunders, Lewis, & Thornhill, 2016). Research strategies or approaches involve processes that span steps broad assumptions to detailed methods of data collection, analysis, and interpretation (Creswell & Creswell, 2017). (Saunders et al., 2016) define it as “as a plan of how a researcher will go about answering her or his research question”.

Before selecting a research strategy (Dawson, 2019) argues that we must first start by answering the five ‘Ws’, (i) What is my research?, (ii) Why do I want to do the research?, (iii) Who are my research participants?, (iv) Where am I going to do the research?, (v) When am I going to do the research?, and only once we have answered that, can we start thinking about the how (Dawson, 2019).

When thinking about a research strategy one should avoid viewing various strategies in terms of which one is better than the other as neither is better than the other, each one has its strength and weakness and are also dependent on the skills, training and experience of the researcher (Dawson, 2019). Empirical evidence can either be “quantitative (i.e., expressed as numbers) or qualitative (i.e., expressed as words, visual images, sounds, or objects)” (Neuman, 2013, p. 22). Qualitative and quantitative represent different ends on a continuum and should not be viewed as rigid, distinct

categories, polar opposites (Creswell & Creswell, 2017). According to (Marczyk, DeMatteo, & Festinger, 2010), quantitative research makes use statistical analysis to conclude its findings, where “a process is describe in terms of one or more quantities” (Locharoenrat, 2017), while qualitative research makes no attempt to quantify its results through statistical summaries or analysis, but through observation without formal measurement (Marczyk et al., 2010).

The aim of this study is to understand the social realities of those active in the agriculture sector of the Limpopo province in relation with the adoption of technology, it seeks to understand and explain the how (i.e. how is technology being used), why (why is technology being used) and the social factors if any driving the use of technology in the sector and thus the research strategy that was adopted for this study is a qualitative research approach. Qualitative research according to (Dawson, 2019, p. 14), “explores attitudes, behaviours and experiences through such methods as interviews or focus groups. It attempts to get an in-depth opinion from participants”. A quantitative approach to this study would not have yielded the desired out due it focusses on quantities (numbers) and measurement.

3.2 Research design

Research designs according to (Creswell & Creswell, 2017) are types of inquiry within the various research strategies that provide direction for actions in a research study. According to (Bryman, 2016, p. 46) research design “provides a framework for the collection and analysis of data”. It is the choice of design that reflects the priority given to the various aspects of the research process (Bryman, 2016).

This research adopted a cross-sectional design to solicit answers from experts and practitioners through interviews and questionnaires

3.3 Research procedure and methods

This section documents the actual procedure and the methods employed in this research to collect, collate, process, and analyse empirical evidence. Broadly, we detail the data and information collection instruments (Section 3.3.1), the target population and sampling of respondents (Section 3.3.2), the ethical considerations during the research process (Section 3.3.3), data and information collection process and storage (Section 3.3.4), data and information processing and analysis (Section 3.3.5) as well as the

background description of the respondents who provided empirical evidence for this research study (Section 3.3.6).

3.3.1 Research data and information collection instrument(s)

Researchers collect data in various ways, data can be collected on instruments or involve a site visit to observe without predetermined questions or through conducting structured and unstructured interviews (Creswell & Creswell, 2017) . According to (Creswell & Creswell, 2017) “data collection steps include setting the boundaries for the study through sampling and recruitment; collecting information through unstructured or semi-structured observations and interviews, documents, and visual materials; as well as establishing the protocol for recording information”.

For the purposes of this study data was collect through semi-structured observations and interviews, it will be captured on recording devices as well on questionnaires.

3.3.2 Research target population and selection of respondents

3.3.2.1 Research target population

(Bryman, 2016) defines a population as “the universe of units from which the sample is to be selected”. The usage of the term unit by (Bryman, 2016) in his definition is to emphasize that it’s not only people that can be sampled but various entities animals, cities, regions, firms etc. (Bryman, 2016). To be eligible as a population member participants must at least share at least a single attribute (Asiamah, Mensah, & Oteng-Abayie, 2017).

A population might be challenging to research due to unknown elements or ease of access to the researcher (Saunders et al., 2016), for example the inclusion of sustenance farmer or household farmers in our study population may badly affect our research outcomes as it violates the assumptions and context of the research (Asiamah et al., 2017). Refinement of the population is therefore required to filter out individuals or units that violate goal, assumption or context of the research (Asiamah et al., 2017), it is the refined subset of the population that is known as the target population (Saunders et al., 2016).

The target population for this research was mainly commercial and small hold farmers, as well as experts in the agricultural sector chain of Limpopo province.

This study will target a minimum sample size of between 10-15 participants.

3.3.2.2 Sampling or selecting respondents from the target population

(Saunders et al., 2016) state that sampling technique can be divided into:

- **Probability or representative sampling** – selection is random to increase the likelihood of each unit in the target population to be selected, the aim of the technique is to minimize possible sampling errors (Bryman, 2016).
- **Non-probability sampling** – none-random selection technique, which increases the likelihood of some units in the target population to be selected over other (Bryman, 2016).

Snowball sampling according to (Naderifar, Goli, & Ghaljaei, 2017) is a purposeful method of sampling in qualitative research. Snowball sampling is convenient when it is difficult for a researcher to “access subjects with the target characteristics, wherein the existing study subjects recruit future subject among their acquaintances” (Naderifar et al., 2017, p. 2).

