Adopting Green Information and Communication Technology: Barriers for South African Small and Medium Enterprises

by

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ABSTRACT

Green information and communication technology (ICT) is viewed as a pioneering initiative that plays a key role in reducing the negative impact of ICT on the environment. The research problem of the study was the low green ICT adoption rate in South African small and medium enterprises (SMEs). The primary objective was to identify the most prominent barriers resulting in this low adoption rate. The first secondary objective was to determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs. The second secondary objective was to recommend strategies on how to improve the adoption rate of green ICT. A self-administered questionnaire was used to collect data through electronic and paper-based surveys. A census study was conducted among owners and managers of high-technology-based SMEs located in Gauteng. An exploratory factor analysis was employed to identify the barriers resulting in the low adoption rate of green ICT. These barriers were found to be a lack of funding, awareness, legislation, skills, and knowledge based on complexity and uncertainty. A lack of funding was identified as the most prominent barrier to adopting low green ICT. Although five constructs were discussed in the literature, the overall results presented six components, with the construct of knowledge being made up of two parts – complexity and uncertainty. This study recommends that SMEs align green ICT initiatives with their strategic goals and that government consider more adequate support structures for SMEs. The study confirmed a low green ICT adoption rate in South African SMEs, and more research is required to explore the impact of each of the factors above on the environment.

Key words: Green ICT, South Africa, SMEs, Barriers, Legislative Regulations, Skills, Funding, Awareness, Knowledge, Complexity, Uncertainty, Sustainability, Environment

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LIST OF ACRONYMS

ASSAf	Academy of Science of South Africa
CEO	Chief executive officer
CO_2	Carbon dioxide
CSR	Corporate social responsibility
GHG	Greenhouse gas
ICT	Information and communication technology
IBM SPSS	IBM Statistical Package for the Social Science
IS	Information system
ISO	International Organisation for Standardisation
IT	Information technology
KMO	Kaiser-Meyer-Olkin
POPI Act	Protection of Personal Information Act
SMEs	Small and medium enterprises
UNISA	University of South Africa

CHAPTER 1: INTRODUCTION TO THE STUDY

1.1 INTRODUCTION

Chapter 1 presents a blueprint of the study and outlines the importance of conducting this research study. An overall view is provided on the background of the study, problem statement, research objectives and questions, motivation for the study, research method, limitations, outline of chapters and a summary of the chapter.

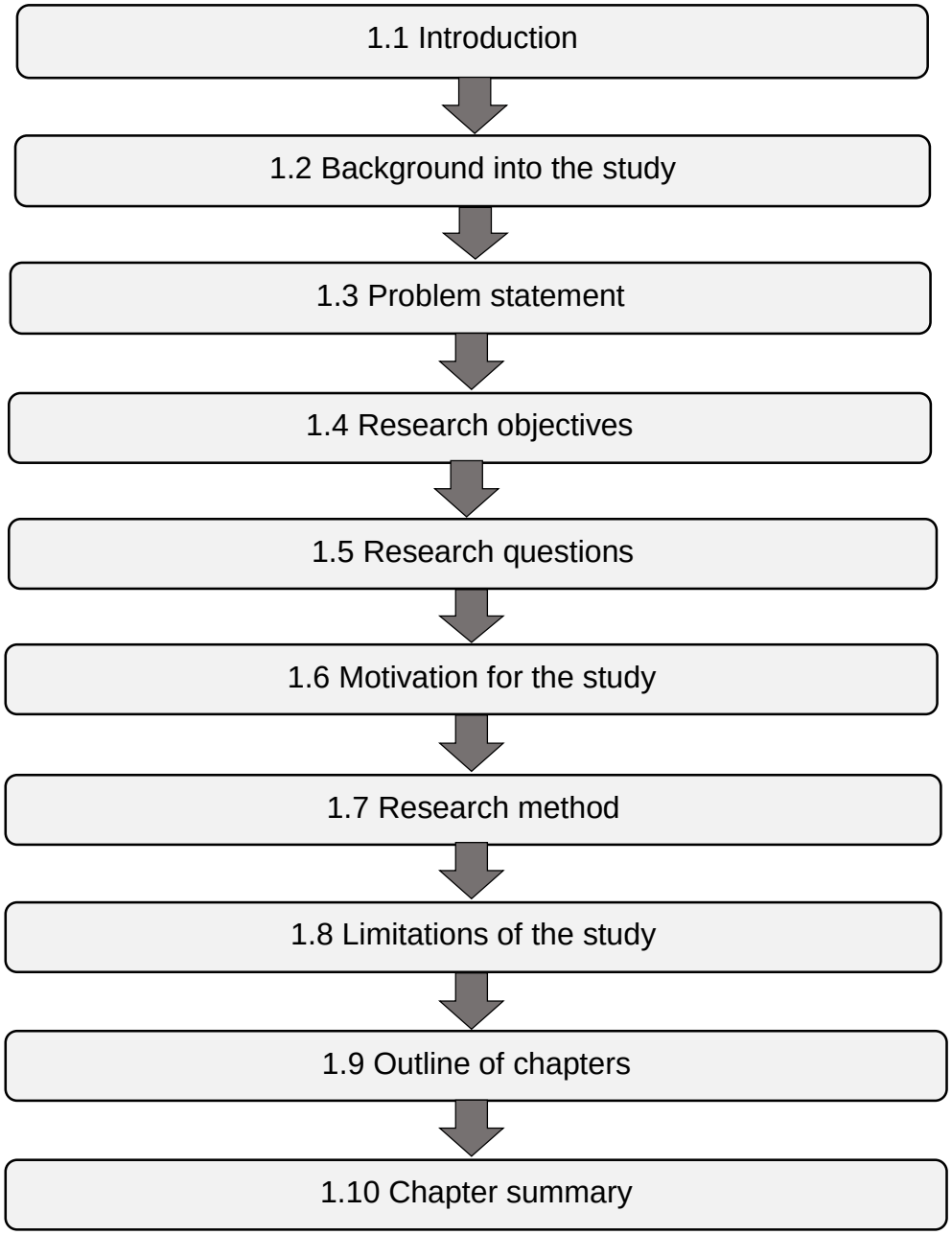


Figure 1.1: Outline of Chapter 1
Source: Author's own composition (2019)

This study endeavours to address the problem of the low adoption rate of green information and communication technology (ICT) encountered in South African small and medium enterprises (SMEs) by determining the context from a developing country's perspective. ICT consists of hardware and software, both of which enable the distribution of information and simplify the sharing of digital communication among individuals and organisations (Beynon-Davies, 2013:18-20). Lee (2017:1123) states that ICT adjusts people's lives radically on a daily basis and contributes to the rise of greenhouse gas (GHG) emissions. According to Anthony and Majid (2016:1-2), sustainability has become a vital part of ICT with the intention to protect the future by decreasing carbon dioxide (CO_2) emissions and alleviating environmental hazards such as hardware and software waste.

Green ICT is defined as the practice of considering and effectively managing the negative effect of ICT by decreasing the total CO_2 on the environment (Hankel, Heimeriks & Lago, 2017:88). ICT can therefore be distinguished from green ICT where standard computerised technology and the latest innovative communication technologies are used to distribute digital data (De Wet & Koekemoer, 2016:275). Thus, green ICT is an improvement in ICT as it has a minimum effect on the environment and promotes the usage of ICT through all the economic and social pillars of sustainability (Asabere, Acakpovi & Quaynor, 2016:14-15). According to Buchalcevova and Gala (2012:111), compared to larger companies' SMEs are being constrained in their adoption of green ICT due to having limited resources such as cloud computing. Yeboah-Boateng and Essandoh (2014:13-14) have found that although cloud computing is an affordable eco-friendly green ICT initiative for enterprises to use, there is a low adoption rate and limited research regarding cloud computing in sub-Saharan Africa. Zhang and Liang (2012:1005) have found that ICT enterprises in China are acquainted with the significance of green ICT but a lack of knowledge is hindering the adoption of green ICT, especially in SME operations. Similarly, a shortage of green technology skills and a poor understanding of green operations are contributing to the low rate of green ICT adoption in Malaysian enterprises (Abdullah, Zailan, Iranmanesh & Jayaraman, 2016:703). This low green ICT adoption rate is also evident in South Africa SMEs and therefore the focus of the

study is on the barriers hindering the low green ICT adoption rate in South African SMEs.

It has been suggested that greening enterprise operations assist in addressing barriers that commonly impact the success of an enterprise and which may have economic, environmental and social ramifications (Hsu, Tan, Zailani & Jayaraman, 2013:658). Small and medium enterprises are defined as small scale (1-50 employees) and medium scale (50-250 employees) enterprises employing up to 250 staff and currently this sector makes up 80% of South Africa's economy (Adeniran & Johnston, 2016:60-61). Moreover, Mafini and Muposhi (2017:1) emphasise the important role that South African SMEs play in the country's economy since SMEs contribute up to 57% of the country's gross domestic product. Although research has been conducted on the adoption and impact of ICT (Gono, Harindranath & Özcan, 2016:717), and ICT utilisation (Adeniran & Johnston, 2016:59) in South African SMEs, none of the studies have explored the adoption of green ICT in South African SMEs. In view of this, the research problem investigated in the current study was the low green ICT adoption rate in South African SMEs. The study thus sought to identify the most prominent barriers resulting in the low green ICT adoption rate in South African SMEs.

1.2 BACKGROUND INTO THE STUDY

In this section, a discussion will be provided on literature regarding green ICT-related research conducted over the last few years. The subsections that follow include an overview of the literature, drivers of green ICT and barriers of green ICT.

1.2.1 Overview of the literature

Figure 1.2 reflects the foremost drivers and barriers influencing the low adoption rate of green ICT found in the literature. The figure also provides a conceptual framework of the current study by summarising the key drivers and barriers resulting in the low green ICT adoption rate in South African SMEs. In Figure 1.2 the four key drivers are shown as a reduction in cost, competitive advantage, product life cycle and environmental conditions. The key barriers are lack of awareness, lack of knowledge,

lack of expert ICT skills, legislative regulations and lack of funding. These key drivers and barriers will be addressed in more detail in sections 1.2.2 and 1.2.3 respectively.

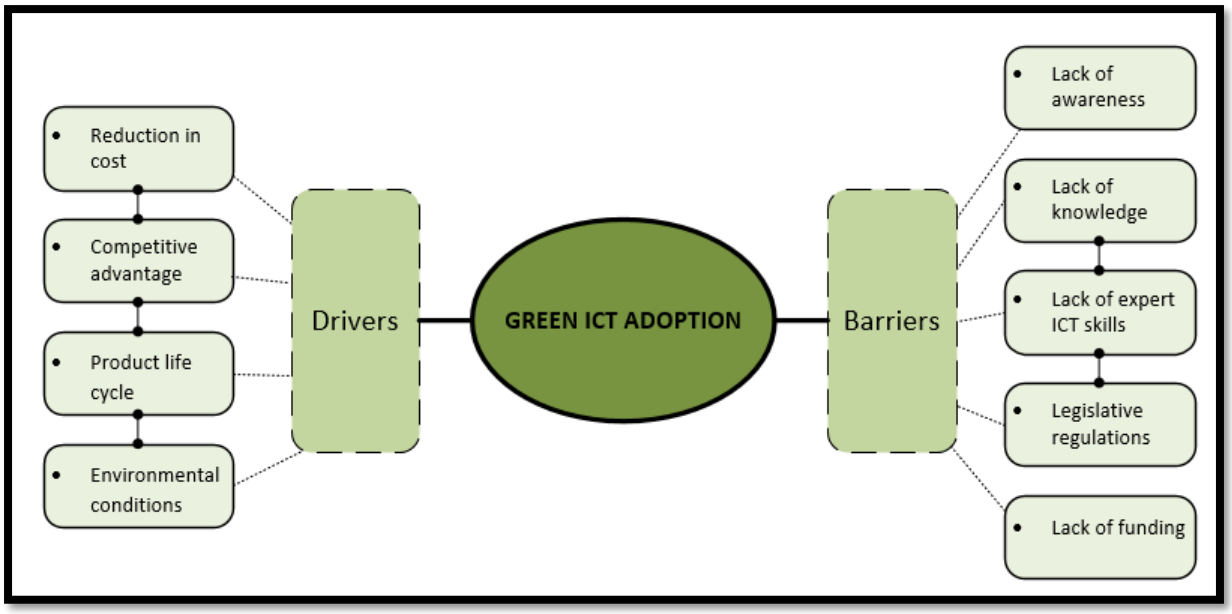


Figure1.2: Conceptual framework
Source: Author's own composition (2019)

Suryawanshia and Narkhedeb (2017:702) propose the following description of green ICT: "Pioneering way of using ICT that consists of policies and practices which deal with environment sustainability by minimizing carbon footprint, ICT waste and by optimising energy consumption and by conserving natural resources for cost-effectiveness, sustenance of ICT and to save planet." Mele and Russo-Spena (2015:10) support the view that green ICT in regard to industrialists, suppliers and specialists include solutions to enhance sustainability through "hardware, software and service". Radu (2016:733) emphasises the important role green ICT plays in terms of its enormous impact on the environment, namely green by IT (information technology) (impact of IT on the environmental production of other industries) and green in IT (the IT industry's actions and its impact on ecological effectiveness). Radu (2016:733) furthermore describes green in IT as follows: (a) Green in hardware – strategies by the entire ICT sector to decrease the utilisation of finite resources and hazardous waste and; (b) Green in software – reducing harmful effects on the ecosystem impacted by software development and helping to strengthen the entire life cycle of "sustainable software system engineering".

This study will focus on the green in IT as the ICT industry is at the forefront in promising to implement energy-efficiency technology due to its vastly innovative initiatives and development of technology that impact various industries (Welfens & Lutz, 2012:157). In the next sections, the key factors influencing the adoption of green ICT will be highlighted based on what is revealed by the literature.

1.2.2 Drivers of green ICT adoption

There are several drivers that impact the adoption of green ICT in SMEs. The four key drivers frequently mentioned in the literature are as follows:

(a) Reduction in cost – refers to minimising operations and infrastructure costs through eco-friendly processes (Mele & Russo-Spena, 2015:13-17).

(b) Competitive advantage – refers to gaining a favourable position in the market over competitors by enhancing green ICT usage (Buchalcevova & Gala, 2012:111).

(c) Product life cycle – refers to improved methods to minimise waste throughout the whole life cycle of a product (Anthony & Majid, 2016:1).

(d) Environmental conditions – refer to actions taken towards protecting the environment such as the prevention of pollution (Yang, Han, Zhou & Yuan, 2015:15344-15345).

The next section provides an overview of the general barriers to green ICT adoption identified from the literature. These barriers are seen as a visible lack of commitment to establish global standards for the adoption of green ICT in SMEs. This research study is based on a specific set of barriers found globally to determine whether South African SMEs are experiencing the same barriers when trying to adopt green ICT.

1.2.3 Barriers of green ICT adoption

The main focus of the study looks at the barriers which are viewed as obstacles hindering the adoption of green ICT in SMEs. The five key barriers identified in the literature are as follows:

(a) Lack of awareness – refers to insufficient information regarding green ICT adoption practices preventing ecological initiatives (Wabwoba *et al.*, 2013:100).

(b) Lack of knowledge – refers to an insufficient understanding regarding aspects related to green ICT to make well-informed decisions and exchange knowledge (Lundfall, Grosso, Lago & Procaccianti, 2015:74).
(c) Lack of expert ICT skills – refers to the shortfall of unqualified employees not possessing the necessary proficiency to develop ecological initiatives (Abdullah *et al.*, 2016:689).
(d) Legislative regulations – refers to a shortage in government subsidiaries, support of sustainable programmes and execution of lawful regulations to overcome hindrances of green ICT adoption (Buchalcevova & Gala, 2013:44-48).
(e) Lack of funding – refers to a shortage of capital to adopt green ICT practices in businesses (Welfens & Lutz, 2012:159).

A comprehensive discussion is provided in section 2.5 regarding the key drivers and barriers which have an impact on the adoption practices of green ICT in SMEs. Moreover, a summary with collective descriptions of various economies is presented about these key drivers and barriers in Tables 2.4 and 2.5 respectively.

1.3 PROBLEM STATEMENT

A literature search revealed that there is a lack of research regarding the low adoption rate of green ICT practices in developing countries (Radu, 2016:743; Bekaroo, Bokhore & Pattinson, 2016:1589, 1592; Yeboah-Boateng & Essandoh, 2014:13-14; Zhang & Liang, 2012:1001; Fatoki, 2019:2; Higgs & Hill, 2019:29). The focus of the current study is to examine the fundamental aspects contributing to the low adoption rate of green ICT to achieve sustainable business practices. Moreover, the specific barriers resulting in the low adoption rate of green ICT in operation practices are examined. South Africa is viewed as the 13th largest emitter globally with an estimated 468 metric tonnes of CO_2 based on 2016 statistics (Global Carbon Atlas, 2017). It is therefore important to investigate the barriers identified in the literature influencing the low adoption rate of green ICT. The problem, therefore, is the low adoption rate of green ICT in South African SMEs.

1.4 RESEARCH OBJECTIVES

To possibly solve the research problem, the primary and secondary objectives of the research need to be investigated.

1.4.1 Primary objective

The primary objective is to identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs.

1.4.2 Secondary objectives

The following secondary objectives were identified:

- To determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs.
- To recommend strategies on how to improve the adoption rate of green ICT in South African SMEs.

1.5 RESEARCH QUESTIONS

To achieve these objectives a primary and two secondary research questions were posed.

1.5.1 Primary research question

The primary research question is:

- What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs?

1.5.2 Secondary research questions

The secondary research questions addressed in the study are:

- What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs?

- What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?

