Cape Peninsula University of Technology

THE E-AGRICULTURE RESEARCH LANDSCAPE IN SOUTH AFRICA: A SYSTEMATIC LITERATURE REVIEW

By

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Thesis submitted in fulfilment of the requirements for the degree

Magister Technologiae: Information Technology

in the Faculty of Informatics and Design

at the Cape Peninsula University of Technology

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Cape Town Campus

July 2017

DECLARATION

I, Alain Nzuzi Kintoki, declare that the contents of this thesis represent my own unaided work, and that the thesis has not previously been submitted for academic examination towards any qualification. Furthermore, this study represents my own opinions and not necessarily those of the Cape Peninsula University of Technology.

Signature

Date

ABSTRACT

The objective of this study was to determine the current status of e-agriculture research in the South African context. A systematic literature review was used to gather and analyse data in alignment with the objective of the study. The researcher used keywords and combined search keywords on web search engines and digital databases to obtain pertinent research papers. The scope of the study was limited to the period 2000-2016. The books, theses, conference papers and journal articles identified as pertinent to conduct the study, amounted to 114 in number. The analysis of the study described the focus of research papers, research methods, research approaches, theoretical lenses, units of analysis and observation, levels of analysis, historical development, and major concepts and disciplines used by authors in their studies. The study also sought to discover the year of publication and assessment of searchability of the papers.

The results indicate that 13 papers (11.4%) were published in the first five years (2000-2004) and 51 papers (44.7%) in the last five years (2012-2016) of the delimited period for the study. The results of the study further indicate that the application of geographic information systems (GISs) towards improving agriculture was the most prominent e-agriculture research area in South Africa (27 papers, 23.6%), followed by the use of satellite enhancing agriculture (26 papers, 22.8%). E-government direct services, mobile in agriculture, and agricultural information systems were the least prominent e-agriculture research areas in South Africa with a contribution of two papers (1.8%) each. The results of this study show that information mapping was the most used research method by researchers in their studies (57 papers, 50%), followed by the case study method with 31 papers (27.1%). The results further denote that the least used research method was industry reports with no mention of it in any of the pertinent papers, followed by grounded theory with two papers (1.7%). Interpretivism was the most used research approach by researchers (six papers, 5.2%) during the period 2000-2016.

The findings of this study clearly show that researchers still need to address certain issues or problems regarding e-agriculture in South Africa in order to improve the agricultural sector. The contribution of the study is to understand the importance of enhancing research capability and socio-economic transformation of farmworkers and farmers through enhanced communication of agriculture research knowledge in the area of agricultural informatics. A foundation for further studies was created for continuous e-agriculture research in South Africa.

Keywords: Agriculture, e-agriculture, research, information and communication technology (ICT), South Africa, systematic literature review

ACKNOWLEDGEMENTS

I wish to thank my Lord Jesus Christ for supporting and protecting me during the writing of this thesis.

I also wish to thank the following people and institutions who have contributed to the successful achievement of completing this thesis:

- To my research supervisor, Prof Izak van Zyl, thank you for your support and guidance
- To my research supervisor, Prof Ephias Ruhode, thank you for your support and guidance
- To my mother and father, Eleuther and Marie-Eugenie Kintoki, thank you for your love, continued prayers, encouragement, and support
- To my siblings, Cyril, Fabien, Odette, Patrick, Nathalie, and Nanette Kintoki, thank you for your prayers, encouragement and support
- To my postgraduate colleagues, thank you for your help, advice, and encouragement
- To my friends, thank you for your support and encouragement
- To Cape Peninsula University of Technology and the Faculty of Informatics and Design, thank you for accepting me to conduct this study
- To all the Uncles and Aunties, thank you for your encouragement and prayers

DEDICATION

This thesis is dedicated to my family: Eleuther, Marie-Eugenie, Cyril, Fabien, Odette, Patrick, Nathalie, and Nanette Kintoki.

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LIST OF ABBREVIATIONS

Abbreviation	Meaning
AGIS	Agricultural Geo-Referenced Information System
ASTER	Advanced Spaceborne Thermal Emission and Reflection Radiometer
BEE	Black Economic Empowerment
CD-ROM	Compact Disc Read-Only Memory
DVD	Digital Versatile Disc
E-agriculture	Electronic Agriculture
EO	Earth Observation
ETM	Enhanced Thematic Mapper
GDARD	Gauteng Department of Agriculture and Rural Development
GDP	Gross Domestic Product
GIS	Geographic Information System
GPS	Global Positioning System
ICT	Information and Communication Technology
IoT	Internet of Things
MCDM	Multi-Criteria Decision-Making
MWT	Mobile and Wireless Technologies
NCRF	National Community Radio Forum
NDVI	Normalised Difference Water Index
OLSR	Optimised Link State Routing Protocol
PREX	Predicted Relative Exposure
PRRI	Predicted Relative Risk
SDSS	Sloan Digital Sky Survey
SLR	Systematic Literature Review
SPOT	Satellite Pour l'Observation de la Terre
SSD	Sub-Surface Drip
TM	Thematic Mapper
VR	Virtual Reality

CHAPTER ONE: INTRODUCTION TO THE RESEARCH

1.1 Introduction

Agriculture is fundamental for South Africa's economic development. The agricultural industry of South Africa needs to be healthy in order to participate in job creation, social welfare, ecotourism, food security, the country's gross domestic product (GDP), and the value of raw materials (Goldblatt, 2010). The growing attention in e-agriculture research in recent years has shown e-agriculture to be an emerging trend in information and communication technology (ICT) use of agriculture in the rural development domain (Patrikakis & Maumbe, 2012). E-agriculture research in general is focused on efforts to harness the potential of ICTs in agriculture with various stakeholders, such as private, public as civil society, as well as international governmental and non-governmental organisations in various parts of the world willing contribute to the sustainability and productivity of agricultural industries (Chisenga, 2008). Researchers should prioritise investigating specific contributions of e-agriculture research to enhance agriculture and specific problems in ICT implementation and use (Milovanović, 2014). Understanding early e-agriculture research in South Africa will assist both current and future generations with creating new and better ways to develop the agricultural sector when using this modern technology (Tembo & Maumbe, 2011).

The aim of this research was to determine the current status of e-agriculture research in South Africa. Different categories were included in the systematic literature review, covering specific e-agriculture research keywords and presenting new direction to be considered for future research in e-agriculture in South Africa.

This study sought to investigate and review studies related to the following:

- ICT adoption and use in agricultural companies
- E-government direct services
- Mobile in agriculture
- Computerised back-end developed systems
- Networking in agriculture
- Agricultural information systems
- The use of geographic information systems improving agriculture
- The use of global positioning systems improving agriculture
- The use of satellite enhancing agriculture, e-commerce
- ICT in agricultural supply chains

- Empowering local agricultural communities through information and ICTs
- Providing broader information on agriculture

1.2 Background to the research problem

1.2.1 Introduction

All over the world, people are beginning to adopt electronic agriculture (e-agriculture) for sustainable agriculture and rural development. Sylvester (2011) defines electronic agriculture as a particular emerging branch of study paying attention to improvement agriculture and rural development by using enhanced information and communication procedures. E-agriculture is determined by important components such as capacity development, education, support of standards and norms, facilitation, and technical support (Ghogare & Monga, 2015). Electronic agriculture requires the conceptualisation, evaluation, development, application, and design of new processes to use information and communication technologies in rural areas, with more emphasis on agriculture (Sylvester, 2011). E-agriculture deals with technology to encourage the use of technology tools in culture, multimedia, and knowledge, with the objective to enhance learning and communication procedures between different individuals or groups acting in agriculture locally, regionally, and worldwide (Ghogare & Monga, 2015). E-agriculture offers an excellent opportunity to facilitate communication channels and traditional delivery of services to support the agricultural organisation's ability to meet the needs of farmers (Namisiko & Aballo, 2013). It improves access to information and resources, empowers farmers to make agricultural decisions, and streamlines organisational processes and transactions. It also enhances quality, value, and agricultural productivity satisfaction.

South Africa is classified as the world's 25th largest country because of its land area and is located at the southern tip of the African continent. It is considered as the 24th most populous nation in the world as the population is close to 53 million people (Arteaga, 2014). South Africa has been classified among African countries where the use and adoption of technology was a ‘desert’ (Maumbe & Okello, 2010). However, South Africa’s agriculture has followed the trends toward using and adopting e-agriculture with the purpose of facilitating agricultural information and knowledge exchange, improving agricultural delivery programmes, processing and marketing functions, and promoting productivity among farmers (Jones, 2011; Mpofu, 2011). This is observed by many e-agriculture initiatives across the country and through websites in order to improve the agricultural sector and encourage rural development (Maumbe, 2010). The growth of e-agriculture is considered an

important and practical means to facilitate rural development and develop the agricultural sector, as well as to promote food security and reduce rural poverty in South Africa (Tembo & Maumbe, 2011). South African farmers have improved the way they access agricultural information after their adoption of e-agriculture for farming activities (Fua & Akterb, 2012).

The importance of e-agriculture research has been recognised by industries and academic researchers as a crucial tool to enhance the competitiveness of the agricultural business in South Africa (Simpson & Calitz, 2014). The development of agricultural organisations and industries in South Africa can be enhanced by conducting different types of e-agriculture research (Maumbe & Owei, 2013). E-agriculture research in South Africa can offer several expectations to agricultural industries and organisations for agricultural sustainability and development (Maumbe, 2010). Previous studies on e-agriculture in South Africa concentrated on specific sectors, and were limited to certain geographical locations in South Africa, but the country as a whole was not considered in terms of how e-agriculture research can contribute to agricultural development in South Africa (Hooper, Kew & Herrington, 2010). E-agriculture research in South Africa is still growing compared to studies in developed countries, and academic studies have not sufficiently and in-depth investigated or provided insight into the state of e-agriculture research in South Africa (Gono, Harindranath & Özcan, 2013).

There is lack of understanding of how e-agriculture research in South Africa can influence agriculture towards improve the wealth level of millions of farmers in the country (Maumbe, 2010). For this thesis, a systematic literature review was conducted to understand different studies related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, networking in agriculture, agricultural information systems, the use of geographic information systems improving agriculture, the use of global positioning systems improving agriculture, the use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture for the objective of this study.

1.2.2 Systematic literature review

According to Baumeister (2013), a systematic literature review can be described as a strategy using explicit and organised procedures to assess, determine, and identify pertinent research, as well as to gather and analyse pertinent research papers that are relevant to the study. Furthermore, Okoli (2015) points out that a

systematic literature review is considered as scientific and the correct secondary study currently preferred by researchers when conducting primary and secondary studies as it uses a predetermined search method that allows the evaluation of search integrity. Moreover, Siddaway (2014) describes a systematic literature review as a method that allows integrating, identifying, and critically evaluating conflicting findings produced by research papers every year. It helps to describe high-quality individual studies and improves the research questions of the study.

According to Cronin, Ryan and Coughlan (2008), the purpose of a systematic literature review is to present a full and possible list of research papers, published and unpublished, on a specific topic of field. Ryan (2010) reveals that framing the question, identifying pertinent studies, evaluating study quality, summarising the evidence, and interpreting the findings are the five stages to consider when conducting a systematic literature review. The author furthermore indicates that in order for a researcher to conduct a successful systematic literature review, the following aspects must be taken into consideration:

- Determine the progress of current studies regarding a specific problem
- Overall conceptualisation or general statements must be created as this helps to make a point
- Inconsistencies, contradictions, relations, and gaps must be determined in the literature
- Theory must be developed, expanded, and assessed
- Implications for policy and practice must be produced to conduct the study
- Determine different issues revealed in the current studies to provide direction for further research

According to Boell and Cecez-Kecmanovic (2014), systematic literature reviews are of particular interests because of the importance they place on the literature search process. A *systematic* literature review is different to a literature review because it uses a well-defined and more accurate approach to conduct the literature review within a particular field of for a specific topic (Ryan, 2010). A systematic literature review presents advantages that are completely different from those observed by the researchers when conducting a literature review. Providing information on the impact of a phenomenon across a large selection of empirical methods and settings is one of the advantages of systematic literature reviews.

A systematic literature review contains features that differentiate it from a conventional or traditional literature review:

- In a systematic literature review, researchers always begin by defining the review protocol, which describes the research question(s) and techniques to be employed in order to improve the review of the study
- A systematic literature review is focused on a search strategy that enables researchers to determine several pertinent studies
- The search strategy is reported when conducting the systematic literature to assist readers with evaluating its precision and perfection and to avoid repeating the process
- Each possible primary study is evaluated as specific inclusion and exclusion criteria are required when conducting a systematic literature review
- A systematic literature review uses interesting methods to obtain the needed information from each primary study and evaluates these methods through quality assessment

1.3 Problem statement

Despite the growing interest in e-agriculture research in South Africa, academic studies have not sufficiently and in-depth investigated the current e-agriculture research trends in the South African context. It is unclear how primary e-agriculture research in South Africa will aid both current and future generations to create new and better ways to transform agricultural development using this modern technology.

1.4 Research question

What is the current status of e-agriculture research in South Africa?

1.4.1 Sub-questions

1. What has been the focus of research on e-agriculture in South Africa?
2. What types of research methods and tools have been used in e-agriculture research in South Africa? What types of research approaches have been used in e-agriculture research in South Africa?
3. What types of theoretical lenses have been used in e-agriculture research in South?
4. What are the units of analysis and units of observation that have been used in e-agriculture research in South Africa? What levels of analysis have been used in e-agriculture research in South Africa?

5. What historical development and major concepts have been investigated in e-agriculture research in South Africa?
6. What types of discipline are involved in e-agriculture research in South Africa?

1.5 Research aim

It is understood that policy makers, the government, and academic researchers are making efforts to conduct studies on e-agriculture for agricultural development and sustainability (Tembo & Maumbe, 2011). The aim of this research was to understand the current status of e-agriculture research in the South African context. The objective of this study was to gain information about e-agriculture research that is focused on the following:

- ICT adoption and use in agriculture companies
- E-government direct services
- Mobile in agriculture
- Computerised back-end developed systems
- Networking in agriculture
- Agricultural information systems
- The use of geographic information systems improving agriculture
- The use of global positioning systems improving agriculture
- The use of satellite enhancing agriculture
- E-commerce
- ICT in agricultural supply chains
- Empowering local agricultural communities through information and ICTs
- Providing broader information on agriculture

To achieve this, a systematic literature review was conducted to obtain all information required. In this study, a population sample of 114 e-agriculture research papers was selected. The information gained from the systematic literature reviews assisted in understanding the status of e-agriculture research in South Africa, and provided direction for future studies.

1.6 Limitations of the study

This study was delimited to e-agriculture research in the South African context, with the focus on data collection using web search engines and academic databases. This implicated ethical responsibilities such as thoroughness in searching, checking all details, and avoiding misrepresentation of original research when searching the literature and analysing data. The study was limited to

reviewing literature published during the period 2000-2016, as e-agriculture research in South Africa is still growing.

1.7 Contribution of the research

This study contributes to the agricultural body of knowledge by informing efforts that need to be addressed within the e-agriculture research field. The study explored, described, and provided insights into the state of e-agriculture research focused on ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, networking in agriculture, agricultural information systems, the use of geographic information systems improving agriculture, the use of global positioning systems improving agriculture, the use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture. The findings of this research therefore provide relevant information to policy makers, industries, government, and academic researchers able to encourage the efforts made to enhance the agricultural sector in South Africa by using this technology. Direction for future studies is also provided.

1.8 Thesis structure

Chapter One includes the introduction of the thesis, background to the research problem, problem statement, research question, research aim, limitations of the research, and the contribution of the research.

In **Chapter Two,** the context and background of the research are described.

Chapter Three includes the research design and methodologies used by the researcher to conduct the systematic literature review. The chapter explores the research aim and its appropriateness to the study. The chapter furthermore provides a discussion on the research approach used as well as the appropriateness of this approach. Moreover, the chapter explores the research paradigm used and the appropriateness of the paradigm. The research method used to gather and analyse data is explored, as well as the basic ethical principles of the study.

Chapter Four reports on the research findings of the current status of e-agriculture research in South Africa.

Chapter Five offers a discussion of the findings of this study**.**

In **Chapter Six,** the research is concluded and a set of recommendations in line with the findings is provided.

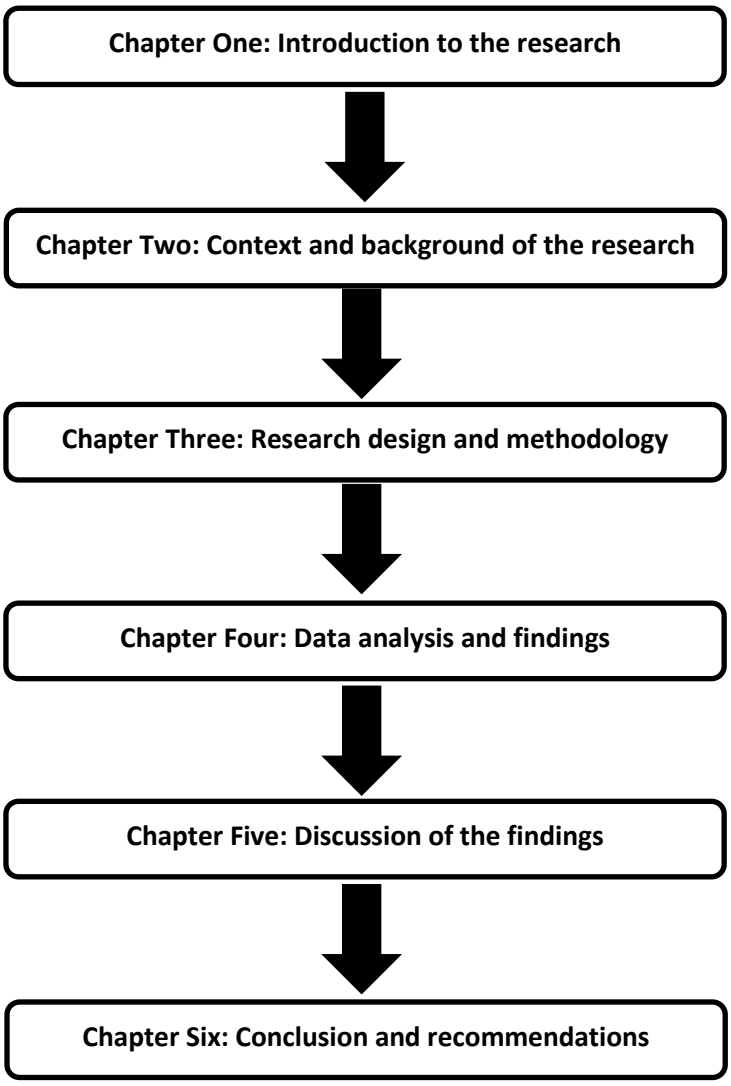


Figure 1-1: Graphical representation diagram of thesis layout

1.9 Conclusion

In this chapter, the area of the research under investigation was presented and the aim of the study was provided. The chapter also discussed the background of the research problem which includes the introduction and description of a systematic literature review. In this chapter, the problem statement and research questions considered in this study were presented. It also discussed the limitations and contribution of the study.

CHAPTER TWO: CONTEXT AND BACKGROUND OF THE RESEARCH

2.1 Introduction

According to van der Burg, Lindoor, Messina, Baessler and Dyata (2009), agriculture is the backbone of the South African economy and the majority of the population depends on it as a source of livelihood. To be successful, farmers have to get the latest farming technologies related to their activities to improve production. South African farmers must compete with farmers of developed countries because globalisation has adverse impacts on their farming activities; they must improve their production for the world market at reasonable prices in order to manage problems posed by the globalisation of agriculture (Ntaliani, Costopoulou, Karetsos, Tambouris & Tarabanis, 2010). Therefore, farmers need to be well trained and informed in the management of production and natural resources of agricultural products. E-agriculture can play a crucial role to solve these problems and improve the livelihood of South African farmers (Ghogare & Monga, 2015).

2.2 Definition of e-agriculture

According to the E-agriculture Working Group (2007), e-agriculture is considered a modern way to investigate the role of information and communication technology in agricultural development. Furthermore, Chandra and Malaya (2011) point out that the Food and Agriculture Organisation (FAO) describes e-agriculture as a growing area in the intersection of entrepreneurship, agricultural development, and agricultural informatics involving information-enhanced or delivered technology dissemination and agricultural services through the Internet and associated technologies.

Ghogare and Monga (2015) define e-agriculture as the Internet programme of the global initiative seeking to support food security and develop the agricultural sector by enhancing the use of integrated technologies, communication, and information. According to Pradhan and Mohapatra (2015), there are several steps involved in e-agriculture, namely conceptualisation, design, development, evaluation, agriculture, and application. These steps are depicted in figure 2-1.

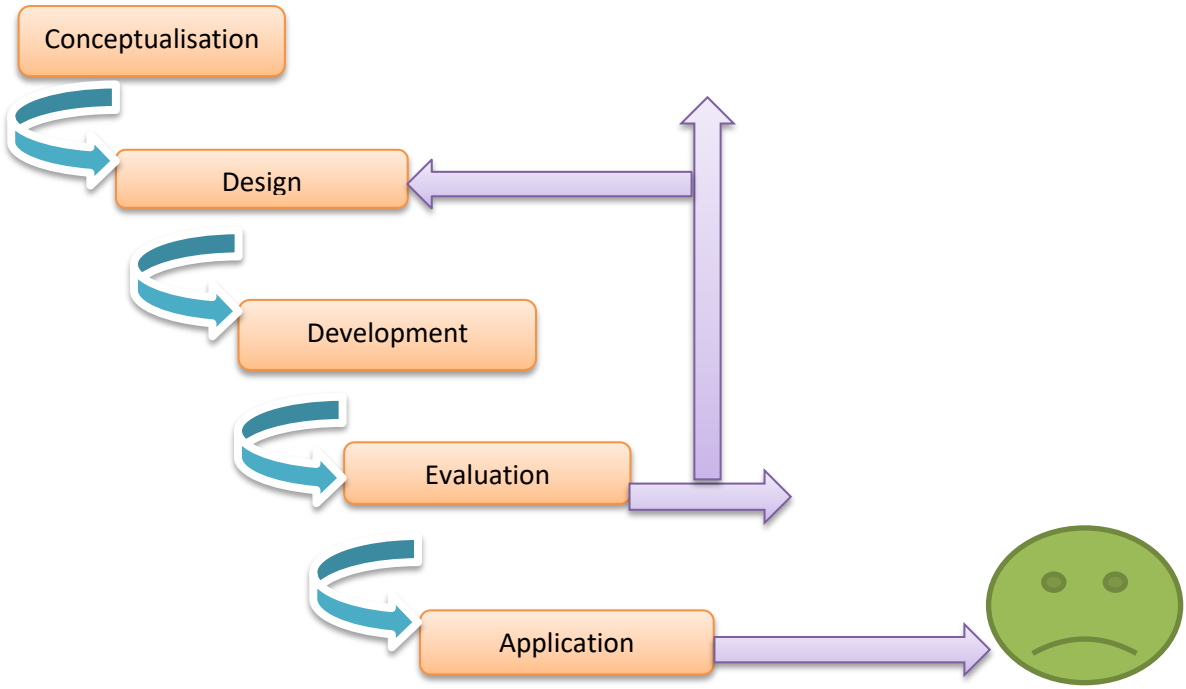


Figure 2-1: Steps implicated in e-agriculture
(Source: Pradhan & Mohapatra, 2015:1)

2.3 Role of ICT in e-agriculture

According to Pradhan and Mohapatra (2015), a large range of technologies, applications, and services is denoted by information and communication technology (ICT) using different types of software and hardware, often operating over telecom networks. ICT provides tools such as application software, operating systems, and computer hardware as well as electricity and telephone lines, intranets and networks, satellite systems, and radio (Ntaliani et al., 2010). ICT is composed of three technologies: information management technology, communication technology, and computer technology. These technologies are used for managing, exchanging, and processing data, knowledge, and information.

According to Dlodlo and Kalezhi (2015), information and communication technologies (ICTs) are crucial tools used in e-agriculture to support agricultural development. ICTs facilitate access to information and communication for agricultural and rural development (Ghogare & Monga, 2015). ICTs encourage and disseminate existing and new farming knowledge and information, which is transferred within the agricultural sector since information is indispensable for enabling rural and agricultural development and creating economic and social changes (Swanson & Rajalahti, 2010). Furthermore, Ferrer et al. (2003) note that

ICTs allow farming businesses to have access to university and government research and reports, communicate with customers and suppliers, have access to product information, price, and application software, interact with other specialists and producers, sell production, and buy inputs. Moreover, Awuor (2016) indicates that ICTs provide a broad range of social and public services to farmers in remote villages, as these technologies become important tools to facilitate access to the current prices in the market.

According to Chandra and Malaya (2011), e-agriculture plays several roles for agricultural development in rural areas:

- Provides the practical diffusion of information by using ICTs on food and forestry, animal husbandry, and agriculture
- Offers ready access to detailed, up-to-date, and comprehensive information for farmers, especially in rural areas
- Use of ICTs as a tool to enhance production (quality and quantity) by maximising public-private partnerships

2.4 ICT for development agriculture

Information and communication technology for development agriculture involves the interaction between agriculture and ICT (Department of Agriculture, Forestry & Fisheries, 2013). It is focused on sustainable agriculture improvement and rural development through enhanced information and communication procedures (*ibid*). ICT for development agriculture presents several benefits:

- Allowing household-level food security
- Promoting economic development through:
  - ✓ Enhancement of efficiency and productivity
  - ✓ Extension of reach along the value chain
- Enhancing development practice by:
  - ✓ Allowing sustained profit from development initiatives
  - ✓ Facilitating community-driven development
- Encouraging the development of new business models

The opportunity of ICT for development agriculture is situated on the interface between ICTs, agricultural development, and rural development; a role could potentially be determined in terms of the fields that are not currently addressed by the communities, government, and private sector, and the fields that can cover agricultural development and the ICT disciplines. A framework was suggested to

determine fields in which ICT for development agriculture can be employed to encourage emerging farmer development in South Africa (*ibid*).

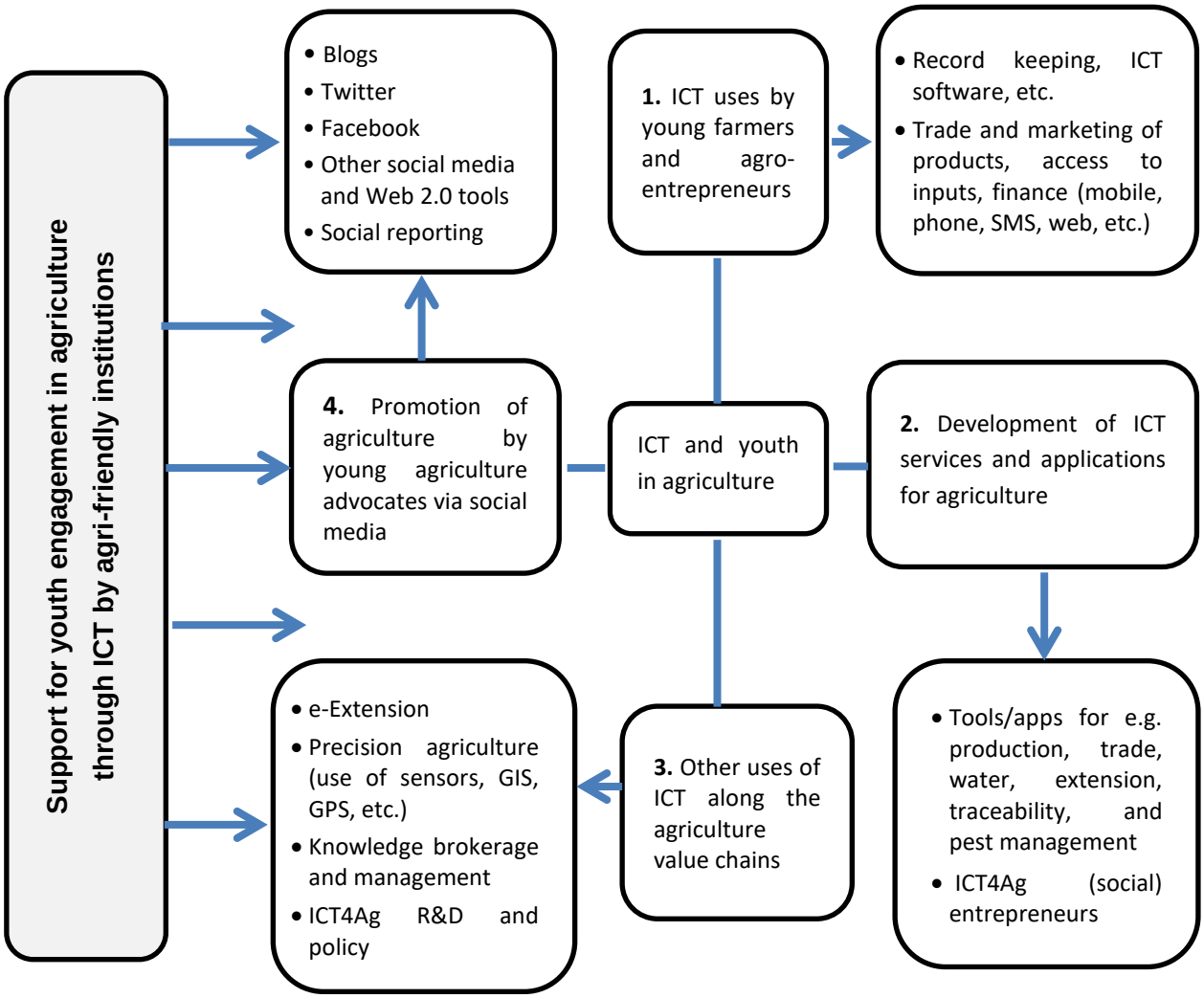


Figure 2-2: Frame for encouraging youth in agriculture through ICTs
(Source: Department of Agriculture, Forestry & Fisheries, 2013:2)

According to Maumbe (2010), there are growing expectations that ICT provides renewed hope for service delivery and agricultural development in South Africa. Joseph and Andrew (2007) note that ICT use tools such as the Internet, e-mail, telephony, and video camera to support rural South African woman who are dependent on agriculture to face challenges such as public transport and the lack of a public waste management system. ICT intervention helps to enhance the livelihoods of poor rural farmers in South Africa as it is playing both a direct and indirect role in improving post-harvest activities, marketing, and agricultural production to reduce poverty (Dlodlo & Kalezhi, 2015).

2.5 Problems affecting the use and adoption of ICTs in agriculture in South Africa

According to Ortmann (2000), lack of education in the efficient use of ICT, high cost of certain modern ICTs (such as GIS and GPS), poor infrastructure in rural areas, and time taken to obtain information from the Internet are the major problems affecting the use and adoption of ICT in South Africa. Furthermore, Simpson and Calitz (2014) point out that the manner and extent to which ICTs such as mobile technology and the Internet are used by the farming community is a big challenge for South African agricultural organisations when updating or implementing techniques for extension services.

According to Dlodlo and Kalezhi (2015), a number of problems are challenging the domain of agriculture in rural areas of South Africa:

- Distance: access to government and administrative services and structures
- Economic: access to labour markets and larger business
- Social: access to social services, health, training, education, and information
- Traceability of services and products
- Age: younger farmers are using ICT more than elders
- Farm size: smaller farms started to use ICT later than larger farms
- Gender: the probability to use ICT increases with female farmers
- Farming experience: farmers with less farming experience are using ICT less than those with more experience
- Income: when farmers do not have enough income, they do not have much access to ICT
- Attitude: a negative attitude towards ICT results in a negative impact on the use of ICT, while a positive attitude results in opposite results
- Household size: a large household size is often more associated with a positive impact on the use of ICT than a smaller household size

2.6 The need for ICT in agriculture in South Africa

According to Maumbe (2010), there is a need to improve ICT infrastructure in South Africa to support rural Internet. This makes e-agriculture services ineffective in South Africa. The author adds that the importance of e-agriculture within the agricultural sector needs to be realised by the government of South Africa, and ICT skills of emergent farmers need to be improved. Furthermore, Ortmann (2000) points out that there is a need to enhance the quality of telecommunication services and electricity in the rural areas of South Africa. Ortmann adds that there

is also a need to improve educational programmes (involving phone-in support workshops and courses) for farmers who want to adopt and use modern information systems and software. Moreover, Tembo, Simbanegavi and Owei (2010) note that ICT awareness and training are needed by farm employees in South Africa to be able to use more advanced technologies on the farms. Tembo et al. (2010) continue by stating that pertinent content, technical support, and important ICT facilities need to be provided to farming employees in South Africa.

2.7 ICT contribution to agriculture in South Africa

According to Maumbe (2010), the use of ICT in the agricultural sector of South Africa enables the government of South Africa to improve public service delivery and socio-development. Furthermore, Ntaliani et al. (2010) point out that ICT offers a promising choice to deliver agriculture-related information and knowledge to farmers in rural areas of South Africa. Oladele (2015) notes that ICTs contribute to reducing uncertainty in transactions and activities, the extent to which information asymmetries are exploited, and the extent to which markets are incomplete or missing in the agricultural sector in South Africa.

According to Ortmann (2000), modern ICTs such as global positioning systems (GPSs) assist with determining individual property rights to cropland for small-scale farmers in South Africa. De Winnaar, Jewitt and Horan (2007) note that ICTs such as geographical information systems (GISs) offer an effective approach because it contains a framework for gathering, storing, analysing, modifying, and presenting spatial and non-spatial data for specific objectives. This is especially important because the majority of South African rural communities are faced with a lack of water resources and land to support agricultural practices. Moreover, Simelane, Kogeda and Lall (2015) point out that cloud computing can be used to store information on fertilisers, crops, pests, and diseases for farmers in marginalised rural areas in South Africa.