This research employed both probability sampling and snow ball sampling technique to increase the likelihood of attaining responses from a large pool of respondents and to also compensate for any sampling errors. This study targeted a minimum sample size of between 10 participants.

3.3.3 Ethical considerations when collecting research data

Ethics refer to standards of behaviour that guides one’s conduct in relation to the rights of those that become one’s subject of research or affected by it (Saunders et al., 2016).

Researchers need to protect:

- their research participants;
- develop a trust with them;
- promote the integrity of research;
- guard against misconduct and impropriety (Creswell & Creswell, 2017).

To ensure ethical conduct, the process that was followed during the research when collecting data involved the distribution of a study information sheet to all participants, that elaborate the purpose of the research and the need to solicit their participation, an interview consent form was also distributed to participants and required to be signed.

Furthermore, an ethical clearance certificate was completed and submitted to Wits prior to commencing with the study.

3.3.4 Research data and information collection process

Data and information collection processes involve setting boundaries for the research through sampling and recruitment, information collection through observation, interviews, documentation, visual materials, it also involves establishing protocols for recording information (Creswell & Creswell, 2017).

Collection of data for the purpose of this research was mostly captured in the field through observation and interview, it was recorded on an electronic recording device and transcribed at a later stage. Where on site visit are not possible, this researcher conducted interviews through online communication video channels such as skype, Microsoft teams and Zoom.

3.3.5 Research data and information processing and analysis

3.3.5.1 Research data and information processing

Data processing involves the organizing and of collected data into usable in formation. Data processing activities according to (Given, 2008) include first sorting and checking data ,as well as producing meta data.

For this study data was organized and catalogued using an open source tool for organizing research data.

3.3.5.2 Research data and information analysis

The purpose of data analysis is to make sense of data collected, it involves segmenting and disassembling data, as well as reconstructing it back together (Creswell & Creswell, 2017). In deciding on the analysis approach researchers can begin either from a deductive or an inductive approach (Saunders et al., 2016).

When starting a research using a deductive approach, a researcher will seek to use existing theory in shaping their research processes and aspects of the data analyses, when starting with an inductive approach however a researcher will seek to build up theory a theory that is sufficiently grounded in their data (Saunders et al., 2016). According to (Creswell & Creswell, 2017, p. 257) qualitative researchers “typically work inductively, building patterns, categories, and themes from the bottom up by

organizing the data into increasingly more abstract units of information. This inductive process illustrates working back and forth between the themes and the database until the researchers have established a comprehensive set of themes. Then deductively, the researchers look back at their data from the themes to determine if more evidence can support each theme or whether they need to gather additional information. Thus, while the process begins inductively, deductive thinking also plays an important role as the analysis moves forward”.

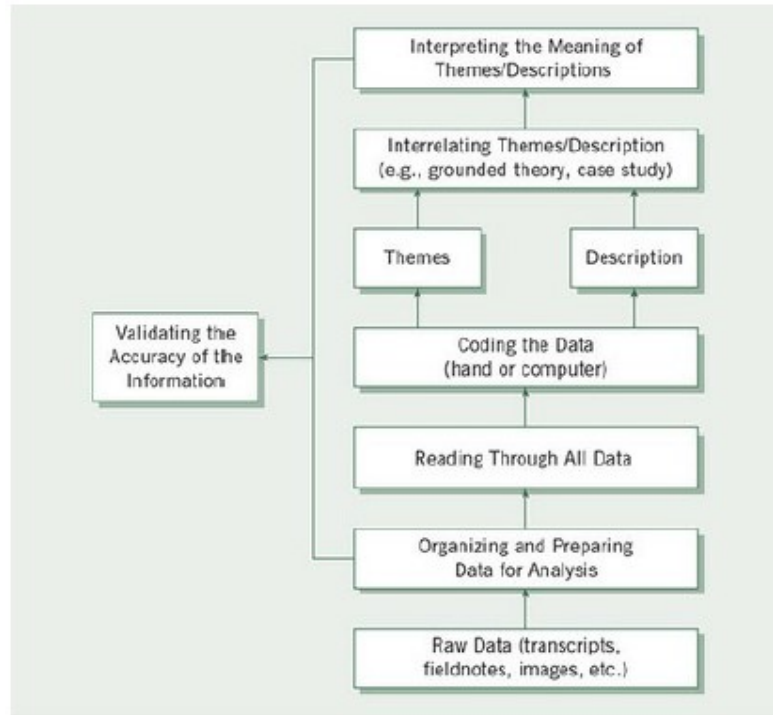


Figure 4: Data Analysis in Qualitative Research (Creswell & Creswell, 2017)

This study adopted a thematic analysis method to analyse data and information collected during the study, the purposes of this approach was to search for themes or patterns that occur across a data set (Saunders et al., 2016). Thematic analysis is accessible and flexible (V. Braun & Clarke, 2012), it may be used irrespective of one's adoption of a deductive or an inductive approach (Saunders et al., 2016).