1.6 MOTIVATION FOR THE STUDY

The motivation for the study can be found in the fact that the findings might contribute to the body of knowledge on the low adoption rate of green ICT in South Africa. The research study envisaged to fill the void in the literature regarding the limited research on the low adoption rate of green ICT (Bekaroo *et al.*, 2016:1592). A literature review revealed that the reasons for the low adoption rate of green ICT should be investigated in more detail to determine why green initiatives such as cloud computing are adopted at a low rate in sub-Saharan Africa (Yeboah-Boateng & Essandoh, 2014:13-14). This study will also examine the green ICT principles that may influence the low rate of adopting green technology into regulations to protect the environment (Radu, 2016:743). South Africa is the largest emitter of carbon dioxide in Africa producing 24% of all Africa's emissions (Radu, 2014:434). It is therefore imperative to understand the reasons for the reluctance of South African SMEs to adopt green ICT practices to address this problem. Many researchers are also inviting more research on the development of greener technologies (Tuskeentushi, Sedera & Recker, 2013:11; Baggia, Maletič, Žnidaršič & Brezavšček, 2019:1589; Capasso, Hansen, Heiberg, Klitkou & Steen, 2019:400). As a result, the low green ICT adoption rate is a particular concern in developing countries and the study will therefore focus on South Africa as a developing country.

1.7 RESEARCH METHOD

This section focuses on the research method that was followed to conduct this study. A detailed outline is presented on the quantitative approach, nature of the study, timescale, population and sample, data collection, data collection instrument, data analysis, validity and reliability, and correlation analysis.

1.7.1 Nature of the study

In this section, a detailed discussion is provided regarding the nature of the study.

1.7.1.1 Research strategy

The study is in the form of a quantitative, non-experimental and descriptive research study. A quantitative research design is precise, properly formulated, examined for its validity and reliability, and can be interpreted and identified (Creswell, 2014:54). Salkind (2014:72) states that non-experimental research investigates the connection among constructs to identify the key barriers to the low adoption rate of green ICT. Furthermore, descriptive research defines the present condition of a situation (Cohen, Manion & Morrison, 2007:205). This design enabled the researcher to include a larger number of SMEs in the study and was deemed suitable for collecting data regarding the low adoption rate of green ICT in South African SMEs.

1.7.1.2 Research philosophy

Creswell (2009:5-6) defines paradigms as a worldview based on predetermined philosophies which direct activities. The paradigm approach is positivist whereby the truthfulness of the information gathered is questioned and the researcher seeks to understand this information (Creswell, 2014:7-8). In addition, a mono method (a single quantitative study) was followed which included a questionnaire as a data collection method and a deductive approach to uncover the required information (Saunders, Lewis & Thornhill, 2009:124-151). According to Leedy and Ormrod (2010:32), deductive reasoning refers to the use of existing literature and philosophies to test the information collected during the study. By selecting this research philosophy, the investigation of the research question can take place and a positivist approach can be taken.

1.7.2 Timescale

A cross-sectional method involves a measurement with numerous collections of individuals at a specific place in time (Cohen *et al.*, 2007:212). The cross-sectional method was used to determine the reason for the low green ICT adoption among South African SMEs at a specific point in time. Moreover, the cross-sectional method is a simplified, short-term and low-cost method that provides a complete overview of a study at a specific point in time (Kumar, 2011:107).

1.7.3 Population and sample

This section presents a comprehensive discussion regarding the population and sample selection for this research study.

1.7.3.1 Population of the study

A population is a collection of prospective participants to which the outcome of a study may be generalised whereas a sample is a subgroup of a population (Salkind, 2014:185). The study population consisted of high technology-based (ICT, biotechnology, electronics industries) SMEs registered with The Innovation Hub and located in Gauteng (South Africa) with a population size of 400. The Innovation Hub was chosen as the population for this study because it has an accessible and reliable database with a registered list of SMEs. The reason for using the population of The Innovation Hub was that it was viewed that this particular population would benefit from more guidance and development to increase the adoption rate of green ICT. According to the strategic focus of the Innovation Hub, the registered SME members seem to be susceptible to innovation (The Innovation Hub, 2019). Hence, the registered SME members are deemed appropriate as a population to test their perceptions on contemporary green ICT issues.

1.7.3.2 Unit of analysis

Mouton (2016:51-52) describes the unit of analysis as the "what" of the research, namely the object, phenomenon, entity, process or event to be studied. Thus, the unit of analysis for this study is the collective perception of SME owners and managers registered with The Innovation Hub and who are involved in decision-making processes regarding green ICT adoption in South African SME operation practices. Questionnaires were therefore sent out to SME owners and managers of high technology enterprises based in Gauteng to test their perceptions regarding the low adoption rate of green ICT.

1.7.3.3 Census population

A census is described as the gathering and analysis of data collected from all individuals of the target population (Saunders *et al.*, 2009:210). The census study was deemed to be suitable to use in this research study with a smaller population from The Innovation Hub of 400 high technology SMEs. The approximate sample unit obtained for the purpose of this study from the registered members of The Innovation Hub is the population. The Gauteng region was selected as most of the South African SMEs with a high-level of ICT distribution are based in the province (Adeniran & Johnston, 2016:70).

1.7.4 Data collection

The data was collected by means of a questionnaire by the researcher in person and via an e-mail link. The measurement levels of the constructs are discussed below.

1.7.4.1 Constructs of the study

"A construct is a general idea or an abstract inferred or derived from specific instances" (Sreejesh, Mohapatra & Anusree, 2014:108). The focus of the study was to determine whether there was a consequential statistical relationship among constructs resulting in the low adoption rate of green ICT. Table 1.1 depicts the foremost barriers (constructs) identified in the literature that have a significant impact on green ICT adoption.

Table 1.1: Summary of constructs

Constructs
Barriers
(1) Lack of awareness
(2) Lack of knowledge
(3) Lack of expert ICT skills
(4) Legislative regulations
(5) Lack of funding

Source: Author's own composition (2019)

1.7.4.2 Measurement level for constructs

The study made use of nominal and ordinal levels of measurement to assess categorical data received from primary sources (Salkind, 2014:160-163). An empirical primary data collection approach was followed, and a self-administered survey was conducted to gather information from the participants directly.

1.7.5 Data collection instrument

A self-administered questionnaire survey was used from an online software tool (SurveyMonkey®). SurveyMonkey® is an online survey tool whereby a research questionnaire can be designed, information collected, processed and examined within the software (Saunders *et al.*, 2009:365). The survey design allows indirect observation through structured interviews, questionnaires and obtains an extensive overview of a sample of a larger population (Mouton, 2016:152-153). The selected participants received an e-mail with a link inviting them to take part in the study and directing them to the website. The participants in the survey were also guaranteed anonymity.

1.7.6 Data analysis

Data analysis was conducted by using the IBM Statistical Package for the Social Sciences (SPSS), Version 25. To determine the degree to which the barriers contributed to the low adoption rate of green ICT in South African SMEs, descriptive (central tendency, dispersion), multivariate (univariate and bivariate analysis) and inferential (independent-samples t-test, Pearson's product-moment coefficient) statistical analysis were used to analyse and examine the constructs (Saunders *et al.*, 2009:444; Hair, Black, Babin & Anderson, 2014:35-36; Zikmund, Babin, Carr & Griffin, 2009:516; Bereson, Levine & Krehbiel, 2012:264; Pallant, 2011:128). Comparing the distribution of scores and scientific analysis of the data assisted in the interpretation of the results linked to the research problem and research objectives.

1.7.7 Validity and reliability

This section presents a description of the validity and reliability measurements to be used in the research study.

1.7.7.1 Validity

Validity is described as the capability of a measurement tool to measure what is intended to be assessed (Kumar, 2011:178). The construct validity approach was followed to test the variance among the constructs both allied and unallied. Moreover, external validity was used to determine the level of generalisability that can be reached according to the original sample compared to another sample (Leedy & Ormrod, 2010:99-100).

1.7.7.2 Reliability

This refers to a measurement that reflects consistency by assessing the same object through a test several times and obtaining the same results (Saunders *et al.*, 2009:156). In this study, internal consistency will be used to measure reliability using Cronbach's alpha coefficient. It assesses the reliability of answers throughout the questionnaire be it the reliability of the answers to all the questions or merely the reliability of the answers in subsections.

1.7.8 Correlation analysis

Correlation analysis measures the magnitude of a linear relationship between two variables which indicates either a positive (+1) or negative (-1) relationship based on the direction and values (Pallant, 2011:128). This provided insight into the constructs (barriers) with the strongest underlying correlation (objective 2 of research) resulting in the low green ICT adoption in South African SMEs.

1.8 LIMITATIONS OF THE STUDY

The study may be affected by the fact that data was only collected from high technology-based SMEs and limited by the sample size obtained from one specific region in South Africa (Gauteng). Further limitations might be due to budget and time constraints.

1.9 OUTLINE OF CHAPTERS

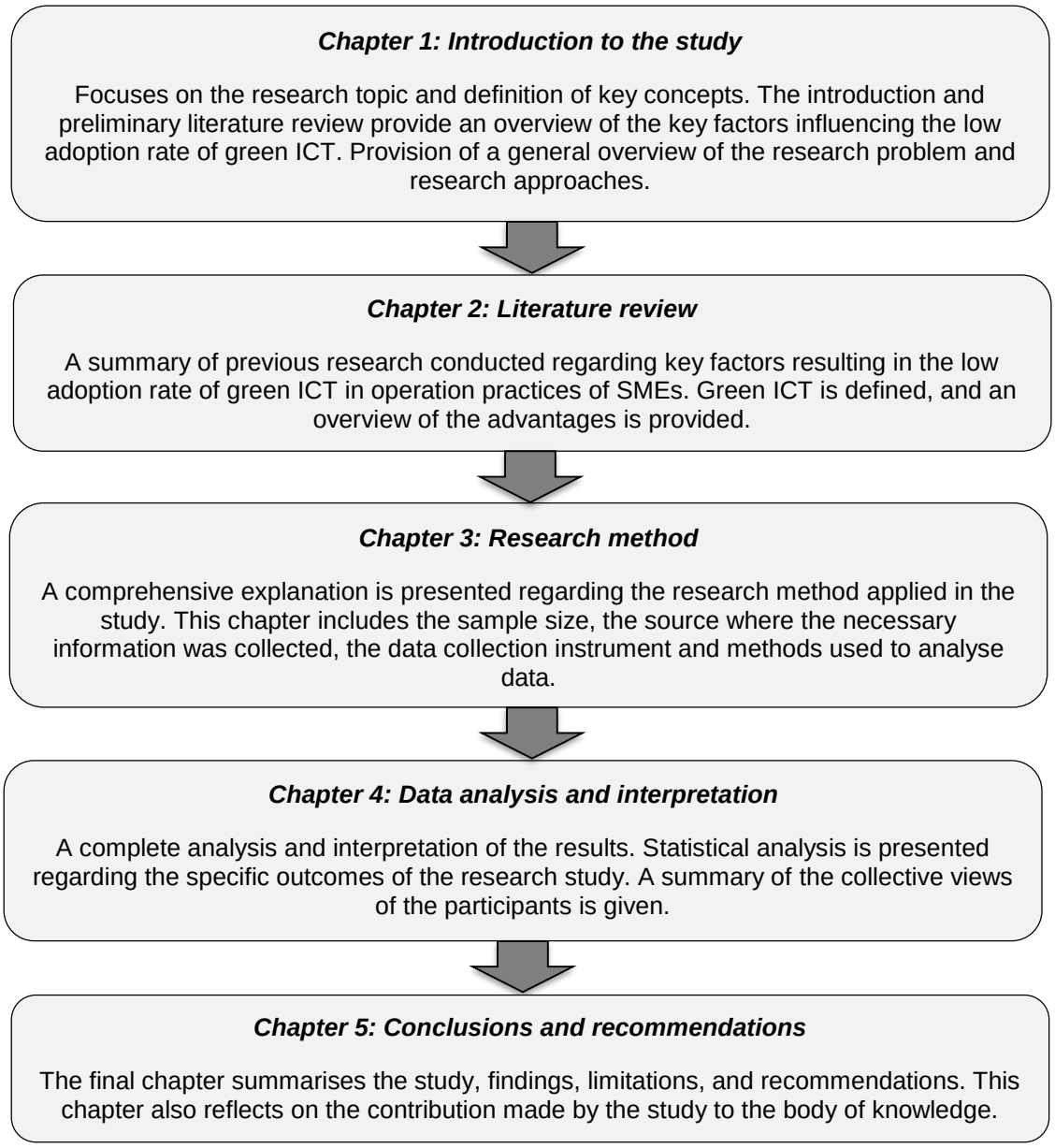


Figure 1.3: Outline of chapters
Source: Author's own composition (2019)

1.10 CHAPTER SUMMARY

Chapter 1 illustrates the importance of the research study on the low adoption rate of green ICT in South African SMEs. In Section 1.1 the concept of green ICT is addressed. Section 1.2 presents a background to the research study. In this section, the relevance and challenges of green ICT in SMEs are discussed. Section 1.3 to 1.6 presents the formulated research problem regarding the low green ICT adoption rate in South African SMEs. Section 1.7 provides a comprehensive picture of the research method deemed appropriate for the study. Sections 1.8 highlight aspects related to the certain limitations of the study. The chapter concludes with an outline of the chapters in section 1.9 and concluding remarks are made regarding the study in section 1.10.

This research study investigates and reports on the low green ICT adoption rate in South African SMEs. This is still a relatively new research area that is not well presented in the literature. It investigates the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs. The primary and secondary objectives help to obtain a better understanding of the topic under discussion (see Table 1.2). In Table 1.2 a summary of the research study is shown together with the formulated research problem as well as the objectives, research questions and motivation for the study.

Table 1.2: Summary of the study

Research problem	Objectives	Research questions	Motivation for the study
• The problem is the low green ICT adoption rate in South African SMEs	*Primary objectives*: • To identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs *Secondary objectives:* • To determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs • To recommend strategies on how to improve the adoption rate of green ICT in South African SMEs	*Primary research question:* • What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs? *Secondary research questions:* • What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs? • What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?	• The motivation for the study can be found in the fact that the findings might contribute to the body of knowledge on the low adoption rate of green ICT in South Africa. • The research study envisaged to fill the void in the literature regarding the limited research on the low adoption rate of green ICT (Bekaroo *et al.*, 2016:1592). • A literature review revealed that the reasons for the low adoption rate of green ICT should be investigated in more detail to determine why green initiatives such as cloud computing are adopted at a low rate in sub-Saharan Africa (Yeboah-Boateng & Essandoh, 2014:13-14). • This study will also examine the green ICT principles that may influence the low rate of adopting green technology into regulations to protect the environment (Radu, 2016:743). • South Africa is the largest emitter of carbon dioxide in Africa producing 24% of all Africa's emissions *(*Radu, 2014:434). It is therefore imperative to understand the reasons for the reluctance of South African SMEs to adopt green ICT practices to address this problem. • Many researchers are also inviting more research on the development of greener technologies (Tuskeentushi *et al.*, 2013:11; Baggia *et al.*, 2019:1589; Capasso *et al.*, 2019:400).

Source: Author's own composition (2019)

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter presents a critical review of existing literature by highlighting some of the challenges faced regarding the barriers for the adoption rate of Green ICT. This chapter will proceed according to the flow diagram represented in Figure 2.1.

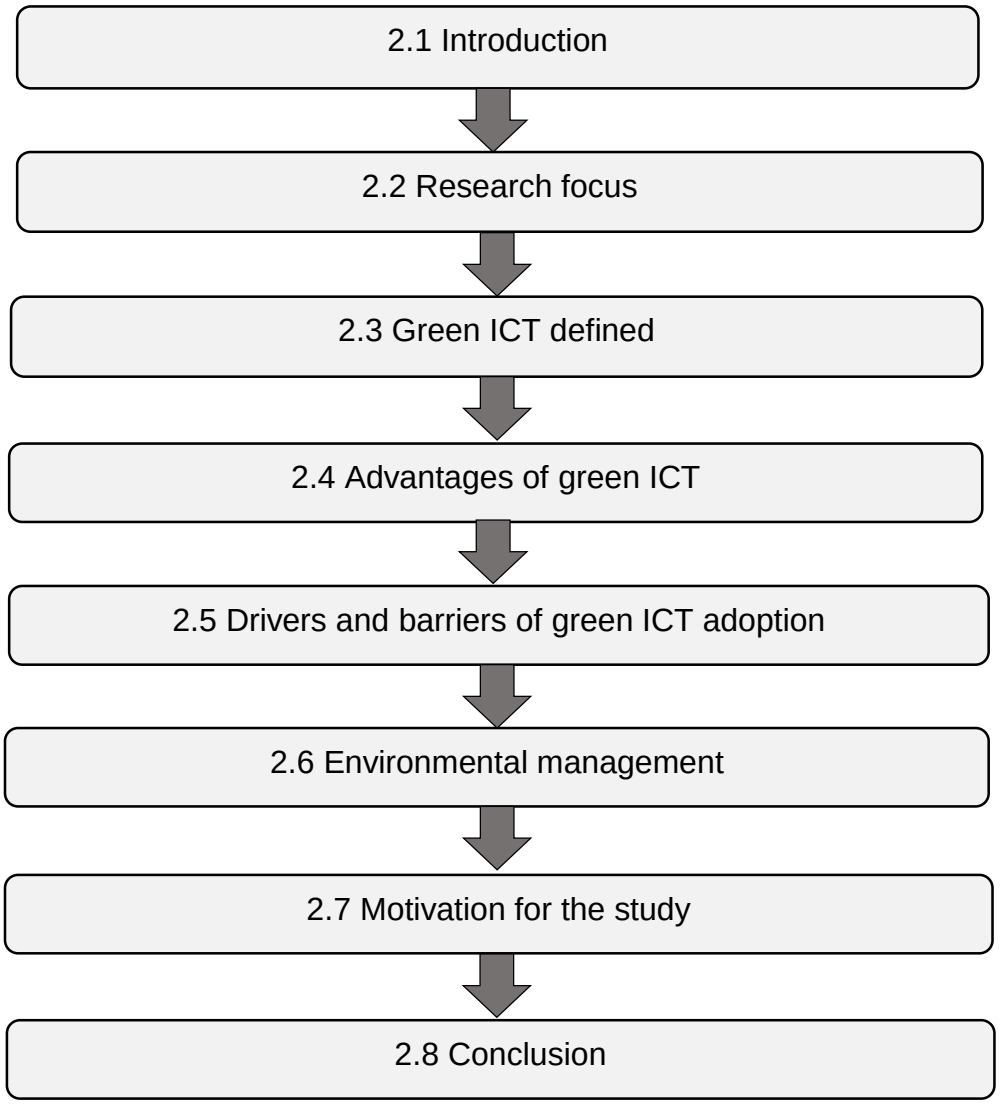


Figure 2.1: Flow diagram of Chapter 2
Source: Author's own composition (2019)

First, an outline of Chapter 2 is provided and background on green ICT is given. In section 2.2 the research focus is presented by linking it to the literature. Then in section 2.3, a general understanding of the definition of green ICT is explained. Next, the advantages of green ICT are addressed in section 2.4. This is followed by a detailed discussion about the different drivers and barriers resulting in the low adoption rate of green ICT in section 2.5. Next, environmental management is discussed in section 2.6. Afterwards the motivation for the study is discussed in section 2.7. Lastly, a conclusion is presented in section 2.8.