2.8 E-commerce in South Africa

According to Cloete and Fourie (2003), it was in 2000 that South Africa adopted the attitude and imitated successful techniques and trends to follow the first world countries on e-commerce. South Africa has learnt from mistakes made by the first world countries to avoid losses before engaging in important investments. E-commerce has made South African agriculture a technologically advanced and more modernised industry worldwide today (Breytenbach, 2015b). E-commerce helps consumers, regulators, transporters, retailers, processors, producers, growers, and wholesalers involved in South African agriculture to coordinate,

cooperate, and communicate (Cloete & Fourie, 2003; Cloete, 2003). E-commerce further helps South African agriculture to improve and facilitate their market exchange (Breytenbach, 2015b).

In a study conducted by the International Society for Horticultural Science (2004) among all sectors of South African business, it was found that the rate of e-commerce adoption was 76.7% (at the time), meaning that the percentage of the average of all sectors in South African business is higher than e-commerce adopters in South African agriculture. However, even if several non-adopters of e-commerce are not yet informed about the opportunities that e-commerce can provide, approximately 80% of them are planning to use e-commerce in agriculture in the future (Cloete & Doens, 2008).

2.9 Systematic literature review

2.9.1 Reasons for using a systematic literature review

A systematic literature review must be investigated in conformity with a predetermined search strategy (Baumeister, 2013). The search strategy has to consider the integrity of the search to be evaluated. Kitchenham and Charters (2007) point out that there are several reasons to adopt a systematic literature review in a study. The principal reasons are as follows:

- To outline the existing evidence regarding a technology or treatment, e.g. to outline the empirical documentation of the limitations and benefits of a particular active technique
- To determine any contrast in current research to give directions for further investigation in these areas
- To present a background or framework to correctly position new research activities

2.9.2 Reasons for conducting a systematic review on e-agriculture research in South Africa

The researcher conducted a systematic literature review on e-agriculture research in South Africa because agriculture plays a crucial role in creating employment opportunities and incomes for the poor, while nurturing natural resources (Oladele, 2015). Furthermore, e-agriculture research is essential to enablers in the agricultural sector in South Africa, and e-agriculture studies help farmers and actors involved in the agricultural sector to overcome development obstacles by enhancing new methods and answering particular questions (Swanson & Rajalahti, 2010). Determining the state of e-agriculture research in South Africa will therefore

help researchers to understand what has been done and what could be done to support agricultural development in South Africa.

2.9.3 Principal features of a systematic literature review

According to Emam, Babar and Hye-young (2009), a systematic literature review has features that differ from a conventional literature review:

- Reviewing tools and data extraction forms are employed to register the information that is extracted
- Coherent research studies from different sources on the same topic are produced during meta-analysis of the systematic literature review

Furthermore, Oakley (2012, cited by Sammut, 2013) points out that one of the features of a systematic literature review is that the techniques employed are created to ensure accuracy in the process being used and are predefined to avoid excluding pertinent research. Other aspects include:

- Comprehensiveness in the search conducted by the researcher
- Other researchers can be involved when searching the literature
- The most accurate papers are used when concluding a study
- Conclusions are based on the most rigorous studies

2.9.4 The advantages of systematic literature reviews

According to Ryan (2010), a systematic literature review presents advantages that differ from a conventional literature review:

- A well-established technique makes it less probable that the outcomes of the literature will be influenced
- Information about the impact of a phenomenon across a large range of areas and empirical methods can be provided. The evidence that the phenomenon is transferable and strong is provided in a systematic literature review when studies provide reliable outcomes. The investigation of sources of variation can be conducted when the studies provide inconsistent outcomes
- The combination of data can be possible by using meta-analytic procedures with quantitative studies

2.9.5 The important steps of a systematic literature review

According to Gough, Olivers and Thomas (2012), there are important steps that a researcher must consider when conducting a systematic literature review. These steps are follows:

- Review initiation: establishing a review team, and participation of stakeholders
- Protocol preparation: review the questions, methodology, and conceptual framework
- Search strategy: search and partition literature on the premise of eligibility criteria
- Mapping: describe and determine pertinent research studies
- Appraising: using systematic methods to examining the research publications in-depth
- Synthesis: the outcomes of the review are collated into a well-organised structure, using a conceptual framework to create something new
- Reviews are used (interpret and report results to stakeholders)
- All techniques and decisions are justified and explained

2.9.6 Example of studies that have used a systematic literature review

A sample of fields where a systematic literature review was conducted has been presented in this study; the particular nature of results was obtained using this methodology. Systematic literature reviews have been conducted in several fields of study such as medicine, software engineering, e-business, e-commerce, education, computer ethics, e-agriculture, etc. A large number of papers indicate that this methodology have been used to conduct research in software engineering. Only a few papers indicate that systematic literature reviews have been conducted on e-agriculture.

2.9.6.1 Systematic literature review in software engineering

In the past years, many researchers conducted investigations into the field of software engineering using different types of methodology. However, software is built using several components for which developers do not have sufficient evidence to confirm their inherent risks, costs, limits, sustainability, and quality. It is difficult to determine whether evolving software practices will be an important change for the future. In a study conducted by Kitchenham, Dyba and Jorgensen (2004), the idea of evidence-based software engineering was evaluated and a guideline for conducting suitable systematic literature reviews in software engineering was proposed. The guideline is composed of three steps, (planning, conducting, and reporting the review), and is adapted to reflect particular issues in software engineering research. However, the influence of questions is not considered in the review techniques, and the guideline does not explain in detail the procedures needed to manage the meta-analysis. Pressman (2002) points out

that developing this research methodology in a software engineering area entails researchers to align the methodical and conceptual dimensions of research synthesis to the area by considering its specificities as a scientific knowledge field.

In a study conducted by Hauge, Ayala and Conradi (2010), a systematic literature review of the adoption of open source software (OSS) in software-intensive organisations was investigated. The study attempted to determine how OSS is adopted by organisations, to assess the research on adoption of OSS in organisations with a focus on software development, and to classify the literature according to these ways of adopting open source software. Furthermore, a systematic literature review of human factors in software development was conducted by Pirzadeh (2010). The research sought to characterise and determine human factors that have an effect on the software development process from a software management perspective, and on the development lifecycle.

2.9.6.2 Systematic literature review in e-agriculture

In the last decade, several studies have been conducted in the field of e-agriculture using different types of methodology, but not many studies have considered reviewing e-agriculture research and understanding how e-agriculture research can contribute to agriculture development. There is a need to understand the current state of e-agriculture research conducted by researchers. In a study conducted by Zewge and Dittrich (2015), a systematic literature review was conducted to understand ICT-based studies for agriculture in developing countries. The results of this study indicate that there is still a long way to go despite gaining the attention of ICT in agriculture with several contributions. The study furthermore indicates that there are limited knowledge areas in user interface designs, including methods and theory explaining the design of information systems for rural community areas.

2.10 Conclusion

In this chapter, the context and background of the research was presented. The chapter started with an introduction and the definition of e-agriculture. The chapter discussed the role of ICT in e-agriculture and ICT for development agriculture. It also discussed problems affecting the use and adoption of ICTs in agriculture, the need for ICT in agriculture, ICT contribution to agriculture and E-commerce in South Africa. In this chapter, the systematic literature review was discussed. This includes reasons for using a systematic literature review, reasons for conducting a systematic review on e-agriculture research in South Africa, principal features and advantages of systematic literature reviews, important steps of a systematic literature review and example of studies that have used a systematic literature review.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

In this chapter, the research design and methodology used in the study is presented. First the research design is discussed, which includes the research purpose, research approach, and research philosophies adopted. Next, the research methods and techniques considered in the study are elaborated on. Literature abstractions are also discussed in this chapter. Finally, ethical issues that could have affected the intellectual content of the study are considered in this chapter.

3.2 The research design

According to Monroe (2011), research design refers to any list of steps used as guide during the research process to gather and analyse data. Furthermore, Thomas (2010) points that research design is the logic diagram of a study that shows how the study will be carried out. It demonstrates how all of the important sections of the study contribute to determine the research questions. Research design is viewed as a building plan containing a set of strategies, enhancing the findings that represent a phenomenon for a given research issue. Moreover, Yin (2003) describes research design as a sequence of activities for progressing from here to there. Therefore, *here* is described by the author as the first set of questions to be met, and *there* is described as some set of answers or conclusions.

According to Mouton (1996), research design first allows the researcher to organise and structure the research, and then execute the study to enhance the results. This assists the researcher with finding directions, from the fundamental theoretical framework to research design, to gather, analyse, and interpret the data. Furthermore, Rajasekar, Philominathan and Chinnathambi (2006) point out that the research design creates the starting point for the whole study. The design therefore assists the researcher with accomplishing the chosen task(s) easily and methodically; and once the research design is completed, the real study is ready to commence.

According to Yin (2003), the first steps a researcher must consider while developing a research design is to determine the research purpose and research questions as these provide relevant information about a substance that needs to be evaluated. In this systematic literature review, the researcher determined the research purpose and research questions appropriate to the objective of the study.

3.2.1 Research purpose

Research purpose is a pertinent step of the research design that helps the researcher with providing solutions to issues, and with studying and analysing typical issues (Collis & Hussey, 2003). It enables the examining or summarising of existing knowledge a well as creating and building new methods or structures. It also describes new events, explores existing cases or issues, and creates new knowledge. Since the aim of this research was to understand the current status of e-agriculture research in the South African context, exploratory research was adopted as research design in terms of purpose.

3.2.1.1 Descriptive research

According to Mulya (2012), descriptive research is a technique that enables the researcher to make particular predictions, discover the degree to which marketing variables are integrated, understand the perceptions of product characteristics, and evaluate the percentage point in a particular population with a certain behaviour. It also determines the characteristics of different groups of people such as market organisations areas, salespeople, and consumers. Descriptive research helps the researcher to draw a picture of a situation (Gray, 2012). It also helps an event to be interpreted, and demonstrates how things are related to each other. According to Wyk (2012), the first objective of descriptive research is to provide a correct, high-quality representation (encapsulation) of variables or elements concerned with or pertinent to the research question. Furthermore, Karley (2014) points out that the goal of descriptive research is to obtain a true profile of situations, events, and persons. This may be a continuation of, or precursor to a part of exploratory research or, more often, a part of explanatory research.

Since the aim of this study was to understand the current status of e-agriculture research in the South African context, descriptive research was not deemed appropriate.

3.2.1.2 Explanatory research

According to van Wyk (2012), explanatory research can be described as a research style or technique where the main goal is to understand and know the mechanism and trait of the association and relationship between the dependent and independent variable. Explanatory research uses correlations to study relationships between dimensions or characteristics of individuals, groups, situations, or events (Ezzat, 2014). It explains how the parts of a phenomenon are related to each other and asks the “why” question. The objective of explanatory

research is to determine any causal links between variables or factors pertinent to the research problem (Van Wyk, 2012).

Since the aim of this study was to understand the current status of e-agriculture research in the South African context and the “why” question was not used, explanatory research was not deemed appropriate for this study.

3.2.1.3 Exploratory research

According to Karley (2014), exploratory research is an interesting strategy making use of open questions to understand what is occurring and to gain insight into the researcher’s topic of interest. Exploratory research is especially important if the aim is to understand the exact nature of an issue that is not evident or clear. Exploratory research enables the researcher to create or describe a problem (Mulya, 2012). It determines possible courses of an event, creates hypotheses, and identifies important relationships and variables for further investigation. It further assists with gaining an in-depth perception of a situation, which enables the development of an approach to the problem. Exploratory research attempts to examine and understand a phenomenon in order to ask questions about this occurrence (Gray, 2012). Exploratory research is important when the researcher does not have sufficient knowledge of the phenomenon. In exploratory research, the researcher has the opportunity to determine whether researching the issue is worthwhile.

According to Wyk (2012), the most crucial goal of exploratory research is to determine the principal variables or elements that might be found pertinent to the research and to identify the limits of the environment in which the situations or opportunities of relevant problems are inclined to reside. Furthermore, Cuthill (2002) notes that the purpose of exploratory research is to assist the researcher with the following:

- Familiarise him/herself with the basic details, settings, and concerns
- Have a deep or clear understanding of the situation being investigated
- Be able to create new ideas and assumptions, and develop tentative theories or hypotheses
- Have the opportunity to establish whether a study will be useful in the future
- Clarify issues for more methodical investigation and formulate new research questions
- Give direction for future research and techniques to be developed

According to Saunders, Lewis and Thornhill (2007), exploratory research can be conducted in several ways:

- Literature search
- Experts in the field
- Focus group interviews
- In-depth individual interviews

Since the aim of this study was to explore and understand the current status of e-agriculture research in the South African context, the exploratory method was adopted.

3.2.2 Research questions, sub-questions and objectives

Table 3-1: Research questions

Research problem	Despite the growing interest in e-agriculture research in South Africa, academic studies have not sufficiently and in-depth investigated the current e-agriculture research trends in the South African context. It is unclear how primary e-agriculture research in South Africa will aid both current and future generations to create new and better ways to transform agricultural development using this modern technology.	
Research question	What is the current status of e-agriculture research in South Africa?	
What has been the focus of research on e-agriculture in South Africa?	Literature analysis	To determine what objective e-agriculture research in South Africa was focused on.
What types of research methods and tools have been used in e-agriculture research in South Africa? What types of research approaches have been used in e-agriculture research in South Africa?	Literature analysis	To indicate different research methods and tools used by researchers in e-agriculture research. To indicate different approaches used by researchers in e-agriculture research.
What types of theoretical lenses have been used in e-agriculture research in South?	Literature analysis	To indicate different theoretical lenses used by researchers in e-agriculture research.
What are the units of analysis and units of observation that have been used in e-agriculture research in South Africa? What levels of analysis have been used in e-agriculture research in South Africa?	Literature analysis	To indicate different unit of analysis and observation used in e-agriculture research. To indicated the level of analysis used in e-agriculture research.
What historical development and major concepts have been investigated in e-agriculture research in South Africa?	Literature analysis	To indicate the historical development and major concepts studied in e-agriculture research.
What types of discipline are involved in e-agriculture research in South Africa?	Literature analysis	To indicate the disciplines involved in e-agriculture research.

3.2.3 Research approach

3.2.3.1 Qualitative research

According to Thomas (2010), the qualitative research approach is a method of study that detects the way in which people are observing the world; it is composed of material practices and a set of interpretive techniques that show the visibility and transformation of the world. Hanson, Balmer and Giardino (2011) describe a qualitative research approach as a naturalistic or interpretative approach with the purpose of understanding the participants' viewpoints of the phenomena of interest and transmitting the significances that are constructed by participants with regard to these phenomena. The qualitative research approach focuses on finding and perceiving people's significance and understanding how people interpret their world and experiences (Merriam, 2009; Braun & Clarke, 2006). The qualitative research approach helps researchers to describe, explore, and examine the richness and variety of social life (Patton, 2002). It further seeks to examine and identify important questions about the problem being investigated, as not much is known about the problem (Domegan & Fleming, 2007).

According to Weinreich (2009), the objective of qualitative research is to let the researcher immerse him/herself in a culture or situation and to have direct interaction with participants in order to gain relevant information needed for the study. In a qualitative research approach, the researcher becomes an important tool for collecting data, and results depend on how the person understood the data when conducting the study (Patton, 1987; Ritche & Lewis, 2003). The researcher turns the world into a set of representations and use tools such as recordings, conversations, field notes, memos, photographs, and literature searches to collect relevant information for the study (Thomas, 2010). An interpretive and naturalistic approach to the world was therefore considered by the researcher. This means the researcher sought to interpret and make a sense of the phenomena, as well as attempted to study things in their natural environment. The qualitative research approach let the researcher enter into a situation to make sense of different interpretations and several realities that exist in any given context (Thomas, 2010; Moriarty, 2011).

According to Creswell (2003), there are various data collection methods, analyses, enquiry strategies, and knowledge declarations used by the researcher when using the qualitative research approach. This approach involves the researcher using several methods such as participant observation or simple observation, documents and texts, focus groups, interviews and questionnaires, as well as the researcher's

conceptions and reactions when conducting a study (Myers, 2009). However, the qualitative research approach does not test hypotheses; rather, it uses the inductive data analysis method to give a clear or in-depth understanding of the interaction between mutually shaping influences.

Since, the aim of this study was to explore the current status of e-agriculture research in the South African context and the researcher used the inductive data analysis method, the qualitative research approach was deemed appropriate to adopt.

3.2.4 Research philosophies and paradigms

3.2.4.1 Axiology philosophy

According to Saunders, Lewis and Thornhill (2009), axiology can be defined as conducting philosophical research on how different people determine the value of things. This raises the question of suppositions about the way the world works and commitment held to specific views. It lets researchers recognise and understand the role their values and opinions can play when collecting and analysing data for a study instead of eliminating or trying to balance the influence on it. Furthermore, McGregor (2011) describes axiology as a science that allows people to select their principal values. Therefore, axiology is a science enabling people to make value judgments and moral decisions every day, and to determine the value of world. It also allows people to determine what is the most important and to know where they have to pay attention, as well as to have a clear idea of their prejudices and biases.

According to Saunders et al. (2009), two types of values can be derived from philosophy axiology: aesthetics (harmony and beauty) and ethics (bad and good). In ethics, value can be described as the ownership of something or an action that reflects its importance. Values serve as a background against what people think, believe, and perceive. Values are extremely useful, priceless, and encourage relationships. Values are important to transdisciplinary work. It is integrated into everything people do, write, say, perform, and create in their life (McGregor, 2011). Values play a crucial role in informing people of their behaviours and actions.

Since the aim of this research was to understand the current status of e-agriculture research in the South African context, the axiology research philosophy was adopted as it helped the researcher to recognise and have a clear, in-depth understanding of the role his/her values and opinions are playing when collecting and analysing data.

3.2.4.2 Ontology philosophy

According to Phillimore and Goodson (2004), ontology is a philosophy concerned with the nature of reality. It entails researchers asking themselves how they think the world operates, how the society is constructed, and how this influences everything around us. Ontology talks about the difference between reality and the way people perceive reality (Saunders et al., 2009). It addresses the following questions: What is the form and nature of reality and what can be known about this reality?

In general, social science has divided ontology into two categories in relation to these issues: realism and idealism (Ritchie & Lewis, 2003). Realism posits that independently of people's beliefs about or understanding of it, there is the existence of an external reality. Contrary to this, idealism declares that reality is essentially mind-dependent; it is only knowable through socially constructed meanings and through the human mind, and no reality exists apart from these. Saunders et al. (2009) describe two aspects of ontology among management and business researchers, and both are susceptible to be accepted as delivering effective knowledge by several investigators: objectivism and subjectivism. Objectivism posits that social organisations exist in a reality that is external to individuals affected with their existence. On the other hand, subjectivism supports the belief that social phenomena are produced from the related actions and perceptions of those individuals affected with their existence.

Since the main objective of this study was to understand the current status of e-agriculture research in the South African context, this philosophy of existence was not adopted.

3.2.4.3 Epistemology philosophy

According to Blaikie (1993), epistemology can be described as a science or theory of methods or motifs of knowledge. Epistemology is considered to be a set of claims or assumptions explaining how to acquire knowledge of reality and how to understand properly what already exists. It helps to determine different criteria to be satisfied so that these can be defined as knowledge. Norris (2005) explains that epistemology is the study that allows people to ask what knowledge exactly is. The researcher is allowed to identify acceptable knowledge of the area of the study and assist with understanding what information is true, as testing is strict.

Moreover, Hatch and Cunliffe (2006) define epistemology as a study in which the researcher realises how to know and develop something by asking the following questions:

- How is knowledge produced?
- What criteria make the difference between good knowledge and bad knowledge?
- How should people represent or describe the reality?

Epistemology is often used in scientific research because it does not aim to change situations and opinions; rather, it looks for facts and information that can be proven without doubt (Norris, 2005). Epistemology is almost associated with ontology and is more concerned with what constitutes the reality (Easterby-Smith, Thorpe & Jackson, 2008). There are two types of epistemology: objective and subjective (Eriksson & Kovalainen, 2008). Epistemology is objective when it confirms the existence of an external world beyond people's interpretations and observations. On the other hand, epistemology is subjective when it assumes that there is no access to the external world beyond our own interpretations and observations.

Since the aim of this research was to explore the current status of e-agriculture research in the South African context, epistemology was not suitable for this study.

3.2.4.4 Philosophical hermeneutics

According to Cole and O'Keefe (2002), hermeneutics is described as an underlying philosophy with epistemological assumptions. Furthermore, Boell and Cecez-Kecmanovic (2014) point out that hermeneutics is a theory that helps the researcher make use of interpretation to deal with issues of the meaning of texts. Moreover, Introna (2011) characterises hermeneutics as a methodology or mode of analysis.

According to Alexander and Numbers (2010), hermeneutics in the past was focused on pertinent texts to convey the objects in which human life is expressed. This interpretation, together with an ideological bias, has the ability to inhibit human potential in order to create a better understanding. However, hermeneutics now encourages humans to use all their potential to understand the meaning of language in order to extend the unlimited potential of human thought (Regan, 2012). Hermeneutics philosophy provides a solid theoretical foundation for the researcher to describe and understand the literature review process (Ricoeur, 1981).

According to Ramberg and Gjesdal (2009), philosophical hermeneutics is more focused on questions that promote understanding to happen, rather than with techniques of interpretation and understanding. Hermeneutics can play a crucial role in understanding all institutions and ideologies that encourage or preserve leading power structures when it is placed in the service of critical theory (Agrey, 2014). Critical hermeneutics contains four main principles used for interpreting: reproduction, hegemony, reflection, and application. The first two principles still need to be recognised and should therefore be avoided, but the last two are already considered as principles of possibility. Reproduction allows legitimising traditional power structures. Hegemony is considered as the principle of critical hermeneutics that should be avoided by the researcher when conducting a study. Reflection and application are classified as the last two principles of critical hermeneutics that help the researcher in the emancipation of thinking.

Since the aim of this research was to understand the current status of e-agriculture research in the South African context and the study used a systematic literature review to collect and analyse data, hermeneutics philosophy was not appropriate.

3.2.4.5 The positivist paradigm

According to Petty, Thomson and Stew (2012), positivism is a research paradigm known as empirical science or scientific technique created during the advancement in the eighteenth century when coherent reasoning and thought replaced faith and religion to explain phenomena. Positivism is determined by values of validity, truth, and reason (Easterby-Smith et al., 2008). It is focused on facts and is gathered through experience, direct observation, and empirical measure using a quantitative research strategy such as statistical analysis, experiments, and surveys. The role of positivism is to handle the stability of reality that can be observed and measured in a systematic and correct way to increase objective knowledge (Petty et al., 2012). The purpose of positivism is to gain explanatory and predictive knowledge of the external world by creating universal laws that express constant relationships of phenomena discovered through methodical experiments and observations (*ibid*).

According to Henning, van Rensburg and Smit (2004), the systematisation of the knowledge generation process with the help of quantification and scientific methods are adopted by positivistic thinkers to enhance precision in the description of parameters and the relationship among them. Easterby-Smith et al. (2008) points out that a positivist position is characterised by the testing of hypotheses developed from existing theory, thus theory testing, or deduction, or through clear social realities that are measured. This position supposes that the

social world exists objectively and externally, that knowledge is valid only if it relies on observations of this external reality, and that universal or general laws exist or that theoretical models can be developed. In this paradigm, the observers bring their own knowledge and experiences to the research, and it is crucial to separate this from the study, thus remaining objective (Petty et al., 2012).

Since the aim of this research was to understand the current status of e-agriculture research in the South African context rather than using quantifiable measurements or hypothesis testing, the positivist research paradigm was not appropriate.

3.2.4.6 The critical theory paradigm

According to Guba and Lincoln (1994), critical theory lets the investigator adopt more transactional and subjectivist epistemology, where the researcher and the investigated object are presumed to be interactively linked with the values of the investigator. Critical theory maintains socio-political critiques on ideology and social practices that mask systematically distorted deformed accounts of reality, which seek to legitimate and dissemble unbalanced asymmetrical power relations (Bottomore, 2001). Critical theorists assert that the examination of systems of domination can usher in social transformation, motivate self-empowerment, and awake the consciousness (Freire, 2000).

According to Newman (1997), the goal of critical theory is to provide people with resources that will help them change and understand their world. Once people discover the resources, they can use it to enhance the manner in which things are done and to modify social relations. Critical theory interacts and grows with the world it is trying to explain. Critical theory is explicitly prescriptive and normative (Morrison, 1995). It necessitates a view of what behaviour in a social democracy should require. Its objective is not only to give an account of behaviour and society, but also to realise a society that is based on democracy and equality for all its representatives. The purpose of critical theory is not only to gain a better understanding of the phenomena and situations, but also to change them. Critical theory tries to release disempowered inequality and to encourage freedom of people within a democratic society (Cohen, Manion & Morrison, 2000). It tries to discover the interests at work in specific situations and examines the legitimacy of those interests by determining the extent to which they are legitimate in their service of democracy and equality.

Since the aim of this research was to understand the current status of e-agriculture research in the South African context, a critical research paradigm would be useful

but inadequate for this purpose. Whilst the thesis could borrow from this paradigm, a contextual, more interpretive approach was required.

3.2.4.7 The interpretivist paradigm

According to Blaikie (1993), the interpretivist paradigm is an approach that considers social reality as result of a series of actions by which social actors hold talks on the meaning of actions and circumstances. It is composed of constructed meanings in social science. According to Petty et al. (2010), researchers should not consider social reality as something that has to be interpreted in different ways. The main role of social reality is to help people understand the world in which they live (Walsham, 1993). Hence, the social reality is directly present in objects or social situations, it is something individuals have to construct and create. This involves the development of subjective meanings of individuals' experiences that are multiple and diverse. Individual experience does not involve a method of sensory in interpretivist paradigm, but a method of interpretation. The procedure of understanding the external physical world and human behaviour relies on people's interpretation of the conditions in which they find themselves.

According to Deetz (1996), the interpretivist paradigm helps the researcher obtain a greater alternative to address issues that are affecting and influencing the research. It helps to ask questions such as "why" and "how" specific technological trajectories are developed. Interpretivists think the understanding of the subject in which any kind of study is carried out is exceptionally important for the examination of collected data (Willis, 2007). Interpretivists usually try to have a better understanding of a specific context, and they believe that reality is socially constructed. With the interpretivist paradigm, the researcher accepts and tries different perspectives; he/she is forced to be open in order to practice iterative and emergent methods of data collection; he/she is also obliged to promote participatory and holistic research, and go beyond the inductive and deductive approach.

According to Hatch and Cunliffe (2006), knowledge is based on how the knower understands things, and interpretivists have the role of working together with others to clarify, draw meaning from, and create their realities to have a better understanding of their points of view, as well as to explain their experiences in academic research contexts that are inductive. Furthermore, Gephart (1999) points out that reasoning and thinking always work together with knowledge because meaning and knowledge form part of interpretation. Interpretive studies are often

inductive in nature, and qualitative approaches are generally used to collect and analyse data (Gray, 2012).

Since the aim of this research was to understand the current status of e-agriculture research in the South African context, and the study was inductive in nature, adopting a qualitative approach to collect and analyse data, the interpretive paradigm was deemed appropriate.

3.3 Research methodology

According to Schwandt (2007), research methodology is a set of principles on which an investigation (study) should be conducted. It involves the investigation of principles, procedures, and notions in a specific approach. Furthermore, Myers (2009) defines research methodology as a strategy of investigation that helps the researcher to start with the fundamental assumptions to understand a study, and then continue with the research design to gather and analyse all relevant information. Moreover, Rajasekar, Philominathan and Chinnathambi (2006) describe research methodology as a logical way to find a solution to a problem. It is the process researchers use to describe, explain, and predict their study.

Research methodology explains and defines the types of issues that are worth studying, as well as what constitutes a researchable issue and testable hypotheses (Creswell & Tashakkori, 2007). The objective of research methodology is to provide the work procedure of the topic to be investigated (Rajasekar et al., 2006).

Since the aim of this research was to understand the current status of e-agriculture research in the South African context, the researcher used a systematic literature review method that was appropriate to the objective of the study.

3.3.1 Systematic literature review

The procedure and design of the systematic literature review is described in this chapter. The review plan, search strategy, selection criteria and procedures, and data extraction steps are the principal emphasis of the chapter. These steps indicate how the study was conducted by the researcher. Figure 3-1 presents the different steps and a schematic view of the systematic literature review process in general.

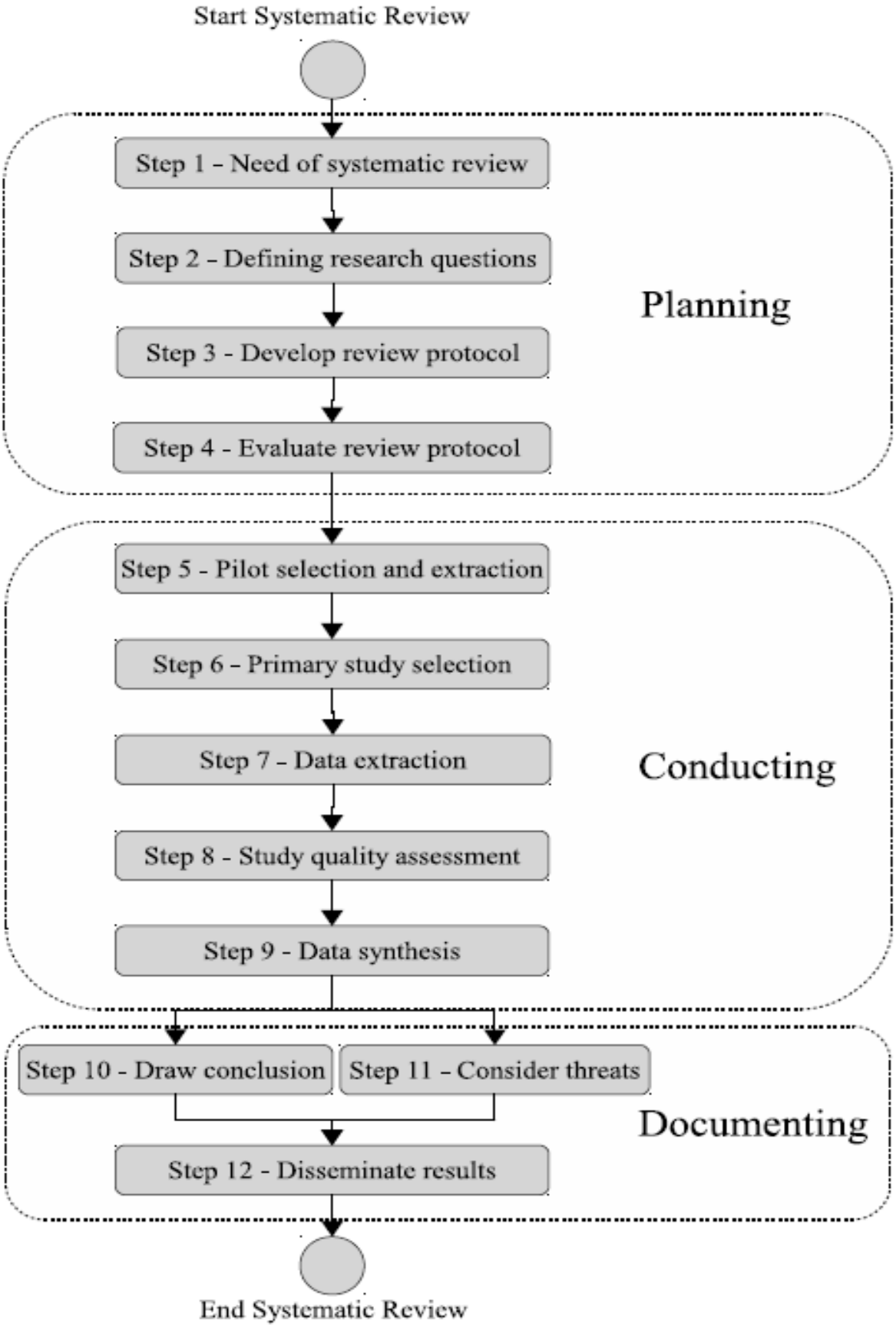


Figure 3-1: Steps of systematic literature review process in general way
(Source: Unterkalmsteiner, Gorschek, Moinul-Islam, Cheng, Permadi & Feldt, 2010:7)

This methodology is generally composed of three main parts: planning, conducting, and documenting.

3.3.2 Planning the review

The research begins with determining the need for a review and developing a protocol composed of different stages, research questions, inclusion and exclusion criteria, and procedures to analyse the data.

3.3.2.1 Identification of the need for a systematic literature review

In this study, the identification of the need for a systematic review was discussed in the motivation sections of previous chapters.

3.3.2.2 Development of a review protocol

According to Kitchenham and Charters (2007), a review protocol is a confined strategy that allows the researcher to conduct a systematic literature review and a procedure to select primary studies. The review protocol used to conduct the systematic literature review for this study was determined in this section. Figure 3-1 presents the protocol developed during the review process to carry out the systematic literature review. The research questions were designed to conduct the systematic literature review. This was described in section 3.2.2. In this study, the research questions were related to the current status of e-agriculture research in South Africa. These research questions addressed different perspectives considered for e-agriculture research in South Africa. The questions are elaborated on later in the data extraction phase (see section 3.3.6).

The need for a particular review protocol (step 3, figure 3-1) allowing the researcher to replicate the review for further studies is required to minimise the bias of the search and the systematic literature review. In this study, the researcher assessed and examined the review protocol in the field of e-agriculture in South Africa, with a positive experience of investigating systematic literature reviews.