3.3.6 Description of the research respondents

Respondent	Job Title	Sex	Agricultural activity/Produce	Years In the industry
1	Marketing Manager	Male	Fruits Producer	6
2	General Manager	Male	Livestock & Vegetables	7
3	Technical Specialist/ market Access/ research Coordinator	Male	Agricultural Association Body	3
4	Chief Impact officer/Researcher	Male	Avocado	5
5	HR Specialist	Female	Egg Producer	3
6	Operations Manger	Male	Nursery	2
7	General Manger	Male	Blue berries	38
8	Horticultural development Manger	Male	Intellectual property (technology)	2
9	IT/ Automation Specialist/ Compliance and HR Manger	Male	Blue Berries	2
10	General Manger	Male	Macadamia	5

Table 1: Description of Research Respondents

3.4 Research strengthens—reliability and validity measures applied

Reliability refers to replication and consistency, that is the ability of a researcher to replicate an earlier research design and obtain the same findings, such research would be deemed reliable (Saunders et al., 2016). Validity according to Saunders et al. (2016, p. 202) refers to the “appropriateness of the measures used, accuracy of the analysis of the results and generalisability of the findings”, however (Creswell & Creswell, 2017) argues that validity has different implications for qualitative research and quantitative research, and it is not a companion to reliability or generalizability. A Distinction must be made between quantitative validity and qualitative validity, quantitative validity measures a researcher’s approach in terms of consistency whereas qualitative validity measures a researcher’s findings accuracy by employing certain procedures (Creswell & Creswell, 2017). Reliability and validity are conceptualized as trustworthiness, rigor and quality in qualitative research (Golafshani, 2003).

Creswell and Creswell (2017, p. 274) recommend using a multiple validity procedure to check for accuracy in qualitative studies, this they argue “should enhance the researcher’s ability to assess the accuracy of findings as well as convince readers of that accuracy”.

This research will adopt, triangulation, participant validation which involves sharing research data with participants to provide them an opportunity to validate the accuracy of the data, providing them the ability to comment and correct it, bias elimination and peer debriefing to access validity, to check for reliability transcripts will be proof read to eliminate mistakes, and by continuing data comparison with defined codes.

3.5 Research weaknesses—technical and administrative limitations

Due to the period in which the research will be taking place there could be potential challenges in obtaining access to farmers and experts in the field, Limpopo province is one of South Africa's largest province therefore it would be impossible to cover it in period given for the research, therefore the results of the research will merely constitute a snapshot of the province and will not be a full representation of the entire agriculture industry in the province.

4 PRESENTATION OF RESEARCH RESULTS

The primary objective of this study is to evaluate the extent to which technologies of the forth industrial revolution are used within the agricultural sector of the Limpopo province. The second objective is to understand factors driving the use of technology within the agricultural sector of the province. The research found that so far, no literature is available that report on the use of technologies of the fourth industrial revolution within the Limpopo agricultural sector. Therefore, this chapter is set out to present and discuss findings of the research questions as presented in Chapter 1 (section 1.2.3).

The findings presented in this chapter are derived from data collected through conducting semi-structured interviews with respondents whom are active within the agricultural sector of the Limpopo Provinces. The preliminary processing of data was done in the following sequence: interviews were recorded in audio format; the recordings were then converted from audio to text (transcribed) and then analysed using a thematic analysis method as outlined in Chapter 3 (section 3.3.52) to search for themes and patterns that occur across the data sets and later processed through all the data sets for theme identification.

4.1 Types of Technologies used by farmers in their agricultural processes and activities

4.1.1 Presentation of empirical results

4.1.1.1 Discussion of key themes

The table below describes the themes that came out when soliciting responses on the type of technologies participants are using within their own agricultural activities as well as within the sector of the province in general.

Table 2: Types of Technologies used in Limpopo's agriculture sector

Respondent Id	Question	Themes					
		Automated Systems	Big Data	Drones	Software Integration	Mobile Technology	Satellite Technology
1	“We've adopted that philosophy and we continue to investigate and look at any tool that can make us a better at our job and make us make the best decisions possible that includes drones, It includes sensors;” “Drones have helped us with birds that used to eat our berries.”			*			
2	“I mean a lot of these people use some apps, where data is consolidated, formatted in some shape or form” “As they are picking we can get live feed of information, I can see each individual person performance and how much they're picking and also, the teams now how they are performing”		*		*		

3	“We want to fly a drone into the tunnels and that will automatically count all the trees we have available;”			*			
4	“I think, for example, irrigation scheduling, that would be something where you'd have the Internet of Things involved in actually programming it through your cell phone or activating it through your cell phone” “I know that we've got drones that are being used, in the orchards I think that's more for just seeing whether there's missing trees and so on and also obviously giving some idea of what's going on the Orchard floor like NDBI and just perhaps stress that's present within Orchard.”			*		*	
5	“So using drones for surveillance with specific cameras and lenses and filters and so on to, for example, try and determine what the chlorophyll content is of a tree or an Orchard to try and identify trees which are not performing optimally” “Also, to Capture data in a way that it can be analysed and consolidated so that we can look at a season's data and say this is what we produced, so let's say plans break there. This is what it costs us”		*	*			

6	“we all carry smartphones It's easy to roll out and do data capturing, which I think is the first step maybe, maybe it's debatable, but it's leveraging technology on mobile devices specifically to capture data” “Most of the stuff I'm using is open source code I optimize it” “a Google sheet that's linked to a data studio and suddenly you have insight in a very visual way of what's happening when we farm.” “t's using satellite imagery and terrain models etc. to model complex aspects of a farm”		*		*	*	*
7	“We don't have to go on to the field, switch on the centre pivot, to go on and switch on the borehole, we do everything where we are now (remotely), using my cell phone I just log in switch on or switch off the system”; “We have an automated centre pivot system for irrigation” “Drones are still in the pipeline”	*		*		*	
8	“We have 6 sites, of which one site is technology driven, where everything is automated from when the chicken lay eggs, its moving towards the conveyor belt up until packed, there isn't any human contact with the egg”	*					

4.1.1.2 Response to research question

This study found that various technologies are used in the agriculture sector of the Limpopo province, drones are largely used for surveillance, pests scouting and monitoring yields, the use of mobile technology with big data to enable automation and decision making is also prevalent within the sector. The study also found that satellite imagery and advanced data modelling techniques are utilized to achieve optimal designs.