2.1.1 Background on green ICT

In this section, a background on green ICT is given to provide a context for the problem regarding the low green ICT adoption rate. Sustainability generally consists of three essential pillars - economic, social and environmental and has become a key factor in preventing the exploitation of resources (Kim & Kim, 2017:1011). According to Aghelie (2017:42), sustainability is defined as meeting the current requirements without jeopardising the wellbeing of the requirements for future generations. Garg and Singla (2017:1) state that SMEs in the information technology (IT) industry has increased but these enterprises are unaware of the significance of environmental sustainability. This is taken further by Corrocher and Solito (2017:569) who believe that big corporations tend to invest more in environmental sustainability through green research and development, whereas SMEs attempt this too to some degree but with limited resources. SMEs therefore, play an important role in the sustainability of society.

Dezdar (2017:292) points out that sustainable development is a global concern and green IT is considered an essential eco-friendly practice to adopt. This idea is also reflected by Muafi (2015:722) that green IT consists of “environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which include the cost of disposal and recycling”. The latest statistics reveal that the ICT industry is now liable for 3% of the CO_2 emissions globally including other toxins, and green ICT is viewed as one of the ways through which SMEs can reduce the impact on the environment (Garg & Singla, 2017:2).

Andreopoulou (2016:495) describes green ICT or ICT for sustainability as “an approach of efficient and effective design, manufacturing, use and disposal of computers, servers, and associated sub-systems in order to achieve reduction of energy, emissions, and consumption resources”. It can thus be said that different concepts are used synonymously for green ICT which leads to the enhancement of more green business processes.

Nizam and Vilhi (2018:238) indicate that a positive attitude of employees towards green ICT in a corporation from the bottom to the top of the hierarchy increases the adoption rate of green ICT. Green ICT is multifaceted and should be effectively used to impact the business operations and procedures in companies such as the organisational culture while decreasing the ecological footprint (Hankel *et al.,* 2017:91-92). Moreover, sub-Saharan Africa has been rated among the world’s top ten rapidly developing economies on the rise (Asongu, Le Roux & Biekpe, 2018:210). De Wet and Koekemoer (2016:264) have pointed out that South Africans are also shifting towards a position where ICT has become an important part of life through constant connectivity. This research study will thus provide an overview of the current state of the green ICT adoption rate in South African SMEs. Against this background, this research study can be considered imperative to address the low green ICT adoption rate which is specifically evident in South African SMEs.

2.2 RESEARCH FOCUS

In this section, the research focus is reiterated by addressing the research problem, objectives and questions.

2.2.1 Research problem

The research problem under investigation is the low green ICT adoption rate in South African SMEs (Mohlameane & Ruxwana, 2014:6). Pattinson (2017:1238) mentions that the fairly short lifecycle of ICT appliances usually leads to a harmful impact on the

environment by the end of their lifecycle when disposed. The energy demands in Africa have significantly increased by about 45% between 2000 and 2012, and further growth is expected to reach up to 80% in 2030 (Shen & Power, 2017:678).

Green ICT is regarded as a fairly new research area and a complex topic that is growing rapidly and with few research studies this has led to a void in the literature (Verdecchia, Ricchiuti, Hankel, Lago & Procaccianti, 2017:43-47). More green ICT research is therefore required to fill the void in the literature; a relatively small number of studies were published between 2003 and 2015, and a slight increase started to show from 2009 onwards (Verdecchia *et al.*, 2017:41). Green ICT, which consists of both green IT and green information system (IS), is also seen to be capable of addressing numerous ecological challenges (Dalvi-Esfahani, Ramayah & Nilashi, 2017:585). It is important to conduct this research as ICT is on the rise as one of the fastest-growing trends resulting in high energy consumption impacting the future sustainability of the environment.

2.2.2 Research objectives

There are numerous barriers that prevent SMEs from adopting green ICT (Silajdžić *et al.*, 2015:376; Corrocher & Solito, 2017:571-573; ASAF, 2014:131-160; Dalvi-Esfahani *et al*., 2017:595; Ongondo, Williams, Dietrich & Carroll, 2013:2603; Aghelie, 2017:46). Thus, the key areas to be investigated for this research study are the barriers playing a leading role in the hindrance of adopting green ICT. In response to this, the primary research objective was to identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs.

The secondary objectives of this research study were the following:

- To determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South Africa SMEs.
- To recommend strategies on how to improve the adoption rate of green ICT in South African SMEs.

2.2.3 Research questions

To determine the barriers resulting in the low adoption rate of green ICT, the following research questions were set. The primary research question addressed is as follows: What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs?

The secondary research questions examined by the study are as follows:

- What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs?
- What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?

Figure 2.2 shows the link between the research problem, objectives, questions and literature to be discussed next (see sections 2.3, 2.4, 2.5 and 2.6).

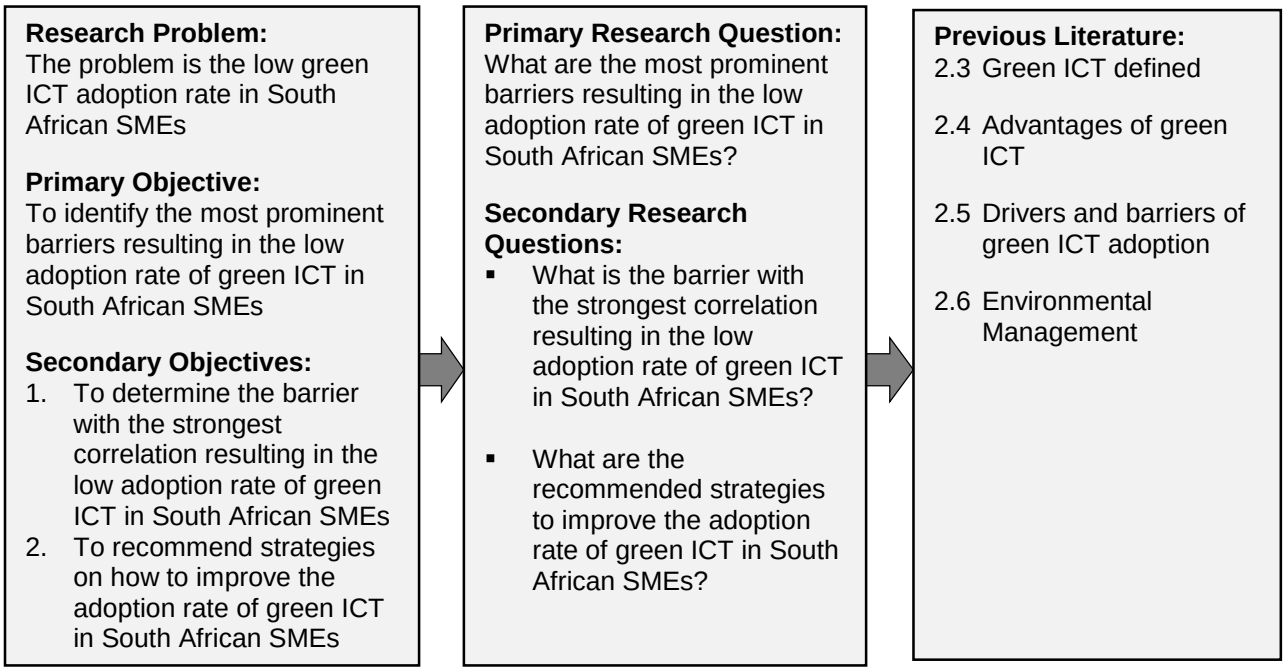


Figure 2.2: Link between the research problem and literature
Source: Author's own composition (2019)

2.3 GREEN ICT DEFINED

Green technology is defined as an eco-friendly technology used to protect the ecosystem and natural resources by lessening the negative effect of human actions, to diminish waste (Ramdhani, Aulawi, Ikhwana & Mauluddin, 2017:955). The Academy of Science of South Africa (ASSAf) (2014:53-61) emphasise five important sectors based on national policies that direct green technologies, namely energy, water, waste, buildings, and information and communication. However, this study will focus on ICT-related sectors as green ICT doesn't only impact the ICT industry but other sectors as well. Prior to the 2017 statistics mentioned in section 2.1.1, ASSAf (2014:115) reported that the ICT industry is accountable for 2% of CO_2 emissions globally but can decrease the outstanding 98% released by non-ICT sectors.

According to Malison and Thammakoranonta (2018:107), people are becoming more familiar with green terminologies but there is still a low degree of awareness regarding the term 'green ICT' especially in developing countries. Dezdar (2017:292) explains that the concepts of green IT, green computing or ICT sustainability were created due to the high energy usage that has turned into a serious concern from an ecological or economic viewpoint. Thus, some unclearness still exists regarding the definition of green ICT despite of the important role it plays due to the similarity in concepts used.

Malison and Thammakoranonta (2018:108) refer to green of ICT as a process that takes into consideration the effect of ICT on environmental conditions both from an implicit or explicit perspective, and favourable or unfavourable perspective. A similar stance is taken by Deng, Ji and Wang (2017:147-148) who believe that green IT can be differentiated into an internal approach based on practices within the IT sector or external approaches which focus on the improvement of sustainability in other industries. It is therefore clear that there is a variety of concepts regarding green ICT. These concepts can be seen as collective activities directed at decreasing the harmful impact of technology on the environment. Even though the ICT industry contributes towards CO_2 emissions, it has the potential to decrease this negative impact through technological tools.

In Table 2.1 below a summary of the various concepts related to green ICT is provided. This is based on the literature which uses these different terminologies and definitions.

Table 2.1: Definitions of concepts related to green ICT

Concept	Definition	Source
a) Eco-innovation (green innovation or sustainable innovation)	"innovation towards more sustainable processes in which resource use and waste production remain within proper environmental limits"	Kılkış (2016:235)
	"innovations that contribute to a sustainable environment through the development of ecological improvements"	Xavier, Naveiro, Aoussat & Reyes (2017:1281)
b) ICT for sustainability	"a field which provides a critical perspective that challenges every technological solution by assessing its impact at the societal level"	Pattinson (2017:12941)
c) Environmental technologies	"in general refer to new or modified processes and products that enable companies to reduce environmental damages compared to relevant alternatives"	Ozusaglam, Kesidou & Wong (2018:114)
d) Efficiency-increasing technologies	"refer to the adoption of new production methods and/or modification of existing methods that reduce input or energy usage (prevent pollution by increasing operational efficiency)"	Ozusaglam *et al.*, (2018:114)
e) Green computing	"refers to the practice of using information technology with little harm to the environment in particular and the society in general"	Banerjee, Sing, Chowdhury & Anwar (2018:90)

Source: Author's own composition (2019)

As reflected in Table 2.1, one can recognise the similarities and common goals about green ICT which is to protect the environment. According to Hilty and Aebischer (2015:15), the terms “green IT” and “green ICT” are used synonymously and gained popularity in 2007 after the publication of a report. From Table 2.1 and Table 2.2 key concepts can be extracted to formulate a single definition of green ICT for this research study.

Table 2.2 provides a summary of the various homogenous terminology found in the definitions of green ICT.

Table 2.2: Summary of similar green ICT terminology

Concept	Common terms used in the literature
Green ICT similarities	Enhancing sustainable energy, reducing environmental harm, promoting environmental responsibility, increasing operational efficiency practices, reengineering of production processes, reducing energy consumption, stay within the ecological limits, enhancing environmental technology initiatives.

Source: Author’s own composition (2019)

As can be seen, there is no unique single definition of green ICT that emerges from the literature. Based on the uniqueness of the green ICT concept, this research study will adopt the following definition:

“The study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimal or no impact on the environment” (Ardito & Morisio, 2014:24; Dezdar, 2017:294; Klimova, 2016:116; Hilty & Aebischer, 2015:15).

Thus, the literature uses many related terms interchangeably that can be linked to green ICT. For this study, the term “green ICT” was used to provide a clear context. Although a

broad overview of the literature on green ICT is presented, this research study will focus on the low adoption rate in South African SMEs, specifically in the ICT industry. Asongu *et al.*, (2018:210) report that sub-Saharan Africa is encountering increasing challenges regarding energy as well as increasing global warmings in this regard coupled with an upturn in the development of the economy. There is thus an urgent need to examine potential solutions and focus on the adoption of environmentally sustainable practices such as green ICT.

This section has provided clarity regarding key concepts of green ICT and identified a definition applicable to this research study. In the next section, the advantages of green ICT will be discussed.

2.4 ADVANTAGES OF GREEN ICT

Hojnik and Ruzzier (2017:583) indicate that 80.4% of eco-innovations lead to the reduction of costs and have an estimated throughput rate of 32% more. Green products use fewer resources, have lower impacts on the environment, and eliminate waste generation already at the conception phase (Fraccascia, Giannoccaro & Albino, 2018:1078). It is thus important to incorporate green ICT within SMEs as many of the green ICT practices are beneficial to both the enterprise and the environment.

Table 2.3 lists the different advantages related to green ICT practices.

Table 2.3: Advantages of green ICT

Advantage	Description of advantage	Source
a) Protecting the environment	Lessening GHG released, supports the reusability and the usage of material with a minimum negative effect.	Ardito & Morisio (2014:24)
b) Provides cost-effective and energy-efficient ways	Better quality performance of processes, decreases costs, enhances partnerships, lessens energy usage, decreases space utilised, and lessens CO_2 released.	Akman & Mishra (2015:477)

Advantage	Description of advantage	Source
c) Enhances environmental protection activities	Decreases the impact on the environment through efficient ICT operation processes and development of advanced information systems creates a shift towards a more environmentally sustainable attitude.	Baek & Park (2015:1310)
d) Saving of costs	The adoption of cloud computing reduces expenditure, increases competitiveness in the market, offers recovery solutions including automatic system updates and maintenance.	Kumar, Samalia & Verma (2017:26)
e) Fewer resources are utilised through the production of green products	Minor effect on the environment and prevents wastage as early as in the beginning phase of production.	Fraccascia, Giannoccaro & Albino (2018:1078)

Source: Author's own composition (2019)

From Table 2.3 it can be seen that the most noticeable advantage of green ICT is the shift towards the enhancement of more sustainable practices resulting in a positive impact on SMEs and the environment. Different factors can hinder the adoption of green ICT but it can be seen that the advantages have a far greater positive effect in the long run.

In contrast to these advantages identified in the literature, Abiola, Ashamu and Yekini, (2014:203) have reported that 42% of non-adopter SMEs in Nigeria indicated that ICT does not provide benefits. This view may be linked to various reasons such as the barriers addressed in section 2.5.2. Even though this is from a non-adopter's point of view about ICT and not green ICT, it still provides insight to how developing countries are lagging behind on the development of green ICT practices. Nevertheless, the advantages of green ICT override the above negative view as green ICT enables companies to keep up to date with the latest and most advanced technology trends in the market.

Fernandez, Procaccianti and Lago (2015:123) refer to the development of a web-based calculator that enables companies to calculate one-time savings (capital invested) and

monthly savings regarding electricity usage, CO_2 released and additional operational expenditures. It is therefore quite evident that there are numerous advantages for SMEs in adopting green ICT. At the same time, green ICT practices could enhance an enterprise's operational efficiency by aligning it with organisational strategies. In light of these advantages it can be concluded that it is important for SMEs to engage in green ICT practices to ultimately gain profitable advantages and shift towards a more sustainable environment.

2.5 DRIVERS AND BARRIERS OF GREEN ICT ADOPTION

ICT has become increasingly more convenient and popular with the public and business users all over the world. Currently, the universal policies of a green economy are challenging countries to move towards eco-friendlier innovation to secure a green world for future generations to come (Yang, Sun, Zhang & Wang, 2017:1369). Green ICT has developed in response to the increasing demand for technology devices and their overall impact on the environment and it is therefore highly important for SMEs to adopt green ICT.

The main focus of the study is on the key barriers hindering the adoption of green ICT, but an overview will also be provided on the key drivers leading to the adoption of green ICT to gain an overall view of the theory. To understand the industry and the problem of the low green ICT adoption rate, the researcher needed to obtain a more in-depth understanding of the key drivers and barriers impacting sustainable green practices in SMEs. These key drivers and barriers have been identified as the most important factors when considering the adoption of green ICT. The four key drivers that were identified in the literature are reduction in cost, competitive advantage, product life cycle and environmental conditions.

The following five key barriers were identified in the literature as hindering factors of green ICT adoption: lack of awareness, lack of knowledge, lack of expert ICT skills, legislative regulations and lack of funding. Green ICT adoption can thus be classified into two groups: the first group being the drivers pushing towards advancing the adoption of green

ICT and the second being the barriers pulling away from the adoption of green ICT. Green ICT adoption therefore, consists of a combination of push and pull factors.

2.5.1 Drivers of green ICT adoption

The key drivers are now addressed in more detail. The relevance of each of these drivers in practice is discussed to provide a better understanding. The four most frequent key drivers identified in the literature as motivators that push towards green ICT adoption are discussed in the sections below.

2.5.1.1 Reduction in cost

The reduction in cost is the most important driver in the adoption of green ICT and is seen as the most significant economic goal for many companies especially during times of economic depression (Fernandez *et al.*, 2015:108). It has been suggested that the reduction in cost is a key motivator for green ICT adoption to decrease various costs such as high tariffs (Díaz-García, González-Moreno & Sáez-Martínez, 2015:16). Ardito and Morisio (2014:29) proposed cloud computing as one of the green ICT practices to reduce data centre costs due to servers rated as the highest cost factor, at 53% of the total monthly data centre cost experience.