3.3.3 Search strategy

According to Boell and Cecez-Kecmanovic (2014), a successful search procedure is not one that occurs in high recollection, but rather one that results in high accuracy. Moreover, searching is not something that is established at the beginning of the review process of a study, although it is an important part of the literature review study (*ibid*). The researcher can use the searching technique to move from the general to the particular to determine pertinent publications for a

subject. This causes the researcher to become engaged with the literature and familiar with names of important authors, journal articles, reports, books, theses, conferences, specialised terms, expressions, and research approaches on e-agriculture in the South African context. It assists the researcher with having a clear, in-depth understanding of the field of study and improves the way in which literature is searched, for example, the researcher can become aware of new search terms. In this study, the researcher used different techniques and methods of searching to find relevant literature using web search engines and digital databases.

For the researcher to conduct the review and answer this systematic literature review research questions efficiently and scientifically, pertinent papers from the following web search engines and digital databases were covered: EBSCOhost, Google, Google Scholar, IEEE Xplore Digital Library, ProQuest, SA Theses, SA ePublications, ScienceDirect, and Scopus, published within the period 2000-2016. This was investigated to provide a picture of the current state of e-agriculture research in South Africa. The quality of search strategy adopted by the researcher to avoid overlooking pertinent publications was high. Figure 3-2 illustrates the general view of the search strategy used during this study.

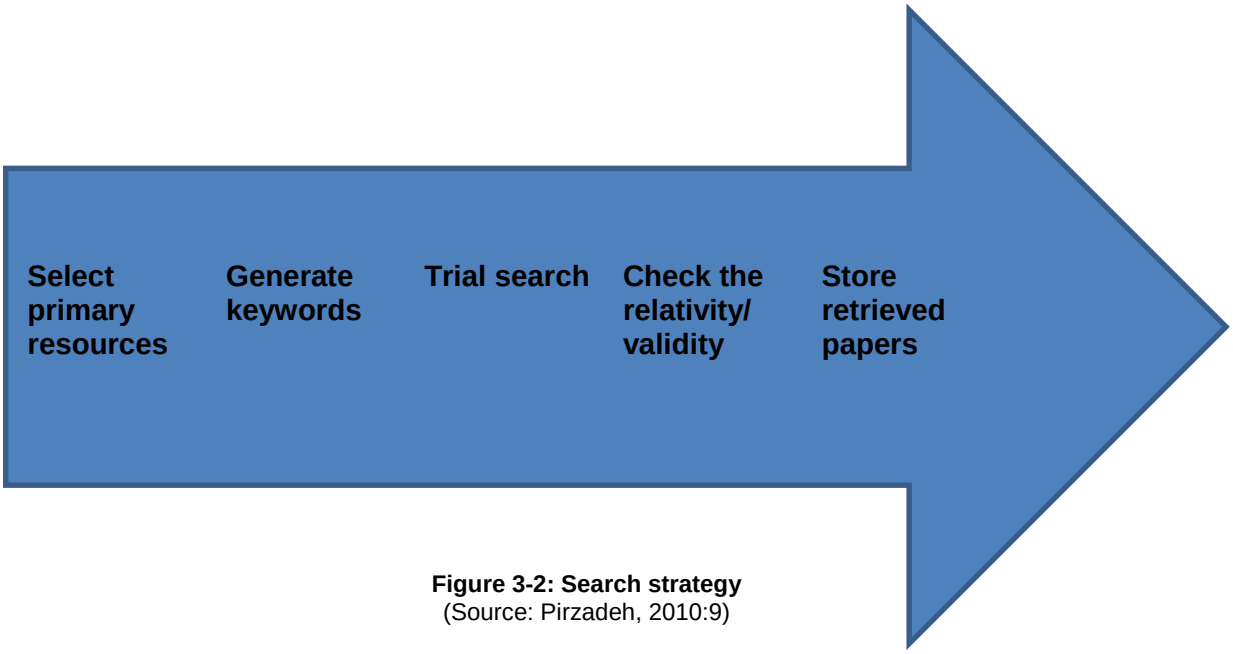


Figure 3-2: Search strategy
(Source: Pirzadeh, 2010:9)

In this study, different keywords were created by the researcher regarding the research questions to find the pertinent papers. These keywords are indicated in table 3-2. Firstly, the researcher used keywords in Google and Google Scholar. The keywords encapsulated electronic agriculture in South Africa and e-agriculture in South Africa.

Table 3-2: Combined search keywords used for literature on e-agriculture in South Africa

Search Keywords
a) Electronic agriculture AND South Africa
b) E-agriculture AND South Africa
c) Internet AND agriculture AND South Africa
d) ICT AND agriculture AND South Africa
e) Information and communication technology AND agriculture AND South Africa
f) E-farming AND South Africa
g) Digital AND agriculture AND South Africa
h) Mobile phone AND agriculture AND South Africa
i) M-agriculture AND South Africa

Secondly, the researcher extended the search results by using many keywords combined with the AND operator as indicated in table 3-2. Thirdly, the researcher used keywords and combined search keywords in digital databases such as ScienceDirect, Scopus, SA ePublications, IEEE Xplore Digital Library, EBSCOhost, SA Theses, and ProQuest to obtain more pertinent research papers. This process yielded 142 published papers on e-agriculture in South Africa. The papers included books, conference papers, Master's theses, Doctoral theses, and journal articles.

3.3.4 Study selection criteria

In this phase, the researcher conducted the abstract reading step to exclude the papers not pertinent to this systematic literature review. Publications that were not written in English, that were not full papers, and that were not within the related fields (i.e. ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, providing broader information on agriculture), have been excluded.

3.3.5 Selection procedure

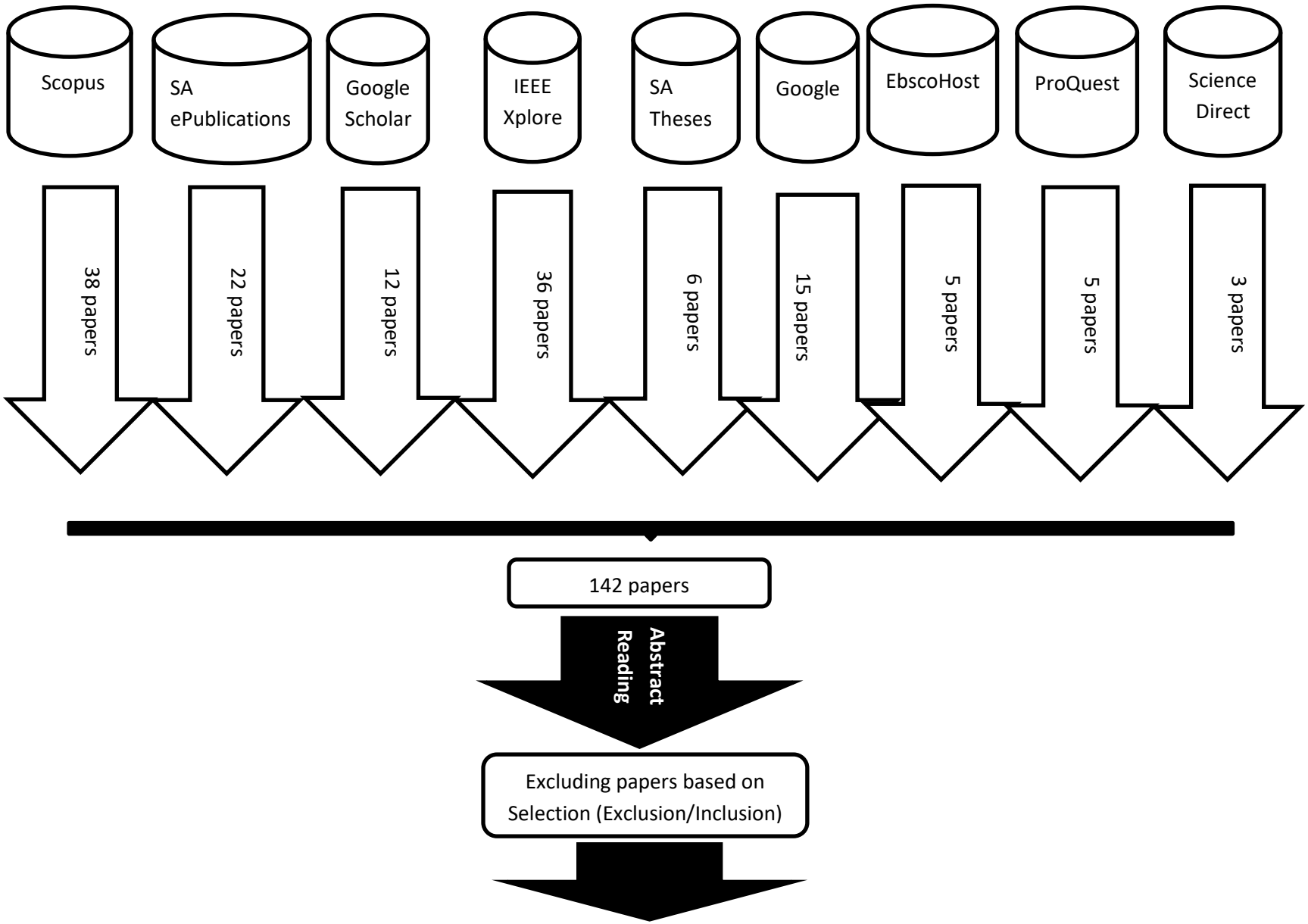
In this phase, the researcher reviewed the papers for the second time by means of keywords and abstracts to be more focused on the research questions and the objective of the study. The researcher reviewed publications on e-agriculture in the

South African context related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture, based on *titles*, *abstracts* and *by date*. Only literature published within the years 2000-2016 was analysed by the researcher to determine the current status of e-agriculture research in the South African context. A total of 114 papers on e-agriculture in South Africa were yielded in this process. These papers included books, conference papers, Master's theses, Doctoral theses, and journal articles. The following table describes the relevant resources considered in the study.

Table 3-3: Research publication and number of pertinent resources analysed

Research publications	References	Number of papers
Book	[159], [165]	2
Conference	[276], [196], [198], [65], [187], [79], [275] , [215], [199], [132], [81], [68], [155]	13
journal article	[157], [292], [64], [130], [91], [208], [176], [47], [265], [146], [185], [219], [89], [221], [291], [125], [121], [126], [220], [264], [173], [128], [205], [245], [209], [186], [166], [176], [167], [124], [43], [63], [144], [133], [5], [6], [183], [119], [16], [78], [56], [259], [266], [158], [25], [102], [145], [134], [139], [147], [120], [148], [268], [248], [54], [31], [154], [74], [140], [296], [1], [2], [40], [206], [182], [101], [111], [153], [181], [211], [60], [26], [163], [127], [288], [247], [149], [58], [250], [104], [296], [244], [262], [161], [129], [142]	88
Thesis	[7], [273], [125], [117], [150], [24], [49], [137], [287], [110], [67]	11

The entire selection obtained from the first search results is described as a schema (abstract reading, exclusion/inclusion criteria, etc.), indicated in figure 3-3 below.


Scopus
SA ePublications
Google Scholar
IEEE Xplore
SA Theses
Google
EbscoHost
ProQuest
Science Direct
38 papers
22 papers
12 papers
36 papers
6 papers
15 papers
5 papers
5 papers
3 papers
142 papers
Abstract Reading
Excluding papers based on Selection (Exclusion/Inclusion)

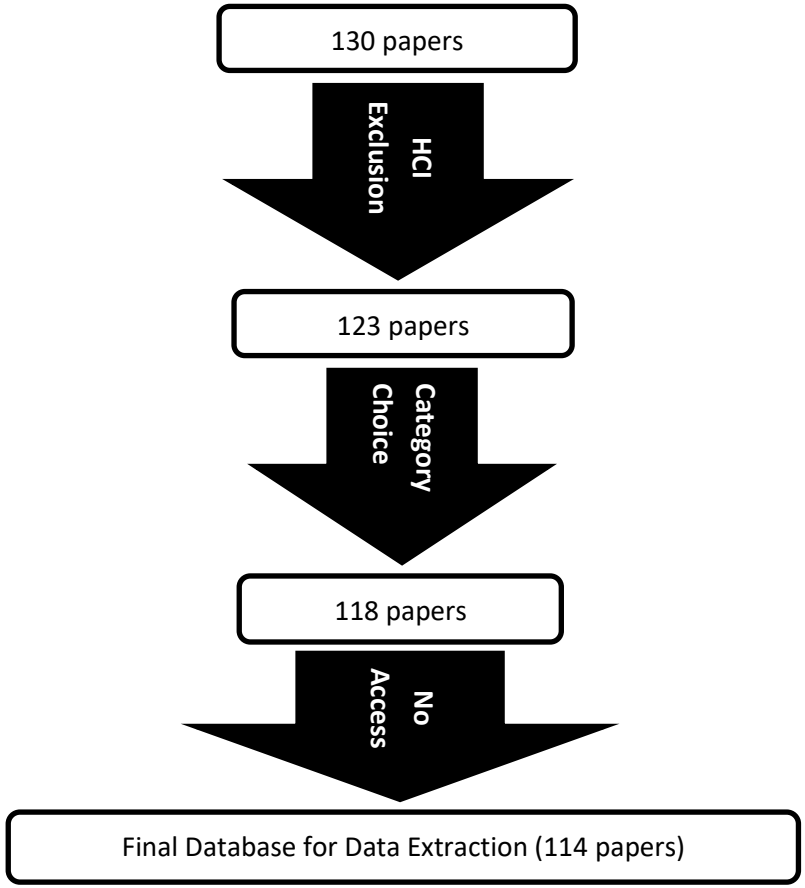


Figure 3-3: Primary study selection/selection procedure

3.3.6 Data extraction

In this phase, the researcher took the 114 remaining papers for full text reading to extract data (step seven of systematic literature review, figure 3-1). To enable the researcher to conduct this phase more effectively, the extraction of data were created based on the research questions of this study. A pilot review was conducted to assess the form. The focus of e-agriculture research in South Africa (i.e. ICT adoption and use in agriculture companies, e-government direct services, mobile phone in agriculture, computerised back-end developed systems, networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture), was the principal perspective of the first version of the data extraction. According to Staples and Niazi (2007), it is somewhat difficult to determine values for all concepts used when extracting data because the values depend on the papers and the contents. During the data collection phase, the researcher extracted data from each of the publications. Table 3-4 describes all the data collected and the related research questions considered in the first version of the data extraction in this study.

Table 3-4: Extracted data

Data collected	Research question
Focus of e-agriculture research	RQ1
Research methods	RQ2
Research approach	RQ2
Theoretical lens	RQ3
Unit of analysis	RQ4
Unit of observation	RQ4
Level of analysis	RQ4
Historical development	RQ5
Major concepts	RQ5
Discipline	RQ6
Publication Year	Overview of studies

For this study, the researcher first sought to find values based on information collected after reading the abstract of each paper to determine the focus of e-agriculture research in South Africa. This was described above. Next, the researcher sought to determine different empirical research methods used in these

papers. The empirical methods were categorised into eight parts, namely information mapping, case study, design of system/method/model/solution, survey, experiment, industry report, field study, and grounded theory. The researcher then ascertained different research approaches used in the papers of the study. The research approach was categorised into six parts (interpretivism, objectivism, constructionism, reductionism, criticism, and positivism). Next, different theoretical lenses used in the papers of this study were identified. The theoretical lenses were categorised into three parts, namely decision-making theory, technology acceptance model, and diffusion of innovation. Thereafter, the unit of analysis used in the papers was determined. The researcher also sought to determine the unit of observation used in the papers. The next step was to establish the level of analysis used in the papers, which was categorised into three parts (the micro, meso, and macro level). Then, the researcher sought to determine the historical development used in the papers of this study. Following this, the major concepts used in the papers were identified, which were categorised into four parts, namely technology adoption, information system value, information systems development methodology, and general concepts. Next, the researcher determined different disciplines used in the papers, and finally, the publication year of the papers in this study was determined.

3.3.6.1 Focus of e-agriculture research in South Africa

This study sought to respond to the research question: what has been the focus of e-agriculture research in South Africa? The study further sought to describe the results found in studies on e-agriculture research in South Africa, and summarised what has been achieved by authors in their studies. This was divided into several categories based on papers extracted for the purpose of this study. Therefore, in this systematic literature review, the categories used to extract data have been identified as:

- ICT adoption and use in agriculture companies
- E-government direct services
- Mobile in agriculture
- Computerised back-end developed systems
- Networking in agriculture
- Agricultural information systems
- Use of geographic information systems (GISs) improving agriculture
- Use of global positioning systems (GPSs) improving agriculture
- Use of satellite enhancing agriculture
- E-commerce

- ICT in agricultural supply chains
- Empowering local agricultural communities through information and ICTs
- Providing broader information on agriculture

The researcher sought to compile a general, brief description of each category and provide some information obtained after extracting data in sections A to M.

A. ICT adoption and use in agriculture companies

The importance of information and communication technology has been recognised in agricultural private enterprises. This substantiates a move towards ICT adoption by agricultural private enterprises. According to Gelb, Gal and Wolfson (2010), ICT adoption is a single occurrence of technological innovation that seriously enhances the management, sharing and transfer of information, integration, and production chain productivities within and with the agricultural sector. Joseph and Andrew (2008) indicate that it is crucial to observe the effects or the changes of adoption of a specific information and communication technology by the farming community. Furthermore, Franklyn and Tukur (2012) reveal that it is essential to understand the elements affiliated with ICT adoption and use in agriculture that increase the efficiency and effectiveness of information use in agriculture and the development of techniques to support ICT adoption.

According to Tembo (2008), several famers are not interested in traditional ways of keeping data anymore because the use of ICT is becoming increasingly popular. However, the use and adoption of ICT is sensitive to variables such as educating the producers, age and technological level, insertion in the production chain, market access, size, location, and income level of the operation (Rodrigues, 2012).

In this study, papers were grouped into category A if authors explained how people in agricultural enterprises or environments in South Africa have adopted and used ICT.

B. E-government direct services

ICTs are used by the government of South Africa to enhance the agricultural sector and service delivery (Maumbe, 2010). A promising alternative is offered by e-government to deliver services and public agricultural information to rural areas (Costopoulou & Karetsos, 2008, cited by Maumbe, 2010). E-government in agriculture is described as a type of e-government focused on use of ICT by state administration to provide quality, accessible and fast information services and facilitate common information exchange between agricultural enterprises and the

involved agricultural public authority to enhance productivity of its internal use (Ulman, Vostrovský & Tyrychtr, 2013).

E-government has been used by several countries to boost their agricultural public services to farmers and other agricultural actors (Ntaliani et al., 2010). The World Wide Web (WWW) and use of the internet are included in e-government to deliver online services and public information to a number of agricultural actors and farmers to enhance the quality of their public services by making them more citizen-centred, accessible in real-time, dependable, and faster (Maumbe, 2010).

In this study, papers were grouped into category B if authors investigated government use of ICT to support the agricultural sector in South Africa.

C. Mobile in agriculture

Agricultural development and rural transformation in South Africa have grown quickly through using mobile and wireless technologies (Maumbe, 2010). Mobile agriculture is considered as a new procedure or technique used by the government to deliver public service to rural communities. Mobile agriculture is well positioned as the new strategy to drive national economy and provide food security. Simpson and Calitz (2014) point out that there is a growing usage of mobile technology as medium for supporting agricultural organisations to provide extensive services to farmers and help them access information. Mobile technology is covering a large population working in the agricultural sector in rural communities (Mandioma, 2007).

According to Chhachhar, Qureshi, Khushk and Ahmed (2014), mobile phone technology helps farmers who are educated by using short service messages (SMSs) to obtain the latest updates on agricultural information, such as marketing information that assists farmers with taking logical decisions. Aker and Mbiti (2010) point out that mobile phones can be used to increase market productivity, reduce the cost of searching for information, improve co-ordination between parties, and enhance access to information. Nojozi, Scott and Nomnga (2016) indicate that information can be broadcast to people through answers and questions by using a mobile application. It can be used to enhance market access and communication and to make information sharing more coherent in rural areas.

In this study, papers were grouped into category C if authors investigated mobile technology in agricultural enterprises or environments in South Africa.

D. Computerised back-end developed systems

The use of computers has significantly transformed the business structure of farms and improved the production processes (E-notes, 2016). Hill (2008) posits that computers have been added to many types of equipment by industrialists of farming equipment, and a large range of software has been incorporated into farming applications. In addition, many types of applications have been offered by software producers to alleviate the process of farm operations. Computer technology is incorporated into most elements in use on specialised farming operations and crops (Oladele, 2015). Michailidis (2006, cited by E-notes, 2016) indicates that computers have enhanced productivity and have enabled farmers to change spending on labour to spending on capital products.

In this study, papers were grouped into category D if authors investigated computer technology in agriculture in South Africa.

E. Networking in agriculture

According to Odongo, Mugivane and Olubayo (2012), networking technology has a high impact on different communities in terms of increasing awareness and income. This technology has been introduced to the agricultural sector to offer new approaches to farmers in order to develop agriculture. Networking technology contains different features that help farmers to communicate with each other, especially when they are not disturbed by mobile phone users (Javaid, Mugivane & Olubayo, 2013). Networking helps farmers to overcome challenges such as pest management, development of virulence, development of pesticide resistance, and climate change (Hansen, 2016). Networking is often executed with tiny devices forming a multitude of connectivity that expand the reach of cyberspace into the physical world. It enables electronic devices and computers to communicate and have access to the internet by using a cable or without being physically connected (Vellidis, Garrick, Pocknee, Perry, Kvien & Tucker, 2007).

In this study, papers were grouped into category E if authors investigated networking in agriculture in South Africa.

F. Agricultural information systems

Agricultural information is a crucial element that interacts with other production elements. The efficiency of these other elements such as managerial and capital ability, labour, and land can be enhanced by pertinent, useful, and reliable information (Demiryurek, Erdem, Ceyhan, Atasever & Uysal, 2008). According to Roling (1988), an agricultural information systems can be described as a system

that allows feedback, receiving, consolidating, producing, transferring, and transforming agricultural information in such a way that these procedures work synchronously to establish knowledge utilisation by agricultural growers. Agricultural information systems refer to a particular farming system that offers the understanding of how to enhance system management (system performance) and how strongly the system functions (Demiryurek, 2000). It allows the understanding of the structure of the system and identification of fundamental elements and various information sources employed by different elements in the system.

According to Vidanapathirana (2011), ICT-based agriculture information systems are crucial to supporting the diffusion of agricultural techniques and information for the rural farming community. Agricultural information systems include system operations (management and control), information related procedures (utilisation, integration, storage, generation, diffusion, retrieval, and transformation), and components.

In this study, papers were grouped into category F if authors investigated ICT-based agriculture information systems in South Africa.

G. Use of geographic information systems (GISs) improving agriculture

The development of GIS-based approaches started in the 1990s and consisted of two categories: those depending on soil landscape data, and the available environment (Carey, Saayman, Archer, Barbeau & Wallace, 2008). Several studies have been conducted using geographic information systems in agriculture (Gangodagamage & Clarke, 2001). GIS refers to a technology that can be used to assist decision makers in the agricultural sector with achieving conclusions on a particular matter and reach pertinent, reliable, and accurate information (Collett & Lindemann, 2007). GIS produce a powerful and flexible tool that assists with obtaining large quantities of different types of data sets (Meghdadi & Kamkar, 2011). Data are combined and manipulated in the form of thematic maps.

According to Naesset (1997), the preservation of forest biodiversity can be done using geographic information systems as a decision support tool. Furthermore, Kabanda (2015) indicates that GISs can be used to provide thematic information on the rigidness of land restrictions connected to land use and crops through land assessment techniques. Moreover, Buchanan, Butchart, Dutson, Pilgrim, Steininger and Bishop (2008) note that geographic information systems can be used to facilitate forest cover change mapping through multi-temporal images. Mutanga and Adjorlolo (2008) reveal that GISs can be used to provide a coherent

and helpful means to manage different type of pertinent information in order to understand spatial patterns of crop.

In this study, papers were grouped into category G if authors investigated how the use of GISs can enhance the agriculture in South Africa.

H. Use of global positioning systems (GPSs) improving agriculture

According to Groenewald (2015), the agricultural sector is guided by Global positioning systems that facilitate precision farming possibilities. GPSs are part of geo-spatial information technology that assists with gathering remote sensing data based on soils, variability of crops, and other related elements supporting a paradigm shift in agriculture and precision farming (Petja, Nesamvuni & Nkoana, 2014). The use of a global positioning system enables farmers to have evenly spaced and accurate rows of crop (Hussey & Staier, 2008). GPSs enable farmers to enhance crop yield at a more precise level (Joyce, 2003, cited by E-notes, 2016).

According to Hussey and Staier (2008), a guidance system can be introduced by producers through using GPSs that can streamline cultivation and planting and lead to enhanced products. The authors furthermore posit that environmental impacts and farming costs could also be reduced by using GPSs. Roberson (2000) points out that global positioning system contains several applications that can be used in the agricultural sector:

- Advice (point advice and swath advice)
- Handle (variable irrigation, variable depth tillage, and variable rate application)
- Mapping (planting and tillage of maps, soil properties, pest and yield mapping, topographic mapping, prescriptions and chemical applications)

In this study, papers were grouped into category H if authors investigated how the use of GPSs can enhance the agriculture in South Africa.

I. Use of satellite enhancing agriculture

According to Adjorlolo, Mutanga and Cho (2013), new opportunities characterising the biochemical and biophysical state of vegetation are offered by satellites. Satellites and aerial photographs are remote sensing systems that assist with collecting data on land cover, periodic land use, and other thematic agricultural information (Petja et al., 2014). Petja, van Zyl and Malherbe (2004) point that satellites can be used as a tool to monitor agricultural applications and natural

resources. It provides influent information for development decisions in South Africa. Satellites provide remote sensing images capable to produce and update land cover maps of the considered agricultural site (Bruzzone Cossu & Vernazza, 2002). A particular view of the landscape for decision makers can be provided by satellites, enabling land managers to enhance natural resource management in the agricultural sector (Petja et al., 2014).

In this study, papers were grouped into category I if authors investigated how the use of satellites can enhance the agriculture in South Africa.

J. E-commerce

According to Breytenbach (2015b), E-commerce is described as an act of selling and buying goods online that assists farmers with making large amounts of money and saving their time. Furthermore, Qureshi and Davis (2007) indicate that e-commerce is defined by other proponents as a mechanism through which market is accessed among the influential. Information is concentrated and flows into the digital divide. Cloete and Doens (2008) note that e-commerce is where well-organised market theory estimates a sharing of gains and risks between households, agribusiness managers and farms.

The implications and effect of e-commerce on the agricultural sector for agribusiness and farmers have been considered as a component to empower the economy, facilitate markets, and provide information (US Library of Congress, 2004). Governments in developing countries have created some conditions facilitating the growth of e-commerce industry (Datta, 2011). This was created through the modifications of several laws, which allowed the e-commerce industry to extend its potential from a legal opinion. Producers of developing countries are given several opportunities to enhance customer services and improve competitiveness, reduce transaction and overheads, and access new international markets at minimal capital investment and low cost by using e-commerce (Cloete, Courney & Finch, 2002).

In this study, papers were grouped into category J if authors investigated e-commerce in agriculture in South Africa.

K. ICT in agricultural supply chains

Agriculture is considered as a business in which employment benefits are most interpretative (Cloete & Doens, 2008). Agricultural supply chains involve the forward and backward linkages among enterprises, farmers, market

intermediaries, government institutions, and consumers (Narula & Nainwal, 2010). The growth of ICT has offered new opportunities that can be employed to benefit agricultural sector (Cloete & Doens, 2008).

ICT has been recognised by advisors, managers, and researchers as an instrument enhancing the competitiveness of agricultural enterprises (Ortmann, 2000). ICT in supply chains encourages the development of market linkages of farmers in the system and remove marketing activities (Narula, 2009). USAID (2010) points that ICTs have a positive effect on all market actors and facilitate the management of supply chains that increase predictability and efficiency.

In this study, papers were grouped into category K if authors investigated ICT in the agricultural supply chains in South Africa.

L. Empowering local agricultural communities through information and ICTs

According to Joseph and Andrew (2008), ICT is crucial for rural community empowerment, global trade, participatory communication, encouraging competitiveness, and eradicating partialities between the information poor and the information rich. Joseph and Andrew (2007) point out that the rural empowerment in agriculture and poverty alleviation in developing countries can be helped by using ICTs. Richardson (2011) notes that livelihoods of poor rural farmers can be enhanced by the intervention of ICT, which will have an important indirect and direct impact on improving post-harvest activities, marketing, and agricultural production in order to reduce poverty.

According to Simelane et al. (2015), ICT can encourage rural and urban communities in agriculture by enhancing their quality of life, raising their income, and creating opportunities for accessing better social benefit programmes, healthcare, and education. Mammo, Derso and Haji (2012) posit that ICT can play a significant role in empowering all stakeholders in the agricultural sector by providing financial and banking services.

In this study, papers were grouped into category L if authors investigated how ICT can empower agricultural communities in South Africa.

M. Providing broader information on agriculture

ICT is described as an alternative way to provide agricultural information to famers (Simpson & Calitz, 2014). It has transformed the way farmers have access to

agricultural information on internet. According to Dlodlo and Kalezhi (2015), ICT can support rural farmers to have access to information markets for their rights, prices, products, and government services. Pertinent information needed by farmers can be provided through ICTs (Ortmann, 2000).

According to Mittal and Mehar (2012), ICT helps to disseminate information on cropping systems and the appropriate technology for geographical zones. It helps to generate awareness among farmers by recommending suitable quality and quantity of inputs. Swanson and Rajalahti (2010) point out that ICTs allow the dissemination and promotion of existing and new farming knowledge and information, which is exchanged within the agricultural sector because information is crucial for facilitating rural and agricultural development.

In this study, papers were grouped into category M if authors investigated how ICT can provide agricultural information for famers in South Africa.

3.3.6.2 Research methods and tools

The researcher sought to determine research methods and tools used by authors to conduct their study. According to the research methods applied by authors of the pertinent papers and used by the researcher of this study to conduct the systematic literature review, the research methods are empirical. The empirical research methodology adopted in this study was divided into eight data extraction categories: survey, field study, experiment, information mapping, grounded theory, industrial report, case study, and design of system/method/model/solution.

Case study: according to Thomas (2010), a case study can be described as a procedure of investigation in which the researcher examines in-depth an activity, event, process, program and one or several individuals using various suitable data collection tools. A case study focuses on a small case that should provide an understanding into a causal relationship over an important population of cases (Gerring, 2007). This presents the researcher with the impressive problem of case selection. A case study is limited by activity and time, where researchers gather specified information using different data collection techniques over a prolonged period of time (Thomas, 2010).

According to Neale, Thapa and Boyce (2006), observations, evaluation reports, monitoring visits, survey results or questionnaires, project documents including meeting minutes, interviews, mystery client reports and midterm reviews, project reports including a set financial statements, and facility assessment reports are

mostly used by researchers as sources of information and procedures to present a complete concept of case study research. Papers fulfilling one of the following criteria have been grouped into this case study category:

i) The author described the research questions (Easterbrook, Singer, Storey & Damian, 2008).
ii) The author evaluated a theoretical concept that meets a predetermined research objective and determines the sustainability of a theory in an experimental environment (Zelkowitz & Wallace, 1997).
iii) The author of the paper indicated that the research method is a case study or similar concept.

Survey: a survey can be described as a research method enabling the researcher to gather qualitative or quantitative data by using techniques such as questionnaires and interviews (Unterkalmsteiner et al., 2010). Pfleeger (1998) notes that a survey can be considered as a study conducted in retrospect when this technique or tool has been used over a long period of time. According to Wohlin, Runeson, Höst, Ohlsson, Regnell and Wesslen (2000), a deep or clear understanding of a current status of a situation can be given using a survey method. Babbie (1990) points out that surveys assist researchers with having a clear understanding of a population from which the sample has been selected and used. According to Wohlin et al. (2000), a survey using the interview as technique to collect data many advantages over a survey using questionnaires as technique, including more accurate answers (there will be a few answers such as “I don’t know”), and the observation technique can possibly be used by interviewer. In papers grouped into the survey category, different techniques when conducting their surveys were discussed. Different research methods such as a controlled experiment or a case study could be found accompanying a survey method in some cases. For example, in a particular survey a researcher can use a controlled experiment to gather important information.

Experiment: papers were grouped into this category if an experiment with a predetermined design was conducted by the author, and if the author had control over the experiment (i.e. the results were checked and the elements of the experiment were set by the author). Authors usually conduct experiments that produce a strong level of control in a laboratory environment. Themes are assigned to different analyses at random when experimenting. Wohlin et al. (2000) point out that the purpose of experiment method is to control all other variables at

predetermined levels and to utilise one or more variables. According to Michael (2000), the experiment method contains several features:

i) A variable is directly manipulated by the researcher.
ii) Strong discussion for cause-effect relationships are provided through empirical observations by using experiments.
iii) The experiment method can use a problem statement, theory, constructs, operational definition, variables, and hypotheses during an investigation.
iv) In the empirical data, the research question formulated as the possible hypothesis is often used to interpret differences.
v) The population is selected at random when conducting subjects.
vi) A comparison of theme performances by the two groups is made after application.
vii) The papers are categorised into this category if the authors of the papers mentioned that experiments have been employed as part of the study.

Industry report: Papers meeting the following conditions were grouped into this category:

i) If the author indicated on the paper that it is a project or research report of experiences, results and lessons learned, or that it is an industrial report.
ii) The paper has been derived from an industrial experiment with no pre-determined research questions even though the research method is not mentioned.