4.1.2 Comparison of research results to other similar studies

The research results found in this study were similar to those discussed by (Ungerer et al., 2018), however (Ungerer et al., 2018, p. 30) only sought to answer “What are the technologies and trends that will most likely have an impact on the Western Cape agricultural and agri-processing sector? ”, their study was not looking into what has already been adopted by the Western Cape agricultural sector, this study is similar to (Ungerer et al., 2018) to the extent of the technologies mentioned in their studies.

4.2 Factors driving farmers towards the application of technology

4.2.1 Presentation of empirical results

4.2.1.1 Discussion of key themes

The table below describes the themes that came out when soliciting responses on the key drivers towards the adoption and application of technology within their own agricultural activities.

	Question	Themes						
Respondent Id	What are the key drivers pushing to adopt technology in your business?	Accuracy	Competition	Cost/Time Saving	Consumer/Third Party Interest	Efficiency	Sustainability	Societal Issues
1	“To remain competitive, (yeah), that's it, Simple competition just drives it. It's		*					

	simple as that.”							
2	“It's an efficiency, so the benefits, we can't deny it, so we are looking at it”					*		
5	“The reason that we are moving more towards a technological base or basis or approach is to streamline production, but also to Captured data in a way that it can be analysed and consolidated” “To try and understand and improve on their husbandry to produce fruits with as little water as possible and even if it's with spray programs, with the amount of water used there is very little as compared to irrigation water, but here we are looking at using electrostatic machinery to reduce the amount of water in a spray program from, let's say 10,008 litters per hector to 1000 litres per hector; and also using your resources more wisely”					*		
2	“It will also make sure that you actually make that decision when you have to make decisions because you know in agriculture sector and I think and most sectors it's very important to make that decision as		*					

	quickly as possible; so, it's accuracy, definitely some accuracy thing.”							
7	“We have potatoes one side of the field and sweet potatoes on the other and we just want to irrigate on the potatoes, a human being would forget to stop it, but with this technology, automatically it will end up there (the intended area to irrigate) then it will stop itself”		*					
2	Essentially, yes, time, I think especially with the software and big data, I think that were you especially save time, and also using your resources more wisely”			*				
4	“I think farmers will try and increasingly implement technology more and more. Where it can save on costs where it can save on overheads. I think they'll try and implement it as much as they can. But obviously, bearing in mind that, they have to look at the bottom line. How much is it going to cost and what's the what's the benefit?”			*				
5	“so that we can look at a season's data and say this is what we produced, this is what it			*				

	costs us. If we look at this, the labour on this pie chart is the most expensive components, followed by electricity to pump water and fertilizer and so on and so forth”							
7	“I would say we have to move on with technology, because it saves you cost, like you have to take that tractor or the bakkie, and go there, inside the field is wet and you want to switch on the pivot, the bakkie get stuck (in the mud), time is wasted, further more how many people do you now need to come and assist you there, but with the technology we just sit here and do the job”			*				
6	“Labour that's getting too expensive and complicated.; But then also not necessarily having all the overheads of your I would say the normal day-to-day running costs of having personnel to look or to manage tedious tasks, administrative tasks and I think technology assists in eliminating some of those administrative tasks, automating that in a sense, so that we can			*				

	focus on the things that we value most and that's spending time in the Orchard and formulating relationships with other farmers within the space and all with the packers, for instance, its reducing that administrative side. “							
5	“I would say one of the big ones is consumers or third parties and their agendas to drive consumer to understand where food come from, what was required to produce that fruit, whether it's done sustainably, organically, chemically, conventionally. So consumers are becoming more aware and more aware of what food production entails and I want to use the word becoming more and more opinionated, which is on the one hand positive, but on the other hand it is that ignorant even though it's not that positive.” “So people have requirements, terms of fruit must meet, these standards must have or must meet certain MRL levels, So from				*			

	a health perspective and sustainability perspective, it is positive, but then you have people, Without the necessary knowledge, but with a lot of opinion or very strong opinion and unfortunately, that word of mouth approach can make a lot of damage or cause a lot damage because People can run away with an idea or a notion which is not founded or grounded in a scientific or via a scientific approach”							
4	“Obviously technology is very competitive, so for example, if you look at irrigation scheduling, there's several players that are filling that niche. If you look at just sensors in an Orchard, there's also several players that fill that niche, so it's competitive. I'd definitely say that not only are we competitive internationally, that technology that's been adopted has helped the industry”		*					
6	“Being competitive, so I think to try and get that edge” "the technology allows the way in which data is being captured and analysed, I think allows for the formulation		*			*		