2.5.1.2 Competitive advantage

Competitive advantage refers to the ability of an enterprise to differentiate its products from other competitors in the market through cost-effective green practices (Hamann, Smith, Tashman & Marshall, 2017:30). Green ICT enterprises should be able to adjust easily to the various market requirements and adapt according to their current manufacturing processes (Kanda, Sakao & Hjelm, 2016:164). SMEs should thus aim at offering economical low carbon products with a minimum impact on the environment to satisfy the customers' needs and create competitiveness in the market for themselves (Verdolini, Bak, Ruet & Venkatachalam, 2018:3).

2.5.1.3 Product life cycle

The product life cycle refers to products that have an extended reproduction life cycle which includes the longevity of raw materials and recycling capabilities (Marcon, de Medeiros & Ribeiro, 2017:85).

Hilty and Aebischer (2015:23) state that the product life cycle consists of:

- activities whereby physical resources are required to manufacture ICT hardware;
- production of ICT hardware;
- supply of electrical energy for ICT processes; and
- the discarding of waste that can't be recycled.

Klimova (2016:116) concurs with this idea that green ICT deals with the sustainability of products over the entire life cycle to decrease the consumption of resources. A good example of this would include the recovering and reprocessing of electronic waste like IT systems, old hardware, computers and cell phones (Andreopoulou, 2016:493). According to Garg and Singla (2017:2), the components (rubber, glass, plastic and batteries) of IT devices consist of harmful elements such as mercury, lead, phosphors, and lithium at the end of their lifetime. It is therefore important to extend the lifetime of a product through green ICT practices which include but are not limited to re-using and recycling IT devices.

2.5.1.4 Environmental conditions

Environmental conditions refer to businesses actively participating in environmental activities that are profitable but also less harmful because they are employing green ICT practices (Muafi, 2015:723). Hojnik and Ruzzier (2017:584) believe that environmental investments lead to the increase of an enterprise's competitive advantage which out-turns into the reduction of costs through its competitiveness. Environmental management systems can improve the performance of a business and lead to an increase in earnings and a positive trademark of products (Ozusaglam *et al.*, 2018:113). It is predicted that the production of technological devices (computers, servers and cell phones) including the CO_2 released will dramatically increase by the year 2020 (Ardito & Morisio, 2014:27).

In Table 2.4 the key drivers characterised with the most significant push factors towards the adoption of green ICT are set out, namely reduction in cost, competitive advantage, product life cycle and environmental conditions. A collective description is presented for the four key green ICT drivers identified in the literature. Table 2.4 provides a summary of the literature explored and shows the source, country and economic status about the drivers found in the literature.

Table 2.4: Key green ICT drivers

Drivers (collective description)	Source	Country	Status (economy)
a) Reduction in cost: • Innovative green ICT hardware and software can decrease costs, improve performance and lessen the effect on the environment. • Green technologies enhance the manufacturing effectiveness of companies and decrease operational expenditure like maintenance. • The reduction in operational costs can take place through eco-friendly enterprise practices, intelligent utilisation of green ICT in resolutions, cost-effectiveness by improved energy efficiency and smarter utilisation of materials.	Chou (2013:233)	Global perspective	Developed and developing
	Masud & Malik (2014)	Malaysia	Developing
	ASSAf (2014:145)	South Africa	Developing
	Akman & Mishra (2015:477)	Turkey	Developing
	Hankel *et al.*, (2017:91)	Netherlands	Developed
	Corrocher & Solito (2017:571)	European Union	Developed
	Marcon *et al.*, (2017:88)	Brazil	Developing
	Banerjee *et al.*, (2018:96)	Global perspective	Developed and developing
	Radu (2016:735-737)	Global perspective	Developed and developing
	Zhang & Liang (2012:1004)	China	Developing

Drivers (collective description)	Source	Country	Status (economy)
	Mele & Russo-Spena (2015:13)	Italy	Developed
	Buchalcevova & Gala (2013:46)	Czech	Developed
	Buchalcevova & Gala (2012:111)	Czech	Developed
	Anthony & Majid (2016:23)	Malaysia	Developing
	Wabwoba *et al.*, (2013:94)	Kenya	Developing
b) Competitive advantage: • Enhances market entree of businesses through the production of green products as customers are more green-conscious. • Green technologies are seen as an essential part of a business to obtain competitiveness and a crucial element in building the business world in the long run. • Cost-effective fees charged on goods and services along with the decrease of environmental effects. Integration of key capabilities and skills with enterprise training, up-to-date infrastructure, incentives and inventive technologies. Reduction in energy costs. Distinctiveness in the marketplace from a competitor through green ICT initiatives.	Chou (2013:233)	Global perspective	Developed and developing
	ASSAf (2014:143)	South Africa	Developing
	Akman & Mishra (2015:484)	Turkey	Developing
	Cecere & Mazzanti (2017:88)	European Union	Developed
	Aghelie (2017:45)	Global perspective	Developed and developing
	Hamann *et al.*, (2017:28)	South Africa	Developing
	Ozusaglam *et al.*, (2018:113-115)	European Union	Developed
	Banerjee *et al.*, (2018:90)	Global perspective	Developed and developing
	Radu (2016:735-737)	Global perspective	Developed and developing

Drivers (collective description)	Source	Country	Status (economy)
	Abdullah et al., (2016:691)	Malaysia	Developing
	Buchalcevova & Gala (2013:46)	Czech	Developed
	Anthony & Pa (2015:43)	Malaysia	Developing
	Yang *et al.*, (2017:1377)	China	Developing
	Buchalcevova & Gala (2012:111)	Czech	Developed
c) Product life cycle: • Related to minimising the usage of the limited physical resources available through the effective use of green manufacturing processes such as recycling. For example, 90% of technology devices such as computers and cellular phones can be reprocessed. The life cycle assessment is a technique utilised to evaluate the life cycle effect of products. • Green designing taking into consideration the product itself, procedures and ecological effects such as recycling at the design phase. Incorporating environmental-friendly procedures and technology in green lifecycle practices. The complete life cycle of a product consisting of extrication of natural resources, production, transport,	Hilty & Aebischer (2015:23)	Global perspective	Developed and developing
	Andreopoulou (2016:493)	European Union	Developed
	Klimova (2016:116*)*	Global perspective	Developed and developing
	Marcon *et al.*, (2017:85)	Brazil	Developing
	Abdullah *et al*., (2016:699-700)	Malaysia	Developing
	Anthony & Pa (2015:41-42)	Malaysia	Developing
	Aleksic (2014)	Austria	Developed
	Buchalcevova & Gala (2012:109-110)	Czech	Developed

Drivers (collective description)	Source	Country	Status (economy)
functionality, maintenance and re-using phases. The life cycle assessment is a method used to determine the environmental effect of a product throughout the entire life cycle.			
d) Environmental conditions: • International Organisation for Standardisation (ISO) 14001 improves the performance rate of companies. Environmental management systems can increase the profitable and ecological performance of a business. CO_2 emissions released in the atmosphere are reduced by businesses that are pursuing green ICT solutions. Green ICT contributes towards the safeguarding and rebuilding of the natural environment. • Upfront investments in environmental management can improve return on investment in the long run. • Factors influencing the environment consist of "pollution and diminishing of exhaustible resources and global warming" leading to the rising importance of the environmental aspect to be considered through the entire product lifecycle. Green ICT	Cuerva, Triguero-Cano & Córcoles (2014:105-06)	Spain	Developed
	Muafi (2015:723)	Indonesia	Developing
	Akman & Mishra (2015:477)	Turkey	Developed
	Andreopoulou (2016:494)	European Union	Developed
	Hojnik & Ruzzier (2017:584).	European Union	Developed
	Corrocher & Solito (2017:573)	European Union	Developed
	Aghelie (2017:45)	Global perspective	Developed and developing
	Ozusaglam *et al.*, (2018:113)	European Union	Developed
	Radu (2016:735, 740, 741)	Global perspective	Developed and developing
	Yang *et al*., (2017:1371, 1377)	China	Developing
	Mele & Russo-Spena (2015:10, 19-20)	Italy	Developed

Drivers (collective description)	Source	Country	Status (economy)
viewed as an essential resolution to address environmental challenges as it decreases energy usage. The rapid development of emerging economies resulting in high levels of CO_2 emissions mostly due to the reliance on natural resources such as coal.	Buchalcevova & Gala (2013:43)	Czech	Developed
	Abdullah *et al.*, (2016:685)	Malaysia	Developing
	Chen & Chang (2013:107)	Taiwan	Developing
	Zhang & Liu (2015:12)	China	Developing
	Wabwoba *et al.*, (2013:94)	Kenya	Developing
	Lee (2017:1123)	Korea	Developing

Source: Author's own composition (2019)

Corporate social responsibility (CSR) is also viewed as a driver for the adoption of green ICT (Nizam & Vilhi, 2018:238). Reuvers (2015:4) believes that green innovation can be utilised to accomplish CSR objectives although it can still occur in the absence of CSR. Hence, CSR can be seen more as a benefit and does not appear as a major push factor and relates more to larger companies than SMEs. Apart from drivers, numerous barriers are resulting in the low adoption rate of green ICT in SMEs which will be examined in greater detail in section 2.5.2.

2.5.2 Barriers of green ICT adoption

Reflecting on the problem statement in section 2.2.1, it is important to reiterate that the main focus of the study is to investigate the low green ICT adoption rate in South African SMEs. The key focus of the study is on barriers which are addressed in more detail to gain a clear understanding and to make recommendations (objective 3 of the research) on how to overcome these specific barriers. The five most frequent key barriers were

identified in the literature and are deemed to impact the adoption rate of green ICT. These key barriers are discussed in the subsections that follow.

2.5.2.1 Lack of awareness

There appears to be an unawareness about technology and the positive influence of certain technologies to elevate social, economic and environmental sustainability (ASSAf, 2014:25). Uninformedness regarding organisational and environmental policies provides a barrier in gaining the advantages that green ICT presents through efficient productivity (Díaz-García *et al.*, 2015:14). According to Robinson and Stubberud (2015:130), the acknowledgement of green awareness by SMEs doesn't ensure a definite change towards green practices if a business lacks the necessary resources for adoption. It is therefore clear that green ICT barriers are interlinked as one barrier may have an impact on another.

2.5.2.2 Lack of knowledge

Lack of knowledge may result in an unclear perception regarding green ICT without insight to change for the better (Hankel *et al.*, 2017:89). It has been suggested that insufficient information leads to a lack of knowledge about the selection of green ICT adoption (Gu, Lago & Bozzelli, 2015:285). According to Ociepa-Kubicka and Pachura (2017:286), inadequate knowledge regarding the profitable advantages of green ICT creates a barrier for adoption. A similar stance is taken by Garg and Singla (2017:2) who believe that green ICT cannot be put into practice if there is a lack of knowledge regarding green ICT.

2.5.2.3 Lack of expert ICT skills

A shortage of multiple skills to enhance the competencies of the adoption of green technologies such as innovative technical skills is another barrier (ASSAf, 2014:137) is another barrier. It has been suggested that employees with inadequate skills in environmental management are reluctant to undertake green practices due to a lack of their expertise (Abdullah *et al.*, 2016:689). Chou (2013:234) holds the view that a lack of

expertise to apply and use knowledge management principles creates a barrier in adopting green ICT practices. Thus, a lack of high-level trained skilled employees presents a hindrance to the successful utilisation of green ICT tools.

2.5.2.4 Legislative regulations

Legislative regulations are often viewed as complicated and tedious government procedures that provide uncertainty and are a hindrance to the development of green technologies (ASSAf, 2014:136). According to Osembe and Padayachee (2016:1288), government regulations and legalised matters present a barrier in terms of green ICT adoption practices such as cloud computing. Ociepa-Kubicka and Pachura (2017:285) point out that unpredicted changes in government laws, be they more considerable or stringent, may cause a negative effect on certain green innovations. Thus, unclear legislative regulations create vagueness and governments should ensure that policies are well balanced and transparent.

2.5.2.5 Lack of funding

The lack of funding is recognised as one of the most notable barriers to sustainable innovation due to financial constraints encountered, especially in developing countries (Kılkış, 2016:236). Continuous investments are required to assure the sustainability of green technology and not only research and development capital upfront (ASSAf, 2014:139). Financial hindrances for SMEs differ among the various industries and countries but have quite a large impact on smaller and informal enterprises, especially in developing countries (Verdolini *et al.*, 2018:4). Thus, serious financial shortages are encountered internationally although limitations of funding may differ and are further addressed in Table 2.5.

In Table 2.5 the key barriers characterised with the most significant pull factors hindering the adoption of green ICT are set out, namely lack of awareness, lack of knowledge, lack of expert ICT skills, legislative regulations and lack of funding. A collective description is

presented regarding the five key green ICT barriers identified in the literature. To further highlight the literature reviewed, Table 2.5 reflects the source, country and economic status of the research studies conducted.

Table 2.5: Key green ICT barriers

Barriers (collective description)	Source	Country	Status (economy)
a) Lack of awareness: • Relates to a reduction in operational costs through eco-friendly enterprise practices, intelligent employment of green ICT in resolutions, cost-effectiveness by improved energy efficiency and smarter utilisation of materials. Unfamiliarity with the implementation of green practices prevents adoption. • Inadequate awareness hindering green operation processes from being successful in enterprises. Inadequate awareness of green information applicable to the marketplace resulting in green ICT hindrances to enterprises. Inadequate awareness of technology preventing enterprises from recognising prospective advantages gained through the adoption of green ICT.	Suzuki (2015:231)	Underdeveloped countries view	Developing
	Radu (2016:735-737)	Global perspective	Developed and developing
	Verdecchia *et al.*, (2017:43)	Global perspective	Developed and developing
	Aghelie (2017:46)	Global perspective	Developed and developing
	Ramdhani *et al.*, (2017:958)	Indonesia	Developing
	Malison & Thammakoranonta (2018:107-108)	Thailand	Developing
	Zhang & Liang (2012:1004)	China	Developing
	Buchalcevova & Gala (2013:47)	Czech Republic	Developed
	Abdullah *et al.*, (2016:688-700)	Malaysia	Developing
	Wabwoba *et al.*, (2013:95)	Kenya	Developing
	Mohlameane & Ruxwana (2014:6)	South Africa	Developing

Barriers (collective description)	Source	Country	Status (economy)
b) Lack of knowledge: • Insufficient knowledge about green practices is due to complexity, financial shortages, risk of failure and uncertainty about benefits. • No shared knowledge collaboration exists among companies on how to utilise green ICT to its full capacity. • Inadequate knowledge inhibiting green operation practices in enterprises. • Lack of knowledge of progress towards green ICT solutions such as cloud computing. • Inadequate knowledge preventing the adoption of green ICT practices.	Chou (2013:235)	Global perspective	Developed and developing
	Suzuki (2015:231)	Underdeveloped countries view	Developing
	Corrocher & Solito (2017:571)	European Union	Developed
	Aghelie (2017:46)	Global perspective	Developed and developing
	Hankel *et al.*, (2017:89)	Netherlands	Developed
	Ramdhani *et al.*, (2017:957)	Indonesia	Developing
	Zhan, Tan, Ji, Chung & Chiu (2018:240)	China	Developing
	Zhang & Liang (2012:1004)	China	Developing
	Abdullah *et al.*, (2016:688-700)	Malaysia	Developing
	Mohlameane & Ruxwana (2014:6)	South Africa	Developing
	Lundfall *et al.*, (2015:74)	Netherlands	Developed
c) Lack of expert ICT skills: • Extra training needs arise due to the complexity of green ICT and staff members need to be equipped with the necessary competencies for the adoption process. • A lack of suitable expertise limits companies in enhancing	Chou (2013:234)	Global perspective	Developed and developing
	ASSAf (2014:157)	South Africa	Developing
	Suzuki (2015:231)	Underdeveloped countries view	Developing
	Kanda *et al.*, (2016:164)	Sweden	Developed
	Aghelie (2017:46)	Global perspective	Developed and developing

Barriers (collective description)	Source	Country	Status (economy)
attractiveness in the market through green technologies. • Inadequate technical capabilities and poor expertise in green ICT operation processes.	Hankel et *al.*, (2017:89)	Netherlands	Developed
	Zhang & Liang (2012:1004)	China	Developing
	Buchalcevova & Gala (2013:47)	Czech Republic	Developed
	Abdullah *et al.*, (2016:704)	Malaysia	Developing
	Thomas, Costa & Oliveira 2016:695	Europe	Developed
d) Legislative regulations: • Carbon taxes implemented by legislation may lead to a rise in expenditures. • Insufficient support and unqualified abilities of government organisations provide unclearness regarding government policies. • Unclear legislative regulations regarding environmental protection resulting in the low adoption of green ICT as a significant imbalance exists among various countries. Governance within the law restricts environmental conservation participation. • Lack of appropriate lawful structures to address regulatory challenges within developing marketplaces of green ICT sector due to failing legislative regulations. Lack of governing support due to poor	Chou (2013:234)	Global perspective	Developed and developing
	Suzuki (2015:231)	Underdeveloped countries view	Developing
	Silajdžić e*t al.*, (2015:382)	Bosnia and Herzegovina	Developing
	Aghelie (2017:46)	Global perspective	Developed and developing
	Pattinson (2017:12939)	European Union	Developed
	Verdecchia *et al.*, (2017:43)	Global perspective	Developed and developing
	Radu (2016:736, 742)	Global perspective	Developed and developing
	Zhang & Liang (2012:1004, 1009)	China	developing
	Buchalcevova & Gala (2013:47)	Czech Republic	Developed
	Abdullah *et al.*, (2016:698, 704)	Malaysia	Developing

Barriers (collective description)	Source	Country	Status (economy)
understanding of green operation processes by government.	Thomas *et al.*, (2016:695)	Europe	Developed
	Wabwoba *et al.*, (2013:98-99)	Kenya	Developing
e) Lack of funding: • Uncertainty regarding the return on investment hinders the adoption of green ICT. Expenditure associated with mass production is costly due to insufficient capital. • A large amount of investment is required for green ICT to be adopted in businesses. • Large investments are required beforehand to cover the operational costs of green technology which constrain SMEs. • More capital is required for the development of new advanced green ICT products. High research and development costs are experienced by subsidiaries of ICT enterprises. High-priced controlling costs lead to poor alliances of green operation processes.	Chou (2013:234)	Global perspective	Developed and developing
	ASSAf (2014:139)	South Africa	Developing
	Cuerva *et al.*, (2014:105-106)	Spain	Developed
	Silajdžić *et al.*, (2015:382)	Bosnia and Herzegovina	Developing
	Suzuki (2015:231)	Underdeveloped nations view	Developing
	Kanda *et al.*, (2016:164)	Sweden	Developed
	Aghelie (2017:46)	Global perspective	Developed and developing
	Ramdhani *et al.*, (2017:959)	Indonesia	Developing
	Corrocher & Solito (2017:571)	European Union	Developed
	Verdolini *et al.*, (2017:4)	Global perspective	Developed and developing
	Verdecchia *et al.*, (2017:43)	Global perspective	Developed and developing
	Banerjee *et al.*, (2018:90)	Global perspective	Developed and developing
	Zhang & Liang (2012:1005)	China	Developing

Barriers (collective description)	Source	Country	Status (economy)
	Welfens & Lutz, (2012:159)	Germany	Developed
	Buchalcevova & Gala (2013:47)	Czech Republic	Developed
	Abdullah *et al.*, (2016:703)	Malaysia	Developing
	Thomas *et al.*, (2016:695)	Europe	Developed
	Bekaroo *et al.*, (2016:1592)	Mauritius	Developing

Source: Author's own composition (2019)

Government and legislation can be viewed as a driver (government loans or lower tax) and a barrier (lack of support in financing green projects) but are recognised more as an obstacle to be overcome (Aghelie, 2017:45-46). The main focus of this study is to investigate the barriers resulting in the low adoption rate of green ICT and therefore legislative regulations will be viewed as a barrier.