Design of system/method/model/solution: Papers were grouped into this category if the authors proposed a method, guideline, framework, and a model employable by other investigators or practitioners in their fields of research. For example, the author suggests a framework for investigators working with particular subject in the field, which has been investigated in many research projects before. Papers proposing a model, solution, system, and framework, and providing some evidence as well as a practical and empirical background were grouped into this category. For example, a model, framework, and system proposed by the authors could be evaluated when conducting a case study.

Information mapping: papers were grouped into this category if authors analysed data by using techniques such as web-portals, code repositories, and other historical data sources in their studies (Schmitz, 2012). Most of the time, authors used trends or statistical analysis.

Field study: field study is described as a qualitative research method that allows a researcher to observe, understand, and interact with participants in their natural settings to collect pertinent information for the study (Schmitz, 2012). Glass, Vessey and Ramesh (2002) point out that in a field study, data are collected with techniques such as direct observation, contribution in meetings, and other workplace activities. Artefact analysis or documents, participant interviewing, and observation are combined when conducting a field study (Schmitz, 2012). Therefore, papers were grouped into this category if authors used these techniques to conduct their study and mentioned the use of a field study as research method**.**

Grounded theory: papers were grouped into in this category if authors mentioned the use of grouped theory as research method to conduct their study. According to Corbin and Strauss (2008), grounded theory can be described as iterative procedures built to determine concepts and categories within text that are associated with proper theoretical models. Charmaz (2006) points out that grounded theory is a method composed of different techniques consisting of flexible and systematic procedures for gathering and analysing qualitative data. Grounded theory helps the researcher to gather and analyse data by developing analytical codes. By using these codes, the researcher is enabled reorganise data into categories in order to develop a theory (Karley, 2014).

According to Wertz (2011), inductive methods are used in grounded theory to explain and predict behaviour that helps to build a theory. This starts with data being gathered from predictions, theory, and observations and then predictions are tested. Silverman (1993) points out that grounded theory contains the following steps and characteristics:

i) Categories derived from data are developed.
ii) Several examples, developed to determine their importance, should be given in these categories.
iii) The categories must be built into broader and general theories (or analytical frameworks) with pertinence to other situations outside the research subject.

3.3.6.3 Research approach

The researcher sought to determine the research approach used by the authors of the pertinent papers to conduct their study. Therefore, this study sought to determine the epistemological position on which a section of study is based (Boell & Cecez-Kecmanovic, 2014). Epistemology is concerned with what constitutes

reality and is often affiliated with ontology (Easterby-Smith et al., 2008). Epistemology asks the researcher to determine what the true information is because it is treated as fact (Norris, 2005). It determines limits and sources of knowledge, as well as what knowledge is (Eriksson & Kovalainen, 2008).

In this systematic literature review, the categories used for extracting data were identified as positivism, interpretivism, reductionism, criticism, and objectivism.

Positivism: papers were grouped into the positivism category if the authors mentioned the use of this approach in their studies. According to Thomas (2010), the purpose of positivism is to create a true statement by explaining the world in an objective way. The positivist research approach is associated with research methods such as structured observations, experiments, measurements, and empirical research (Cecez-Kecmanovic, 2011). The positivism research approach is conducted with several types of studies such as descriptive, quantitative, statistical analysis and verification of a hypothesis.

In the positivist approach, reality is normally explained and observed from an objective point of view (Orlikowski & Baroudi, 1991) using (among others) a unique independent variable (Persson, 2010). This helps relationships to be formed and regularities to be determined between factors of the social world.

Interpretivism: papers were grouped into the interpretivism category if the authors mentioned the use of this approach in their studies (Ojong & Muthuki, 2010). Interpretivism helps the researcher to understand both an individual and organisational level. In interpretivism, knowledge is viewed based on observable understanding, reasons, personal beliefs, and events.

Objectivism: papers were grouped into the objectivism category if the authors mentioned the use of this approach in their studies. According to Lakoff (1987), essentialism and realism are the principal sources of objectivism. Realism believes in private human experience and existence of the real world (Jonassan, 1991). The existence of dependable knowledge about the world is what this belief relies on. On the other hand, essentialism believes that the existence of essential properties makes a structure of a specific thing. Lakoff (1987) notes that objectivism is a specific type of essentialism.

What makes objectivism a significant conceptual position is that the world has a structure that can be formed for the learner, and it is real (Jonassan, 1991).

Furthermore, the epistemology of objectivism believes that the objective of the mind is to reproduce reality and its structure *(ibid).* Rand (1966) points out that acquiring the referents of the world is what constitutes learning. This is considered as types of concepts or entities that the world represents in reality. Jonassan (1991) believes that learning is the procedure of studying those concepts and entities.

Reductionism: papers were grouped into the reductionism category if the authors mentioned the use of this approach in their studies. Reductionism is described as a method that represents successful mitigation of one theory to another (Mittelstrass, 2014). The concept of reduction implicates theories or concepts and back entities. Nagel (1998) indicates that explanatory and constitutive approaches are two aspects involved in reductionism. Firstly, with explanatory thesis, for everything that occurs, a fundamental explanation in terms of laws governing those factors can be provided. Secondly, with constitutive thesis, everything is created with the same factors.

Criticism: papers were grouped into the criticism category if the authors mentioned the use of this approach in their studies. Criticism is often connected to nature's focus on the negative and grave aspects of constructivism (Liu & Matthews, 2005). Fox (2001) points out that the negative side of constructivism depends on its inclination towards epistemological relativism (including social community and individual relativism), which is considered as a serious problem for constructivists.

3.3.6.4 Theoretical lens

The researcher sought to determine the theory used by authors to conduct their study. A theory is defined as a set of propositions, definitions, and fundamental concepts that predict and explain situations or events by describing relations among variables (Glanz, 2012). In a theory, a number of functions are performed. This provides information and assists with structuring observations, thus helping to reveal implications and look for relationships among facts (Slavin, 2011). Peterset, Holmberg, Moore, Bernath and Vidal (2007) posit that hypotheses, assumptions, and facts are included in a theory (unit of knowledge). In this study, the categories used for extracting data include decision-making theory, diffusion of innovation (DoI), and the technology acceptance model (TAM).

Decision-making Theory: papers were grouped into this category if authors mentioned the use of *decision-making theory* to conduct their study. According to

Wang, Wang, Patel and Patel (2004), decision-making theory is a technique that chooses a procedure of actions or preferred option from among a set of choices on the foundation of strategies or given criteria. The process of decision-making theory contains many decision makers and can be summarised in three steps: an exploratory, convergent, and divergent step where the emphasis is to minimise the number of choices and then make the decision (Turpin & Marais, 2004). There are multiple disciplines involved in decision-making theory: statistics, political science, economics, sociology, psychology, cognitive science, cognitive informatics, management science, and decision science (Edwards & Fasolo, 2001).

Technology Acceptance Model (TAM): papers were grouped into this category if authors mentioned the use of TAM to conduct their study. According to Legris, Ingham and Collerette (2003), TAM is a theoretical model that helps to predict and explain user behaviour of information technology. Furthermore, Alharbi and Drew (2014) point out that TAM is a theory most used in the area of information systems to measure technology acceptance. TAM provides the foundation with which one discovers how external variables determine intention, attitude, and belief (Park, 2009). The technology acceptance model proposes two cognitive beliefs: perceived ease of use and perceived usefulness of use, which influence one's actual use of a technology system directly or indirectly.

Diffusion of Innovation (DoI): papers were grouped into this category if authors mentioned the use of DoI to conduct their study. According to Brown, Dennis and Venkatesh (2010), the objective of the DoI theory is to present individuals from disciplines interested in the diffusion of an innovation with a theoretical paradigm to understand the social change and process of diffusion. A large body of empirical results and well-developed ideas appropriate to the study of implementation, adoption, and technology evaluation is provided through DoI (Fichman, 1992). The categories of adopters, factors indicating the rate of adoption, and the innovation decision process are explained in the diffusion of innovation theory (Bhattacherjee, 2012). The adoption of innovations within a population of possible adopters is also explained in this theory. Rogers (2003) indicates four factors included in the DoI process:

i) Innovation: ban object or idea that is recognised to be new
ii) Communication channels: the means that allows facilitating the propagation of messages from one individual to another

iii) Time: there are three elements (the innovation's rate of adoption, relative time with which an innovation is adopted by a person or association, and innovation's decision process)
iv) Social system: a set of interrelated components that are involved in joint issue solving to obtain a unique objective

3.3.6.5 Unit of analysis

The researcher sought to determine the unit of analysis used by authors to conduct their study. According to Babbie (2010), unit of analysis is the principal entity that researchers analyse in their study. It is the "who" or "what" the researcher investigates. It is also considered as the focal point of the study that is specifically being investigated. Humphrey (2001) points out that the unit of analysis is established by an interest in explaining or exploring a particular phenomenon. Three properties determine the unit of analysis, namely:

i) Social entities: a single social entity can be observed, such as an institution or a person; there can also be, several entities, such as employer-employee, family
ii) Time: observations can be made at a single point in time, often described as a cross-sectional research; observations can also be made at several points in time (the researcher can organise data in a series of time intervals, or specific types of repeated measures of subject or content can be structured according to timelines)
iii) Space: observations can be conducted within a particular spatial field or within a social scale of spatial fields

3.3.6.6 Unit of observation

The researcher sought to determine the unit of observation used by authors to conduct their study. According to Sedgwick (2014), the unit of observation is mostly considered as the unit of measurement. It is described numerically as the "what" or "who" for which data are gathered or measured. Humphrey (2001) points out that the unit of observation is a fundamental notion in quantitative research that describes the entities that are perceived and about which information is methodically gathered. It is identified by the technique used to select observations.

3.3.6.7 Level of analysis

The researcher sought to determine the level of analysis used by authors to conduct their study. Level of analysis is described as a procedure that helps to discuss a difficult active system where the researcher can identify significant hierarchical differences (RationalWiki, 2016). Papers were grouped into several

categories for data extraction. The scale or size as well as the location of a research project points towards social sciences when determining the level of analysis. In this study, the categories used for data extraction have been identified as the micro level (individuals), meso level (organisations or teams) and macro level (cultures or nations).

Micro level: papers were grouped into this category if authors looked at small-scale interactions such as group dynamics or conversation between individuals to conduct their study.

Meso level: papers were grouped into this category if authors looked at the size of the population ranging between the macro level and micro level (e.g. as an organisation and a community) to conduct their study.

Macro level: papers were grouped into this category if authors looked at large-scale social processes such as social change and stability to conduct their study.

3.3.6.8 Historical development

The researcher sought to determine the historical development used by authors to conduct their study. Historical development enables researchers to determine intellectual developments and genealogy of concepts in a research domain (Boell & Cecez-Kecmanovic, 2014). It helps to discover influences and steps in the development of ideas.

3.3.6.9 Major concepts

The researcher sought to determine the major concepts used by authors to conduct their study. This enabled the researcher to determine variables or constructs and central theoretical concepts investigated by authors in their studies (Boell & Cecez-Kecmanovic, 2014). In this study, the categories used for data extraction have been identified as information system value, information systems development methodology, technology adoption, and general concepts.

Information system value: papers were grouped into this category if authors looked at the enhancement of value in decision-making that could be assigned to using information systems when conducting their studies (Schell & Cocoma, 2016).

Information systems development methodology: this concept has been created to deliver a repeatable and consistent process that helps with developing systems (Ghini, Kinsey & McNease, 2012). It enables the use of a framework to control, plan, and structure the process of developing information systems. It is

also considered as a system development methodology or a software development methodology. Papers were grouped into this category if authors used information systems development methodology to conduct their study.

Technology adoption: papers were grouped into this category if authors indicated that individuals have adopted a specific technology to conduct their study.

General concept: papers were grouped into this category if concepts could not be categorised as information system value, information systems development methodology, or technology adoption concepts.

3.3.6.10 Discipline

The researcher sought to determine the various disciplines indicated by authors in conducting their studies. This enabled the determination of the disciplinary lenses employed to explore a specific research problem or phenomenon (Boell & Cecez-Kecmanovic, 2014).

3.3.6.11 Publication year

In this study, the researcher sought to enhance searches of literature published in recent years as it provides a picture of the current research on e-agriculture in the South African context. A list of values ranging from 2000-2016 was pre-determined. The researcher selected this period to obtain a true view of the state of e-agriculture research in South Africa. As indicated before, books, conference papers, Master's theses, Doctoral theses, and journal articles were examined in this systematic literature review. The researcher sought to understand both lack and enhancement of research in different steps during this period. Therefore, the objective behind this study was to determine the need for more studies in the field of e-agriculture research in the South African context by indicating the research enhancement over recent years. The research gap during this period was also determined and indicated.

3.3.6.12 Assessment of searchability

The quality assessment of the study (step 8) was investigated to assess the validity of the pertinent papers used in this systematic literature review. According to Staples and Niazi (2007), the level of validity threats addressed by the researchers of papers is always extremely difficult to determine. In this study, the researcher adjusted the quality assessment to another level of assessment by judging the pertinent papers on their content, title, abstract, and keywords (searchability assessment). To do so, a table was compiled by the researcher,

explaining how data were extracted. The search assessment was divided into three categories (questions) containing three parts (*yes*, *partially*, and *no*). Partially refers to pertinent papers that were categorised in the middle, neither *yes* nor *no*.

Table 3-5: Explaining the search assessment

Search assessment	Objective
Q1. Are keywords of papers similar to Keywords of SLR?	To determine the keywords of the authors in the pertinent papers that are similar to keywords considered by the researcher in this study
Q2. Are keywords of the research in the abstracts of papers?	To determine which of the keywords considered in this study are included in the abstracts of the pertinent papers
Q3. Are keywords of the research in the titles of papers?	To determine which of the keywords considered in this study are included in the titles of the pertinent papers

3.4 Ethical considerations

An ethical consideration alludes to the ethical principles used to approach a specific problem (Polonsky & Waller, 2010). Ethical considerations focus on moral decisions taken and on the social values of a person or group of people. These decisions generally imply ignoring acts or techniques that could compromise the moral values of a single person or the group of people being involved. Miles and Huberman (1994) allude to the many potential problems that should be considered by the researchers when analysing data. Therefore, the researcher must be aware of all problems that arose before, during, and after the study. Cultural sensitivity is one of the concerns that are related to unexpected ethical issues. This being a qualitative research study, the researcher used a systematic literature review to collect and analyse data, which implies that various ethical considerations had to be addressed.

According to Mathúna (2008), researchers must always remember their ethical responsibilities when conduct their study. Understandably, this raises many ethical problems, including thoroughness in searching, examining all details, and avoiding misrepresentation of original research.

Ethical considerations also involve following up on suspicions arising from the following:

- Different outcomes
- Impressions
- Controversy about publication ethics
- Incompatibility of concerns

In this study, ethical issues in authorship were considered by the researcher. Authorship credit was focused on the following:

- The researcher noted important contributions from the conception and design of the research to the acquisition, analysis, and interpretation of data for the objective of the study
- The study was recorded and revised correctly, and important intellectual content was taken into consideration.
- Only the publication of the last version of the study was considered

According to Wager and Wiffen (2011), five ethical issues need to be considered by researchers when conducting a systematic literature review. These issues are avoiding duplicate (redundant) publications, transparency, avoiding plagiarism, ensuring accuracy, and protecting data. All five these issues were considered by the researcher for the systematic literature review on e-agriculture research in South Africa.

Avoiding duplicate (redundant) publications: Multiple publications on e-agriculture research in South Africa can misrepresent the results when the collected data are analysed. Suppression of negative findings and repeated publication of positive findings can also have a negative impact on the results when conducting a systematic literature review (Wager & Wiffen, 2011). It is therefore extremely important to avoid repeating multiple papers of the same study. This can confuse the readers.

Transparency: it is crucial to provide information on competing interests and funding (Wager & Wiffen, 2011). Therefore, the researcher must declare all sources of funding or support. It is also extremely important to indicate why the researcher might not be considered an impartial or neutral author when preparing a review. Reasons can include financial support, but competing interests can also be academic, political, and personal.

Avoiding plagiarism: the author must avoid using somebody else's ideas, data, images, or other original creations, without permission or acknowledgement, as his own interpretation of the work (Wager & Wiffen, 2011). However, researchers are allowed to cite or interpret the work of other people, and then acknowledge them by including their publications/details to reference list.

Ensuring accuracy: it is extremely important to extract data precisely and avoid any attempt to biased results in any given form (Wager & Wiffen, 2011). Researchers must have the responsibility to ensure the accuracy of data during data extraction by involving at least two others researchers; the data considered in the systematic literature review must be approved by all researchers. In this systematic literature review, the researcher involved two of his colleagues during the extraction of data on e-agriculture research in South Africa.

Protecting data: it is essential to keep data in a safe place where nobody can access it. In this systematic literature review, data on e-agriculture research in South Africa were kept in a safe place where only the researcher had access by means of a password. The researcher made sure that the data files have not been corrupted or altered in any way, and managed to restrict access to the data considered in this systematic literature review. The researcher avoided storing or transferring data using cloud storage or via the internet.

CHAPTER FOUR: DATA ANALYSIS AND FINDINGS

4.1 Introduction

This chapter continues from Chapter Three, where the research design and research methodology have been discussed. Since the aim of the research was to determine the current status of e-agriculture research in the South African context, a systematic literature review was used to gather and analyse the literature on e-agriculture research in the South African context. A sample of 114 papers from the population of papers on e-agriculture research in South Africa was seen as suitable for the objective of this research. Findings were presented in line with the research questions. The research was conducted in South Africa, which is the world's 25th largest country by land area and is located at the southern tip of Africa. Agriculture is one of the primary pillars of the South Africa economy, and there are many agricultural activities in this country. The figure below shows the map of all nine provinces of South Africa.

Figure 4-1: Map of South Africa provinces

4.2 Focus of e-agriculture research in South Africa

The investigation into various types of research papers for this study was designed with the focus on e-agriculture research in the South African context to identify the focus of e-agriculture research investigated by researchers in their studies. It was therefore anticipated that different topics on e-agriculture research would be found the research papers.

Table 4-1: The focus of e-agriculture in South Africa

The focus of e-agriculture research in South Africa	Papers	Frequency
ICT adoption and use in agriculture companies	[208], [265], [146], [147], [276], [173], [167], [273], [79], [275], [145], [268]	12
E-government direct services	[158], [159]	2
Mobile in agriculture	[134], [199]	2
Computerised back-end developed systems	[264], [186], [187], [177], [287], [110], [149], [58], [155]	9
Networking in agriculture	[291], [121], [196], [215]	4
Agricultural information systems	[16], [266]	2
Use of geographic information systems improving agriculture	[64], [130], [91], [47], [185], [219], [220], [128], [209], [183], [78], [56], [259], [150], [140], [111], [24], [49], [67], [288], [247], [296], [244], [262], [161], [142], [68]	27
Use of global positioning systems (GPS) improving agriculture	[198], [102], [155], [81], [250], [104]	6
Use of satellite enhancing agriculture	[292], [89], [221], [31], [165], [119], [139], [54], [144], [74], [216], [1], [2], [40], [206], [280], [182], [132], [101], [153], [181], [211], [137], [163], [127], [130]	26
E-commerce	[184], [274], [277], [26]	4
ICT in agricultural supply chains	[7], [43], [25]	3
Empowering local agricultural communities through information and ICTs	[157], [176], [125], [126], [65], [124], [63], [5], [248], [148], [120], [60]	12
Providing broader information on agriculture	[205], [245], [133], [6], [117]	5

The results of this study show that a large number of e-agriculture research studies in South Africa have been focused on the use of geographic information systems improving agriculture (27 papers, 23.6%), followed by the use of satellite enhancing agriculture (26 papers, 22.8%). ICT adoption and use in agriculture companies as well as empowering local agricultural communities through information and ICTs contributed 12 papers (10.5%) each. The results of this study furthermore indicate that computerised back-end developed systems contributed nine papers (7.8%), followed by use of global positioning systems (GPSs) improving agriculture with a contribution of six papers (5.2%). The provision of

broader information on agriculture was discussed in five papers, followed by networking in agriculture that was discussed in four papers (3.5%). The least focus was on e-government direct services, mobile in agriculture, and agricultural information systems with two papers each (1.7%), followed by ICT in agricultural supply chains with three papers (2.6%) each.

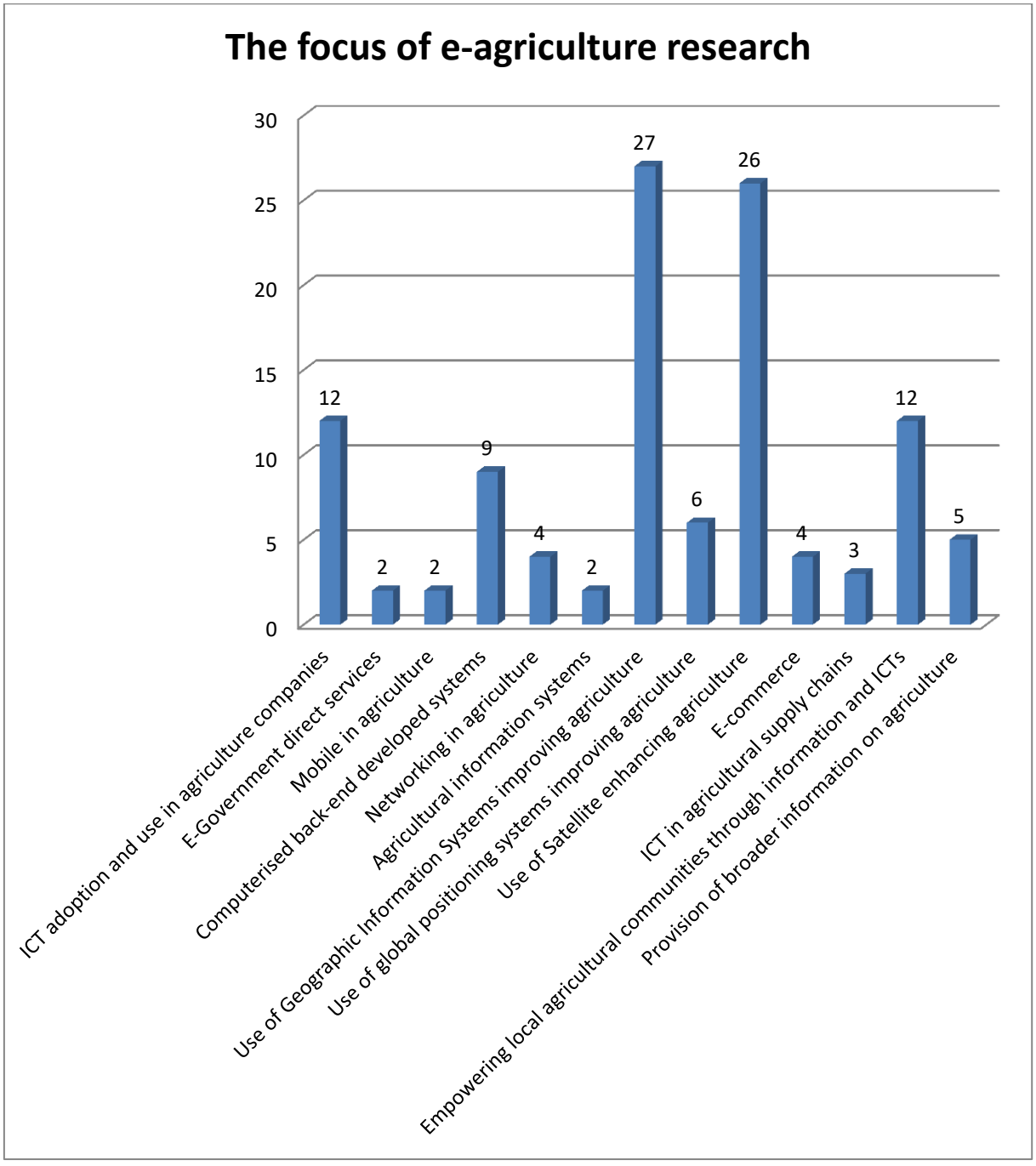


Figure 4-2: The focus of e-agriculture research in South Africa

4.2.1 ICT adoption and use in agriculture companies

Table 4-2: Focus and findings of research papers on ICT adoption and use in agriculture companies

ID	Topics
[208]	Sought to review studies on how ICTs have been used by commercial and small-scale farmers in South Africa. Identified and discussed the obstacles of information technology use in both sectors. There is an increasing use of computers by commercial farmers in South Africa, with three studies presenting the rate of adoption as 48% in 1993, 64% in 1996, and 72% in 1998.
[265]	Explored the internet access profile of farmers and sought to examine which devices are employed for internet access by commercial farmers. Sought to determine the objective for which mobile technology is employed in the South African farming community. 70% of farmers use their mobile devices to access the internet. No brand of tablet computer or mobile phone was found to dominate the agricultural community.
[146], [147]	In North West Province, South Africa, the level of awareness of ICTs among agricultural extension officers was examined. There are several ICT tools used by extension officers to share agricultural messages and information such as CD-ROM, radio, organisation website, fixed telephone, fax machine, video, computer, personal e-mail, overhead projector, television, mobile phone, World Wide Web, DVD, internet, newspaper, and organisation e-mail.
[276]	Investigated factors helpful in the development of commercial agriculture in South Africa that affect ICT use by farm employees. ICT training, race, age, current occupation on farm, educational level, and ICT literacy are elements affecting the use of ICT by farm employees.
[173]	Reviewed several irrigation technologies in agriculture enhancing socio-economic conditions in both Kenya and South Africa. Sought to determine farmers' constraints on modern technology adoption for irrigation and the role played by both government and non-governmental organisations to encourage modern technology adoption for irrigation. The total cultivated areas in South Africa and Kenya with modern technologies for irrigation are only 9% and 3%, respectively.
[167]	The use and adoption of information and communication techniques by rural women in agriculture in Kenya and South Africa were examined. The most information and communication techniques used by rural women in agriculture are radio and television.
[273]	Sought to determine different elements of ICT use imperative for the recognition of the benefit and importance of ICT in Western Cape commercial agriculture, particularly in the wine industry. Sought to identify the different types of ICT employed in the wine industry, the factors affecting their use, what they are used for, how they are being used in the industry, and how important these technologies are as facilitators of production.
[145]	Sought to understand how farmers and agribusiness are utilising Instagram to raise the profile of farming in South Africa. The author revealed that with Instagram, farmers have started sharing snaps from the farm. This raised the profile of their product and generated positive sentiment in the process.
[275]	Sought to identify the challenges affecting the use of ICT by farmers in South African commercial agriculture, and proposed a framework for ICT use in agriculture. There are several problems influencing ICT use, such as income, agricultural qualification, distance from centre of development, type of enterprise, farm size, farming experience, cooperative membership, ICT goal, off-farm income, market, attitude towards ICT, attitude towards BEE, ICT affordability, household size, gender, and nature of work contract.

ID	Topics
[268]	Sought to understand how postgraduate students at the University of KwaZulu-Natal in Pietermaritzburg's Faculty of Science and Agriculture in South Africa are using electronic databases to conduct their studies. There is a need to enhance database access for all campus and off-campus users because many students have problems to use them.
[79]	Evaluated how farmers perceive the internet as a tool supporting their business. The use of internet applications for the businesses of farmers is determined by the following factors: characteristics of other farm computer users, the internet connection duration, farmers' availability to spend time on the Internet, the level of education of the principal farm decision-maker, and how farmers perceive the Internet as source of information.

4.2.2 E-government direct services

Table 4-3: Focus and findings of research papers on e-government direct services

ID	Topics
[159]	Proposed an e-agriculture and e-government marketing framework and used the Cape Gateway Project (CGP) experience to determine communication and marketing strategies for e-agriculture and e-government in the South African context.
[158]	The existing and potential use of ICT in agriculture and rural development were determined in Sub-Saharan Africa (Kenya and South Africa). Sought to determine e-government developments as a medium that helps to support the deployment of ICT in the agricultural sectors of South Africa and Kenya. ICT use can be considered a useful instrument to support agriculture and to enhance rural development and the living standard of South Africans and Kenyans.

4.2.3 Mobile in agriculture

Table 4-4: Focus and findings of research papers on mobile in agriculture

ID	Topics
[134]	Sought to understand how applications that farmers can download from their smart phones and tablets can be used for their benefit. A variety of weather apps are available that can serve as an information source and early storm warning system for farmers.
[199]	A mobile application was developed to disseminate agriculture information to rural subsistence farmers of the Eastern Cape. The authors found that mobile application was easily accessible, usable, and useful for farmers in disseminating agriculture department information and new fertiliser information.

4.2.4 Computerised back-end developed systems

Table 4-5: Focus and findings of research papers on computerised back-end developed systems

ID	Topics
[264]	Developed a cloud-computing model to enhance agricultural enterprises in marginalised rural areas in South Africa. The model includes a cloud architecture described as mobile information system with the purpose of helping farmers to download, share, and upload agricultural information such as weather, markets, seeds, and farming techniques.
[186]	Used virtual engineering tools for functional visualisation, evaluation, and decision-making of intended infrastructure outcomes without physical modeling improve development of agricultural post harvesting and farm produce handling technologies. The introduction of virtual reality (VR) facilitates design interpretations during the preliminary stages through elaborative visualisation.
[177]	Developed a computer simulation model (ACRUCane) to provide management information to irrigators of sugarcane and catchment water managers. There was interdependency between irrigation application uniformity and irrigation scheduling. Enhanced application uniformities must be put together with enhanced scheduling to gain maximum profit, and it was approximately estimated at R3 000/ha.
[287]	Proposed or existing irrigation water use aligned with the purpose of the National Water Act was evaluated by using a computer spreadsheet.
[110]	An impressive computerised cattle management system was developed to facilitate the complicated nature of beef cattle farming in South Africa.
[149]	A seasonal time-step computerised integrated model with prediction capability was developed and applied to facilitate decision-making under integrated water resources management (IWRM).
[58]	Sought to observe crop fields in heterogeneous agricultural landscapes in South Africa by employing a generalized computer vision approach. Great gains of performance were produced by multi-temporal information without adding multi-spectral bands that are incorporated in Digital Globe WorldView-2 imager.
[155]	Sought to examine the irrigation scheduling schemes for water management and effective utilisation in the Piesanghoek Macadamia cropland in Limpopo Province of South Africa. Several farmers are still using conventional irrigation techniques, leading to low irrigation productivities and poor water utilisation, but only a few have adopted new computerised technologies to manage the irrigation.
[187]	The experience of integrating different low-cost virtual reality (VR) tools to help instructional delivery and junior researchers' visualisation of a cattle handling system prototype.

4.2.5 Networking in agriculture

Table 4-6: Focus and findings of research papers on networking in agriculture

ID	Topics
[215]	A model facilitating wireless node deployment that is focused on experimental outcomes was proposed to disperse the impact of surrounding foliage on the wireless signal.
[121]	Evaluated the delay performance and throughput of the OptimiSed link state routing protocol (OLSR) employed in the mesh network. The range of users starts from farmers who are located in areas where the network signal is poor using the protocol for the first time, to farmers who are used to the network and who are located in wealthier farming areas.
[291]	A specific software protocol for a low power radio frequency network supporting farm management in the 433 MHz band was developed to facilitate remote setup of node parameters and automatic initialisation of nodes. There is evidence to suggest that the network layer determines the routing of farm wireless networks.
[196]	Signal strength for three different types of agricultural crops (density vegetation, medium height, and ground foliage) and the impact of near vegetation on the wireless signal with regard to link accuracy were examined. Showed how current radio propagation foliage loss models are not developed for use in satellite farming or site-specific crop management.

4.2.6 Agricultural information systems

Table 4-7: Focus and findings of research papers on agricultural information systems

ID	Topics
[16]	An information management system was developed to encourage technology transfer for decision support; it could be fixed and updated by weed specialists. Record keeping was maintained for observations, related insights, and experimental results. This enables uniformity and sustainability for weed research programmes.
[266]	Described a high-technology system constituting of a web-based simulation model that allows real-time testing in a realistic setting on a small-scale farm irrigation system, and provides practical irrigation advice. Small-scale farmers who have adhered to the system advice enjoy advantages such as low cost of irrigation, deep drainage (64%), and reduction in irrigation applied (33%).

4.2.7 Use of Geographic Information Systems (GISs) improving agriculture

Table 4-8: Focus and findings of research papers on use of geographic information systems improving agriculture

ID	Topics
[209]	Delineated small-scale irrigation farms by using GIS technology to assess the possible risk management and the importance of farmers to be close to buyers of fresh products. The scope of the distance between consumers and farmers was from 60 km to 265 km and a large number of farmers were situated far from the main roads. In addition, the authors found that cash crop was the most preferred technique to alleviate poverty among poor farmers.