	of better questions and better questions then in effect drives more effective farming practices and or management and then from there on you can start driving efficiency on those effective practices in a sense, so I think at least for us the thing was how can we as a small scale farmer be, how can we compete with anybody that's 3, 4, 5 times our size within the same market, same quality fruit. "							
6	“while we try aim for farmers to see their properties differently in sense they see it as a living system that if you understand it, the more you understand that complex variables terrain, terrain variables, for instance, in that matter, soil, climate, all those aspects, the moment you see that from day one before you actually start planting and you do your planning properly, you'll probably reap the benefits of that 10, 15, 20, 25 years down the line so it makes your farming operation more sustainable and all even degenerative in that sense. Although with the pressure for						*	

	farming more sustainably, looking at environmental impacts, you know things like that you have your early adopters within any industry;"							
3	"we put people first, we are just scared that if we implemented some technologies right now, half of our people will lose their jobs, so we're not pushing it at the moment with the pandemic"							*
4	"I think I think that with a lot of a lot of technology, it's same as a lot of business, it's reliant on word of mouth, so If your neighbours tried out this technology and they've had a bad experience, or they've had a good experience you're more likely to adopt it or not adopted"							*
6	"Having a whole workforce adopting new technology is also disruptive especially for large businesses that's the one side, the other side is might be saying OK, we see technology, we see the potential, but we don't really feel that it's going to benefit the business all that much. And then on the other side is probably the knowledge							*

	aspect as well as, age basically I can see even on our farm, what's easy for me to just go and implement is not easy for my dad"							
7	"creating jobs it's an important thing in our society, if it for that, the farm would be dominated by technology, meaning it could be a one man show, like from harvesting, packaging to planting everything would be machinery that are technology driven, at this moment we are trying to limit the usage of technology regarding some of the manual labour, hence you see now in terms of harvesting you are looking at between 60 to 80 casuals around the community, with technology it would imply that this people would not have jobs, so I'd say in agriculture there must be this technology in some instance and in other technology must be excluded it depends on the society, like the society where we are now there isn't any employment except in agriculture"							*

*	“It's not many people who are going to be employed because we're depending on this technology” “we know that agriculture sector is largely an unskilled industry, to say people should be deployed to be reskilled is almost impossible because of the level of education. If you want to take somebody who's got a grade 10 and say we are going to reskill you, you are giving that person a very difficult task, they're not willing to go back to school, they're comfortable with what they're doing.”								*
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Table 3: Factors driving farmers towards the application of technology

4.2.1.2 Response to research question

This study found that various factors influenced participants towards the adoption of technology in their processes in the main there was a need to save on cost and time, as well as to be competitive in the sector. The study also found that efficiency and accuracy were also driving forces, the need to reduce wastage and produce more with less, however the rate of adoption was also influenced by societal factors, some of the participants viewed the adoption of technology from a lens of the type of impact it could have on their surrounding communities more especially around employment.

4.2.2 Comparison of research results to other similar studies

the study found that there was an even adoption of technology within the sector where small scale farmers are not adopting technology at an equal rate to large commercial farmers, this is similar to the findings of (Ungerer et al, 2018, p. 38) which found that “The two dominant themes

from the expert interviews were that smallholder farmers could not compete with mega farmers due to economies of scale and the cost of technologies that is hugely restrictive for small farmers”. In (Ungerer et al., 2018), two central issues emerged around social challenges namely, “minimum wages and the need to upgrade skills and capabilities for the future success of agriculture, are prevalent themes in the discussion on the social challenges to be addressed in order to establish a view on measuring productivity per Rand spent and to transform work in agriculture” (Ungerer et al., 2018), this is in line with the socio-technology perspective, this study found however that labour was considered to be cheap by some participants and technology to be costly to some degree therefore influencing the rate in which technology is being adopted.

5 DISCUSSION OF RESEARCH FINDINGS

5.1 Introduction

The following section will present an interpretation and analysis of the research findings that were presented in chapter 4. The analysis will be done by comparing the findings to the literature review on the topic on agriculture, technology and the fourth industrial revolution.

5.2 Technology Awareness and Adoption

The research found that all participants in the study were aware of technology usage and application within the industry in general and had an even deeper knowledge about the use and application of technologies that have an impact on their businesses, this included technologies already implemented within their business and those that were earmarked for future implementation due to their perceived benefits.

The term the fourth industrial revolution however was not a familiar term with some of the participants.

The study found that various types of technologies are used within the agricultural sector of the province and that participants in the study were well versed in their usage and impact of the technologies on their business, drones, automated irrigation systems, automated chicken houses, mobile phones, Data modelling, cloud computing, and satellite imagery were found to be used within the agricultural sector of the province.

5.3 Factors driving the adoption and application of technology within the sector

The study found that there are a number of key drivers propelling participants of the agricultural industry towards the adoption of technology, the participants of this study predominantly cited efficiency as the main driver, the need to produce more with less land (Ungerer et al., 2018) in order to compete or have a larger footprint in the value chain (Aguera et al., 2020), sentiments echoed by one of the participants were “to maximize the potential for an economic unit, for an example, “If a few years back, an economical unit within the avocado industry was probably around 80 hectares for arguments sake, with the use of technology been reduced considerably up to about I think anything between 30 to 40 hectares could be a very fairly good, economical unit be

competitive on an international scale produce high quality fruit, keeping overheads fairly low”.

Other drivers that were cited as being factors included consumer awareness and perception (Ungerer et al., 2018), sustainability (Rose et al., 2020) as well as precision or accuracy in the application of technology as decision making.