The literature also revealed that the adoption of ICT itself also presents barriers for SMEs in developing countries such as Nigeria whereby the most notable barriers are high costs and the concern of retaining their clientele (Abiola *et al.*, 2014:196). Similarly, Ziemba (2017:3) states that the lack of funding provides a barrier for European enterprises to adopt ICT. Therefore, it is important to note the resemblance in the barriers to the adoption of ICT and green ICT. Thus, some companies first need to overcome ICT challenges before they can look at implementing green ICT.

It appears that "South Africa is among the world's most carbon-intensive economies" (Alton, Arndt, Davies, Hartley, Makrelov, Thurlow & Ubogu, 2014:344). At the same time,

the environmental pollution of SMEs located in the European Union districts is rated close to 70% (Kousar, Sabri, Zafar & Akhtar, 2017:834). As can be seen in both Table 2.4 and Table 2.5, it is also evident that developed and developing countries experience similar drivers and barriers regarding the adoption of green ICT. However, the study focuses on the low adoption rate of green ICT taking into account that the adoption of ICT also presents similar barriers. In the next section, the valuable role played by environmental management is examined as it presents high-value opportunities for SMEs.

2.6 ENVIRONMENTAL MANAGEMENT

This section elaborates on environmental management as this is a main driver in the adoption of green ICT. Higgs and Hill (2019:27) point out that the majority (73%) of South African SMEs in the waste industry are not participating in environmental business practices and only 27% are ISO certified. Environmental management is described as activities intended at enhancing environmental capabilities by decreasing the depletion of resources and minimising the amount of waste disposal (Yang *et al.*, 2015:15344). This description is extended to include the following three motivators which were identified for the execution of environmental management within enterprises (Yang *et al.*, 2015:15345):

- Environmental regulations – an enterprise regarded as legal could forfeit fines when environmental standards are adhered to.
- Economic interest – environmental management also presents economic advantages such as increasing profit, enhancing quality of products and improving social image.
- Competitive advantage – implementation of environmental management operations could lead to a decrease in production expenditure and present favourable prospects.

The greening of ICT proposed the ICT industry as a potential solution to several environmental problematic concerns (Higón, Gholami & Shirazi, 2017:85). Moreover, Hojnik and Ruzzier (2017:582) draw attention to the rise in the number of enterprises

globally accredited by various environmental systems - the ISO 14001 being the predominant one. Simultaneously, ISO 14001 is highlighted as an environmental management system that implements environmental certification practices presenting a fundamental basis for the pioneering of effective environmental operations (Bossle, de Barcellos, Vieira & Sauvée, 2016:868). Figure 2.3 shows the key factors from an environmental management viewpoint that need to be considered to ensure the successful adoption of green ICT. These are the following:

- The type of green ICT tools such as cloud computing, expert systems, environmental apps, learning management systems, videoconferencing, collaborative systems, environmental database and management system.
- The type of green ICT practices such as green ICT strategies, ISO 14001 certification, environmental performance and monitoring, use of alternative energy sources, governance of green ICT services, electronic waste policy, green design and green manufacturing.
- The type of green ICT aims such as a decrease in GHG emission, adoption of energy-efficient production practices and adoption of recycling materials to reduce the usage of raw materials.

Furthermore, the ‘how’ factors in Figure 2.3 are presented by green ICT tools and green ICT practices that can be used daily in SME operations processes to adopt green ICT. The ‘what’ factors presented by green ICT aims indicate the ultimate positive outcome of green ICT in terms of environmental management; these aims are to reduce the negative impact of enterprises on the environment through less harmful operation processes and production of green products.

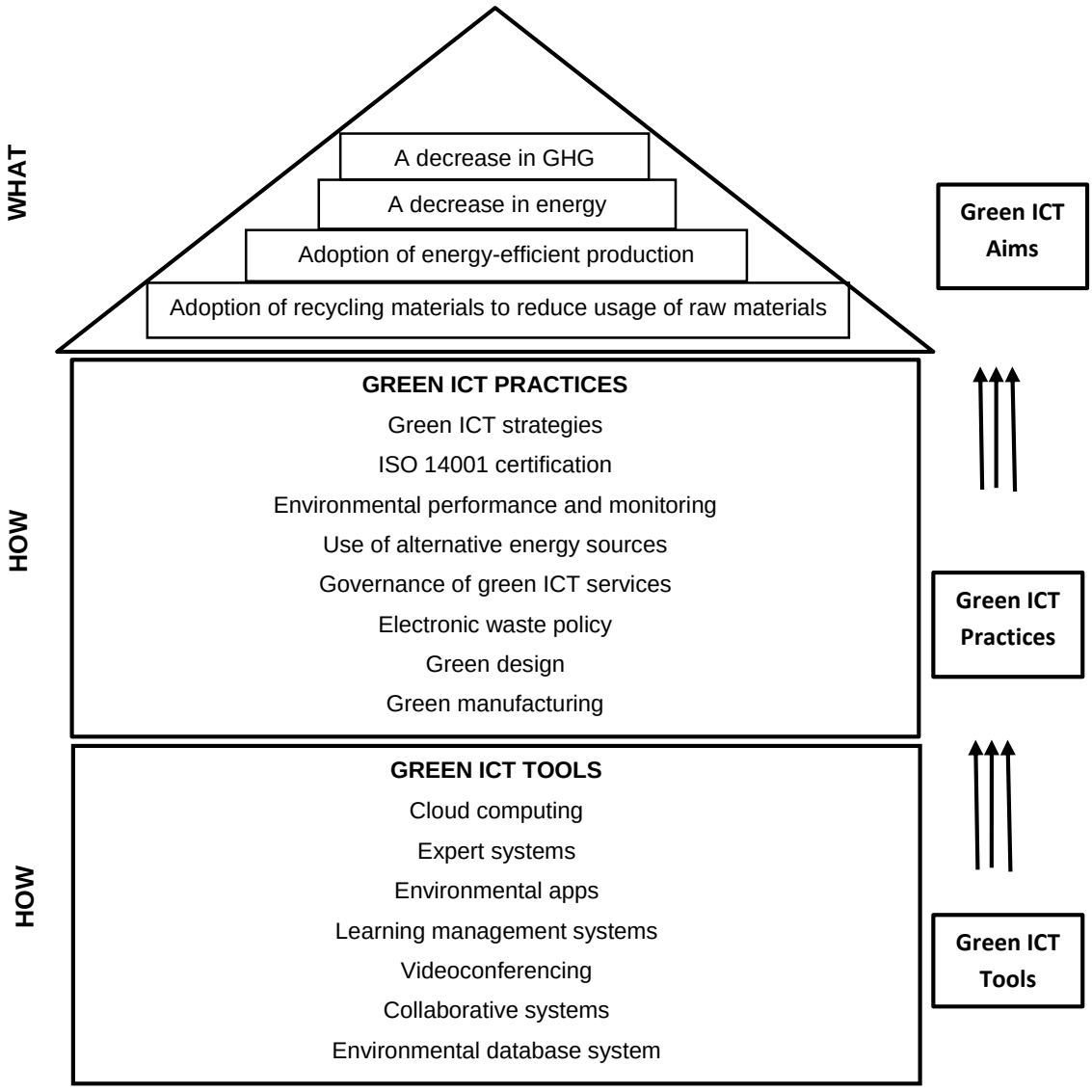


Figure 2.3: Green ICT adoption initiatives
Source: Adapted from Centobelli, Cerchione & Esposito (2017:1069)

Based on the information presented in Figure 2.3, the following assumptions can be made:

- Green ICT tools and green ICT practices are interlinked to achieve the overall green ICT aims to plan and strategise the adoption of green ICT.
- Collaboration is an important element to improve an enterprise's performance
- Multidimensional insight is presented in the form of three viewpoints, namely management viewpoint (goals), enterprise viewpoint (operation) and information and communication viewpoint (ICT tools).

This is supported by Malmodin and Bergmark (2015:37) who believe that the immense seriousness of the increase in GHG cannot be overstated. They believe that a reduction in GHG needs to take place by between 40% to 70% by 2050, to ensure that the global temperature does not rise by over 2%. Thus, this study recommends that green ICT practices be implemented to reduce the future impact of GHG on the environment as discussed in the next section.

2.7 MOTIVATION FOR THE STUDY

The study will contribute to the body of knowledge on the low adoption rate of green ICT in South Africa. This will provide SMEs with a greater understanding of the barriers resulting in the low adoption rate of green ICT and fill the void in the literature regarding this issue (Bekaroo *et al.*, 2016:1592). More importantly, the study will provide guidance on how the challenges of green initiatives such as cloud computing in sub-Saharan Africa (Yeboah-Boateng & Essandoh, 2014:13-14) can be addressed.

In addition, different initiatives and interventions among the policy makers are proposed for the facilitation of green ICT to protect the environment in terms of regulations (Radu, 2016:743). Collaboration can be one of the recommendations to improve the adoption rate of green ICT as researchers invite more research on the development of greener technologies (Tuskeentushi *et al.*, 2013:11; Baggia *et al.*, 2019:1589; Capasso *et al.*, 2019:400). Ultimately, the study would like to improve the understanding regarding the

reluctance of South African SMEs to adopt green ICT practices as South Africa is the largest emitter of carbon dioxide in Africa producing 24% of all Africa's emissions *(*Radu, 2014:434).

2.8 CONCLUSION

In this chapter, a critical review was provided on the importance of adopting green ICT. From the literature review, it is evident that there is a void in the literature regarding the reasons for the low adoption rate of green ICT, especially in developing countries

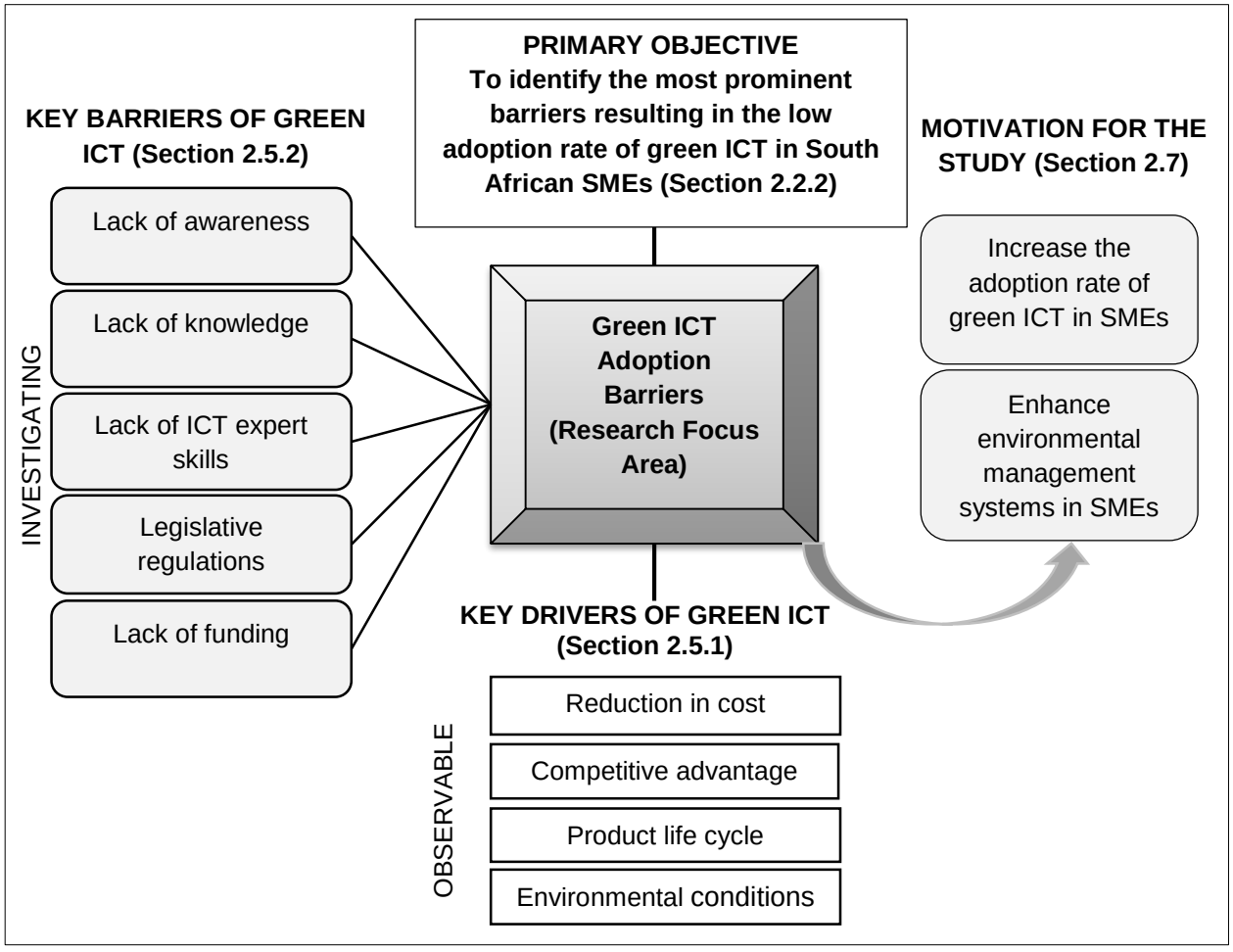


Figure 2.4: Summary of Chapter 2
Source: Author's own composition (2019)

From the summary in Figure 2.4, it is clear that the five key barriers identified in the existing literature - lack of awareness, lack of knowledge, lack of ICT expert skills, legislative regulations and lack of funding (section 2.5.2) - represent major hindrances resulting in the low adoption rate of green ICT. As mentioned in Chapter 1, SMEs play an important role in South Africa's economy. This means that SMEs can benefit greatly by adopting green ICT practices and that they need to recognise the importance that these practices have for the success of their businesses. This study would like to show how South African SMEs can succeed in adopting green ICT.

The study investigated the five key barriers identified to determine the most prominent barriers hindering the low adoption rate of green ICT. The study also examined which of these barriers had the strongest underlying correlation. From Table 2.5 it is evident that China and Malaysia have shown much interest in green ICT research from a developing country's point of view. However, from an overall perspective, the literature review suggests that green ICT has mostly been contextualised in developed countries rather than in developing countries.

In Chapter 3 the research method used in this study to examine the low adoption rate of green ICT will be explained. The research method adopted assisted in examining the status of green ICT for the selected South African SMEs of this research study.

CHAPTER 3: RESEARCH METHOD

3.1 INTRODUCTION

This chapter will look at the research method and methodology used in this study. Below is a flow diagram (see Figure 3.1) to show the structure of this chapter.