ID	Topics
[64]	Used GIS to represent spatial patterns in landscape characteristics such as rainfall, gradient information, land use, and soil that seems to be a crucial stage determining possible runoff harvesting sites, after which modelling the hydrological response in catchments where immense runoff harvesting was being considered, could be performed. Only 17% of the Potshini catchment areas have the possibility to produce surface runoff, while 18% of factors influencing the location of these systems were considered appropriate for runoff harvesting.
[185]	Highlighted the importance of GISs in evaluating spatial scheme of crop damage. Illustrated the application of GISs combined with participatory mapping of eland damage in commercial agricultural farms close to Kamberg Nature Reserve (KNR) in KwaZulu-Natal Province. The potential of participatory GISs is taking out the spatial distribution and configuration of damaged crop fields by elands in KwaZulu-Natal Province.
[47]	Briefly discussed some of the developments within agricultural geo-referenced information systems (AGISs). Geo-referenced information systems provide several opportunities to researchers, farmers, government, and organised agriculture to have access to spatial and non-spatial information via the internet. Agricultural geo-referenced information systems contain a significant number of datasets, particularly information on natural resources.
[91]	In Weenen Nature Reserve of KwaZulu-Natal, the current agricultural potential of the reserve under rainfed farming particularly based on topographic, climatic, crop requirement and soil data gathered by different sources was evaluated by using a geographical information system. Rocky and shallow soils and arid climate are the two factors limiting the rainfed agriculture in Weenen Nature Reserve.
[56]	In the Western Cape, a GIS based pesticide risk indicator composed of toxicity endpoints (using species sensitivity distributions) and exposure variables (physicochemical, pesticide application, crop data, and geographic) was created to evaluate the predicted relative risk (PRRI) and the predicted relative exposure (PREX) of applied pertinent pesticides to aquatic ecosystem health in the Lourens River catchment. International databases provide physicochemical data that are reliable for pesticide behaviour and crop data in the Western Cape.
[259]	Compared the perspectives of former and current farmers by using GISSs to understand why farmers have abandoned farming. Sought to understand the composition of land areas abandoned by farmers at different periods, as well as the uses and woody plant cover. Farmers continued to abandon their farms over many decades with a decrease from 12.5% area of land cover in 1961 to 2.7% in 2009.
[78]	Sought to analyse the effects of rainfall variability on crop acreage in Mafikeng municipal area in North West Province by using GIS techniques and remote sensing applications. The size of cropland in Mafikeng municipal area is not negatively affected by the periodic variation and irregularity of rainfall.
[24]	GIS-based land suitability assessment and allocation decision-making in a degraded rural environment was investigated.
[49]	Used GIS technology to develop a spatial framework to manage a sustainable grazing regime.
[67]	Used GISs to provide accurately based directions for management of the agricultural landscape, as well as to evaluate agricultural landscape functioning in the Koue region of the Western Cape in South Africa.
[247]	In southern Gauteng, stonewalled structures were determined by using GIS software and Google Earth satellite imagery to support different cultures sharing a cattle-centered world-view as well as a rural and a mixed agricultural economic base.

ID	Topics
[288]	Sought to determine the extent of fragmentation of the natural vegetation to indicate regions vulnerable to invasion and to delineate densities and the current extent of Prosopis in the Northern Cape province by using GIS techniques and remote sensing. There is a high degree of accuracy (72%) for densities and extent in the Northern Cape.
[111]	Used GISs that produce Digital elevation models (DEM) to illustrate data acquired for the wetlands in South Africa. Sought to understand how virtual globe systems such as Google Earth can help to obtain high-resolution elevation data acquisition instead of using geographic information systems. High-resolution DEMs can be obtained by using virtual globe systems such as Google Earth, particularly for areas of flat topography where it was very difficult to have access to suitable relief information.
[68]	Sought to determine different changes to critical conservation in the Western Cape of South Africa by GIS techniques and remote sensing in order to avoid the pressure caused by an ever-increasing human settlement footprint, invasive alien vegetation, and extended farming.
[296]	Used a GIS as procedure to investigate the change in land use and the levels of transformation in Blue Swallow nesting sites on five different study sites in KwaZulu-Natal, South Africa. The level of Blue Swallow nest sites has decrease with 55% and corresponds with the 46% of a measured decline in grassland that happened during the period 1981-2000.
[142]	Sought to indicate important technologies available to observe crucial soil degradation issues challenging agriculture throughout and to underline the issues to be solved on a regional scale in South Africa. GISs and remote sensing were the main technologies used to observe soil degradation issues.
[161]	Used a GIS to determine the size of soil erosion in the Tygerberg Hills in Cape Town, South Africa between the period 1938 and 2000 to re-evaluate a study conducted by TALBOT in 1947. There was an important diminution of gully erosion in the area since 1938, and it was in the eastern slopes of the Tygerberg Hills that the most recovery has been noticed.
[244]	Used GISs to evaluate the distribution of commercial forestry plantations and important trees as invasive aliens of stands Acacia mearnsii and Pinus spp in South Africa. Climatic factors are largely influencing the current distribution of invasive stands in South Africa.
[262]	Sought to determine gully erosion processes and forms affecting the agriculture in the Mbuluzi river catchment in Swaziland in South Africa by using GISs and remote sensing.
[140]	Used GIS techniques and remote sensing data to characterise and identify the vineyards based on texture in the Helderberg basin in South Africa to solve the current problems and give direction for further studies on viticultural terroir. Pertinent information on vineyard areas can be obtained through remote sensing data.
[219], [220]	Utilised a remote sensing and GIS to evaluate the agricultural development capacity in a particular area of Limpopo province, with the aim of creating a strategy for agricultural development. Remote sensing and GIS technology provide a possibility for integrated analysis of resource development capacity within a particular period of time and scale.
[128]	In a communal land use area in Barberspan in North West Province, land capability of the redistributed land was evaluated by using remote sensing and a GIS in spatial planning for arable farming. 48.7% of the area is covered by woodland, 29.7% by cropland, 15.1% by bare land, and 6.5% by water body.

ID	Topics
[129]	Presented a GIS to help stakeholders and decision makers by showing the suitability of the rainwater harvesting in any area in South Africa and evaluating the possible effects affiliated with its adoption at catchment scale. Suitable XRWH areas cover 67% (32% moderate and 35% high) of V13D and 14% (2% moderate and 12% high) of C52A, while IRWH areas cover about 67% (20% moderate and 47% high) of V13D and 14% (2% moderate and 12% high) of C52A.
[183]	A spatial decision support system (SDSS) was developed by using multi-criteria decision-making (MCDM), earth observation (EO) data, and GISs to determine strategically located land for land reform. The authors found that GISs and earth observation are important tools that help with facilitating evidence-based decisions for land reform.
[150]	Sought to understand the complexity of introducing centralised GIS decision support ICT applications in GDARD after 2003, with the focus on a specific GIS information and communication technology application for GDARD known as the Gauteng Integrated Decision Support (GIDS) system in agriculture. The needs of stakeholders for e-service delivery have not been fully met.

4.2.8 Use of global positioning systems (GPSs) improving agriculture

Table 4-9: Focus and findings of research papers on use of global positioning systems improving agriculture

ID	Topics
[198]	Used global positioning wireless nodes to understand cow behaviour and determine the position of a cow and the presence of the thieves. The value of the threshold to identify the agitation of an animal was 2.5 km/h. A cow has less chance when standing stand at the outer limits of the farm. The predictive model enables preventing stock theft on South African farms and other farms in the word.
[102]	Tried to explain how GPSs are guiding the commercial agriculture sector in South Africa. GPS technology is important to manage the campaign against the invasive fruit fly and Bactrocerus dorsalis. Farmers are increasingly making use of GPS technology to monitor the movements of tractors and activities such as spraying herbicides or insecticides.
[81]	Used GPSs to evaluate historical sediment products from the infilling of farm reservoirs in Eastern Cape of South Africa. Despite the abandonment of rain-fed agriculture and reductions in stocking density, productions have not declined considerably over the last 50 years.
[250]	Used GPSs to analyse streamflow records, current land use, and long-term rainfall in the Incomati River basin in South Africa. The more important factors of temporary changes in streamflow are flow regulation and land use. Areas under irrigated agriculture and commercial forestry have increased more than 400%.
[104]	Re-evaluated and expanded on a previous study in the Swartland in Western Cape of South Africa that examined land use change and its environmental implications during the period 1960 to 2010 to determine a clear description of land use change and to investigate significant implications and problems of the observed changes by using GPSs.

ID	Topics
[154]	In the South African savannas, a land use transect as well as the tree cover and bare soil consisting of communal, state-owned, and privately-owned conservation areas were evaluated by using discrete return LiDAR data and a high precision GPS-IMU navigation system. The author found that there are high conservation areas with tree cover.

4.2.9 Use of Satellite enhancing agriculture

Table 4-10: Focus and findings of research papers on use of satellite enhancing agriculture

ID	Topics
[165]	Three 15-m resolution bands of the ASTER instrument on-board the Terra platform, with topographic and coarse scale geologic and soil data, and field sampling of selected soil properties, integrated in the initial framework designed for the rapid production of soil information at farm scale, were discussed for spatial analysis and modelling of geomorphic units. Combined field and remote sensing approaches allow a more coherent location of soil samples. It also reduces the time and money spent when conducting a field survey method.
[89]	Satellite remote sensing was used to evaluate the crop areas that have been harvested and to observe areas under sugarcane at Umfolozi. Sought to understand forecasting seasonal yields at Umfolozi. There is a significant difference in spectral characteristics of sugarcane at different thermal ages.
[144]	Tried to demonstrate that precision agricultural requirements can be met with remote sensing technologies in Swartland, Western Cape. SPOT-5 imagery was used to determine the classification of natural areas, agricultural land, and transport features (such as roads and railway lines). SPOT-5 imagery can be valuable for a range of parties, including local farmers, provincial and national agricultural departments, fertiliser, seed, herbicide and pesticide industries, and the agricultural marketing arm (agricultural cooperatives) as well as the insurance industry, soil scientists, and land-use consultants.
[137]	Sought to locate new settlement developments in an automated manner for the agricultural sector by using coarse resolution satellite data.
[221]	Used satellite imagery to analyse NDVI data and rainfall to understand the relationship between NDVI data and rainfall for potential use. Satellite imagery was considered as an application tool to determine agricultural marginal areas. Investigated the trends in vegetation growth as compared to the shift in the 500 mm isohyets. There is a possibility to use satellite imagery to observe global change with rainfall as additional data.
[139]	Sought to investigate the impact of the South African land cover change on a land restitution project and land reform policy on land use by using the Landsat satellite (remote sensing) in Makotopong in Limpopo Province. Social and environmental condition of the land reform project can be supported by quantifying the changes in land cover and land use.
[54]	Sought to determine soil moisture levels in a Brown Locust breeding site in Southern Africa by using ERS-2 images and RadarSat sensor to develop locust egg. Compared the backscatter responses from the satellites with predictions from the IEM model employing data from field measurements. Synthetic Aperture Radar (SAR) imagery plays an important role in managing pest applications.

ID	Topics
[127]	Seek to compare ground-based measurements by evaluating the reliability of SPOT-Vegetation Normalised Difference Water Index (NDWI) and Land Surface Analyses Satellite Applications Facility (LandSAF) evapotranspiration.
[74]	Used synthetic aperture radar data (SAR) included with ALOS PALSAR data and Envisat ASAR to evaluate soil moisture in the Piketberg region of South Africa. There is significant ability of this technique determining the quantification of the surface soil moisture.
[163]	In two highly invaded provinces of South Africa, native vegetation and alien plant species ((IAPs) were evaluated through satellite-based annual evaporation. Sought to determine the impact of the clearing of alien plant species on the availability of water resources through a diminution of evaporation by the Working for Water (WFW) programme.
[1], [2]	In the Cathedral Peak region of the Drakensberg Mountain range in South Africa, mapping and estimating the variability in canopy concentration of C4 grasslands across C3 and nitrogen (N) was determined by using WorldView-2 (WV2) multispectral data. The mapping or estimation of N concentration can also be determined by using WorldView-2.
[40]	Employed SPOT-5 imagery using spatial variance of NDVI to evaluate existing MODIS LAI product accuracy for biomes and important land cover classes in South Africa. Used the inversion of PROSAIL radiative transfer model to evaluate LAI retrieved accuracy. The estimation of the MODIS LAI was specifically poor for Karoo biomes and grassland from November 2012 to February 2013.
[206]	Sought to understand the benefit of WorldView-2 data to map endangered tree species in the Dukuduku Forest of South Africa by employing an artificial neural network (ANN) and support vector machines (SVM) classification algorithms. The accuracy of using ANN was 75% and the accuracy of using support vector machines was 77%. This demonstrates that both machine-learning algorithms are very strong.
[280]	In the upper Molopo river catchment in South Africa, Landsat images were used to evaluate long-term impacts of land use influences that disturb the vegetation. There is statistical significance of the correlation between medium density vegetation and human population ($P < 0.01$, $r = -0.960$).
[182]	Sought to observe woody cover in the Kruger National Park in South Africa by employing SPOT-5 HRG panchromatic band and SPOT-4 HRVIR grey scale band images from 1998 to 2012 in association with panchromatic aerial photographs. There was a high classification accuracy of woody cover on the appropriate multi-temporal texture images.
[132]	Sought to observe the associated agricultural practices and crops in the Western Cape province of South Africa by employing pursuit monostatic TanDEM-X coherence (remote sensing). The general crop cover is extremely sensitive and the growing of crop is changing progressively.
[211]	Used satellite imagery and digital elevation models to determine the soil information requirements in South Africa, and to summarise a way forward in terms of data interpretation, capture, and storage. The current state of soil information of the country was presented through a historical background.
[153]	In a catchment in Ngqushwa district in the Eastern Cape province, temporal and spatial patterns of encroachment, soil erosion, Pteronia incana, and woody shrub species were investigated between 1998 and 2008 by using SPOT data and remote sensing. There is an increase of soil erosion with concentrated woody shrub encroachment on the hill slopes.

ID	Topics
[181]	Sought to determine forest loss in the Soutpansberg mountains of South Africa by using multi-temporal Landsat TM imagery and remote sensing where some of the last remaining indigenous forests are threatened by land use pressure. Residential housing extensions, eucalyptus, and pine plantation are causing a loss of 20% of woodland and forest over a period of 16 years.
[31]	In the Kruger Park in South Africa, woody (shrub and tree) savannas were investigated by employing four Landsat ETM+ scenes and optical remote sensing combined with field measurements. Sought to determine the relationships between the mapped herbivory and fire, topography, climate, woody cover, and soil. The temporal and spatial woody cover plays a crucial role in supporting the maintenance of biotic and structural heterogeneity.
[216]	In KwaZulu-Natal, South Africa, the discrimination of forest species was investigated by using a few strategically placed WorldView-2 multispectral bands. The range of individual forest species accuracy generated by the WorldView-2 imagery was between 63% and 100%. The value of a kappa statistic was 0.83 and the general accuracies were 85.42%.
[292]	Used bootstrapped regression trees and 20-m SPOT satellite images on distinct combinations of morphometric data (wetness index, slope, elevation, and aspect) in order to survey viticultural terroirs on four dates in the Stellenbosch viticultural area. The results indicated that some promise to map viticultural terroirs, capturing expert knowledge on grape harvest quality at many places on a regional scale.
[119]	Used a cost-effective remote sensing to describe and to observe agricultural land use in order to assist the Department of Water Affairs & Forestry of the Republic of South Africa. Panchromatic data and object-oriented image segmentation techniques applied to SPOT help to acquire results that are more accurate (general accuracy is 89.41%).
[130]	Sought to build a suitable model composed of vulnerable, ecological, and physical sub-models from which the vulnerability, ecological, and physical maps are obtained respectively by using an expansion of ArcView 3.3, empowering a complete overlay of datasets to mitigate the potential of rainwater harvesting. About 25% is highly appropriate for ex-field rainwater harvesting and 30% is highly appropriate for in-field rainwater harvesting.
[101]	Used remotely sensed, moderate resolution data (Landsat imagery) from 1978 (MSS) to 2005 (TM) in the Luvuvhu catchment to investigate a land cover classification scheme in order to sustain the agriculture. Understand different changes that happened in the Luvuvhu catchment over the 27-year interval, as well as to compare classification accuracies in the area. There is least accuracy of classification for indigenous forest (46%) and high accuracy of classification for pine and water classes (100% and 92%) because of the misclassification of Shrub land.

4.2.10 E-commerce

Table 4-11: Focus and findings of research papers on e-commerce

ID	Topics
[184]	Evaluated ICTs allowing agricultural commodity market exchange and sought to understand how small-scale farmers could participate more actively in the market. Even though South Africa has a world-class ICT infrastructure, this has not made it easier for small-scale farmers to enter the agricultural market and value chain.

ID	Topics
[274]	Described ICT applications that allow enhancing online marketing to access lucrative global wine markets, electronic packaging, and quality regarding farm management decisions, as well as agricultural market information and product traceability.
[277]	Sought to explain the role a virtual trade platform can play for milk in South Africa. The trade platform can help the producers inform the entire South Africa of their products and encourage buyers to obtain milk from several producers.
[26]	Sought to understand how an e-commerce platform can support the agriculture industries in South Africa. The author found that e-commerce is good for consumers' safety and for facilitating farmers to run their business online.

4.2.11 ICT in agricultural supply chains

Table 4-12: Focus and findings of research papers on ICT in agricultural supply chains

ID	Topics
[7]	Investigated the effect of ICTs on agricultural development in the Alice rural community. Several factors such age, language barriers of ICTs adoption amongst farmers, and low levels of literacy are limiting the rural Alice community with access to ICTs.
[25]	Tried to explain how ICTs such as smart phones and mobile technology can play a crucial role in agricultural businesses in South Africa. Smart mobile devices with applications or software programs downloaded and installed have the capacity to boost productivity and revenue.
[43]	Sought to understand different enterprises within the agricultural supply chain in South Africa, including producers, growers, and exporters of agricultural products that are involved in electronic marketplace adoption. Most of the important decision makers in agricultural enterprises are already contributing to electronic commerce in one form or another. Agricultural enterprises in South Africa are interested in becoming more involved in electronic markets as ICT enhancement in the immediate future.

4.2.12 Empowering local agricultural communities through information and ICTs

Table 4-13: Focus and findings of research papers on empowering local agricultural communities through information and ICTs

ID	Topics
[124]	Emphasised different low-cost ICT strategies and initiatives taken by several businesses, women organisations, and other non-governmental organisations (NGOs) in the South African and Indian agricultural sector to empower rural women. Mentioned several constraints of the community projects discouraging the use of internet and mobile phones by rural women in the agricultural sector in India and South Africa.

ID	Topics
[126]	Tried to look at the impact of ICT connectivity in sectors such as agriculture, health, and government services for rural women in South Africa. Discussed the innovative ways of using information and communication technology in agriculture for women empowerment and the contribution of pertinent groups or organisations involved in ICT policy establishment for additional expectation and relevant communication in rural areas.
[157]	In order to support agriculture service delivery in South Africa, an implementation framework for e-agriculture composed by a multi-functional national agro-portal (MWT) was proposed for agriculture development. Examined the capacity of wireless and mobile applications in agriculture and rural development in South Africa.
[65]	Investigated how IoT technologies can contribute to reduce agricultural needs and reduce poverty in rural environments in South Africa and Zambia. IoT technologies can support the communities to reduce agricultural needs in domains such as livestock farming, rural financing, wildlife management, crop farming, market identification, forestry, and weather forecasting.
[176]	Presented different aspects to use community radio as important tool to diffuse a diversity of developmental and educational content for farming communities in South Africa. Community radio was presented as an instrument to help disadvantaged communities around the country with important issues. South African community radio stations contribute only little to farming diffusion. Therefore, individual stations need to be trained on hosting radio programmes on farming.
[125]	Sought to explain how the use of participatory approaches and ICT adoption can support the development of farming products and the agricultural sector in South Africa and India. Discussed how digital ICT, considered as a tool of action research and participatory learning, can encourage development, provide services, and reduce the poverty of farmers in rural areas. Farmers are open and encourage academics to work with them to reduce poverty and develop the agricultural sector.
[63]	Explored the benefits that South African agriculture can receive from the introduction of ICTs. There are practical issues to be resolved, including communication and knowledge transfer where ICTs can potentially have the biggest positive influence.
[248]	In South Africa, a digital form of aerial photographs was used to investigate the farming history of Okhombe from 1818 to 2009 to support the agricultural sector. Sought to investigate the changes in cattle population through time and rainfall data.
[60]	Explained how big data can improve the agricultural development in South Africa and the entire Africa.
[5]	Sought to understand the existing challenges hampering the transformation of South Africa's emerging farmers into market-oriented farming. Evaluated how ICT could be implemented to provide the needed agricultural knowledge support infrastructure for farmers' transformation. ICT can help black farmers receive agricultural knowledge support infrastructure that could improve direct interaction and collaborative effort of farming stakeholders and that could help in providing solutions to farmers' diverse issues and forming farming educational foundations, which currently lacks.
[120]	Sought to examine different obstacles caused by e-society to the people of Hlabisa in KwaZulu-Natal in South Africa involved in the health, education, and agriculture sectors.
[148]	Sought to investigate e-readiness as an important tool among other ICT tools for extension officers in Mmabatho, South Africa. The age, number of farmers covered, working experience, educational level, and means of mobility and living in the job area are important determinants of e-readiness.

4.2.13 Providing broader information on agriculture

Table 4-14: Focus and findings of research papers on providing broader information on agriculture

ID	Topics
[133]	Investigated how ICTs are utilised to communicate agricultural information to farmers. Radio was the most important source of agricultural information for rural women, followed by television and cell phone, while the least used sources of agricultural information were mobile phone, email, cinema, internet, video, and film.
[205]	Sought to determine the role of ICTs supporting agricultural information access among extension officers in North West Province of South Africa. Electronic readiness (t=-3.01, p=.003), limitations of ICT tools (t=2.60, p=.010), use of ICT tools (t=4.67, p=.000), and education (t=2.61, p=0.11) are important determinants on the impact of ICT on information access.
[6]	Sought to utilise internet resources in creating a shared knowledge space to increase natural and casual contact among individuals in the agricultural domain, especially those without formal agricultural education. Sought to understand problems hampering their transformation into market-oriented farming when using traditional agricultural knowledge diffusion approaches.
[117]	Sought to develop a system with limited resources and limited access to traditional technologies such as telephones and computers to facilitate and allow rural farmers access to their information sources or advertising their products. The system assists farmers with increasing their profit margins and ensuring their viability.
[245]	Tested an operational service with the possibility of enhancing water usage efficiency and the production of table wine in the Western Cape. The operational service had to provide online (via a website) information relating to the nitrogen status, crop growth, and water from 1 September 2010 to 30 April 2011 to all Western Cape producers of grape. Information was provided through parameter maps and vineyard blocks of the participating farmers.

4.3 Research methods

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the methods used by researchers in conducting their studies. Since this study was related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture, empirical methods were expected in these research areas. The empirical methods were divided into eight categories, namely case study, survey and experiment, design of system/method/model/solution, information mapping, field study, industry

report, and grounded theory. The papers related to each method and their frequency are listed and included in table 4-3 below.

Table 4-15: Research methods

Research methods	Empirical papers	Frequency
Case study	[91], [208], [176], [159], [146], [126], [276], [65], [264], [205], [63], [133], [5], [6], [183], [184], [145], [25], [147], [102], [128], [134], [129], [268], [199], [181], [277], [60], [26], [24], [287]	31
Survey	[47], [265], [219], [125], [205], [7], [165], [167], [124], [43], [79], [273], [117], [259], [150], [148], [280], [101], [111], [211], [247], [149], [220]	23
Experiment	[121], [276], [196], [198], [173], [16], [215], [110]	8
Industry report		---
Design of system/ method/model/ solution	[161], [130], [291], [264], [128], [205], [245], [186], [187], [177], [5], [117], [16], [56], [58], [280], [158], [54], [140], [215], [199], [287], [110], [149]	24
Information mapping	[157], [64], [130], [91], [185], [219], [89], [221], [220], [128], [209], [166], [146], [183], [184], [78], [56], [259], [266], [150], [139], [248], [54], [31], [154], [140], [216], [1], [2], [40], [206], [280], [182], [292], [111], [153], [181], [24], [49], [137], [67], [163], [127], [288], [247], [58], [81], [250], [68], [104], [155], [296], [244], [262], [161], [129], [142]	57
Field study	[219], [89], [128], [166], [124], [74], [132]	7
Grounded theory	[5] [6]	2

4.3.1 Results

Table 4-15 indicates that empirical methods have been considered in this study. In some papers, the authors have not indicated the research method, but the researcher managed to interpret these methods. Each research method was categorised and interpreted from the literature. Among the 114 pertinent papers, information mapping was the most used research method by authors in their studies (57 papers, 50%), followed by the use of a case study in 31 papers (27.1%). The third most used research method was the design of a system/ method/model/solution, discussed in 24 papers (21%) followed by survey with a contribution of 23 papers (20.1%). The fifth most used research method was experiment, discussed in eight papers (7%) followed by field study with seven papers (6.1%). The least used research method was industry report with a contribution of nil papers (0%), followed by grounded theory with two papers (1.7%).

4.3.2 Analysis of data

Case study: a case study is one of the research method used among the relevant papers selected in this systematic literature review. After reading the full text, much information could be extracted from the case study as method, e.g. various techniques used during the case study, duration of the case study, number of people involved in the case studies, and the number of case studies investigated in each document. The results show that a large number of case studies conducted in the papers were investigated by academic researchers. A large number of topics, all in alignment with the case study method, focused on empowering local agricultural communities through information and ICTs, use of geographic information systems improving agriculture, ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, e-commerce, and providing broader information on agriculture. The results show that almost all authors used a single case when conducting the study, except for one paper that focused on multiple cases [178].

Table 4-16: Research tools used in a case study

Research tools used in a case study	Papers	Frequency
Workshop	[176], [183]	2
Questionnaire	[146], [276], [205], [147], [199], [264]	6
Document analysis	[126], [65]	2
Observation	[199], [24]	2
Group discussions	[287]	1
Interviews	[120], [264], [5], [6]	4

As indicated in table 4-15, the case study method is the second most used research method by authors with a contribution of 31 papers (27.1%). Of these papers, interviews were selected as research tool for the case study in four papers (table 4-16). In two of these papers [5] [6] semi-structured interviews were selected, one paper indicated that researchers used both structured and unstructured interviews [264], and one paper indicated that the researcher used telephonic and emails interviews for the case study [120]. This study therefore shows semi-structured interviews as the most used research method by authors in their case study.

Table 4-16 indicates that the most used research tool by authors in case study research is questionnaires, with a contribution of six papers. There were different types of questionnaires used by authors: structured questionnaires [146] [147] and close-ended questionnaires [264]. One paper focused on both structured and face validated questionnaires [205], two papers have not indicated the type of questionnaire used. Two papers focused on workshops as research tool [176] [183], two papers indicated observations as research tool [199] [24], and two papers discussed document analysis as research tool for the case study [126] [65]. Only one paper focused on group discussions as research tool for the case study [287].

Survey: a survey is another research method used when conducting empirical studies where researchers often use research tools such as interviews (emails, web based, structured, and semi-structured, among others) to gather qualitative or quantitative data to answer the research question(s) of the paper (Easterbrook et al., 2008). The results of this study show that a large number of topics, all in alignment with the survey method, focused on ICT adoption and use in agriculture companies, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, providing broader information on agriculture, use of satellite enhancing agriculture, and use of geographic information systems improving agriculture. The number of participants implicated for the survey was difficult to determine because the authors of the pertinent papers have not indicated details on this. Only in a few papers was the number of participants involved in the study specified [89] [273] [148].

Table 4-17: Research tools used in a survey

Research tools used in a survey	Papers	Frequency
Discussions	[265], [125], [7], [150], [149]	5
Interviews	[265], [125], [7], [124], [43], [117], [259], [150]	8
Observations	[265], [220], [117], [101], [211]	5
Document analysis	[265], [117]	2
Questionnaires	[265], [43], [79], [273], [117], [148]	6
Peer-reviewed articles	[124], [125]	2
Meetings	[150]	1
Workshops	[211]	1

Of the 23 papers in which surveys were selected as research method, six papers indicated the questionnaire as research tool for the survey (table 4-17). Of these six papers, one paper indicated that authors have used an internet-based questionnaire promoted through direct e-mail [265], and one paper indicated that authors have used structured and face-validated questionnaires to conduct the data analysis [148]. Eight papers focused on interviews as research tool when conducting the survey. Of these eight papers, one paper indicated that telephonic interviews were used to conduct interviews, and interviewees were briefed on the term “participatory approach” during the survey [125]. Other types of interviews were also used by researchers as stated in their papers, including structured interviews [7] [124] [150], face-to-face interviews [150], and household interviews [259]. Three papers have not mentioned the type of interview used for conducting the survey [265] [43] [117].

The results further indicate that observation was identified in five papers as research tool for conducting the survey (table 4-17). Similarly, five papers used discussions as research tool for conducting the survey. Of these five papers, one paper indicated that discussions were conducted via e-mail by authors in the study [125], and one paper indicated that a telephone discussion was the selected research tool for the survey [150]. Two papers identified peer-reviewed articles as research tool [124] [125], and two papers focused on document analysis as research tool for the survey [265] [117]. Only one paper discussed meetings as research tool [150] and one paper discussed workshops as research tool for the survey [211].

Design of system/method/model/solution: this research method was the third most used empirical research method with a contribution of 24 papers (21%) (table 4-15). The results show that a large number of topics, all in alignment with the design of system/method/model/solution method, focused on use of satellite enhancing agriculture, empowering local agricultural communities through information and ICTs, providing broader information on agriculture, computerised back-end developed systems, use of networking in agriculture, and agricultural information systems.

Solution types (model or guideline, framework, method, and system) that can be employed by other authors in the same field were proposed in papers focusing on this method (table 4-18). Among the 24 papers considered in this study, a large number of papers focused on the system solution type with a contribution of nine papers (7.8%), followed by the model solution type with a contribution of seven

papers (6.1%). The least used solution type was method with a contribution of two papers (1.7%), followed by framework with a contribution of six papers (5.2%).

Table 4-18: Design of system/method/model/solution

Papers	Type of solution	Frequency
[157], [128], [117], [275], [158], [149]	Framework	6
[205], [177], [5], [266], [54], [140], [110]	Model	7
[130], [291], [264], [246], [186], [187], [16], [56], [199]	System	9
[140], [287]	Method	2

Industrial report: a report investigated by an industry was grouped into this category. Such a report does not indicate any research method and often explains the industrial case with predetermined research questions. The results of this systematic literature review indicate that no paper among the pertinent papers selected for this study identified industrial report as research method.

Grounded theory: As discussed in section 3.3.6.2, grounded theory refers to iterative procedures built to determine concepts and categories within text that are associated with proper theoretical models (Corbin & Strauss, 2008). Papers were grouped into in this category if authors indicated that they have used this research method for their study. Grounded theory was seventh in line of the most used empirical research method (table 4-15) with a contribution of two papers (1.7%) to the systematic literature review. In one of these papers [6], grounded theory was adopted to gather empirical data directly from the subjects while sitting with the participants, presenting detailed expectations, perceptions, and their views. This study was conducted by engineers and computer scientists during a conference in Hong Kong. The second paper [5] adopted grounded theory for the researcher to see the proposed model or reality from the data, based on theoretical categories or explanations provided through comparisons of experience or literature against the current data sets. It also enabled the researcher to use techniques that help to control biases. The results show that the topics of these studies were focused on providing broader information on agriculture and empowering local agricultural communities through information and ICTs.

Field study: As described in section 3.3.6.2, field study is a qualitative research method that allows a researcher to observe, understand, and interact with participants in their natural settings to gather pertinent information for the research

(Schmitz, 2012). Papers were grouped into this category if authors mentioned that they have used this research method in their studies. Field study was sixth in line of most used empirical research method (table 4-15) and contributed seven papers (6.1%) to the systematic literature review. The results indicate that a large number of topics, all aligned with the field study method, focused on use of geographic information systems improving agriculture, use of satellite enhancing agriculture, and empowering local agricultural communities through information and ICTs.

Experiment: this research method was fifth on line of the most used empirical research method (table 4-15) and contributed eight papers (7.1%) to the systematic literature review. Papers were grouped into this category if authors indicated that they have used experiments for their study. In some papers, it was difficult to determine whether an experiment was used because the authors have not explicitly indicated that they conducted experiments. Of these eight papers, four overlap with the design of system/method/model/solution and the case study research methods, but four papers have only adopted the experiment research method [121] [196] [198] [173]. Some of the papers discussed the case study and experiment as well as the design of system/method/model/solution and experiment. There is therefore a need to conduct e-agriculture research in South Africa using only the experiment research method. The result show that a large number of topics, all in alignment with the experiment method, focused on use of networking in agriculture, computerised back-end developed systems, use of global positioning systems (GPSs) improving agriculture, agricultural information systems and ICTs adoption, and use in agriculture companies.

Information mapping: As described in section 3.3.6.2, papers were grouped into this category if authors analysed data using techniques such as web-portals, code repositories, and other historical data sources in their studies (Schmitz, 2012). Information mapping was the research method most identified in the papers selected to conduct this systematic literature review with a contribution of 57 papers (50%) (table 4-15). As indicated in table 4-19, 35 papers (30.7%) focused on spatial resolution analysis and ten papers (8.7%) on temporal resolution analysis as research tool for information mapping. In eight papers (7%), the use of aerial photographs into digital was identified as research tool for information mapping, and four papers (3.5%) discussed multispectral imagery. Monitoring data, simulation analysis, and hyperspectral imagery were the least used research method tools with a contribution of one paper (0.8%) each. This is followed by radiometric resolutions and digital image processing with two papers (1.7%) each.

The results indicate that a large number of information mapping research methods were used by academic researchers. The results further indicated that a number of topics related to information mapping focused on use of geographic information systems improving agriculture, use of global positioning systems (GPSs) improving agriculture, use of satellite enhancing agriculture, and computerised back-end developed systems.