The study found no prescribed framework or model existed that was used by respondents, respondents adopted technology by their own means.

5.4 Legislation governing the use of technology within the sector

The study found the participants were not aware of anybody or structure governing the use of technology within the sector, however some of the respondents are aware of regulatory bodies such as ICASA. When quizzed whether there is a need for such a body or structure or if there is any perceived value could be derived from such a structure some respondents expressed they'd welcome such a structure if its role is that of an information facilitator and trainer and not one that dictates which technology could be used.

However (Aguera et al., 2020) contrary to some respondents recommends that the South African government and policy makers develop “policies that encourage the uptake of appropriate technology within the agriculture sector while also addressing the emerging challenges regarding data protection, data ownership and governance.

(Dongoski, 2021) recommend the standardization and harmonization of data amongst farmers and role players in the industry if objective is to use technology to meet food demands for the future, Dongoski (2021) argues “If data is harnessed at an individual level, then it is doubtful that enough food will be produced to meet this challenge, If we "pull together" as an industry to resolve data usage concerns, we will not only produce more food to feed more people, we can also create more profitable farmers and use more sustainable farming practices”. (Wiseman, Sanderson, Zhang, & Jakku, 2019) attribute the reluctance by farmers to share, to a lack transparency and clarity around regulatory frameworks governing the collection, sharing and use of agricultural data.

5.5 The human Aspect

Increased technology adoption could erode experiential knowledge between the farmer and the land, the consequence thereof being loss of enjoyment and work satisfaction (Rose et al., 2020). The study found that there was a common understanding and acceptance amongst participants that technology advancement is a major disruptor (Li, Hou, & Wu, 2017) and will impact the agribusiness from the source right through to distribution (Dongoski, 2021), participants of this study specifically pointed out job losses that will be experienced by mostly the workforce in the field, however there were opposing views amongst participants as to what the catalyst for technological disruption to labour will be, the arguments put forward ranged from the cost of labour, to policy implementation by government, upskilling and knowledge transfer.

Labour Laws, Unions and Policies

One participant expressed the high labour cost, unions and government policies as an accelerator that will push businesses towards the adoption of technology, other participants considered labour cost in the agricultural sector of the province and in South Africa generally to still be cheap and as such viewed the “cheap” labour cost as deterrent for some businesses to move towards the adoption of technology.

“at this stage at least within South Africa, we're still fairly behind and maybe why we're behind is because, let's be honest workforce in South Africa is still very cheap and still not expensive, the farmer thinks what do I need to use technology when I have access to fairly cheap labor and everybody moaning about the minimum wage going up is still makes sense to have 10 people, 20 people or 30 people do something ,they say it sustain people”

Corporate Identity and Community First Projects

A respondent attributed having people (workforce) as part of a corporate identity for some business and as those businesses are hesitant to fast track the adoption of technology in their process and activity, however what I observed was compassion and care for society more than a case of corporate identity.

“we put people first, from my side we are, I wouldn't say skeptical, we just scared that if we were to implement it now, half of our people will lose their jobs so we're not

pushing it at the moment with the pandemic. If we have to tell half these people, they're losing their jobs, then I won't come back either”

“if it wasn’t a matter of creating jobs, because creating jobs it’s an important thing in our society, if it wasn’t for that we’d go for technology, meaning it could be a one man show, from harvesting, packaging to planting everything would technology driven, at this moment we are trying to limit the use of technology regarding some of activities, hence you see now in terms of harvesting you are looking between 60 to 80 casuals around the community, with technology it would imply that this people would not have jobs, so I’d say somehow somewhere in agriculture there must be this technology but in other areas I’d say let’s leave it out, it depends on the society, like the society where we are now there isn’t any employment except in the agricultural sector”.

Learning and up skilling

The study found that in some instances management attempted to upskill their workforce in the use of technology however received resistance from their workforce due to their age and perceived lack of value it would bring at the point they are in their lives, however there are those that have managed to get a buy in from their employees and successfully capacitated them in the use of technology.

In addressing human capital challenges with in the South African context, (Aguera et al., 2020) recommended the adoption of several policies such:

- create educational programs to provide the youth with the skills to address the changing needs of the agriculture sector, while at the same time demonstrating awareness of entrepreneurship career opportunities that are emerging along the entire value chain;
- encourage the development of platforms to encourage commercial farmers to engage in knowledge transfer and the up-skilling of small-scale farmers, to ensure they are not left behind in the digitalization of the sector;

5.6 General Literature Review similarities and differences findings

The study found that there was a general acceptance of technology adoption within the sector, due its ease of use and perceived efficiency, this is in line with Sung (2018) precise optimization argument, however similar to (Bronson, 2019) the study found

that there was an even adoption of technology within the sector where small scale farmers are not adopting technology at an equal rate to large commercial farmers, this is similar to the findings of (Ungerer et al, 2018, p. 38) which found that “The two dominant themes from the expert interviews were that smallholder farmers could not compete with mega farmers due to economies of scale and the cost of technologies that is hugely restrictive for small farmers”, The study found that large commercial farmers generally had dedicated technology departments tasked with research and development as well as technology implementation, while small scale farmers would mainly depend on third party technology companies within the sector to either adopt the technology or to trial it out. In other instances, the study found that rate of technology adoption was also influenced by need to balance social sustainability some participants similar to (Xu et al., 2018) recognized the potential inequalities and negative impact technology could amongst their co-works and their surrounding communities. Contrary to (Rose et al., 2020) assertion that the focus around agriculture and technology mostly ignored incorporating social sustainability into the technological trajectory and has predominantly been framed around benefits to productivity and the environment, this study found that social sustainability was at the forefront when technology adoption was considered in the agriculture sector of the province.