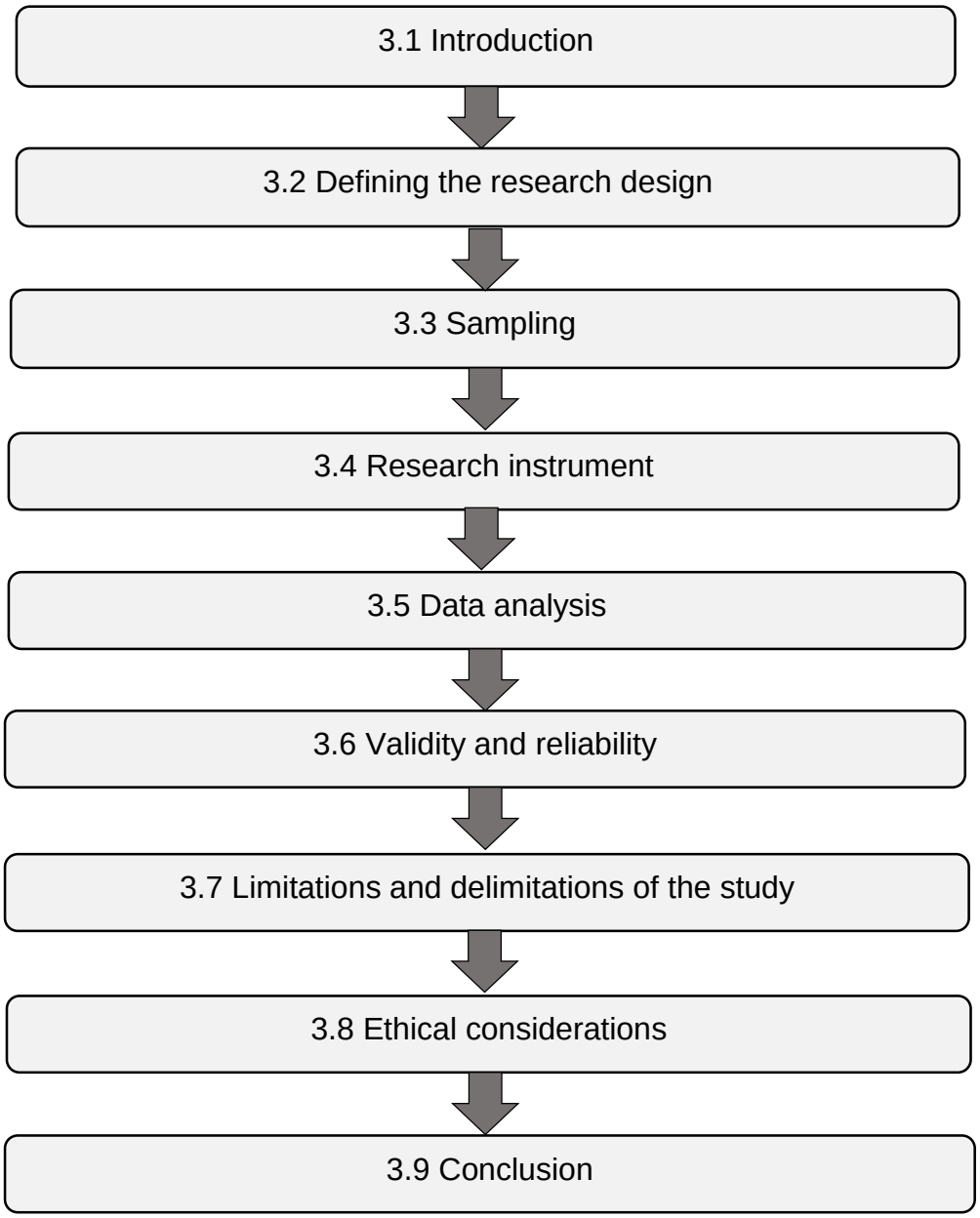


Figure 3.1: Flow diagram of Chapter 3
Source: Author's own composition (2019)

Chapter 3 is structured as follows:

- First, a review of the research problem which underpins this research study is presented in section 3.1.
- Then a general idea of the research design is defined in section 3.2.
- This is followed by a description of the sampling and research instrument in section 3.3 and section 3.4 respectively.
- In section 3.5 the data analysis technique applied for this study is explained. Afterwards validity and reliability are discussed in section 3.6.
- Next, the limitations and delimitations of the study are presented in section 3.7.
- In section 3.8, the ethical considerations with which the study complied will be explained.
- To conclude, a summary of the chapter is provided in section 3.9.

It is important to understand the reason for the low adoption rate in South African SMEs as South Africa contributes approximately 1.2% of the global emissions (Fatoki, 2019:2). The literature review revealed the importance of adopting green ICT, one of the reasons being the current increase of carbon emission which could be curbed by green ICT.

The aim of the study was to investigate the different barriers resulting in the low adoption rate of green ICT in South African SMEs. These barriers identified in the literature (see section 2.5.2) consist of a lack of awareness (Díaz-García *et al.*, 2015:14), lack of knowledge (Gu *et al.*, 2015:285), lack of expert ICT skills (Chou, 2013:234), legislative regulations (Osembe & Padayachee, 2016:1288) and a lack of funding (Kılkış, 2016:236). Many of the studies tend to focus more on green ICT adoption in developed countries and not much consideration is given to developing countries.

The current research study therefore, sought to address the problem of low green ICT adoption in South African SMEs. Accordingly, the research questions are:

- What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs?
- What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South Africa SMEs?
- What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?

As mentioned in the previous two chapters, the primary objective was to identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs. At the same time, the study also measured the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs. Furthermore, the study set out to recommend strategies on how to improve the adoption rate of green ICT in South African SMEs.

As discussed in Chapter 1, the motivation for the study lies in its contribution to the body of knowledge and fills the void in the literature regarding the low adoption rate of green ICT (Bekaroo *et al.*, 2016:1592). The study will thus lead to a better understanding regarding the low adoption rate of green initiatives in sub-Saharan Africa such as cloud computing (Yeboah-Boateng & Essandoh, 2014:13-14). Moreover, the study examined the green ICT principles influencing the low adoption rate of green technology in terms of regulations to protect the environment (Radu, 2016:743). Furthermore, the study will help to understand the reluctance to adopt green ICT as South Africa is the largest emitter of carbon dioxide in Africa (Radu, 2014:434).

3.2 DEFINING THE RESEARCH DESIGN

Kumar (2011:94) refers to research design as a proposal, formation and proposed action of a study formulated to get responses to research questions or problems. This strategy involves the entire representation of the research plan. Figure 3.2 outlines the research

philosophy, approach, strategy, method, timescale, technique and procedure that was followed for this research study. A positivist approach was followed; deductive reasoning took place; a survey was carried out; a mono-method was followed; the study was cross-sectional in design; a questionnaire was designed, and a factor analysis was applied (see Figure 3.2).

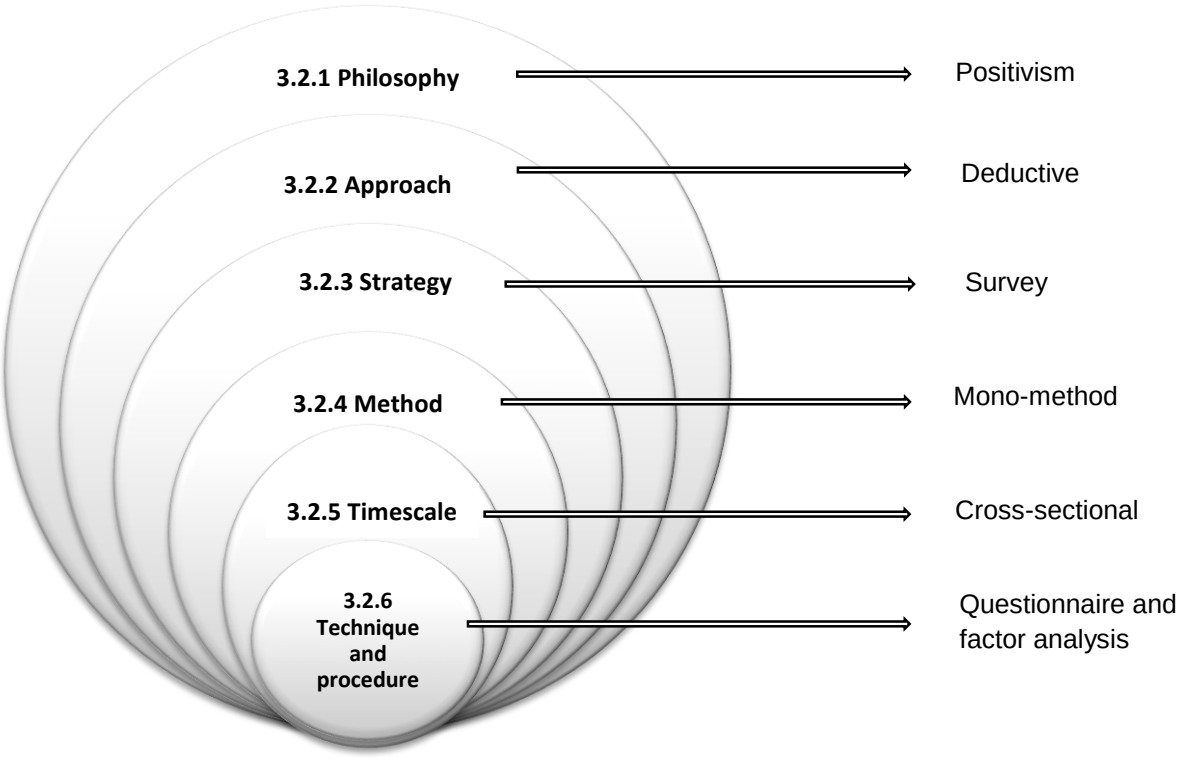


Figure 3.2: Outline of research philosophy and approach
Source: Adopted from Saunders *et al*., (2009:108)

3.2.1 Philosophy

As shown in Figure 3.2, the research study is based on a positivist ontological worldview. An ontological stand of positivism refers to the study of reality that can be objectively viewed and measured (Du Plooy-Cilliers, Davis & Bezuidenhout, 2014:25). According to Burns and Burns (2008:14), the key components of a positivist paradigm consist of the following:

a) An objective view of the real world which is led by-laws

b) Unprejudiced contexts

c) Generally linked to quantitative data using accurate measurements

d) Researcher abides to respect independency of topics

e) Research is precise, thorough and persistent

f) Various techniques exist including structured questionnaires

g) The research method is aligned with deductive reasoning

In line with this theory, the researcher takes the view that the world can be seen independently. This paradigm allowed the researcher to obtain a better understanding of the barriers resulting in the adoption rate of green ICT. The researcher conducted the study in an unbiased and independent manner (provided an equal opportunity to all participants).

3.2.2 Approach

As illustrated in Figure 3.2, a deductive reasoning approach was undertaken as it enabled the researcher to test a theory based on the literature review. Deductive reasoning includes the reasoning of assumptions from general to specific (Zikmund *et al.*, 2009:44). A top-down approach is usually adopted in deductive reasoning where a concept is explored and tested to achieve the research goal whereby the theory is adapted or affirmed (Du Plooy-Cilliers *et al.*, 2014:49). The study used this approach to investigate the theory regarding barriers resulting in the low adoption rate of green ICT. The researcher thus followed the deductive approach with the assumption that there is a low adoption rate of green ICT as found in the literature review, and then investigated this theory to obtain empirical evidence.

3.2.3 Strategy

From Figure 3.2, the strategy that was followed was to use a survey for the data collection. Denscombe (2010:3-4) suggests that a research strategy can be defined as "a plan of action to achieve a specific goal" and that the three questions below should be asked to determine which strategy will work best:

- Is it suitable?
- Is it feasible?
- Is it ethical?

A survey was thus considered appropriate for this research study. A survey is described as a measurement tool to test a theory or fact through the collection of data at a certain point in time (Cohen *et al.*, 2018:334). The study intended to collect primary data from SMEs located across Gauteng through the use of an online survey.

3.2.4 Method

Figure 3.2 shows that a mono-method was chosen for this research study as only one quantitative study was conducted to collect data through a questionnaire (*Saunders et al.*, 151). Zikmund *et al.*, (2009:134) define quantitative business research as follows: *"*Business research that addresses research objectives through empirical assessments that involve numerical measurement and analysis."

To reach the research objectives, the study pursued a descriptive quantitative research method. A descriptive research study is exemplified as a precise profile of individuals, occurrences or a set of problems (Cooper & Schindler, 2014:21). The study was non-experimental and followed a quantitative descriptive research method to explore the green ICT adoption rate in SMEs.

3.2.5 Timescale

As illustrated in Figure 3.2, a cross-section of the entire population selected for the research was undertaken to investigate the low green ICT adoption rate in South African SMEs. Surveys are generally classified as cross-sectional because data is collected at a certain point in time (Sreejesh *et al.*, 2014:61). Cross-sectional studies are viewed as a more affordable method and such a study would also allow the researcher to explain the key barriers related to the low adoption rate of green ICT (Cohen *et al.*, 2007:220).

3.2.6 Technique and procedure

Figure 3.2 shows that a self-administered questionnaire was e-mailed to all the possible participants (owners and managers) in the research study to collect data from SMEs registered with The Innovation Hub. According to Cooper and Schindler (2014:225), a self-administered questionnaire can be distributed both in an electronic and paper-based form. The study used SurveyMonkey® which enabled participants to complete the electronic questionnaire anonymously and at a convenient time for them. An e-mail was sent whereby all participants were directed to an online survey through a link inviting them to participate in the study. In addition, paper questionnaires were also distributed at interventions hosted by The Innovation Hub which included training workshops, Innov8 event and a community engagement project. These additional steps were taken to secure a larger response rate and to further provide an equal opportunity to all participants. At the same time, site visits were also conducted at the different eKasilab branches to increase the response rate. The self-administered questionnaire was thus the primary instrument used to collect the data both through electronic and paper-based procedures.

3.3 SAMPLING

This section is dedicated to a detailed description of the sampling procedure for this research study. A comprehensive description is provided about the population of the study, unit of analysis and census population. A census was deemed an appropriate sampling technique due to the small population size (all 400 SMEs registered with The

Innovation Hub) including budget and time constraints in this particular situation (Cooper & Schindler, 2014:339).

3.3.1 Population of the study

According to Kumar (2011:193), sampling involves choosing a small number (sample) from a larger collection (population) to form the foundation for determining or projecting the frequency of an unidentified part of data, circumstance or result in terms of the larger collection. The target population of the research study included the entire group of SMEs registered with The Innovation Hub. The Innovation Hub is an innovating organisation that focuses on the development of enterprises, improvement of skills and facilitates innovative programmes in science parks and all over the Gauteng province (The Innovation Hub, 2019).

Furthermore, the Innovation Hub is the foremost leading technological and science park in sub-Saharan Africa and accredited on an international level (The Innovation Hub, 2019). The study was conducted in the Gauteng province as it consists of SMEs with advanced technological infrastructures and plays an instrumental role in South Africa's economy (Osembe & Padayachee, 2016:1259). The Innovation Hub also strives towards promoting and growing start-ups, creating jobs and enhancing the competitiveness for the Gauteng Province (The Innovation Hub, 2019).

3.3.2 Unit of analysis

The unit of analysis was the collective perceptions by SME owners and managers registered with The Innovation Hub and who are involved in decision-making processes about green ICT adoption (Hair *et al.*, 2014:640). The emphasis is not on the object itself but rather on how these objects are perceived by the individuals (Hair *et al.*, 2014:482). The Innovation Hub was selected as it is a well-managed institution that operates in an innovative digital space to promote economic development and competitiveness (The Innovation Hub, 2019). The services that The Innovation Hub provides include but are not

limited to commercialisation, networking, and research and development support. Additional support is also offered such as workshops to provide entrepreneurs with insight into how to manage their businesses in terms of their finances. The pre-commercialisation support helps entrepreneurs to move into the commercial space by enabling them to understand their market and regulatory policies for approvals (The Innovation Hub, 2019). Hence, the study focused on SME owners and managers of high-technology enterprises that are involved in ICT daily and have the necessary knowledge required for this research study.

3.3.3 Census population

A census takes into account all the individuals of the population to be investigated (Cooper & Schindler, 2014:338). Thus, a census was considered appropriate for this research study as the population was a small group of 400 SMEs. Moreover, the census would enable the researcher to obtain an in-depth understanding regarding the green ICT adoption rate in South Africa and help to understand to what extent these key barriers still to be identified in the study impact South African SMEs.

The ICT space in The Innovation Hub governs all areas of the business incubators with the idea of identifying high-technology solutions for a demand. These business incubators are categorised into different subgroups to reflect the various focus areas (The Innovation Hub, 2019). The total number of registered SMEs incubated in the BioPark, Maxum and Green Economy Incubation programmes are around 400 and the registered data list consists of owners and managers. This also includes the eKasiLabs which are satellite branches located in townships around Pretoria and Johannesburg. The Innovation Hub also seeks to attract and empower township entrepreneurs that are capable of providing innovative solutions (The Innovation Hub, 2019). This is a unique platform created for high-technology entrepreneurs, world-class enterprises, researchers, and academics to be successful and prosper.

Table 3.1 shows the business incubators classified in different sectors within the Innovation Hub science park located in Pretoria. These four business incubators formed part of the target population for the research study as all these focus sectors operate in a high-technology environment.

Table 3.1: Classification of different business incubators

Business incubator	High-technology focus sector
a) Biopark@Gauteng	Health, agro-processing and industrial
b) Maxum • Maxum Smart • Maxum Digital	 ICT and advance manufacturing gaming, animation and virtual reality
c) Climate Innovation Centre South Africa	Energy, water and waste
d) eKasiLabs	ICT, green and bio sector

Source: The Innovation Hub (2019)

Thus, all the members to be included in the research study were represented by the total population as grouped in Table 3.1. The entire population instead of a sample size provided better generalisability to the groups in this research study. In addition, purposive sampling was also applied to distinguish the different characteristics between owners and managers of the population investigated (Zikmund *et al.*, 2009:396).

According to Cohen *et al.*, (2007:231), non-responses refer to responses whereby questionnaires are completed partially or not at all. A wave analysis was conducted by the researcher to assess the response of items chosen every week to find out whether there was an average change in responses received (Creswell, 2009:152). Additionally, the electronic questionnaire required participants to submit their answers after each screen had been completed which allowed the researcher to use certain data even though the questions might have been only partially completed. This also helped to determine any response bias. The population therefore, allowed a broader and diverse number of participants to be reached through the online survey that was distributed among these SMEs.

3.4 RESEARCH INSTRUMENT

Cohen *et al.*, (2018:337) and Cohen *et al.*, (2007:210) outline the following stages for the planning of a survey as summarised in Figure 3.3 below.

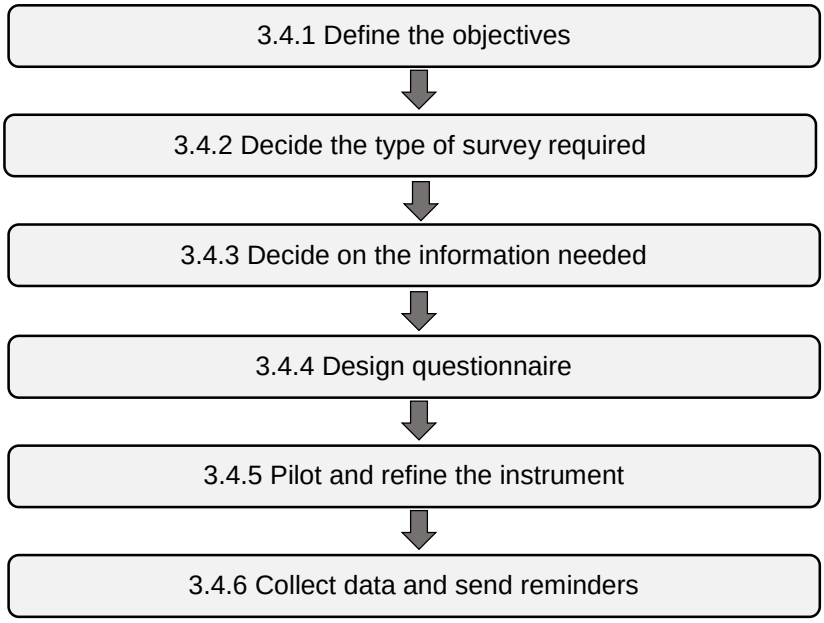


Figure 3.3: Stages in planning a survey
Source: Adapted from Cohen *et al.*, (2018:337) and Cohen *et al.*, (2007:210)

3.4.1 Define the objectives

As shown in Figure 3.3, defining the objectives is considered the first stage in the planning of a survey. The primary research objective was to identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs. These barriers were identified through the literature review that indicated the impact on the low adoption rate of green ICT.