Table 4-19: Research tools used in information mapping

Research tool used in Information mapping	Papers	Frequency
Spatial resolution analysis	[292], [64], [130], [91], [185], [219], [221], [220], [128], [185], [150], [54], [31], [140], [216], [1], [2], [40], [206], [182], [153], [181], [24], [49], [137], [163], [288], [247], [250], [68], [155], [262], [161], [129], [142]	35
Temporal resolution analysis	[130], [89], [166], [31], [153], [137], [250], [262], [129], [142]	10
Radiometric resolutions	[166] [137]	2
Digital image processing	[119] [127]	2
Monitoring data	[56]	1
A simulation analysis	[262]	1
Aerial photographs into digital	[248], [140], [182], [111], [67], [81], [104], [161]	8
Hyperspectral imagery	[154]	1
Multispectral imagery	[89], [216], [287], [58]	4

4.4 Research approach

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the research approach used by researchers in conducting their studies. As indicated in section 3.3.6.2, this research sought to determine the epistemological position on which a section of the study is based (Boell & Cecez-Kecmanovic, 2014). Since this study was focused on ICT adoption and use in agriculture companies, government direct service, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture, different types of research approaches were expected

to be used by researchers. A list of papers related to each approach and the corresponding frequency is included in table 4-20.

Table 4-20: Different research approaches used by researchers in their studies

Research approaches	Papers	Frequency
Interpretivism	[65], [5], [6], [150], [139], [211]	6
Objectivism	[117]	1
Constructionism	[117]	1
Reductionism	[110]	1
Criticism	[110]	1
Positivism	---	---

4.4.1 Results

Table 4-20 indicates different types of research approaches that were found in the pertinent papers selected for this systematic literature review. In several papers, the authors have not indicated the use of a research approach for their study. The researcher categorised and interpreted each research approach from the literature. Among the 114 pertinent papers, interpretivism was the most used research approach by authors in their studies (6 papers, 5.2%). The least used research approach was positivism with a contribution of nil papers (0%), followed by objectivism, constructionism, reductionism, and criticism with a contribution of one paper (0.8%) each.

4.4.2 Data analysis

Interpretivism: interpretivism has been identified as the most used research approach by researchers as indicated in the relevant papers selected for this systematic literature review. Among the 114 papers used in this study, six papers (5.2%) discussed this approach. The interpretive qualitative approach was used to determine the research question and analyse pertinent information [65]; it enabled the researcher to gather empirical data directly from the correspondents by sitting with participants to gather their detailed expectations, perceptions, and points of views on the topic. The interpretive qualitative approach was based on qualitative methods [5] [6], and used to analyse data in the context of operations, strategy and policy, and the impact on the efficiency and effectiveness of incorporated GISs [150]. The approach was used to locate the topic area and the land cover for two images [139]. Finally, it was also used for spatial soil information [211]. The results indicate that a large number of topics, all aligned with interpretivism, focused on

use of satellite enhancing agriculture, providing broader information on agriculture, and empowering local agricultural communities through information and ICTs.

Objectivism: objectivism has been identified as one of the research approaches used as indicated in the relevant papers selected for this systematic literature review. Among 114 papers used in this study, one paper (0.8%) discussed this approach. The objectivist approach was used to develop a system with limited resources and access to traditional technologies such telephones and computers to facilitate and allow rural farmers to access their information sources or advertise their products [117].

Constructionism: constructionism is another research approach identified in the relevant papers selected for this systematic literature review. Among the 114 papers used in this study, one paper (0.8%) discussed this research approach. Constructionism was used to develop a system with limited resources and access to traditional technologies such telephones and computers to facilitate and allow rural farmers to access their information sources or advertise their products [117].

Reductionism: reductionism is a research approach identified in the relevant papers selected for this systematic literature review. Among the 114 papers used in this study, one paper (0.8%) discussed this approach. Reductionism was used in a study where an impressive computerised cattle management system was developed to facilitate the complicated nature of beef cattle farming [110].

Criticism: criticism is a research approach identified in the relevant papers selected for this systematic literature review. Among the 114 papers used in this study, one paper (0.8%) discussed this approach. The criticism approach was used in a study where an impressive computerised cattle management system was developed to facilitate the complicated nature of beef cattle farming [110].

Positivist: papers were categorised into this category if the author mentioned that positivism has been used in the study. The purpose of the positivism approach is to create a true statement by explaining the world in an objective way (Thomas, 2010). Among the 114 pertinent papers considered in this systematic literature review, no paper indicated using this research approach.

4.5 Theoretical lens

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to

identify the theoretical lens used by researchers in conducting their studies. Since this study was related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs and providing broader information on agriculture, different types of theoretical lenses were expected to be used by researchers.

Table 4-21: Different theoretical lenses

Theoretical lens	Papers	Frequency
Decision-making Theory	[24], [287], [110]	3
Technology Acceptance Model (TAM)	[43]	1
Diffusion of Innovation (DoI)	[276], [7], [43], [273]	4

4.5.1 Results

Table 4-21 indicates different theoretical lenses identified in the pertinent research papers selected for this systematic literature review. In many papers, the authors have not indicated the use of a theoretical lens in their studies. The researcher categorised and interpreted each theoretical lens from the literature. Among the 114 pertinent papers, diffusion of innovation (DoI) was the most used theoretical lens by authors in their studies (4 papers, 3.5%), followed by the decision-making theory (three papers, 2.6%). The least used theoretical lens was the technology acceptance model (TAM) with a contribution of one paper (0.8%).

4.5.2 Data analysis

Decision-making theory: Decision-making theory has been identified as the second most used theoretical lens as indicated in the relevant papers selected for this systematic literature review. Among the 114 papers used in this study, the authors of three papers identified the use of this theory in their studies. Firstly, participatory decision-making has enabled evaluation criteria and functional land use objectives to be integrated into computerised multi-objective land use assignment models to attain more appropriate or an idealised land use situation [24]. Secondly, decision-making theory enabled weights to be assigned to the types of aspects examined to discover a quantitative score for the degree in which

the objective of the national water act is being executed for irrigation water use [287]. Finally, decision-making theory offers a descriptive understanding of information to help farmers manage their farms properly [110].

Technology Acceptance Model (TAM): The technology acceptance model is the third most used theoretical lens identified in the pertinent research papers selected for this systematic literature review. Among the 114 papers used in this study, the author of one paper (0.8%) identified the use of TAM for the study. TAM was employed to investigate the acceptance of B2B e-commerce in South African agriculture [43].

Diffusion of Innovation (DoI): Diffusion of Innovation is the most used theoretical lens identified in the pertinent research papers selected for this systematic literature review. Among the 114 papers used in this study, the authors of four (3.5%) papers identified the use this theory in their studies. First, DoI was used as the best existing model to explain the elements influencing ICT use in agriculture [276]. Secondly, DoI and development theories containing development support communication and the participatory approach were used to investigate the effect of ICTs for agricultural development in the Alice rural community [7]. Thirdly, DoI was used to determine the elements for the rate of adoption of B2B e-commerce in South African agriculture [43]. Finally, DoI was used as model to determine farmers' ICT use behaviour [273].

4.6 Unit of analysis

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the unit of analysis used by researchers in conducting their studies. Since this study was related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture, different unit of analysis types were expected to be used by researchers.

Table 4-22: Different unit of analysis types

Unit of analysis	Papers	Frequency
Technology	[157], [208], [176], [159], [291], [121], [126], [65], [173], [209], [287], [167], [124], [43], [63], [133], [183], [184] , [274], [158], [25], [102], [145], [134], [277], [60], [26], [49], [149]	29
Viticultural terroir	[292]	1
Land use/cover and soil	[64], [91], [219], [89], [220], [128], [165], [146], [119], [78], [139], [54], [154], [74], [40], [280], [132], [101], [111], [153], [181], [211], [24], [137], [67], [247], [58], [81], [68], [104], [296], [262], [161], [142]	34
Water resources	[130], [245], [177], [266], [287], [250], [155], [129]	8
Vegetation	[47], [221], [196], [259], [31], [215], [1], [2], [182], [163], [127], [288]	12
Humans	[265], [146], [185], [125], [276], [264], [205], [7], [5], [6], [273], [117], [150], [275], [147], [120], [148], [268], [248], [199]	20
Animal	[198], [187], [110]	3
Organisation	[79]	1
Weed	[16]	1
Pesticides	[56]	1
Vineyard	[140]	1
Plant species	[206], [216], [244]	3

The results of this study show that land use/cover and soil were the most used units of analysis by researchers in their studies (34 papers, 29.8%), followed by technology (29 papers, 25.4%), humans (20 papers, 17.5%), vegetation (12 papers, 10.5%) and water resources (eight papers, 7%). Viticultural terroir, weed, organisation, pesticides, and vineyard were the least used units of analysis with one paper (0.8%) each, followed by animal species (3 papers, 2.6%) and plant species (3 papers, 2.6%). The most used units of analysis were focused on ICT adoption and use in agriculture companies, use of geographic information systems improving agriculture, use of global positioning systems (GPSs) improving agriculture, and use of satellite enhancing agriculture (figure 4-3).

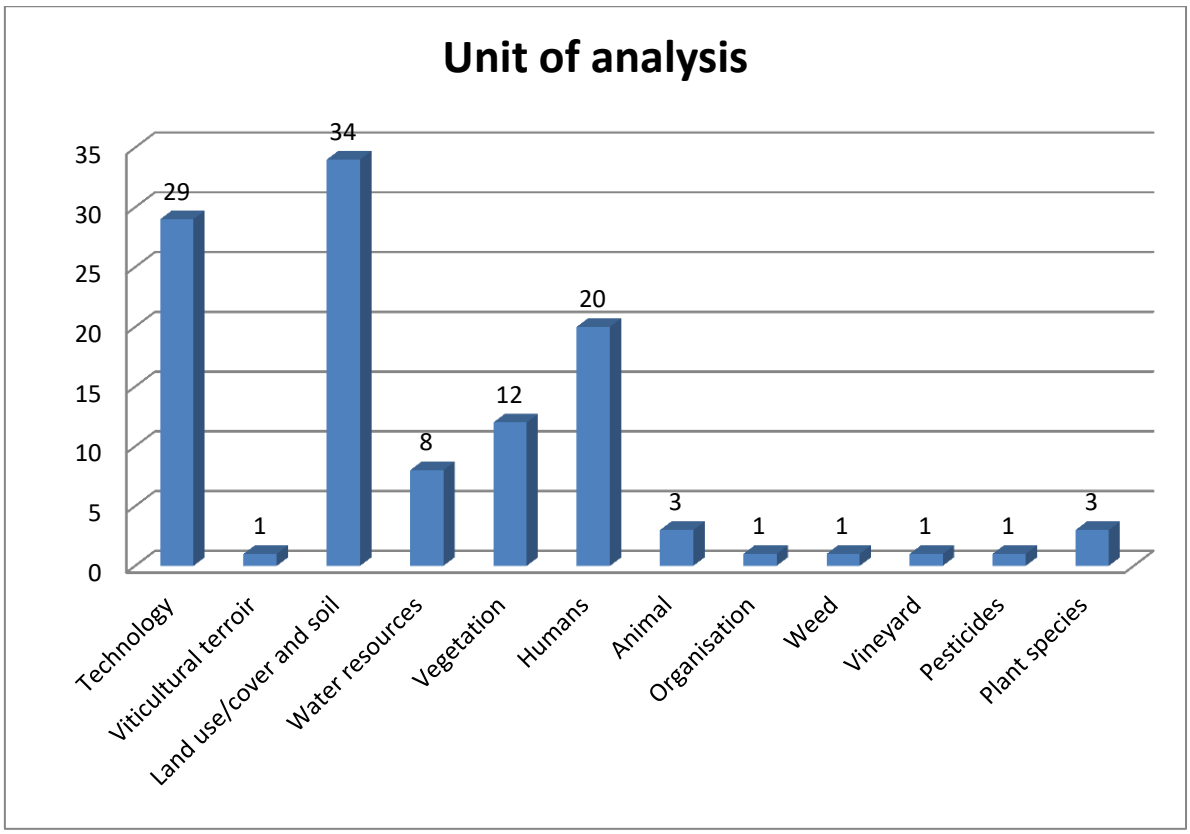


Figure 4-3: Different unit of analysis types

4.7 Unit of observation

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the units of observation used by researchers in conducting their studies. Since this study was related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs and providing broader information on agriculture, different unit of observation types were expected to be used by researchers.

Table 4-23: Different unit of observation types

Unit of observation	Papers	Frequency
Technology	[157], [208], [176], [159], [291], [121], [126], [65], [173], [209], [186], [167], [124], [43], [63], [133], [183], [184], [274], [158], [25], [102], [145], [277], [211], [60], [26], [49],[149]	29
Trees	[292], [31], [154], [182], [288]	5
Land use/cover and soil	[64], [91], [219], [89], [220], [128], [165], [144], [119], [78], [139], [54], [74], [132], [101], [111], [181], [211], [24], [137], [67], [247], [58], [81], [68], [104], [296], [262], [161],[142]	30
Water resources	[130], [177], [266], [287], [127], [250], [155], [129]	8
Plant species	[47], [259], [216], [206], [153], [163], [244]	7
Humans	[265], [146] , [185], [125], [276], [264], [205], [7], [79], [5], [6], [273], [117], [150], [275], [147], [120], [148], [268], [248], [119]	21
Vegetation	[221], [1], [2], [260]	4
Foliage	[186], [215]	2
Animal	[198], [187], [110]	3
Vineyard	[245], [140]	2
Weed	[16]	1
Pesticides	[56]	1
Leaf area index	[40]	1

The results of this study showed that land use/cover and soil were the most used units of observation by researchers in their studies (30 papers, 26.3%), followed by technology (29 papers, 25.4%), humans (21 papers, 18.4%), water resources (eight papers, 7%), plant species (seven papers, 6.1%), trees (five papers, 4.3%), vegetation (four papers, 3.5%), and animal (three papers, 2.6%). Weed, pesticides, and leaf area indices were the least used units of observation with one paper (0.8%) each, followed by foliage (two papers, 1.7%) and vineyard (two papers, 1.7%). The units of observation that were the most used in papers were focused on ICT adoption and use in agriculture companies, use of geographic information systems improving agriculture, use of global positioning systems (GPSs) improving agriculture and use of satellite enhancing agriculture.

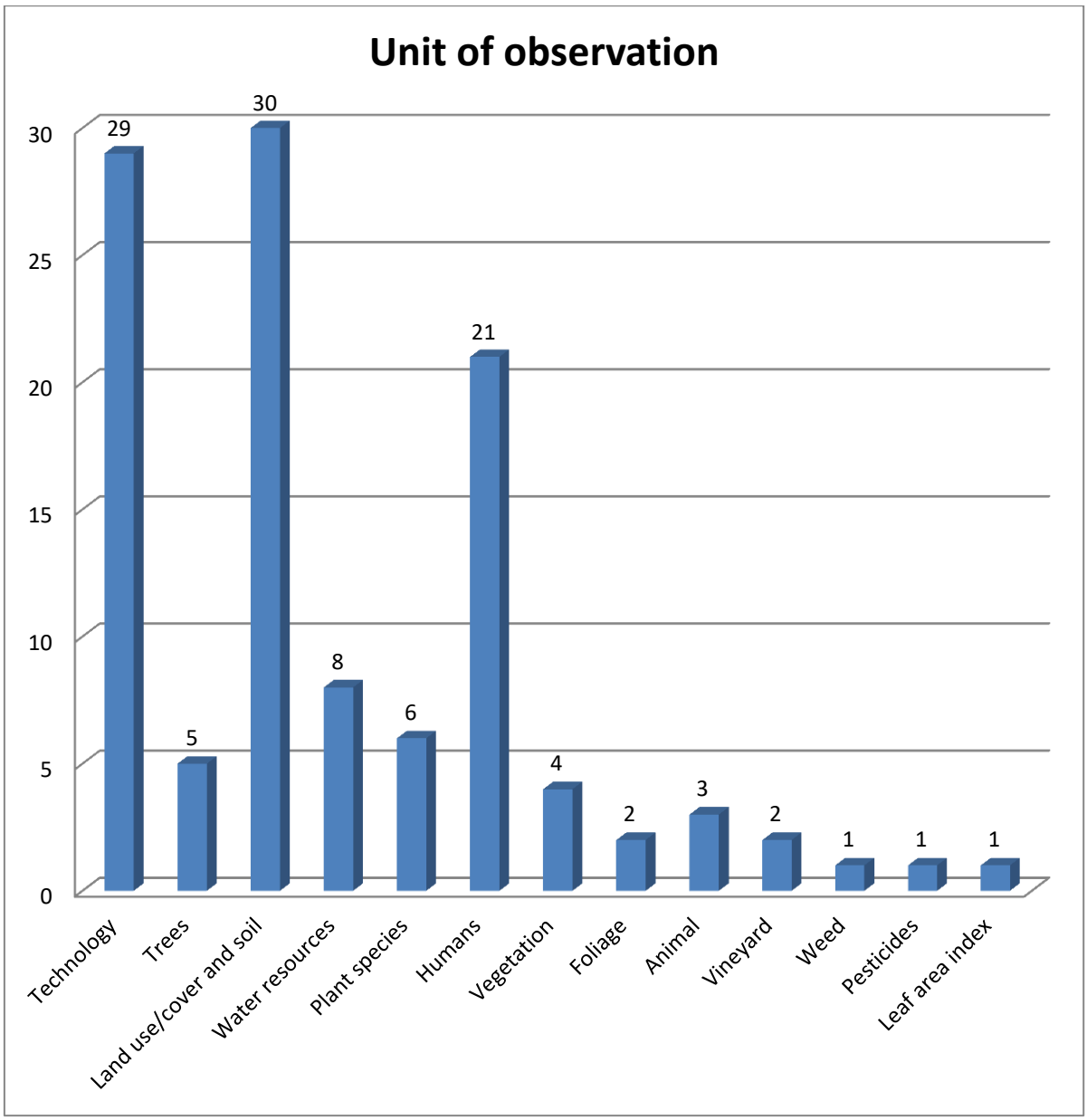


Figure 4-4: Different unit of observation types

4.8 Level of analysis

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the levels of analysis used by researchers in conducting their studies. The level of analysis is described in table 4-24.

Table 4-24: Different level of analysis types

Level of analysis	Papers	Frequency
Micro level	[157], [146], [205], [142], [148], [268]	6
Meso level	[292], [64], [130], [91], [176], [219], [89], [125], [121], [221], [276], [264], [128], [245], [7], [209], [177], [79], [144], [127], [273], [78], [56], [150], [120], [268], [31], [74], [140], [216], [1], [2], [280], [182], [199], [130], [101], [153], [24], [49], [163], [127], [288], [247], [149], [58], [81], [250], [68], [104], [155], [296], [262], [161]	54
Macro level	[208], [47], [265], [159], [185], [221], [291], [165], [196], [198], [65], [173], [186], [166], [187], [167], [124], [43], [63], [5], [6], [117], [183], [184], [119], [16], [274], [259], [266], [275], [158], [25], [102], [145], [134], [147], [54], [154], [215], [40], [206], [111], [181], [277], [211], [60], [26], [137], [287], [110], [67], [244], [129], [142]	54

4.8.1 Results

Table 4-24 indicates the level of analysis that was considered in each paper selected in this systematic literature review. In some papers, it was difficult to determine the level of analysis, but the researcher managed to interpret the levels. Among the 114 pertinent papers selected in this study, the meso and macro level levels of analysis were the most used with a contribution of 54 papers (47.3%) each. The micro level of analysis was the least used in this study with a contribution of six papers (5.2%).

4.8.2 Data analysis

Micro level: as indicated in section 3.3.6.2, papers were grouped into this category if authors considered small-scale interactions between individuals in their studies. The results of this study indicate that the micro level contributed to e-agriculture research in South Africa with six papers (5.2%). A large number of topics, all in alignment with the micro level, focused on ICT adoption and use in agriculture companies as well as empowering local agricultural communities through information and ICTs.

Meso level: as indicated in section 3.3.6.2, papers were grouped into this category if authors considered the size of the population that falls between the macro level and micro level (e.g. an organisation and a community) in their studies. The results of this study indicate that the meso level contributed to e-agriculture research in South Africa with 54 papers (47.3%). A number of topics, all in alignment with the meso level, focused on use of geographic information systems improving agriculture, use of satellite enhancing agriculture, and empowering local agricultural communities through information and ICTs.

Macro level: as indicated in the section 3.3.6.2, papers were grouped into this category if authors considered large-scale social processes such as social change and stability in their studies. The macro level contributed to e-agriculture research in South Africa with 54 papers (47.3%) The results show that a number of topics, all aligned with the macro level, focused on use of computerised back-end developed systems, providing broader information on agriculture, e-commerce, use of satellite enhancing agriculture, and use of networking in agriculture.

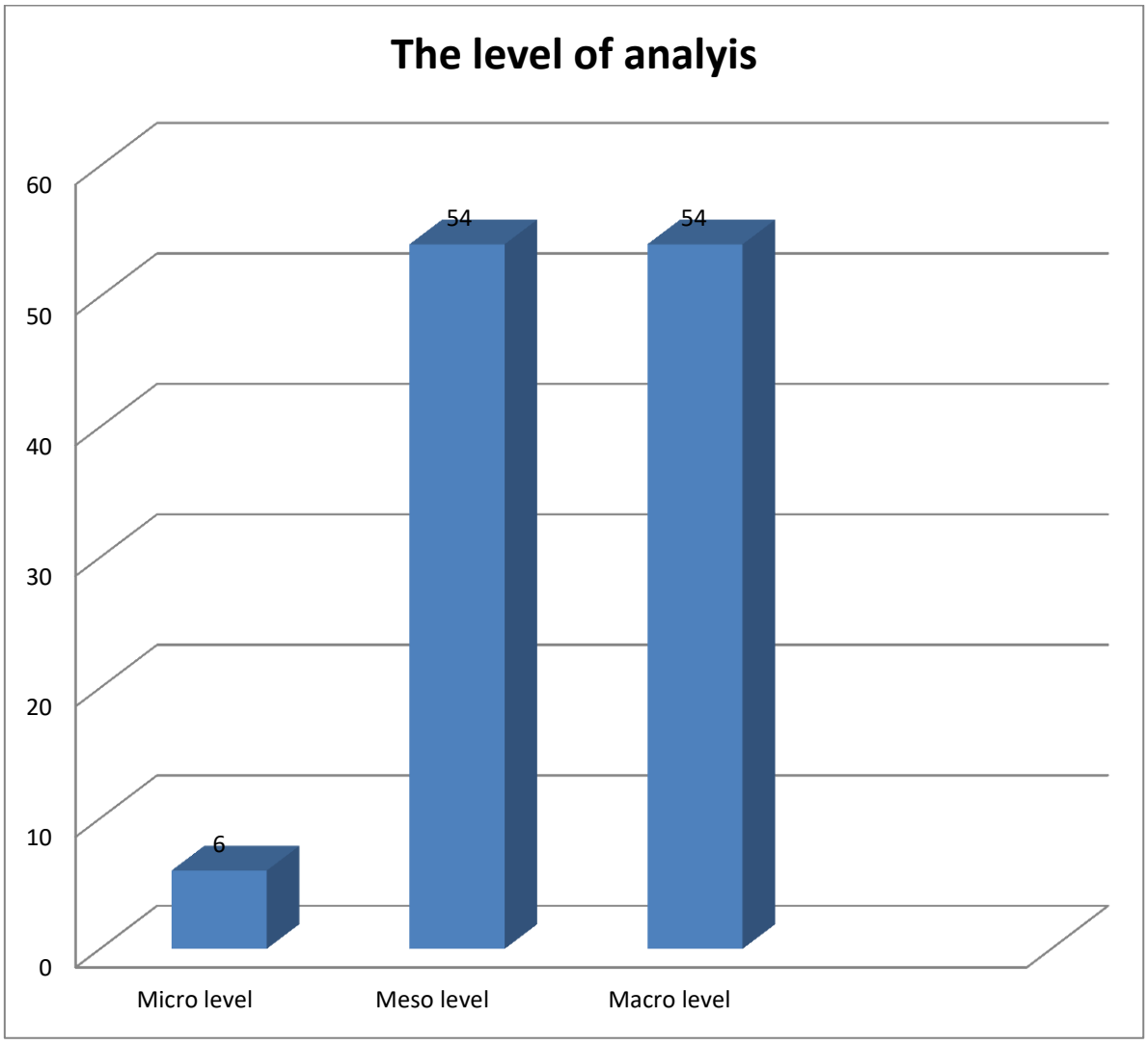


Figure 4-5: Different level of analysis types

4.9 Historical development

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the historical development used by researchers in conducting their studies. The results of this study indicate that historical development contributed with one papers (0.8%). The historical development was used to discover influences and

steps in the development of ICT use in both the developing and commercial agricultural sectors in South Africa [208].

4.10 Major concepts

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the major concepts used by researchers in conducting their studies. Since this study was related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs and providing broader information on agriculture, different types of concepts were expected to be used by researchers.

Table 4-25: Different concepts in e-agriculture research in South Africa

Major concepts	Papers	Frequency
Technology adoption	[43], [276], [7], [147], [273]	5
Information system value	[16], [262]	2
Information systems development methodology	[157], [130], [110], [296], [161], [158]	6
General concept	[145], [64], [91], [208], [176], [47], [265], [159], [146], [185], [219], [89], [221], [291], [125], [121], [126], [221], [196], [198], [65], [173], [205], [245], [209], [186], [165], [187], [177], [167], [124], [63], [79], [144], [133], [5], [6], [183], [184], [119], [274], [78], [56], [259], [150], [25], [102], [134], [139], [120], [148], [268], [248], [54], [31], [154], [74], [140], [215], [216], [1], [2], [40], [206], [280], [182], [199], [132], [101], [111], [153], [181], [277], [211], [60], [26], [24], [49], [137], [287], [67], [163], [127], [288], [247], [58], [81], [68], [104], [155], [296], [244], [262], [129], [142], [117], [266], [275], [149], [250]	101

4.10.1 Results

Table 4-25 indicates different types of research concepts identified in the research papers selected for this systematic literature review. Many concepts were difficult to determine in the papers. Among the 114 pertinent papers, the general research concept was the most used by authors in their studies (101 papers, 88.5%),

followed by information systems development methodology (six papers, 5.2%). Information system value was the least used research concept with a contribution of two papers (1.7%), followed by technology adoption with a contribution of five papers (4.3%).

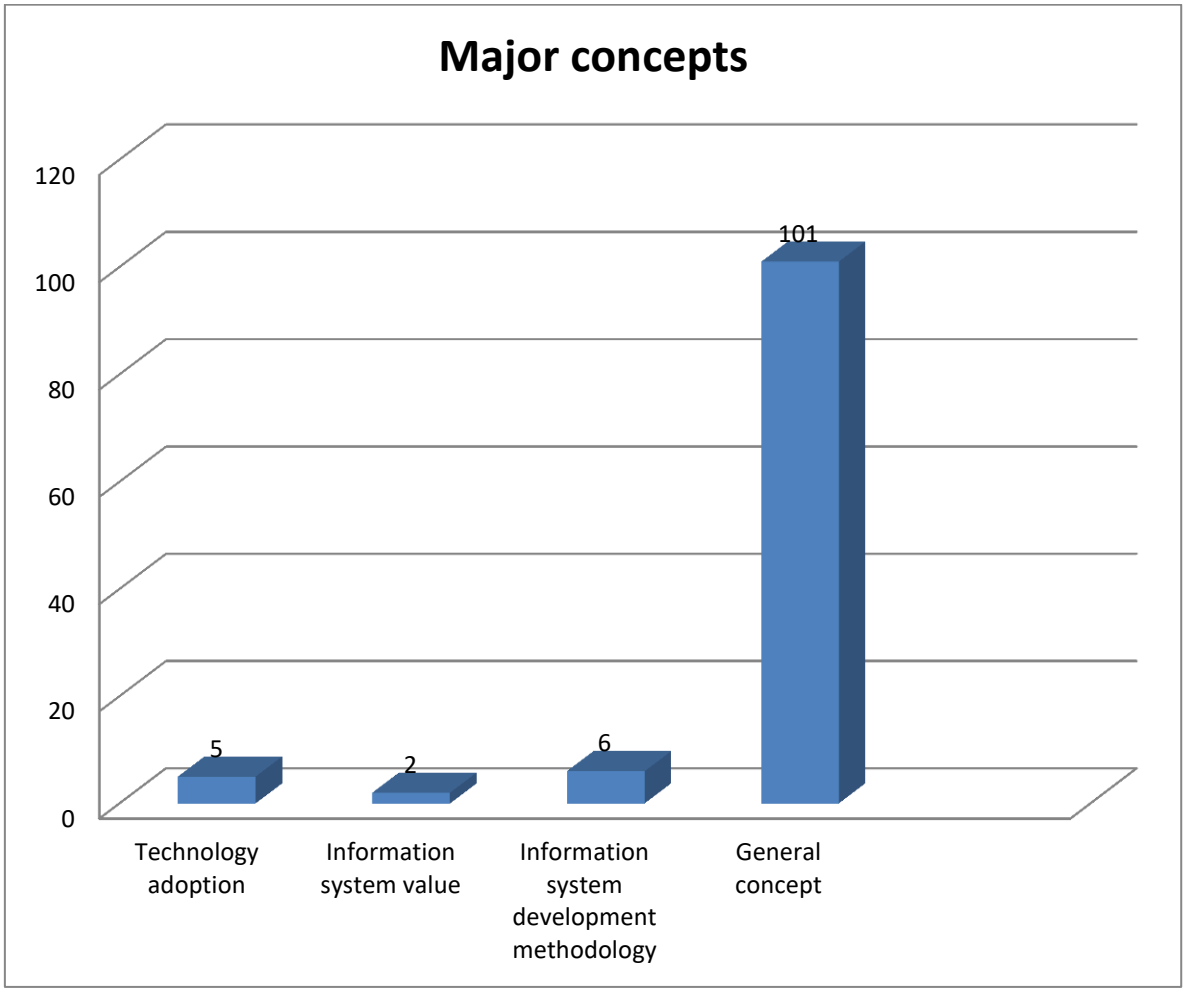


Figure 4-6: Major concepts used in e-agriculture research in South Africa

4.10.2 Data analysis

Information system value: information system value was the least used research concept as indicated in the relevant papers selected in this systematic literature review. Among the 114 papers used in this study, the authors of two papers indicated the use of this research concept in their studies. The results of this study show that information system value was identified in papers focusing on agricultural information systems [16] [262].

Technology adoption: technology adoption is the third most used research concept as indicated in the relevant papers selected in this systematic literature review. Among the 114 papers used in this study, the authors of five papers

indicated the use of this research concept in their studies. These papers were categorised into ICT adoption in agricultural companies.

Information systems development methodology: information systems development methodology is the second most used research concept as indicated in the relevant papers selected in this systematic literature review. Among the 114 papers used in this study, the authors of six papers indicated the use of this research concept in their studies. This research concept focused on computerised back-end developed systems and use of networking in agriculture.

General concept: general concept is the most used research concept as indicated in the relevant papers selected in this systematic literature review. Among the 114 papers used in this study, the authors of 101 papers indicated the use of this research concept in their studies. This research concept was focused on e-government direct services, mobile phone in agriculture, use of geographic Information systems improving agriculture, use of global positioning systems (GPSs) improving agriculture, ICT in agricultural supply chains, providing broader information on agriculture, and empowering local agricultural communities through information and ICTs.

4.11 Discipline

The investigation of the types of research papers was built into the research questions in the field of e-agriculture research in the South African context to identify the disciplines used by researchers in conducting their studies. Since this study was related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, use of networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture, researchers were expected to conduct research in different discipline types.

Table 4-26: Different discipline types involved in e-agriculture research in South Africa

Discipline	Papers	Frequency
Agriculture and environment	[292], [185], [89], [202], [125], [126], [220], [173], [209], [165], [177], [124], [144], [119], [56], [259], [158], [102], [145], [139], [147], [54], [31], [154], [140], [216], [1], [2], [40], [206], [280], [111], [153], [277], [211], [60], [24], [49], [110], [67], [163], [127], [288], [247], [81], [250], [244]	47
Physics and chemistry	[64], [130], [149]	3
Geography	[91], [128], [167], [78], [258], [248], [182], [101], [181], [104], [296], [262], [161], [142]	14
Economics	[157], [196], [146], [205], [79], [184], [132]	7
Public administration	[176], [47], [121], [186], [63], [262], [74], [26]	8
Computer Science	[265], [6], [117], [199]	4
Management	[159], [245], [150], [134], [155]	5
Education	[219]	1
Electronics	[287], [196], [198], [65], [264], [215], [137]	7
Communication	[7]	1
Engineering	[187], [16], [291], [58], [68], [129]	6
Business	[276], [5], [273], [274], [275], [25]	6
Information systems	[43], [133], [183], [120], [148]	5

The results of this study show that agriculture and environment are the two disciplines that have contributed the most to e-agriculture research in South Africa (47 papers, 41.2%). This is followed by geography (14 papers, 12.2%), public administration (eight papers, 7.1%), economics (seven papers, 6.1%), electronics (seven papers, 6.1%), engineering (six papers, 5.2%), business (six papers, 5.2%), management and information systems (five papers, 4.3%), and computer science (four papers, 3.5%). Education and communication are the disciplines that contributed the least to e-agriculture research in South Africa (one paper each, 0.8%), followed by physics and chemistry with a contribution of three papers (2.6%) each.