From a socio-technical perspective the study found that there was a recognition in some instances by participants that were aware that “improving one side will require improving the other side” (Hadid et al., 2016) in order to achieve superior results by ensuring that the technical and social are working in harmony (Cartelli, 2007), that is an improvement in the technical (technology) will also require an improvement on the social (the people), however the prevailing view was that between the technical and the social one would dominate the other, this goes against the socio-technical doctrine which argues “emphasising the technical side of a system by investing more in its practices and neglecting the social system (by investing less in its practices), or vice versa, will not lead to the optimal performance” (Hadid et al., 2016).

6 SUMMARY, CONCLUSIONS, LIMITATIONS, AND RECOMMENDATIONS

6.1 Summary

Global demands in food supply is set to rise, owing much to the increase in population, this places a burden on the agricultural sector to reconfigure itself if it's to meet the demands, thankfully technological advanced brought by the fourth industrial revolution has enabled transformation in the agricultural sector for it to meet this demand. The disruptive nature of these technologies has provided farmers with an opportunity to develop new methods production, they have increased efficiency and accuracy within agricultural processes and activities and have opened new distribution channels for the agricultural sector and have empowered consumers to know more about what they consume.

The Limpopo province agricultural sector is a major producer of some of South Africa's agricultural commodities and a competitor in the export markets of agriculture produce. This study explored the usage and adoption of technology in the Limpopo province agriculture sector. In addition, this study looked at the availability of structures or regulatory bodies governing the usage of technology as well as challenges brought about by the adoption of technology in the province's agriculture sector. This chapter will present the conclusion of this research, its limitation and its recommendation on future research that could be explored.

6.2 Conclusions

The fourth industrial revolution brings about an impact in all facets of life including the agricultural sector. Players in the agricultural sector of Limpopo have embraced the use and adoption of technology within the sector, this adoption of technology has helped the industry to be competitive internationally and remain with other countries such as Australia and New Zealand, South American countries, and US in areas such a fruit production.

The allure of technology has enabled business to calibrate their activities and processes using technology in order to be more efficient in their activities, more accurate in their decision making as well enabled them to farm sustainably.

The embrace of technology is not without its challenges, many in the field are aware of the negative impact that might result as consequence of using technology such as the shedding of jobs within the industry, these sentiments are however not shared by everyone as others remain resolute on putting people's livelihood first before technology.

Technology will continue to advance and bring about change in society and its environment, those in business who chose to ignore this fact and continue with obsolete practices are at the risk of being out of businesses one day. The provincial government too has role to play in advancing awareness and developing policies such as those recommended by (Aguera et al., 2020).

6.3 Limitations

A key limitation to this was the ability to cover the entire agricultural sector value chain, owing much of this to the covid-19 pandemic and the time allocated to complete this study. This study covered producers in the horticulture (avocado, macadamia, blue berries etc.), and egg production, the study was unable to gain insights from a portion of the agricultural value chain such as the supply chain, government and other food and product producers.

6.4 Recommendations

The agriculture sector of the Limpopo province is currently heavily reliant on human labour even as it adopts new technologies to increase competitiveness and efficiency, the reliance on human labour is largely due to the low cost of human labour as a consequence of the lack of education and literacy, however with the passage of time there could be a shortage in human labour, largely due to formal education becoming more accessible to newer generation in those communities, offering them more opportunities in the labour market than was available to the current ageing human labour. It therefore imperative for those in the sector (private and government) to conduct a skills audit and assess the future needs of the sector and establish needed training programmes to avoid a future skills crisis, and to align the investment in technology to the investment in human capital (socio-technical perspective).

6.5 Recommendation for future Research

Qualitative research Study

- Investigating the alignment of agricultural college 's curriculum with industry practices on the adoption and application of technology within agriculture. A study by (John et al., 2019) suggest that “Farmer 4.0 will need to focus on strategy and systems, leaving past tasks to a new generation of smart machines”.
- The role which government player in facilitating compliance and adoption of technology within the agricultural sector.

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APPENDICES

Appendix 1.1: Preliminary Data collection instrument(s)

Part I: Agricultural Activity

1. How many years have you been active in the agricultural sector?

☐ 5 – 10 ☐ 11 – 20 ☐ 21 – 30 ☐ 31 - 40

☐ other (Specify).....

2. How would you describe your role in agriculture?

☐ Farmer ☐ Processing ☐ Distribution and Wholesale

a. In case your role is a farmer, what kind of farming do you conduct?

☐ Crop ☐ livestock ☐ Mixed

i. How would you classify your business?

☐ Commercial/Enterprise Farming ☐ Small Scale farming

b. In case your role is in processing, what do you produce?

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i. Where or to whom are you currently selling your processed products?

☐ Direct/Farm Gate

☐ Retailers/Brokers

☐ Farmers Markets

☐ Wholesalers/Distributors

☐ Other (Specify)

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Part II: Technology Adoption

1. Have you incorporated modern technologies in your agricultural activities?

☐ Yes ☐ No

a. In case “Yes”, what Type of technology have you incorporated in your agricultural activities?