The following secondary objectives were set:

- To determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs.
- To recommend strategies on how to improve the adoption rate of green ICT in South African SMEs.

3.4.2 Decide the type of survey required

Figure 3.3 shows that the second stage involves deciding on the kind of survey required for the study. This refers to whether the study is longitudinal or cross-sectional in nature (Cohen *et al.*, 2018:337). In section 3.2.5 it was revealed that a cross-sectional study would be conducted to collect data to present a "snapshot" of the population at a single point in time (Zikmund *et al.*, 2009:134). By conducting a cross-sectional instead of a longitudinal study certain limitations can be reduced such as time and costs. Together with the online survey and the use of cloud-based software some of the financial constraints of the researcher were reduced.

3.4.3 Decide on the information needed

With reference to Figure 3.3, the next stage is to decide on the information needed for the study. Denscombe (2010:12) explains that a survey is used to obtain information relevant to a population about "what they do, what they think, who they are". The research study investigated the low green ICT adoption rate in South African SMEs. The study also examined the most prominent barriers resulting in the low adoption rate of green ICT of SMEs located in South Africa. The information obtained from the participants provided the researcher with a greater understanding of the barriers hindering the adoption of green ICT. Furthermore, this allowed the researcher to provide recommendations to enhance green ICT adoption in South African SMEs. The barriers resulting in the low adoption rate of green ICT were measured (key focus of research) as mentioned in section 2.5.2.

3.4.4 Design questionnaire

As illustrated in Figure 3.3, the next stage in a quantitative approach is to design the questionnaire. Section 3.2.6 also indicated that an online survey would be used through which a self-administered questionnaire would be distributed to participants. To collect data from SMEs, an online survey which consisted of a link was e-mailed to all the participants through SurveyMonkey®. Although online surveys were mainly administered

for the research study, paper-based surveys were also used to increase the response rate. Paper questionnaires were distributed at interventions hosted by The Innovation Hub for registered members. The researcher also ensured that attendees at these interventions were informed that participants that already participated in the online surveys were not allowed to take part in the paper questionnaires to prevent duplication.

Close-ended (range of predetermined options) and open-ended (responses expressed in participants' way) questions are the most well-known formats of a questionnaire (Sreejesh *et al.*, 2014:148-149). The format of the questionnaire for this research thus comprised close-ended and open-ended questions to offer participants the opportunity to also respond in their own words. The following advantages and disadvantages of close-ended and open-ended questions are identified by Sreejesh *et al.*, (2014:150) as shown in Table 3.2 below.

Table 3.2: Response format of questionnaire

	Close-ended	**Open-ended**
a) Advantages	○ Precise and easy to reply to ○ Enables interviewer to have more control over responses to questions ○ The consistency of the questions makes the analysing of data easier ○ No discrepancy among articulate and inarticulate answerers ○ Increases the rate of responses ○ Cost-effective and takes less time	○ Uncover unusual and useful views ○ Considerable liberty of speech ○ No prejudice ○ Liberty of enabling responses
b) Disadvantages	○ The possibility that the selection of choices might not disclose the truth ○ Poorly structured questionnaires can result in untruthful outcomes ○ Necessitates preliminary test to ensure precision for the selection of choices offered	○ Takes considerable time ○ Decreases the number of questions that can be set in a certain time frame ○ Possibility of answers to be misunderstood

Source: Adapted from Sreejesh *et al.*, (2014:150)

As reflected in Table 3.1, the close-ended and open-ended response formats were the most suitable for the research questionnaire of this study as a rating scale and a level of freedom were included.

According to Du Plooy-Cilliers *et al.*, (2014:152), it is important to include a concise introduction that presents participants with information about the researcher and purpose for the study when designing and structuring a questionnaire. The questionnaire was thus designed and structured with this in mind. Hence, the questionnaire consisted of a participation information sheet (Annexure A) which introduced the researcher, requested the consent from participants and provided an explanation of the reason for the research. This was followed by Section A consisting of questions related to the adoption of green ICT; Section B was based on the drivers of green ICT; Section C was based on the barriers of green ICT; Section D consisted of biographical information; and Section E consisted of general views on green ICT participants may have wanted to add.

A Likert five-point bipolar scale was used to rate the extent to which the participants agreed with the statements presented by a set of opposite adjectives and which measured participants' perceptions about the low adoption rate of green ICT (Saunders *et al.*, 2009:381). The Likert scale consisted of five categories whereby 1 signified strongly disagree and 5 strongly agree (Saunders *et al.*, 2009378-380). The five-point Likert scale was considered more appropriate than the seven-point Likert scale as it would increase the response rate and allow participants to select the most suitable option that best matched their level of agreement (ResearchGate, 2019). Participants' perceptions of the low green ICT adoption rate were tested by this rating scale and enabled participants to respond to the statements presented in the questionnaire. Table 3.4 shows the Likert-type scale used for this research study.

Table 3.3: Likert scale

Appropriate Likert scale for study Level of Agreement					
	1	**2**	**3**	**4**	**5**
Rating Scale	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree

Source: Author's own composition (2019)

The questionnaire was structured in a user-friendly way to encourage participants to take part in the survey and complete the questionnaire with ease. Table 3.4 shows the structure of the questionnaire and outlines the different sections, namely Section A (Adoption), Section B (Drivers), Section C (Barriers), Section D (Biographical information) and Section E (Open-ended questions). The questionnaire (Annexure B) was constructed (self-developed) by the researcher and the constructs measured were obtained from the literature related to green ICT.

Table 3.4: Structure of the questionnaire

Section in questionnaire	Area in chapters or source	Category of question	Scale
A: Adoption	Mitra and Datta (2014:2104); Kousar *et al.*, (2017:845)	Close-ended	Five-point Likert agreement
B: Drivers (cost, competitive advantage, product life cycle, environmental conditions)	Section 1.2.2 Section 2.5.1	Close-ended	Five-point Likert agreement
C: Barriers (awareness, knowledge, expert ICT skills, legislative regulations, funding)	Section 1.2.3 Section 2.5.2	Close-ended	Five-point Likert agreement
D: Biographical information	Demographics - close-ended questions		
E: Open-ended questions	General view on green ICT		

Source: Author's own composition (2019)

The focus of the questionnaire was largely based on identifying the barriers resulting in the low adoption rate of green ICT and determining the barrier with the strongest underlying correlation. Thus, the scale and structure of the questionnaire enabled the researcher to obtain better insight into the perceptions of participants regarding SMEs and their low green ICT adoption rate.

Table 3.5 summarises the questionnaire used in the research study. The categories are provided, namely constructs, sources from the literature and questions. In Sections A, B and C participants were given the opportunity to rate their level of agreement with the statements presented in the questionnaire. Section D presented close-ended questions based on biographical information which provided participants with the opportunity to select the demographic information related to them. In Section E, open-ended questions were presented to offer participants the opportunity to provide their general views on green ICT and any additional information.

Table 3.5: Summary of questionnaire

CONSTRUCT	SOURCE	QUESTION
Section A – Adoption		
Adoption	Mitra & Datta (2014:2104)	**Question 1:** When I adopt green ICT, it will be... a) voluntarily. b) to comply with regulations c) under pressure from customers. d) under pressure from competition.
	Kousar *et al.*, (2017:845)	**Question 2:** I believe that green ICT … a) reduces the negative impact of packaging. b) reduces the negative impacts of producing finished goods. c) reduces the negative impact of the user phase. d) promotes a product that can be recycled.

Section B – Drivers **Question 3:** My understanding is that green ICT can…		
Cost	Buchalcevova & Gala (2012:111); Mele & Russo-Spena (2015:13-17); Akman & Mishra (2015:477); Masud & Malik (2014)	**Question 3.1:** a) enhance operational efficiency. b) decrease operational costs. c) enhance innovative manufacturing processes. d) increase the development of eco-friendly practices. e) improve the company's performance.
Competitive advantage	Verdolini *et al.*, (2018:3); Buchalcevova and Gala (2012:111); Kanda *et al.*, (2016:164); Hamann *et al.*, (2017:30); Chou (2013:233)	**Question 3.2:** a) offer products with less impact on the environment. b) distinguish the company from its competitors. c) allow the company to adjust easily to markets. d) increase the cost-effectiveness of the company. e) enhance market entrance.
Product life cycle	Anthony & Majid (2016:1); Aleksic (2014); Hilty & Aebischer (2015:23); Marcon *et al.,* (2017:85)	**Question 3.3** a) contribute towards the reduction of waste. b) carry out life cycle assessment for products. c) increase the use of recyclables. d) extend the product life. e) increase the reusability of products.
Environmental conditions	Zhang & Liu (2015:12); Hojnik & Ruzzier (2017:584); Andreopoulou (2016:493-494)	**Question 3.4:** a) reduce carbon emission. b) grow profit by environmental management systems. c) improve the competitiveness of environmental investments. d) enhance the rebuilding of the natural environment. e) decrease energy usage.

Section C – Barriers **Question 4:** I believe that the following constructs might hinder the adoption of green ICT:		
Awareness	Malison & Thammakoranonta (2018:107-108); ASSAf (2014:25); Díaz-García *et al.*, (2015:14); Abdullah *et al.*, (2016:688); Wabwoba *et al.*, (2013:95)	**Question 4.1:** a) Unsureness about the implementation of green ICT b) Unawareness of green ICT to improve sustainability c) Inadequate awareness of environmental policies d) Unawareness of green ICT in the marketplace e) Unawareness about green ICT operation processes
Knowledge	Ramdhani, *et al.*, (2017:957); Hankel *et al.*, (2017:89)	**Question 4.2:** a) Too complex b) Risk of failure c) Unclear perceptions of change towards green ICT d) Lack of shared knowledge collaboration e) Uncertainty about green ICT benefits
Expert ICT skills	Abdullah *et al.*, (2016:689); ASSAf (2014:137); Thomas *et al.*, (2016:695); Kanda *et al.*, (2016:164)	**Question 4.3:** a) Lack of qualified employees b) Lack of skills to enhance green initiatives c) Inadequate technical capabilities d) Poor expertise in green ICT operation processes e) Lack of green ICT training
Legislative regulations	(Buchalcevova & Gala (2013:44-48); Ociepa-Kubicka & Pachura (2017:285); Abdullah *et al.*, (2016:704)	**Question 4.4:** a) Insufficient government subsidies b) Unpredictable changes in government laws c) Inadequate capabilities by government d) Unclear government policies e) Insufficient government support for green initiatives

Section C – Barriers **Question 4:** I believe that the following constructs might hinder the adoption of green ICT:		
Funding	Welfens & Lutz (2012:159); Verdecchia *et al.*, (2017:43); ASSAf (2014:139); Suzuki (2015:231)	**Question 4.4:** a) Insufficient capital b) High research and development costs c) Uncertainty about return on investment d) Continuous investment required e) High initial investment required for operational costs
Section D – Biographical information		
Demographics	Constructed by researcher (Participant information)	**Question 1: Position in company** a) Owner b) Manager
		Question 2: Your age group a) 18-29 years b) 30-39 years c) 40-49 years d) 50-59 years e) 60-65 years
		Question 3: Educational level a) Matric or less b) Diploma or certification c) Degree d) Postgraduate degree
		Question 4: Number of operational years of your company a) Less than a year b) 1-5 years c) 6-10 years d) More than 10 years
		Question 5: Number of employees in your company a) Fewer than 50 b) 50-150 c) 150-250 d) Unsure

Section E – Open-ended Questions		
General views on green ICT	Constructed by researcher (Literature review of Chapter 1 and 2)	(1) What is a major barrier for your company in adopting green ICT? (1.1) Why do you see this as a barrier for your company? (2) Why do you see this as a barrier for your company? (3) Why do you think the adoption of green ICT may be a problem for your company? (4) What strategies would you recommend to improve the adoption of green ICT in your company? (5) Is there any additional information that you would like to add?

Source: Author's own composition (2019)

3.4.5 Pilot and refine the instrument

From Figure 3.3 it can be seen that there is another stage which is the conducting of a pilot study to prevent possible obstacles that the survey may present. Any problem areas identified can thus be rectified to ensure that the correct information is given. A pilot study consists of a smaller number of participants out of those used in the entire research study from which data is gathered (Zikmund *et al.*, 2009:65). All the aspects included in the structuring of the survey were piloted to ensure that each section is presented accurately, and instructions and questions are clear to prevent any misunderstandings. The research instrument was piloted in a group of experts (ten academics) and a statistician ensured the face validity of the questionnaire. Minor adjustments were made to the questionnaire based on the feedback received such as including a short description of green ICT and adjusting the layout of sections. The format of the questionnaire (electronic and paper) was finalised accordingly and the pilot study showed that the participants understood all the questions. In this way, the researcher ensured that the objective of the questionnaire was achieved and that the participants wouldn't experience any difficulties in answering the questions (Saunders *et al.*, 2009:394). Moreover, by pilot-testing, the questionnaire

with a group of experts helped to improve the validity and ensured that the participants would understand the questions clearly.

3.4.6 Collect data and send reminders

With reference to Figure 3.3, the final stage considered in the planning of a survey is the collection of data as well as the sending of reminders. The data was collected by means of a survey through a questionnaire completed by SME owners or managers. An e-mail with a SurveyMonkey® link was sent to SME owners and managers responsible for and involved in ICT decision-making processes as they were deemed to be the most suitable individuals to provide information on the research topic. Paper questionnaires were also handed out at several Innovation Hub interventions to extend the research study and increase the response rate.

Based on the categories of these two job functions (managers and owners) a certain level of knowledge and experience of ICT was expected from these participants. For this reason, the SME owners and managers were viewed as subject experts in these enterprises where the focus areas are on high-technology solutions. A reminder was sent out to participants as a follow-up to enhance the response rate and encourage them to complete the questionnaire. The reminders highlighted the significance and valuable contribution to the study. All participants were granted an equal opportunity to respond to the questionnaire distributed.

3.5 DATA ANALYSIS

According to Zikmund *et al.*, (2009:70), data analysis involves the interpretation of the data collected to understand it. Denscombe (2010:235) believes that the aim of data analysis is "to describe its constituent elements or explain how it works or interpret what it means". Descriptive and inferential statistics were applied to collect, code and present the data in a prompt, simplified and understandable manner (Burns & Burns, 2008:7-8). Multivariate statistical techniques (both univariate and bivariate analysis) were also used

to simultaneously examine several measurements of variables under investigation which amongst others included a factor analysis (Hair *et al.*, 2014:4).

For this study, the data collected from the online and paper questionnaires were transferred to a Microsoft Excel spreadsheet. Afterwards the data was electronically coded and analysed by a statistician through the use of the IBM SPSS, Version 25 statistics software program. The primary data collected from the questionnaires was interpreted and information gathered from the literature study helped the researcher to report on the findings of the study (Cooper & Schindler, 2014:130). It was deemed useful to use nominal and ordinary scales given the constructs that were based on the categories of the questionnaire (Denscombe, 2010:243).

Denscombe (2010:241) suggests that descriptive statistics involves the following:

- Categorising the data (editing, coding, data filing)
- Making a summary of the results
- Presenting and showing the data
- Explaining the profile of outcomes regarding the distribution of data
- Seeking noticeable correlations and connections between data

Hence, the descriptive, multivariate and inferential statistical measures used to analyse the data included the following steps:

Step 1: Exploratory factor analysis comprising the following:

- Bartlett's test of sphericity should be significant ($p<0.05$) for a factor analysis to be appropriate (Pallant, 2011:183)
- The Kaiser-Meyer-Olkin (KMO) which measures a sampling adequacy yield greater than 0.6 and is acceptable for the factor analysis (Sreejesh *et al.*, 2014:217)

- Cattell's scree test to plot the eigenvalues and identify a maximum number of factors extracted before the curve starts to straighten (Pallant, 2011:199)
- One sample t-test to measure the statistical difference between the mean and mid-value of the sample (Zikmund *et al.*, 2009:516) 264)

Step 2: Summaries of statistical outcomes of constructs (ratings) were presented for all the six factors identified (legislation, skills, funding, awareness, knowledge based on complexity and uncertainty).

Step 3: An independent-samples t-test to measure the level of statistical significance between the means of different groups. Parametric tests were employed to assess group differences (t-tests) and correlations given a large sample size (n>30) and the central limit theorem assuming normality of the sampling distribution (Bereson et al., 2012:264).

Step 4: Pearson's product-moment coefficient to investigate the relationship between constructs (Pallant, 2011:128).

Thus, the data collected was categorised and checked to seek obvious correlations and patterns between the units of analysis. The unit of analysis was a collective perception tested about the adoption of green ICT with the entire group of SME owners and managers registered with The Innovation Hub. The statistical analysis allowed the researcher to interpret and understand the problem more thoroughly about how green ICT can be sustainable in SMEs. The descriptive, multivariate and inferential statistical analyses were deemed the most appropriate approach to answer the research question and to achieve the primary and secondary objectives of this research study.

3.6 VALIDITY AND RELIABILITY

Cooper and Schindler (2014:52) define a construct as a picture or theoretical viewpoint particularly created for a specific study or development of a theory. Measurements were set out to ensure that the research would be valid and reliable. To demonstrate the validity

of the instrument, a summary of the questionnaire where all the questions originated from was presented (see Table 3.5 above). Each of the five constructs (awareness, knowledge, expert ICT skills, legislative regulations and funding) consisted of five items that were measured through the factor analysis to gain insight into the low adoption rate of green ICT.