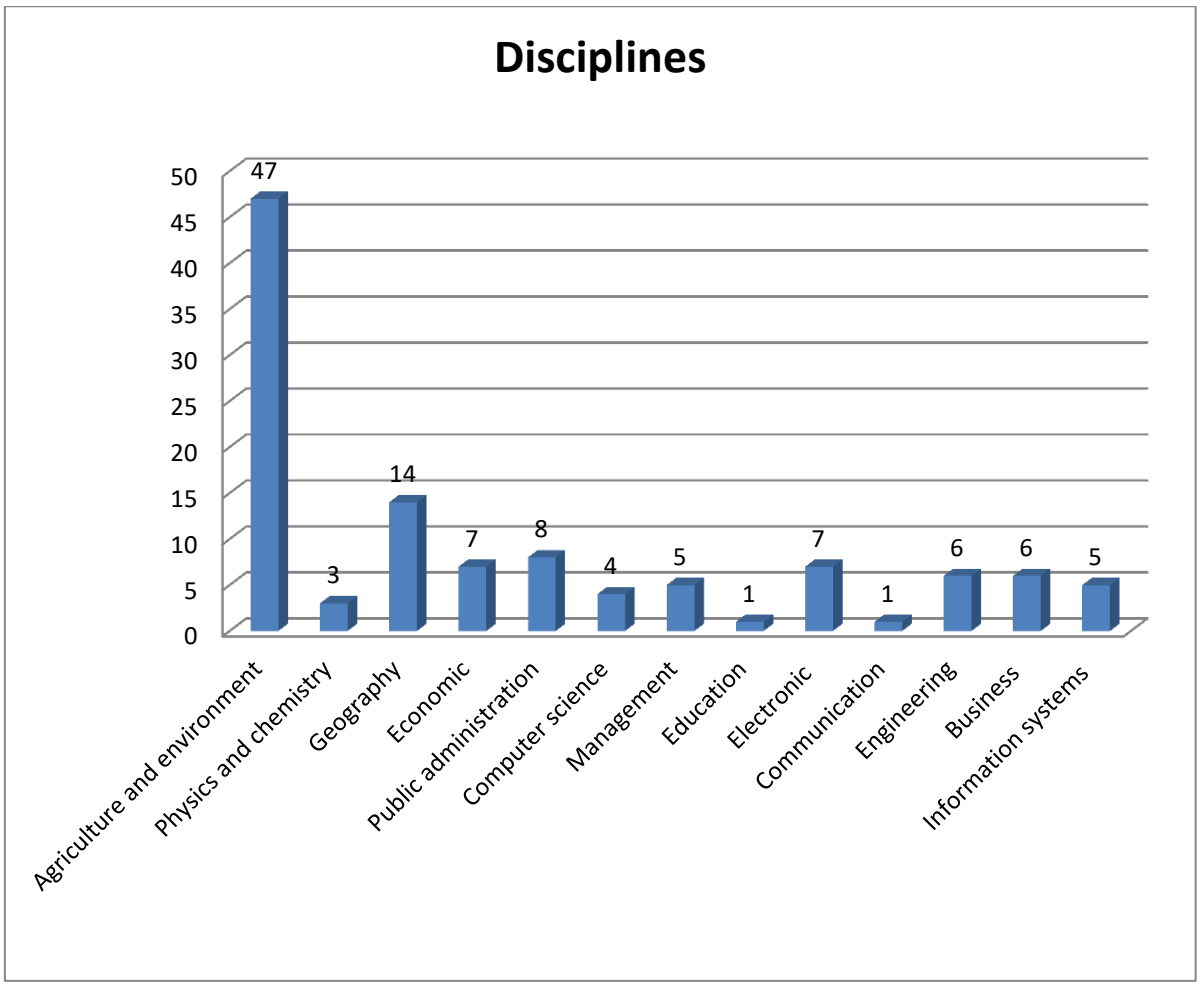


Figure 4-7: Different disciplines involved in e-agriculture in South Africa

4.12 Publication year

The results of this systematic literature review indicate an increase in publications on e-agriculture research in South Africa during certain time periods, and a decrease during other time periods. In this study, a large number of publications on e-agriculture research in South Africa were analysed; these papers were published between 2000 and 2016. As indicated in figure 4-8 of this systematic literature review, 13 papers (11.4%) were published during the first five years (2000-2004) and 51 papers (44.7%) during the last five years (2012-2016). It is clear that that e-agriculture research in South Africa has increased over the last five years.

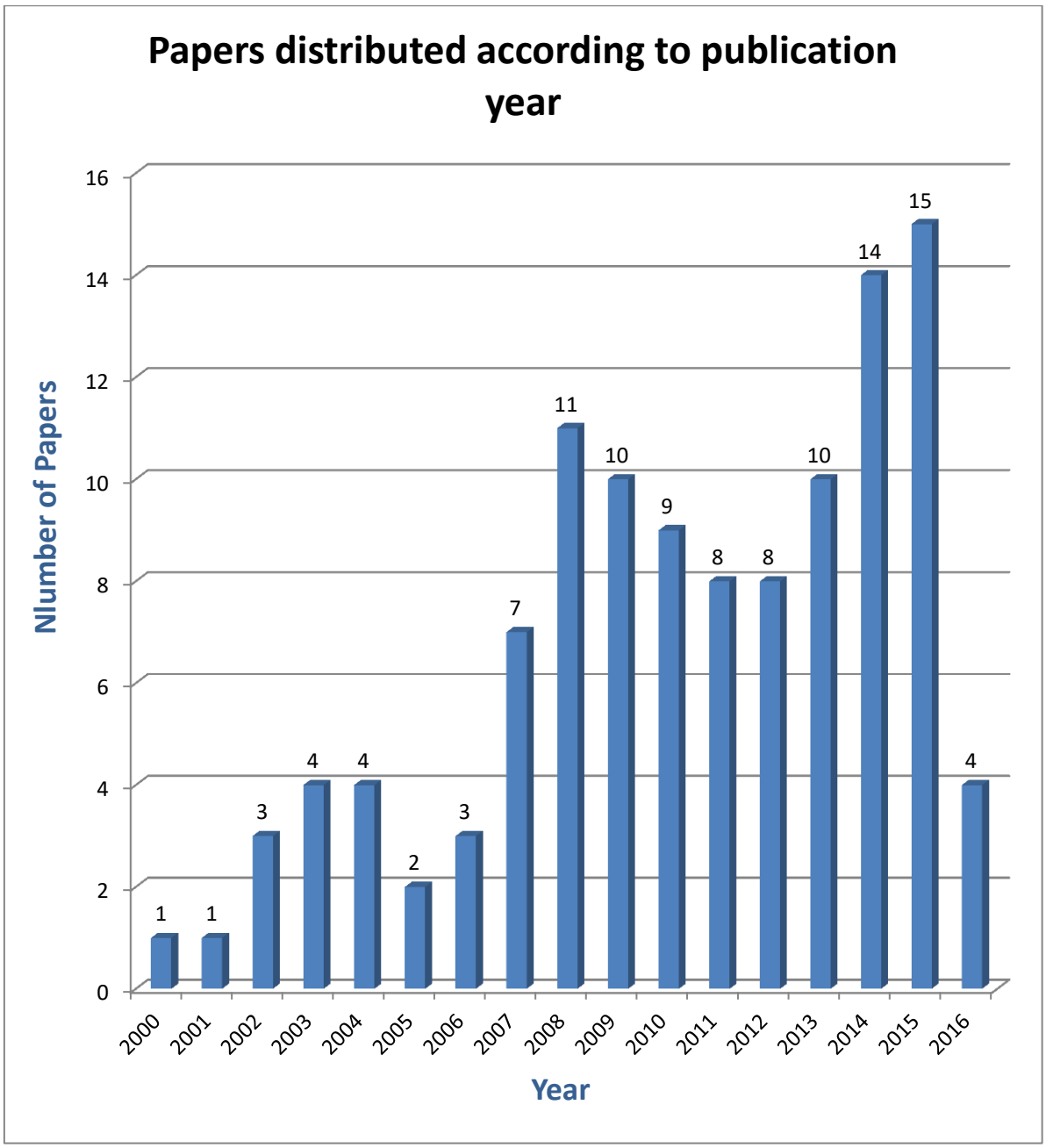


Figure 4-8: Papers distributed according to publication year

4.13 Assessment of searchability

The searchability assessment phase was discussed in section 3.3.6.12. This study reviewed the pertinent papers according to contents, title, abstract, and keywords (searchability assessment). This motivated the researcher to determine how other researchers conduct literature searches in their fields of study. In this systematic literature review, the assessment of searchability was divided into three categories (questions): investigating the keywords, abstract, and title of the papers. These categories (questions) were formed after reading each paper during the data extraction phase. The categories were also divided in three parts: *yes*, *partially,* and *no*. *Partially* refers to pertinent papers that were categorised in the middle,

neither *yes* nor *no*. The summary of the searchability assessment is indicated in table 4-27.

Table 4-27: Results and question of quality assessment

Question of Quality Assessment	Yes	Total	Partially	Total	No	Total
Q1. Are keywords of papers similar to keywords of SLR?	[157], [173]	2	[130], [208], [265], [146], [126], [220], [276], [196], [65], [264], [173], [205], [245], [186], [165], [187], [167], [43], [5], [6], [273], [181], [56], [259], [158], [147], [120], [148], [268], [248], [199], [181], [247], [58], [81], [250], [68], [104], [155], [298], [244], [161], [129]	43	[292], [64], [91], [208], [176], [47], [159], [185], [219], [89], [221], [291], [125], [121], [198], [128], [245], [7], [177], [124], [63], [79], [144], [133], [117], [183], [119], [16], [274], [78], [266], [150], [25], [145], [134], [139], [54], [31], [154], [74], [140], [215], [216], [1], [2], [40], [206], [280], [182], [132], [101], [111], [153], [277], [211], [60], [26], [24], [49], [137], [287], [110], [67], [163], [127], [288], [155], [262], [142]	69
Q2. Are keywords of the research in the abstract of papers?	[157], [276], [167], [273], [274], [158]	6	[292], [64], [130], [91], [176], [47], [265], [159], [146], [219], [89], [221], [125], [121], [126], [220], [196], [198], [65], [264], [173], [205], [7], [209], [186], [165], [177], [124], [43], [79], [5], [183], [184], [119], [78], [56], [259], [266], [150], [275], [139], [147], [120], [148], [268], [248], [140], [215], [216], [40], [206], [280], [182], [199], [132], [101], [153], [181], [137], [110], [67], [163], [288], [247], [149], [58], [250], [104], [155], [296], [244], [262], [161], [129], [142], [208], [205], [111], [31]	79	[185], [291], [128], [245], [187], [63], [144], [133], [6], [117], [16], [25], [102], [145], [134], [154], [74], [1], [2], [277], [211], [60], [127], [81], [68], [24], [26], [49], [287]	29

Question of Quality Assessment	Yes	Total	Partially	Total	No	Total
Q3. Are keywords of the research in the title of papers?	[157], [292], [208], [274], [275], [158]	6	[64], [91], [176], [265], [159], [146], [219], [89], [221], [125], [110], [115], [207], [121], [65], [173], [128], [205], [7], [209], [186], [165], [167], [124], [43], [63], [79], [133], [5], [6], [273], [117], [183], [184], [56], [259], [150], [102], [147], [120], [148], [268], [54], [31], [154], [74], [140], [216], [40], [206], [280], [182], [132], [101], [111], [153], [181], [211], [67], [163], [127], [288], [247], [149], [81], [250], [68], [104], [155], [296], [244], [262], [161], [129], [142]	75	[130], [47], [185], [291], [196], [198], [264], [245], [187], [183], [144], [119], [16], [78], [266], [25], [145], [134], [139], [268], [248], [215], [1], [2], [199], [277], [60], [26], [24], [49], [137], [287], [58]	33
Total frequency		**14**		**197**		**131**

Table 4-27 shows that the *partially* answer has been given the most in answering the second and third research question. This means the authors of the pertinent papers only partially used research keywords in their titles (79 papers, 69.2%) and in their abstracts (75 papers, 65.7%) which corresponded to the keywords of this study. The *no* answer represents the highest number for the first question (69 papers, 60.5%). This indicates that the majority of keywords in the selected papers are not similar to research keywords of this study. The *yes* answer featured the most in second and the third question (six papers, 5.2%) each.

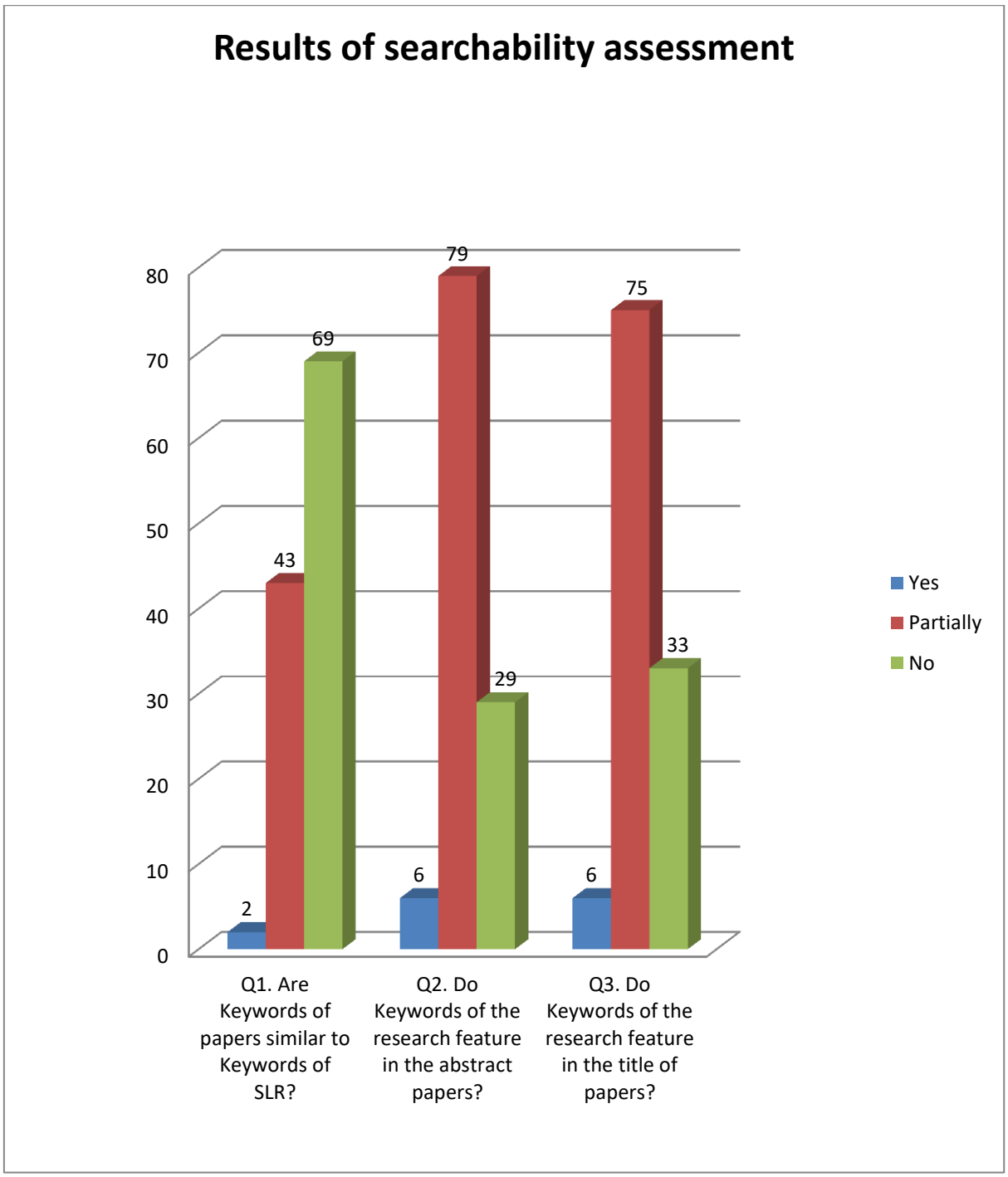


Figure 4-9: Results of searchability assessment

This study show that the highest number of *yes* answers is related to the abstract and title searchability, and the least number of *yes* answers to the keywords. A searchability assessment can help researchers with their search procedure if they want to conduct systematic literature reviews in this field of research.

The results showed that high percentage of the researchers in this field:

- Have no keywords in the papers that are similar to keywords in the systematic literature review
- Have partial keywords of the research included in the abstract
- Have partial keywords of research included in the title

4.14 Conclusion

This chapter analysed data gathered from a systematic literature review which indicates various types of the focus of e-agriculture research investigated by researchers in their studies. The study indicated that a large number of e-agriculture research studies in South Africa have been focused on the use of geographic information systems improving agriculture (27 papers, 23.6%). The analysis also indicated different research methods and techniques adopted by researchers in their studies. The analysis identified different types of research approach and theoretical lens used by researchers in their studies. The study indicated that interpretivism was the research approach the most used and Diffusion of Innovation (DoI) the theoretical lens the most used by researchers in their studies. In this chapter, the analysis indicated different types of units of analysis and observation, and level of analysis considered by researchers in their studies. The study revealed that land use/cover and soil were the units of analysis and observation the most indicated in the pertinent papers of the study. And meso and macro levels of analysis were the most denoted in the pertinent papers. The analysis indicated the historical development used by researchers in conducting their studies. The study revealed that the historical development was used to discover influences and steps in the development of ICT use in both the developing and commercial agricultural sectors in South Africa [208]. The analysis indicated the major concepts used by researchers in conducting their studies. The study revealed that general research concept was the most used by authors in their studies (101 papers, 88.5%). The analysis indicated the disciplines used by researchers in conducting their studies. The study revealed that agriculture and environment are the two disciplines that have contributed the most to e-agriculture research in South Africa (47 papers, 41.2%).

CHAPTER FIVE: DISCUSSION OF FINDINGS

5.1 Introduction

The aim of this study was to determine the current status of e-agriculture research in the South African context. This study found that 114 relevant papers on e-agriculture were published during the period 2000-2016. These include theses, books, conference papers, and journal articles. The findings of this study in response to the research questions are discussed in this chapter. The answers to the following questions are also discussed:

- What has been the focus of research on e-agriculture in South Africa?
- What types of research methods and tools have been used in e-agriculture research in South Africa? What types of research approaches have been used in e-agriculture research in South Africa?
- What types of theoretical lenses have been used in e-agriculture research in South?
- What are the units of analysis and units of observation that have been used in e-agriculture research in South Africa? What levels of analysis have been used in e-agriculture research in South Africa?
- What historical development and major concepts have been investigated in e-agriculture research in South Africa?
- What types of discipline are involved in e-agriculture research in South Africa?

5.2 Summary of findings

The principal objective of this study was to investigate the current status of e-agriculture research in the South African context. There were 13 principal categories identified in this systematic review, with 114 papers pertinent to e-agriculture research in South Africa published from 2000-2016.

Among the 114 pertinent papers considered in this study, the e-agriculture research category in South Africa that was most focused on during 2000-2016 is the use of geographic information systems improving agriculture with a contribution of 27 papers (23.6%). Twenty-six papers (22.8%) related to the use of satellite enhancing agriculture, while 12 papers (10.5%) contributed to ICT adoption and use in agriculture companies as well as empowering local agricultural communities through information and ICTs respectively. The focus of nine papers (7.8%) was on computerised back-end developed systems; six papers (5.2%) focused on the use of global positioning systems (GPSs) improving agriculture, while the provision of broader information on agriculture was contained in five papers (4.3%). Four

papers (3.5%) focused on the networking in agriculture category, and the same number of papers focused on the e-commerce category. ICT in agricultural supply chains was discussed in three papers (2.6%). Finally, e-government direct services, mobile in agriculture and agricultural information systems have each contributed two papers (1.7%).

The second research question (RQ2) investigated in this systematic literature review in the area of e-agriculture in South Africa focus on research methods and tools employed in research papers from 2000-2016. The results of the study indicate that these research methods are empirical. Among the 114 empirical pertinent papers, information mapping was the most used research method with 57 papers (50%), followed by case study with a contribution of 31 papers (27.1%). The design of system/method/model/solution was indicated in 24 papers (21%); survey was indicated in 23 papers (20.1%), and experiment in eight papers (7%). The research method that was least used by authors was industry report with no papers (0%), followed by grounded theory with two papers (1.7%).

The research approaches employed in research papers were also investigated to answer the second research question (RQ2) of this systematic literature review. The results of this study show that interpretivism was the research approach most indicated in the pertinent papers (six papers, 5.2%). The research approach least indicated was positivism with a contribution of nil papers (0%), followed by objectivism, constructionism, reductionism, and criticism with a contribution of one paper (0.8%) each.

Theoretical lenses employed in papers were investigated to answer the third research question (RQ3) of this systematic literature review. Among the 114 pertinent papers, the results of this study depict that diffusion of innovation (DoI) is the theoretical lens that was most focused on in the pertinent papers (four papers, 3.5%), followed by decision-making theory with three papers (2.6%). The theoretical lens that was least focused on by authors is the technology acceptance model (TAM) with a contribution of one paper (0.8%).

The units of analysis discussed in the papers were investigated to answer the fourth research question (RQ4) of this systematic literature review. Among the 114 pertinent papers used in this study, the results indicate that land use/cover and soil were the most used units of analysis (34 papers, 29.8%), followed by technology (34 papers, 29.8%). Humans were the focus of 20 papers (17.5%) and vegetation the focus of 12 papers (10.5%). The results further indicate that water resources

were prominent in eight papers (7%). Viticultural terroir, weed, organisation, pesticides, and vineyard were the units of analysis least prominent with a contribution of one paper (0.8%) each. This is followed by animal species and plant species with a contribution of three papers (2.6%) each. The units of observation employed in papers were also investigated to answer the fourth research question (RQ4) of this systematic literature review. Among the 114 pertinent papers used in this study, the results indicate that land use/cover and soil were the most used units of observation (30 papers, 26.3%), followed by technology (29 papers, 25.4%). Humans were the focus in 21 papers (18.4%) and water resources in eight papers (7%). Plant species were depicted in seven papers (6.1%) and trees in five papers (4.3%). Vegetation was the focus in four papers (3.5%). Weed, organisation, pesticides, and leaf area index were the least used units of observation with a contribution of one paper (0.8%) each, followed by foliage, animal, and vineyard with a contribution two papers (1.7%) each.

The levels of analysis employed in papers were also investigated to answer the fourth research question (RQ4) of this systematic literature review. Among the 114 pertinent papers used in this study, the results indicate that meso and macro levels were the most used levels of analysis with a contribution of 54 papers (47.3%) each. The micro level was the least used with a contribution of six papers (5.2%).

The historical development employed in papers was investigated to answer the fifth research question (RQ5) of this systematic literature review. Among the 114 pertinent papers used in this study, the results indicate that historical development was only discussed in one paper (0.8%). Historical development was used to discover influences and steps in the development of the use of information and communication technologies to both the commercial and developing agricultural sectors of South Africa [208].

The major concepts employed in papers were also investigated to answer the fifth research question (RQ5) of this systematic literature review. Among the 114 pertinent papers used in this study, the results indicate that general (101 papers, 88.5%) was the most used research concept, followed by information systems development methodology with six papers (5.2%). The least used research concept was Information system value (two papers, 1.7%), followed by technology adoption with five papers (4.3%).

The different disciplines employed in the papers were investigated to answer the sixth research question (RQ6) of this systematic literature review. Among the 114

pertinent papers used in this study, the results indicate that agriculture and environment are disciplines that have contributed the most to e-agriculture research in South Africa (47 papers, 41.2%), followed by geography (14 papers, 12.2%). Public administration was indicated in eight papers (7.1%), and economy and electronics in seven papers (6.1%) each. Engineering and business were indicated in six papers (5.2%) each. Management and information systems were the focus of five papers (4.3%) each. The education and communication disciplines contributed the least with one (0.8%) paper each, followed by physics and chemistry with a contribution of three (2.6%) papers each.

The publication year of the 114 papers was also investigated in this systematic review. Among these papers, the results indicate that 13 papers (11.4%) were published in the first five years (2000-2004) and 51 papers (44.7%) in the last five years (2012-2016) of the delimited time period. The year 2015 contributed the most with 15 papers, and the years in which e-agriculture papers were published the least were 2000 and 2001, with a single paper each. The results thus show that e-agriculture research in South Africa has increased over the last five years.

A further purpose of this study was to evaluate the searchability of pertinent papers published in the field of e-agriculture research in South Africa. This paved the way to determine how other researchers were researching their data in the field of e-agriculture in South Africa. As explained in the previous chapters, three assessment questions were determined to evaluate keywords, abstract and title searchability of the papers considered in this systematic literature review. Three types of possible answers were considered in the searchability assessment (*yes*, *partially* and *no*). The results of the searchability assessment indicate that the *partially* marks were higher than the positive and negative marks. The most *partially* marks are related to the second question, assessing keywords of the research and abstract searchability (79 papers, 69.2%). The highest number of positive (*yes*) marks (six papers, 5.2%) are related to the second research question of the searchability assessment of keywords regarding the abstracts as well as the third research question of the searchability assessment of keywords regarding the titles. This indicates a very low number of positive marks. The results of the searchability assessment related to first question assessing keywords of research (SLR) and keywords of paper similarity indicate two positive (*yes*) marks, 43 *partially* marks, and 69 negative (*no*) marks. The searchability assessment regarding keywords included in the abstract papers indicate six positive (*yes*), 79 *partially,* and 29 negative (*no*) marks for the second research question. Finally, the

third research question of the searchability assessment of research keywords regarding the title papers include six positive (*yes*), 75 *partially,* and 33 negative (*no*) marks.

5.3 Validity threats

The validity threats of this systematic literature review were examined and the results were determined and discussed.

This study was investigated by a single researcher, thus, there is a probability of finding more validity threats compared to a study investigated by many researchers because of the impact that anchoring, bias, and particular judgment might have on different steps of this systematic literature review (Siau & Tan, 2005). This could have affected the selection and extraction of data as well as the results obtained in this systematic literature review. However, in order to reduce this threat and bias, some results and steps considered in the study were examined and endorsed by previous researchers who have conducted similar studies.

Several types of web search engines (Google, Google Scholar), digital databases (EBSCOhost, IEEE Xplore Digital Library, ProQuest, SA Theses, SA ePublications, ScienceDirect and Scopus), and papers (thesis, conference, journal article and book) were accessed for this systematic literature review. This implies that the bias might have been reduced and the reliability of information increased because the collection of pertinent information for the purpose of this study was restricted. The search strategy adopted in this study was discussed with other researchers to obtain pertinent information on e-agriculture research in South Africa. As indicated in section 3.3.1 of this study, the researcher used different types of keywords to search for information related to the objective of the study. Papers were categorised according to context after reading the titles, keywords, and abstracts. However, the searching was conducted by one individual researcher, leaving the possibility that this step could have been affected by bias. Notwithstanding, the researcher managed to gain pertinent information for this study despite the existence of threats that might be reduced by future studies in this this field.

5.4 Discussion of the findings

As explained in the introduction of this chapter, the aim of this study was to understand the current status of e-agriculture research in the South African context. To achieve this, different types of questions were adopted to respond to

the objective of the study. This section discusses the findings that answer the research questions considered in this systematic literature review as summarised in the previous section.

The findings of this study reveal that the 114 pertinent research papers reviewed during the systematic literature review deal with a large scope of subjects; each of these papers also has a specific focus. The research papers were grouped into thirteen categories:

- ICT adoption and use in agriculture companies
- E-government direct services
- Mobile in agriculture
- Computerised back-end developed systems
- Networking in agriculture
- Agricultural information systems
- Use of geographic information systems improving agriculture
- Use of global positioning systems improving agriculture
- Use of satellite enhancing agriculture
- E-commerce
- ICT in agricultural supply chains
- Empowering local agricultural communities through information and ICTs
- Providing broader information on agriculture

The findings of this study reveal many unexplored themes/areas within and among these topics. In addition, only a few papers discuss closely related topics on e-agriculture research in South Africa. Petja, Ramugondo and Nesamvuni (2009) and Petja et al. (2014) utilised a remote sensing and geographic information system to evaluate the agricultural development capacity in a particular area of the province. The authors found that remote sensing and GISs offer a possibility for integrated analysis of resource development capacity within a particular period of time and scale. In North West Province of South Africa, the level of awareness of ICTs among agricultural extension officers was examined by Mabe and Oladele (2012a; 2012b). The authors found that there are several ICT tools used by extension officers to share agricultural messages and information. These tools include CD-ROM, radio, organisation website, fixed telephone, fax machine, video, computer, personal e-mail, overhead projector, television, mobile phone, World Wide Web, DVD, internet, newspaper, and organisation e-mail. A large number of papers report on studies focused on the use of geographic information systems improving agriculture and the use of satellite enhancing agriculture. Very few

papers relate to e-government direct services, mobile phones in agriculture, and agricultural information systems. Furthermore, only a few studies have been mentioned in other research papers and almost no publications continue from a previous research paper. The relatively recent birth of ICT adoption in agriculture in South Africa could be the lack of focus on e-agriculture in the South African context.

As indicated in section 4.3, information mapping is the research method that was most indicated in the papers, and many of these were conducted by academic institutions. However, it will be interesting to see other stakeholders such as industry, public civil society and public administration institutions become more involved in e-agriculture research in South Africa. In some papers, researchers have not mentioned the type of research method and tools they used. This poses a challenge for researchers who conduct investigations into a specified field by means of a systematic literature review. Therefore, researchers are advised to indicate the research method and tools they use when conducting a study.

Interpretivism is the research approach that was the most used by researchers, according to the papers considered in this systematic literature review. The results of the study indicate a lack of research approaches in papers as these approaches could only be found in a few papers. Diffusion of innovation (DoI) is the theoretical lens that was the most used by papers considered in this systematic literature review. The results of this study further indicate a lack of discussing theoretical lenses in the pertinent papers as only few researchers applied these lenses in their studies. The results of this study also point to an important number of similarities between the units of analysis and observation among the pertinent papers selected in this systematic literature review.

Based on the findings, this study shows that a small number of pertinent papers have been published during the period 2000-2004, which affects the systematic literature reviews conducted on e-agriculture in South Africa. The results further indicate a growing number of pertinent papers on e-agriculture in South Africa during the last five years (2012-2016) because e-agriculture research in South Africa is growing and receiving more support from the government and other stakeholders involved in e-agriculture research in South Africa.

5.1 Conclusion

This chapter firstly started with an introduction. Secondly, the summary of findings was presented in this study. The validity threats of this systematic literature review were examined and the results were determined and discussed. Finally, the findings that answer the research questions considered in this systematic literature were discussed.

CHAPTER SIX: CONCLUSION AND RECOMMENDATIONS

6.1 Introduction

In this chapter, the contribution of this study is firstly presented. Secondly, research limitations and suggestions for future research are addressed. Thirdly, the chapter presents the research conclusion, which includes a summary of the principal research findings. Finally, a set of recommendations that could encourage conducting studies on e-agriculture in South Africa, is considered.

In this study, the current status of e-agriculture research in South Africa was analysed. The researcher investigated and reviewed studies related to ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture in South Africa as the objective of this study. A systematic literature review was adopted to gather and analyse data in this study.

6.2 Research contribution

This study contributes to the understanding of the current status of e-agriculture research in the South African context. The contribution of this study can therefore be summarised as follows:

- To understand the focus of research on e-agriculture in South Africa
- To understand research methods and tools that have been used in e-agriculture research in South Africa
- To understand research approaches that have been used in e-agriculture research in South Africa
- To understand theoretical lenses that have been used in e-agriculture research in South Africa
- To understand the unit of analysis and observation that have been used in e-agriculture research in South Africa
- May lead to understanding the level of analysis used in e-agriculture research in South Africa
- To understand historical development and major concepts that have been investigated in e-agriculture research in South Africa

- To provide insight into the importance of enhancing socio-economic changes of farmers and research capability through enhanced communication of agriculture research knowledge in the field of agricultural informatics (Barakabitze, Kitindi, Sanga, Shabani, Philipo & Kibirige, 2015)

E-agriculture is still growing and not well known in South Africa as a large number of farmers do not have sufficient access to ICTs, and there is a lack of government support in the agricultural sector. The main challenges preventing the growing of e-agriculture in South Africa are the problems of electricity supply and connectivity bandwidth, as well as the high cost of services and equipment. This systematic literature review therefore contributes by identifying the extent of e-agriculture in South Africa. The contribution of this study stems from research methodologies adopted to conduct the systematic literature review since this study is novel, relevant, and has never been investigated before. This thesis contributes to the knowledge of the investigative approach of the state of e-agriculture research in the South African context.

6.3 Research limitations

Since the aim of this study was to understand the current status of e-agriculture research in South Africa, many limitations have been encountered. Firstly, the scope of this study was limited to the period 2000-2016; pertinent research studies conducted outside this period were not taken in consideration, which means important relevant information could have been omitted. Secondly, the research method adopted for data collection might not have delivered all data related to this study. Thirdly, the study was limited to data collected from digital databases and web search engines, and could thus have missed pertinent research archived in local public or college and university libraries. Some of the studies have not indicated any findings of the data analysis phase. Studies have shown some limitations in their conclusions. In this study, the researcher used a systematic literature review to determine the state of e-agriculture research in South Africa. This enabled the researcher to look for phrases or words in keywords, titles, and abstracts. This is a challenging task as many abstracts often overlook pertinent information (Budgen, Kitchenham, Charters, Turner, Brereton & Linkman, 2008). Therefore, Brereton, Kitchenham, Budgen, Turner and Khalil (2007) recommend to researchers to also consider the conclusions of papers when reviewing.

6.4 Future research

This study has created a foundation for further research on e-agriculture in South Africa. The research was focused on determining the current status of e-agriculture

research in South Africa, thus a systematic literature review was used to collect and analyse data in accordance with the objective of the study. Although academic institutions, public civil society, public administration institutions, and industries play a major role in investigating e-agriculture in South Africa, other important agriculture stakeholders such as the private sector and agriculture extension officers participating in agricultural sustainability and development should participate in future studies for a clearer understanding of ICT adoption and use in agriculture companies, e-government direct services, mobile in agriculture, computerised back-end developed systems, networking in agriculture, agricultural information systems, use of geographic information systems improving agriculture, use of global positioning systems improving agriculture, use of satellite enhancing agriculture, e-commerce, ICT in agricultural supply chains, empowering local agricultural communities through information and ICTs, and providing broader information on agriculture in South Africa. Future research studies could also address the status of e-agriculture research in South Africa with a longer period of years that might be more representative. Another research method could also be used.