- ☐ Smart/Precision farming
- ☐ Drones/Unmanned aerial vehicle technology
- ☐ Robotics
- ☐ Sensor technology
- ☐ Vertical agriculture
- ☐ Artificial intelligence/ Machine learning
- ☐ Genetic modification/Synthetic biology
- ☐ Nanotechnology
- ☐ Platform technology
- ☐ Other technology

(specify).....

i. How was your decision to adopt technology informed?

- ☐ Need to meet demand
- ☐ Efficiency and process improvement
- ☐ Cost saving
- ☐ Need to compete with/gain advantage over competitors
- ☐ Other

(specify).....

- ii. What benefits have you derived from using technology within your processes and activities?

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- b. In case “No”, what are the contributing factors to the non-adoption of technology?

☐ Required infrastructure unavailable (electricity, adequate water etc.)

☐ Access to financial resources

☐ Awareness

☐ None foreseeable benefit

☐ Unskilled labour

☐ Other

(specify).....

...

2. Are you aware of any Industry body governing the usage of technology within the sector?

☐ Yes ☐ No

- a. If yes, please

specify.....

- b. If no, do you think there is a need for such a body to be established?

☐ Yes ☐ No

- I. If yes, what benefits do you foresee arising from such a body?

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3. Have you ever heard about the fourth industrial revolution?

☐ Yes ☐ No

a. If yes, could you briefly specify what does the fourth industrial revolution mean for you?

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Appendix 1.2: Data collection instrument(s)

- 1) How Many years have you been in the agricultural sector?
- 2) How would you describe your role in the agricultural sector?
- 3) What kind of agricultural activities are you involved in?
- 4) What type of technologies do you utilize in your agricultural activities?
- 5) What would you say are the key drives in technology adoption and implementation within your business and within the sector in general?
- 6) What would you say the impact has been the impact of technology on the Limpopo agricultural sector?
- 7) Which emerging technologies have you identified as key in contributing to higher yields, higher incomes and lower input costs for your business and the agricultural sector in the province?
- 8) What influenced your decision in adopting technology?
- 9) What benefits have you derived from using technology within your process and activities
- 10) What are the factors that exist that you think are preventing farmers from adopting technology?
- 11) Are you aware of any industry body governing the usage of technology in the provinces agricultural sector? If No do you think there is a need for such a body and what benefits do you foresee arising from such a body?
- 12) Have you heard of the term the fourth industrial revolution? If yes could you briefly explain what it means to you and your business and sector?

Appendix 2.1: Research Participation Circular



Dear Participant

My name is Khomotso Solomon Kganakga, and I am a graduate student at the Wits Business School (WBS). For my final MBA dissertation, I will be evaluating the use of 4IR technologies in the Limpopo province agriculture sector, and therefore am inviting you to participate in this study. The results of the research will be used to provide insights into the impact of various fourth industrial technologies on the sector, to employers, colleagues, policymakers, and organizational designers to develop strategies, operating models and procedures that could enhance the agricultural sector.

This study has been approved by the Ethics Board of the Wits Business School. As part of your participation in the study, we ask you to take part in an interview (online), which will take no more than forty-five minutes of your time. Your participation is voluntary, and you are free to withdraw at any time. The information you provide will be kept confidential, and no identifying information will be used in the dissemination of the results.

By taking part in the interview process, you are indicating your consent to participate in the study. You are one of a small group of approximately fifteen to twenty people who have been randomly selected to provide feedback about the use of 4IR technologies in the Limpopo province agriculture sector.

Should you have any questions regarding the study, please feel free to contact me at
Tel: +27 76 804 6533

Email: skganakga@yahoo.com/

Khomotso.kganakga1@students.wits.ac.za

Thank you for your assistance

Sincerely,

Khomotso Solomon Kganakga

MBA Candidate
Wits Business School

Lee Larbi
Research Supervisor: PhD Candidate
lee.larbi@wits.ac.za

Figure 5: Research Participation Circular

Appendix 2.2: Ethic documentation



**SCHOOL OF GRADUATE SCHOOL OF BUSINESS ADMINISTRATION ETHICS COMMITTEE
CONSTITUTED UNDER THE UNIVERSITY HUMAN RESEARCH ETHICS COMMITTEE (NON-MEDICAL)**

CLEARANCE CERTIFICATE

PROTOCOL NUMBER WBS/BA1966572/332

PROJECT TITLE

The use of 4IR technologies in Limpopo province agricultural sector

INVESTIGATOR

Mr Khomotso Kganakga

SCHOOL/DEPARTMENT OF INVESTIGATOR

MBA (Research Article)

DATE CONSIDERED

24 November 2020

DECISION OF THE COMMITTEE

Approved unconditionally

RISK LEVEL

MINIMAL RISK

EXPIRY DATE

30 JUNE 2021

ISSUE DATE OF CERTIFICATE 15 December 2020

CHAIRPERSON

(Dr MDJ Matshabaphala)

cc: Supervisor: Mr Larbi

DECLARATION OF INVESTIGATOR

To be completed in duplicate and **ONE COPY** returned to the Chairperson of the School/Department ethics committee.

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

Signature

Date

06 / 01 / 2021

Figure 6: Ethic documentation

Appendix 2.2: Ethic documentation

Appendix 3.1: Dully filled in data collection instrument(s)