6.5 Conclusions

This study was conducted as a systematic literature review. The findings offer insight into the work done by other researchers on e-agriculture in the South African context. The literature search delivered 114 papers for analysis on e-agriculture in South Africa. The findings of this study indicate a small number of papers during the first five years (2000-2004) and a large number of papers during the last five years (2012-2016) due to the growth of e-agriculture research in South Africa, attributed to South African authorities funding local universities according to the number of papers they publish in accredited journals (Pouris, 2015).

The findings of this study indicate that geographic information systems improving agriculture is the category e-agriculture research in South Africa has been most focused on, according to the papers selected in this study. E-government direct services, mobile in agriculture and agricultural information systems were the categories least focused in terms of e-agriculture research. As was found during the analysis of the study, information mapping is the most used empirical research method by researchers from 2000-2016, while industry report was the research method least focused on. However, there were also other empirical research methods, which include case study, survey, experiment, design of system/method/model/solution, field study, and grounded theory. Despite the fact that information

mapping was the research method that assisted researchers the most in their investigations, it was only used to study a single phenomenon.

The findings of this study indicate that interpretivism was the research approach most mentioned in the papers selected in the study as interpretivism includes human factors, meaning that it depends on the interpretation of information required by researchers when conducting a study. Positivism was the research approach least mentioned by researchers. The findings further indicate that diffusion of innovation (DoI) was the theoretical lens most indicated in the pertinent papers as it was considered a “good” theory to investigate ICT adoption and to understand how information technology innovations grow within and between communities. Technology acceptance model (TAM) was the theoretical lens least indicated by researchers.

The findings of this study further indicate that land use/cover and soil were the units of analysis most indicated in the pertinent papers of the study. Viticultural terroir, weed, organisation, pesticides, and vineyard were the least used units of analysis in this systematic literature review. Land use/cover and soil were also the units of observation most indicated in the papers selected in in study. Weed, organisation, pesticides, and leaf area index were the least used units of observation. There were also other units of analysis and observation used in this study, but land use/cover and soil were the most indicated as these are import elements in the agriculture sector. The findings of this study indicate that the meso and macro levels of analysis were the most denoted in the pertinent papers. The micro level of analysis was the least denoted in this systematic literature review.

The findings of this study indicate that historical development was used to discover influences and steps in the development of ICT use in both the developing and commercial agricultural sectors in South Africa (Ortmann, 2000). The general concept category was the most used in this study as it covers different type of topics in e-agriculture research in South Africa. Information system value was the least used concept. The agriculture and environment disciplines were the most represented in this study as these disciplines encourage researchers to find solutions to important environmental and agricultural problems. Education and communication were disciplines that were the least represented.

The findings of this study indicate that a number of papers have not contained searchable keywords in the title and abstract. The possibility therefore exists that pertinent papers of the field could have been overlooked because title, abstract,

and keyword searches are the first means of investigation in systematic literature reviews.

Despite the limitation of the study to conduct a systematic literature review on e-agriculture research in South Africa only for the period 2000-2016, and thus limiting the generalisability of the outcomes of the study, the research provides an accurate and clear understanding of the current status of e-agriculture research in South Africa. The study revealed that all e-agriculture research papers selected were focused on the following categories:

- ICT adoption and use in agriculture companies
- E-government direct services
- Mobile phone in agriculture
- Computerised back-end developed systems
- Networking in agriculture
- Agricultural information systems
- Use of geographic information systems improving agriculture
- Use of global positioning systems improving agriculture
- Use of satellite enhancing agriculture
- E-commerce
- ICT in agricultural supply chains
- Empowering local agricultural communities through information and ICTs
- Providing broader information on agriculture in South Africa

The analysis and understanding of e-agriculture research papers offer ideas for further research. It is evident that researchers still need to address certain issues or problems on e-agriculture in South Africa to improve the socio-economic transformation of farmers and the agriculture sector. This research has revealed that although academic institutions, public civil society, industry, and public administration institutions are involved in e-agriculture research in South Africa, the government should take into consideration all factors that could encourage researchers to conduct research studies on e-agriculture in South Africa.

6.6 Recommendations

By taking into consideration the above findings, this thesis provides important recommendations that could encourage research achievements for e-agriculture in South Africa over a long period of time and increase the capacity of South African farmers and farmworkers in adopting e-agriculture.

These recommendations are as follows:

- Enabling a strong partnership between South African universities, public civil societies, public administrations and industries for the continuous update and clarity of contents of South African e-agriculture programs
- Financial support of e-agriculture research in South Africa by the South African government, industries, bilateral and multilateral partners
- Establishing research centres and different types of institutes that are focused on e-agriculture research papers in South Africa
- Considering the organisation of various e-agriculture related workshops and conferences
- The efforts made to encourage e-agriculture research in South Africa at academic institutions should be revised by providing more funding and appointing personnel to keep record of the funding process
- Considering the complexity of conducting e-agriculture research in South Africa to meet farmers and farmworkers' needs, and to improve the agriculture sector
- Benchmarking of agricultural management bodies to determine how other countries conduct e-agriculture research

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APPENDIX A: Procedures explaining the literature search component of the systematic literature review

This section explains the way in which the literature search was conducted. Understanding the process enabled the researcher to search more effectively for literature on e-agriculture in South Africa. The objective was to find a significant number of pertinent papers that would offer a deeper insight into the topic. The researcher conducted an additional search to obtain pertinent literature. Searching for literature is considered a process that enables the researcher to have a better understanding of the literature in order to identify pertinent papers (Boell & Cecez-Kecmanovic, 2014). A researcher can conduct searches more effectively if he/she has gained a deep or clearer understanding of the literature (Boell & Cecez-Kecmanovic, 2010).

A.1: Searching for literature

According to Boell and Cecez-Kecmanovic (2014), a systematic literature review assists a researcher with finding a small number of documents that are pertinent for a study instead of simply collecting a large number of less useful publications. A researcher can search through databases and web search engines for specific topics to find a significant number of publications. For this study, a significant number of research papers on e-agriculture in South Africa were discovered using EBSCOhost, Google, Google Scholar, IEEE Xplore Digital Library, ProQuest, SA Theses, SA ePublications, ScienceDirect, and Scopus.

i) Field searches

According to Boell and Cecez-Kecmanovic (2014), a field search can be considered a strategy used by a researcher to limit the number of publications found. Furthermore, a researcher can search for specific topics using the field search technique in a database, for instance, the title or author field. In a study, documents discovered in a database do not all have the same importance. Moreover, Boell and Cecez-Kecmanovic (2014) point out that the precision of searches can be obtained by limiting a search to groups of publications pertinent to a study. In addition, the field search technique enables the researcher to obtain omitted/overlooked publications to make a better judgment. It assists the researcher in subsequent searches for new publications without finding the same papers twice. Subject area, year of publication, and type of document are most of the time the important fields used by the researcher when conducting a systematic literature review.

ii) Logging searches

According to Boell and Cecez-Kecmanovic (2014), the researcher needs to keep track of the searches undertaken when conducting database searches. Schwarz et al. (2007), Brocke, Simons, Niehaves, Reimer, Plattfaut and Cleven (2009) as well as Ridley (2008)

explain the role that logging searches can play in conducting systematic literature reviews. This strategy allows the researcher to continuously being informed of which databases have already been covered, which search terms have already been used, and the time span of searches.

iii) Snowballing and citation analysis

According to Boell and Cecez-Kecmanovic (2014), snowballing is a strategy that assists the researcher with determining further pertinent literature after having identified a number of pertinent research papers. The researcher can obtain additional related literature by examining the literature cited by other authors. Greenhalgh and Peacock (2005) point out that a significant volume of pertinent literature can be found using citation tracking as it helps to identify publications in less time. Citation analysis therefore helps the researcher to find related literature cited in a particular publication. Nicolaisen (2007) notes that citation analysis is different from snowballing because it does not have the advantage of references being established within the subject of a publication. This can result in a massive responsibility for a researcher having to analyse hundreds of papers citing a landmark publication. In this case, the researcher can be assisted by using the refining search tool to obtain the relevant papers. Webster and Watson (2002) confirm the importance of using citation analysis and citation tracking (snowballing) when conducting systematic literature reviews.

A.2: Starting to search for literature

i) Google

Google helped the researcher to classify and conduct specific literature searches (figure A.2.1). The researcher used keywords as well as keywords combined with AND to conduct the searches using Google. By doing this, the researcher discovered a number of important research papers.

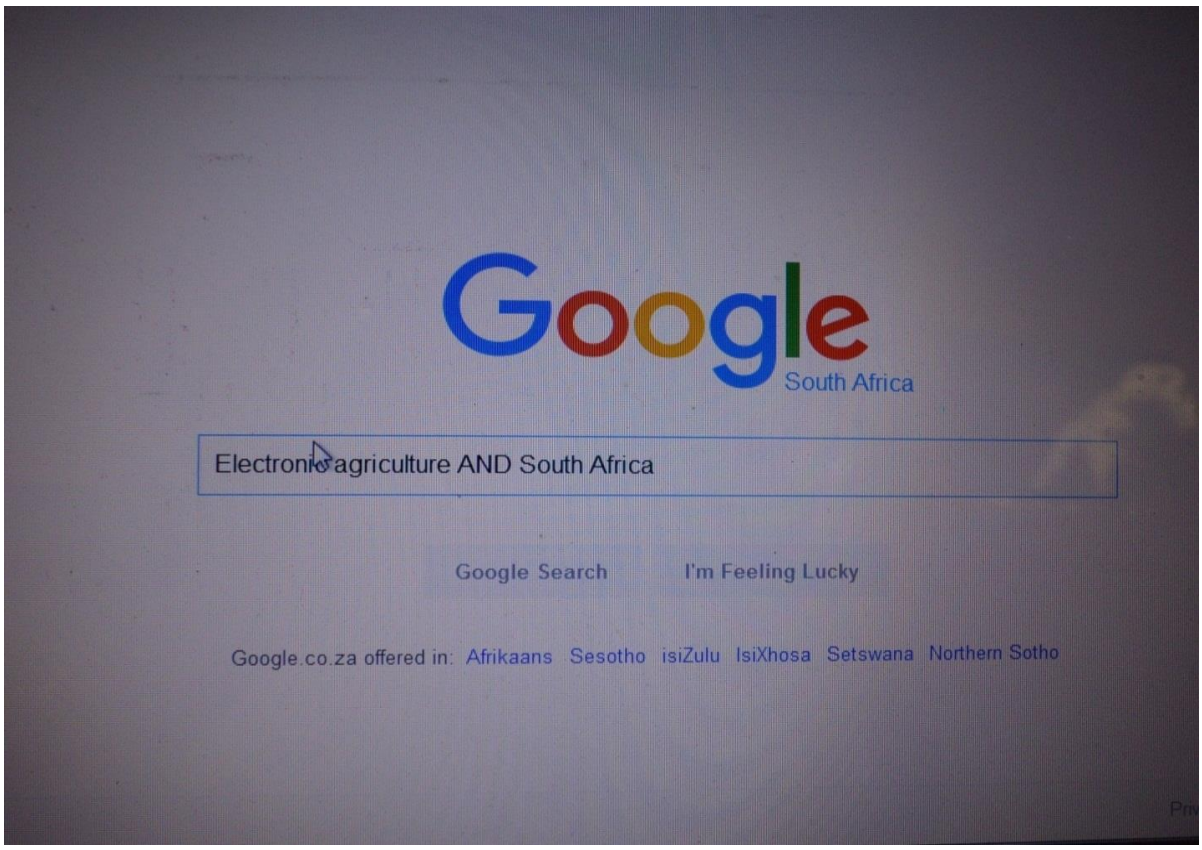

Figure A.2.1: Searching for literature using Google

ii) Scopus

The researcher conducted a successful integrative investigation of academic journals in Scopus, with a secondary advantage of citation searches being allowed. Scopus enables the researcher to search for editorials containing specific terminology. Scopus allows the researcher to use techniques such as author search and affiliation search to find publications from a particular author or organisation (University College London Hospitals, 2012). Scopus facilitates the use of citation analysis to track literatures relevant to the literature review. Burnham (2006) states that a basic search in Scopus enables the researcher to add terms to a search box and select the subject to be searched. Results appear according to relevance, author(s), source, date, and title. In Scopus, the advanced search function helps the researcher to search more specific categories than the ones provided on the first search page (Boell & Cecez-Kecmanovic, 2014). For this study, the researcher used keywords as well as keywords combined with AND to search for literature using Scopus (Figure A.2.2).

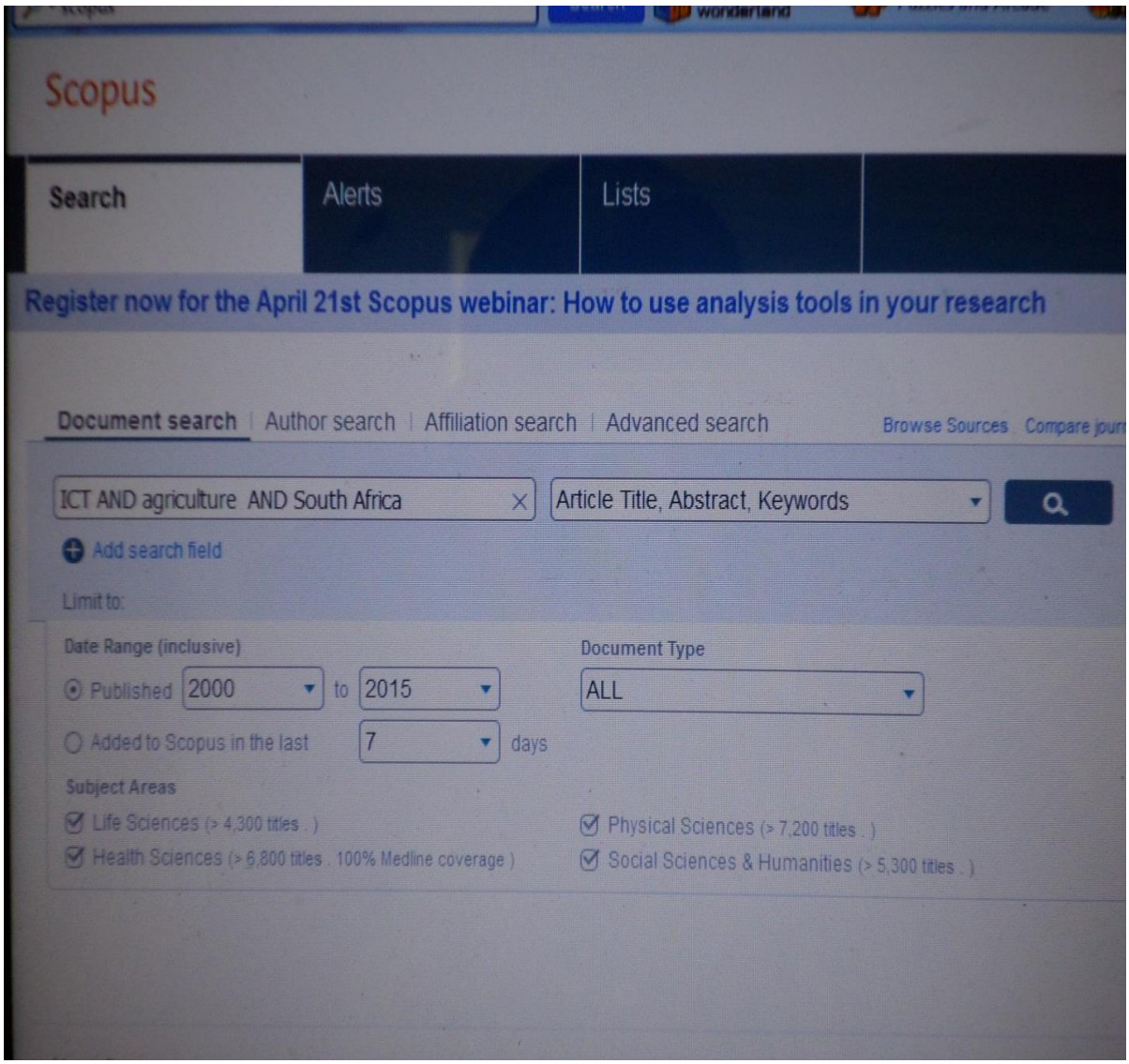

Figure A.2.2: Literature search in Scopus using a search phrase, a year range, and some subject areas

iii) Google scholar

According to Tahirkheli (2009), Google scholar enables the researcher to use search terms such as key words, article titles, and authors to search for relevant literature. Google scholar helps the researcher to easily change the search terms in order to obtain more specific literature (Boell & Cecez-Kecmanovic, 2014). With Google scholar, the researcher can search for an exact publication for a citation, and the publication will be found easily. Walters (2011) points out that the researcher can use Google Scholar to search for literature by using terms within scholarly publications. This search can be restricted to specific topics in Google Scholar's advanced search option. For this study, the researcher used keywords as well as keywords combined with AND to search for literature using Google scholar (Figure A.2.3).

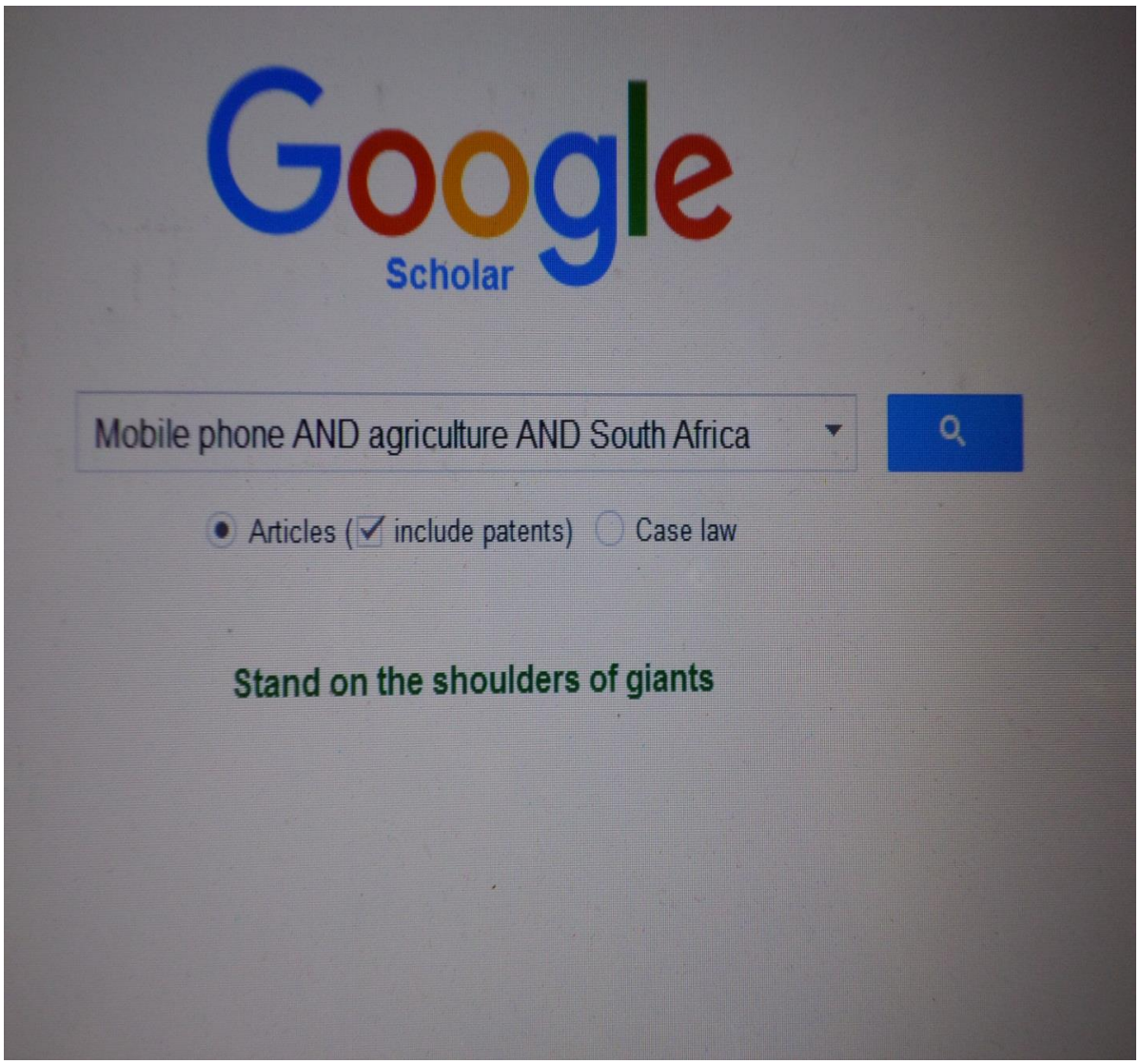

Figure A.2.3: Searching for literature using Google Scholar

iv) SA ePublications

With SA ePublications, the researcher used keywords as well as keywords combined with AND to obtain full papers or the titles of documents on e-agriculture in South Africa. Whenever the full paper (or document) is not available, the abstract can be obtained so that relevant information for the study is always readily available. In SA ePublications, the researcher used the option exact word/phrase that allows searching for the exact version of a word and delivering search results that involve the same type of word (UNISA, 2014). SA ePublications offers an advanced search option that gives the researcher more control over the retrieval of results. It enables the researcher to use the limit function to obtain results limited by year of publication and format. Therefore, results are displayed in search terms as according to title, author, source details, and year of publication, among others.

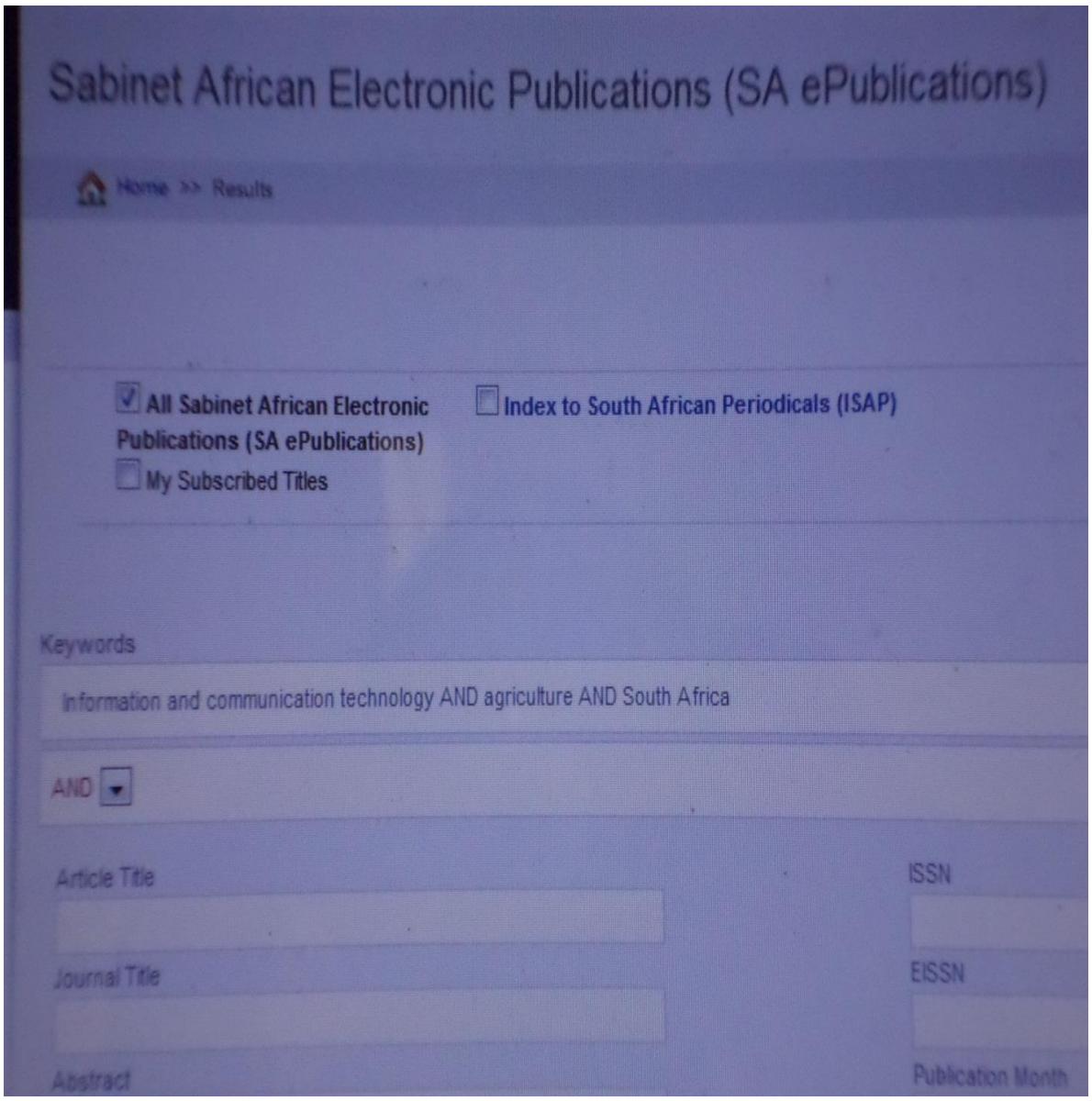

Figure A.2.4: Searching for literature using SA ePublications

v) ScienceDirect

With ScienceDirect, the researcher selected the journal tab from the main search widow, inserted keywords or keywords combined with AND, used the limiter (all fields) in the right menu, and used range restrictions (ScienceDirect, 2010). Afterwards, results appeared with titles, and then the researcher selected the full text to download the PDF article. When the full text of a paper is not available, the researcher can use the abstract or look for other options such as contacting the author of the paper using email. The researcher can use the right menu options to obtain the bibliographic information of the paper and the links related to the paper.

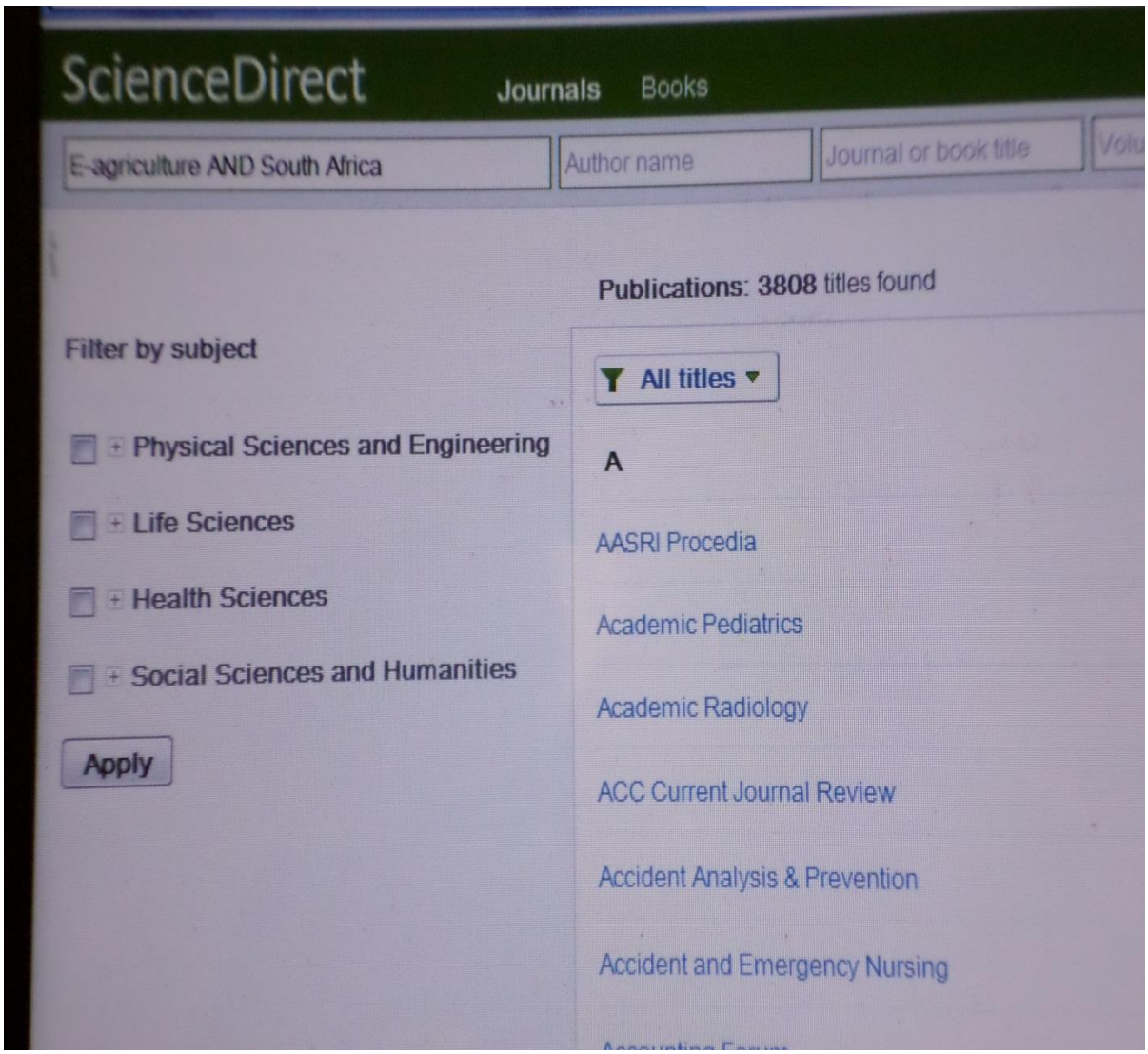

Figure A.2.5: Searching for literature using ScienceDirect

vi) IEEE Xplore

IEEE Xplore is described as a scholarly research database providing full text for papers and articles in disciplines such as electronic and electrical engineering as well as computer science (Wikipedia, 2016). It also provides abstracts and indexes of papers. With IEEE Xplore, the researcher used keywords combined with AND to obtain a full paper or document on e-agriculture in South Africa.

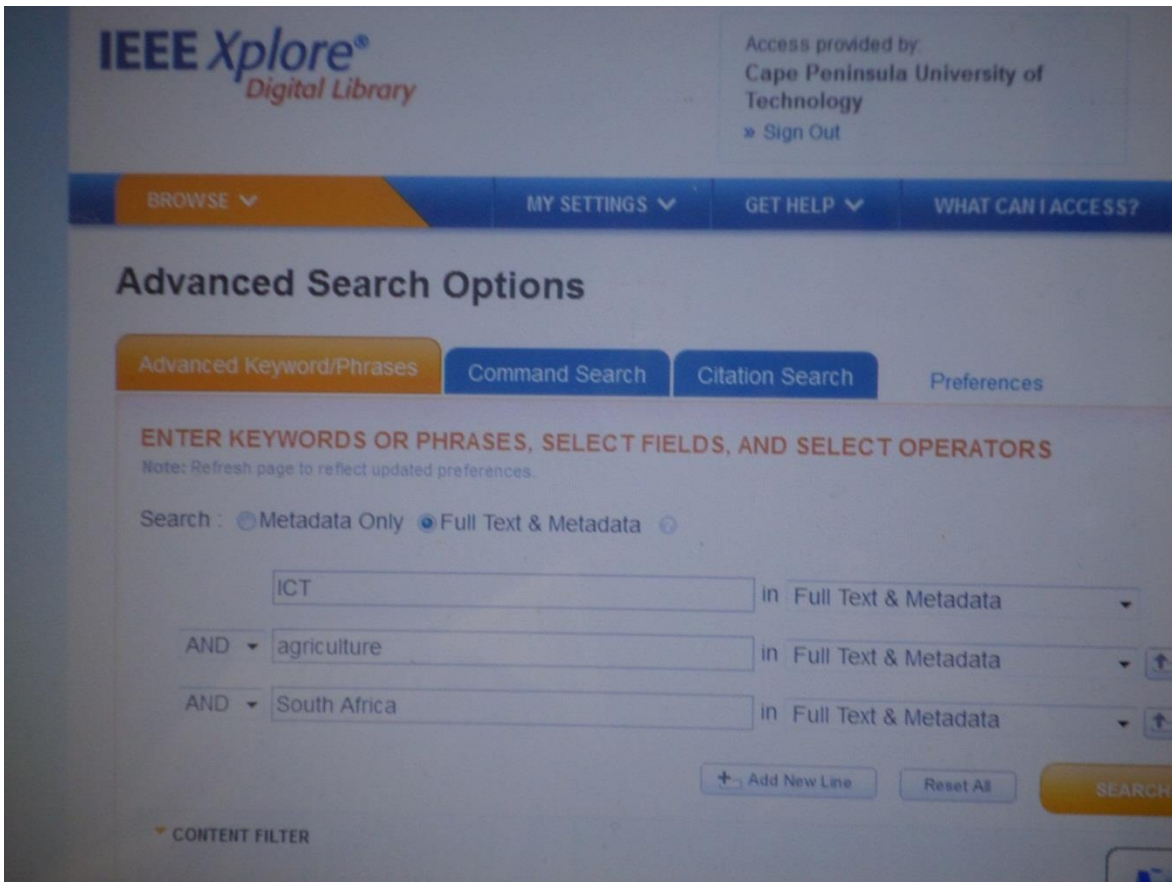

Figure A.2.6: Searching for literature using IEEE Xplore