3.6.1 Validity

Validity is a measurement instrument used to ensure that the data collected is correct for the type of study and that the data has been calculated accurately (Denscombe, 2010:298). Factor analysis is a multivariate, interrelated method of measuring and identifying a lower number of factors from a bigger number of variables (Zikmund *et al.*, 2009:593). An exploratory factor analysis was carried out to explore the interrelationships among a set of items and also confirms the underlying factor structure (Pallant, 2011:181). Hence, factor analysis was deemed the best measurement method for the small population size and well suited for testing the strength between all the constructs, namely awareness, knowledge, expert ICT skills, legislative regulations and funding. This enabled the researcher to understand whether the impact of one barrier was significantly different from another regarding the adoption of green ICT.

A construct validity measurement was used in this study as it seeks to identify the fundamental constructs that are assessed to establish how accurately they are presented by the test (Cooper & Schindler, 2014:257). Thus, validity will ensure the degree to which the constructs will be measured are accurate purports. The researcher therefore, ensured that the questionnaire measured the proposed constructs that the study intended to measure (Zikmund *et al.*, 2009:308). At the same time, the accuracy of the items constructed from the factor analysis in the study was also validated by the researcher.

3.6.2 Reliability

The reliability test measures the extent to which the assessment of the construct is free of errors (Pallant, 2011:6). Reliability is accomplished when the same results are tested for the same thing and the results remain the same (Zikmund *et al.*, 2009:305). There are two types of errors that may impact the reliability of a study: random fluctuation error (degree to which a score has been impacted through possible elements) and systematic error (impact of undesirable variable prejudicing values only in one way) according to Burns and Burns (2008:411-412). The researcher therefore, ensured that the constructs being measured were error-free. Moreover, the consistency of the reliability of all results was measured accurately to establish the preciseness of the assessment conducted.

Cronbach's alpha is the most frequently measuring scale of reliability and presents the average correlation between the entire items that comprise an acceptable scale above 0.7 yielded by the study (Pallant, 2011:6). This concurs with the view of Cooper and Schindler (2014:260) that Cronbach's alpha is the extent to which measuring tool items are similar and reveal the equivalent fundamental construct. Cronbach alpha values were calculated to check the reliability of the scales to measure the constructs being examined.

3.6.3 Correlation analysis

Correlation analysis indicates to what degree variables move together (for if one variable increases the other one will also) or inversely (if one variable increases, conversely the other one will decrease) as mentioned by Cooper and Schindler (2014:469). The IBM SPSS software program was used to carry out a correlation analysis and to determine the correlation coefficient among the specific constructs (barriers) resulting in the low adoption rate of green ICT. According to Field (2013:90), the IBM SPSS program is primarily used in two windows which include the data editor (the entering of data and conducting statistical activities) and the viewer (the outcomes of all analysis is revealed). The correlation coefficients for every construct were measured to determine the strongest underlying barrier since correlation by itself does not allude to causation (Bereson *et al.*, 2012:127). The data was explored numerically to seek a linear relationship among constructs by calculating the correlation coefficients of the different constructs. By

interpreting the values and measuring the correlations, the construct with the strongest underlying correlation resulting in the low adoption rate of green ICT could be determined.

3.7 LIMITATIONS AND DELIMITATIONS OF THE STUDY

As mentioned in Chapter 1, there are a few limitations regarding the study due to constraints related to the budget, time and limited population. Chapter 2 indicated that green ICT is a fairly new concept, especially in developing countries. In this context, certain delimitations were expected from the research study such as a smaller population size though it would be large enough to test the theory. The questionnaire was distributed to all participants, but it was expected that not everyone would participate which resulted in a low rate of responses.

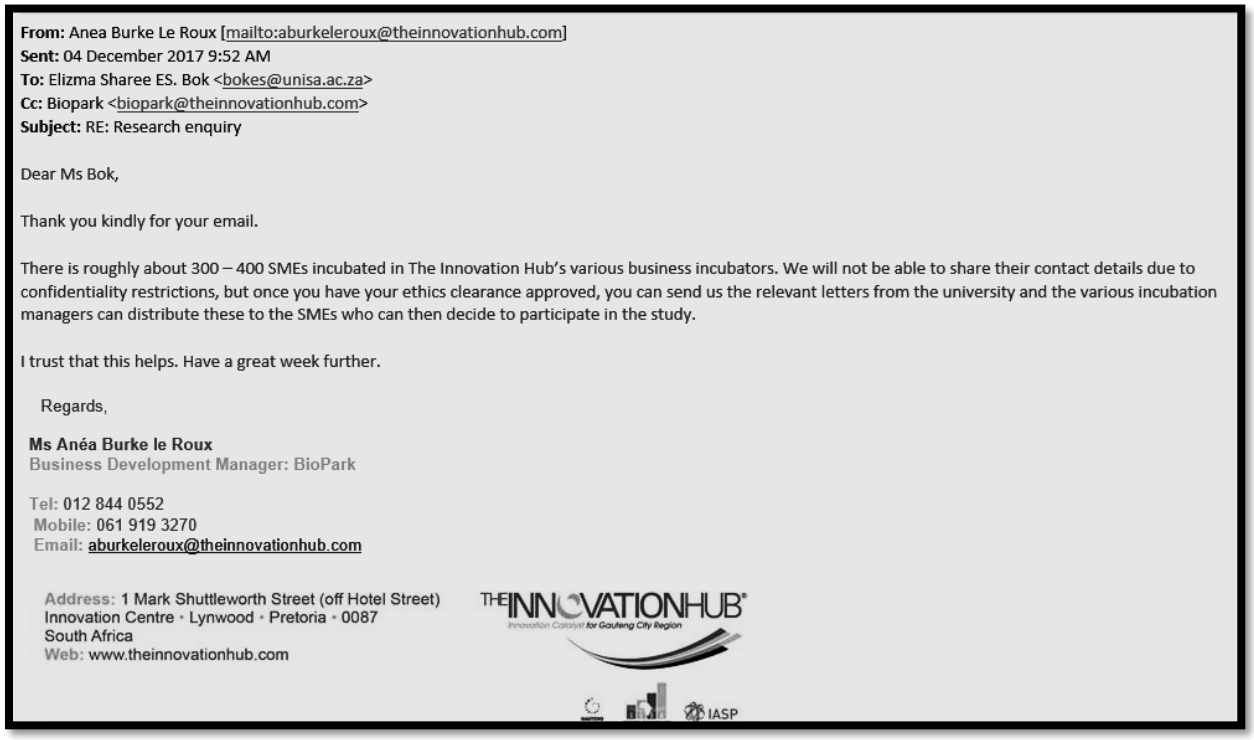
3.8 ETHICAL CONSIDERATIONS

Hofstee (2013:118) describes ethics as principles to take into consideration and follow to ensure the research is conducted within the parameters set by a profession or group. According to Zikmund *et al.*, *(*2009:233), there are various ethical concerns to take into consideration when conducting a survey. These are the participants' right to privacy, and confidentiality and truthfulness in the gathering of data. Although ethics may have a different meaning for different people, Burns and Burns (2008:14) sums it up well as "the application of moral principles and/or ethical standards that guide our behaviour in human relationships". The current study complied with good practices by following the above ethical research codes.

Denscombe (2010:331-338) concurs that the participants' interest should be protected, that informed consent is obtained, and that researchers should act honestly and comply with the laws when conducting a research study. Permission was thus sought from the ethics committee of the University of South Africa (UNISA) to conduct the study. An ethical clearance certificate (Annexure C) was supplied to all participants and the requirements of the study were stipulated. The researcher placed the interests of the participants first

and foremost at all times. Moreover, the researcher also ensured that she was always available to the participants during the study in case they had any concerns regarding the study.

Preliminary permission was obtained from The Innovation Hub via e-mail before an official request letter was submitted to the chief executive officer (CEO). This letter was sent to confirm that the research study could take place at The Innovation Hub. Additionally, information regarding the number of registered SMEs was also obtained. A copy of the communication received by the researcher from the business development manager at the time is shown in Figure 3.4.



From: Anea Burke Le Roux [mailto:aburkeleroux@theinnovationhub.com]
Sent: 04 December 2017 9:52 AM
To: Elizma Sharee ES. Bok <bokes@unisa.ac.za>
Cc: Biopark <biopark@theinnovationhub.com>
Subject: RE: Research enquiry

Dear Ms Bok,

Thank you kindly for your email.

There is roughly about 300 – 400 SMEs incubated in The Innovation Hub's various business incubators. We will not be able to share their contact details due to confidentiality restrictions, but once you have your ethics clearance approved, you can send us the relevant letters from the university and the various incubation managers can distribute these to the SMEs who can then decide to participate in the study.

I trust that this helps. Have a great week further.

Regards,

Ms Anéa Burke le Roux
Business Development Manager: BioPark

Tel: 012 844 0552
Mobile: 061 919 3270
Email: aburkeleroux@theinnovationhub.com

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Web: www.theinnovationhub.com

THE INNOVATION HUB
Innovation Catalyst for Gauteng City Region

IASP

Figure 3.4: E-mail communication
Source: Le Roux (2017)

Thereafter, a letter to request permission from The Innovation Hub to conduct the study was submitted to the CEO. This gatekeeper letter was drafted in a formal manner providing the details of the research study and detailing the ethical practices of the

College of Economic and Management Science within UNISA. A signed permission letter by the CEO was obtained whereby permission was granted for the study to be conducted at The Innovation Hub.

To sustain a high level of professional conduct, the researcher adhered to the research ethics policy of UNISA. This study also complied with the Protection of Personal Information (POPI) Act to protect the confidentiality of all data including personal information received from all participants (South Africa, POPI Act, 2013, s 2a-c). The participants were requested not to make their name known on the questionnaire and the statisticians were requested to sign a confidentiality agreement. The ethical clearance certificate obtained from the university was attached to the survey to indicate that the study had been approved.

Turnitin is an internet-based teaching tool that can be used to check the authenticity of documents by comparing texts in massive databases (Turnitin, 2019). Hence, the manuscript was submitted to Turnitin to ensure the proper interpretation of the resources used and the originality of the dissertation. Turnitin was used by the researcher as per UNISA's policies and ethical practices were adhered to. Lastly, the data and questionnaires were stored after the completion of the study (electronic information saved with protected passwords and hard copies in sealed boxes) to ensure the data was safe.

3.9 CONCLUSION

This chapter presented a comprehensive discussion of the research method of study. First, the research design was defined, and then the sampling of the study was reviewed. The research instrument was described in section 3.4 and the various stages in the planning of a survey were explained in more detail; these were: define the objectives, decide the type of survey required, decide on the information needed, design questionnaire, pilot and refine the instrument, and collect data and send reminders. In section 3.5 the type of data analysis was outlined along with the validity and reliability

measurements in section 3.6 for the study. Then the limitations and delimitations, and ethical considerations were set out to conclude the chapter.

Chapter 3 has provided a detailed explanation of the use of the research method to investigate the barriers resulting in the low adoption rate of green ICT. Table 3.6 provides a summary of the research questions linked to the research design, research instrument, data analysis and population.

Table 3.6: Research method

Research questions	Research design	Research instrument	Data analysis	Population
Primary research questions: **What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs*?*** ***Secondary research questions:*** **What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs?** **What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?**	Quantitative Non-experimental	Survey A five-point Likert questionnaire (bipolar scale)	Descriptive, multivariate and inferential statistics Exploratory factor analysis An independent-samples t-test Pearson product-moment coefficient	Census High technology-based SMEs located in Gauteng

Source: Author's own composition (2019)

In the next chapter, the results regarding the green ICT data related to South African SMEs located in Gauteng will be discussed.

CHAPTER 4: DATA ANALYSIS AND INTERPRETATION

4.1 INTRODUCTION

In this chapter, the data collected is analysed and discussed based on the statistical analysis completed. The purpose of Chapter 4 is to examine and interpret the collection of the data for this research study based on specific results drawn from the investigation conducted. This chapter will proceed according to the structured flow diagram presented in Figure 4.1.

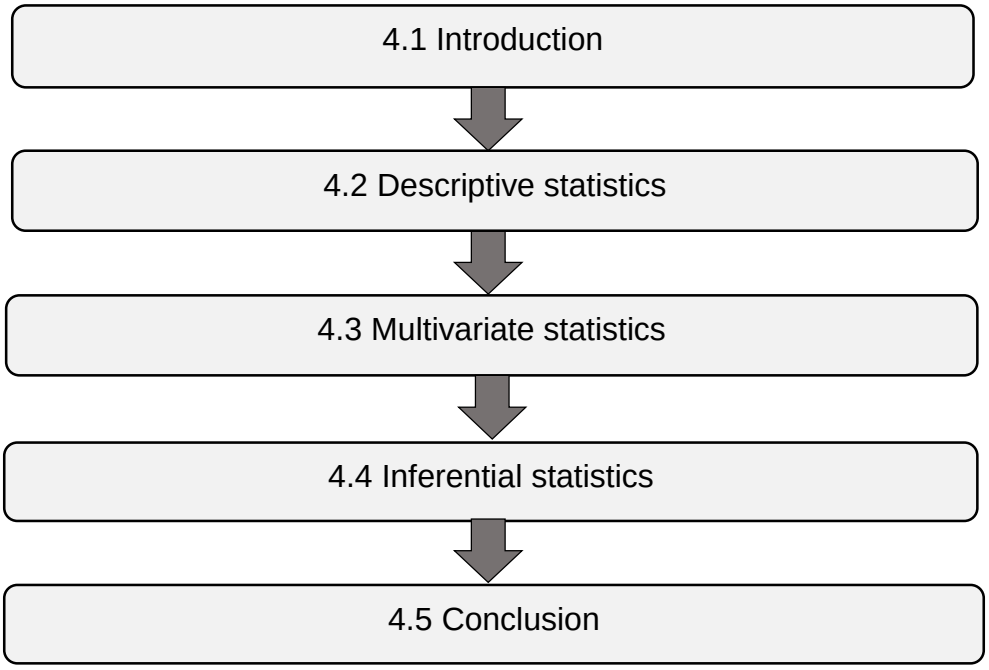

Figure 4.1: Flow diagram of Chapter 4
Source: Author's own composition (2019)

The problem under investigation was the low green ICT adoption rate in South African SMEs. In addition, the primary objective of the research study was to identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs. The study intended to determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs by means of the first secondary objective. Furthermore, the ensuing secondary objective of the study was to recommend strategies on how to improve the adoption rate of green ICT in South African SMEs.

The study pursued a positivist approach (Du Plooy-Cilliers *et al.*, 2014:25) and used deductive reasoning to investigate the assumption (Zikmund *et al.*, 2009:44) that SMEs are not readily adopting green ICT. A quantitative method was applied by making use of a survey in the form of a self-administered questionnaire that was distributed to participants (Cooper & Schindler, 2014:225). In order to obtain empirical evidence, a census was undertaken whereby the entire population of 400 SMEs were included in the study.

Chapter 4 is structure as follows:

- A discussion based on descriptive statistics regarding the response rate of owners and managers, and demographic characteristics is presented (see section 4.2).
- Thereafter, multivariate statistical analysis with reference to exploratory factor analysis and a summary of constructs (see section 4.3) is discussed.
- In section 4.4, inferential statistics are described in terms of group differences and correlations between barriers including shared views.
- The chapter concludes with an overall view on concluding remarks and a summary of the chapter in section 4.5.

Chapter 4 focuses on the results of the statistical analysis with regard to the primary and secondary objectives of the research study. These results are discussed in view of the data based on the research questions of the study. The results of the research study are therefore presented by a descriptive, multivariate and inferential statistical analysis to define the constructs identified.

4.2 DESCRIPTIVE STATISTICS

In this section, a detailed discussion is provided on the statistics of the response rate and demographic characterises.

4.2.1 Response rate

An online SurveyMonkey® link was sent to all of the 400 SMEs registered with The Innovation Hub. This electronic self-administered questionnaire was forwarded to SME owners and managers of enterprises registered with The Innovation Hub. In addition, the researcher attended sessions at the main campus and satellite branches of The Innovation Hub to increase the response rate and provide all participants with an equal opportunity to participate in the study.

The questionnaire was designed in a way that the participants had to complete a page before they could proceed to the next page. A total of six pages had to be completed for the participants to reach the end of the online survey. The questionnaire was also accompanied by a participation sheet that provided an overview regarding the research study and requested their consent to participate. To obtain valid and appropriate information for the study, the questions of the questionnaire were compiled from the constructs obtained from the literature review.

The focus of the study was on the barriers (Section C) although factors impacting the adoption (Section A) and drivers (Section B) were also observed. Additionally, biographical information (Section D) and open-ended questions (Section E) were also taken into consideration for this research study. Thus, the emphasis of the study was on

Sections C, D and E to obtain a better understanding regarding the low green ICT adoption rate in South African SMEs.

The questionnaire offered adequate anonymity to all participants to ensure a good response rate. The participants were asked to answer the questions by means of a five-point bipolar Likert scale where 1 represented strongly disagree and 5 strongly agree. Only n=10 participants out of the 400 targeted SMEs attempted to answer the online questionnaire of which only two were completed and the remaining eight were incomplete. This also included reminders that were sent to participants as a follow-up procedure to encourage the completion of the online survey. Due to the low online response rate an additional strategy was followed to collect data. This strategy encompassed the distribution of paper questionnaires to the same population by attending sessions and site visits. In Table 4.1 the steps taken to collect data over a period of 22 weeks are outlined.

Table 4.1: Outlined strategy

Strategy	Interaction
a) Electronic questionnaire	SurveyMonkey® link of online survey
b) Paper questionnaire	Training workshops
	Innov8 event
	Community engagement project
	Face-to-face meetings
	eKasilabs site visits

Source: Author's own composition (2019)

All reasonable measures were applied by the researcher to ensure that the entire SMEs were included in the study. Furthermore, the researcher provided an equal opportunity for all members to participate in the study. The paper questionnaires were distributed at interventions hosted at the main campus by The Innovation Hub. At these interventions, the attendance rate was not that high, and an average of 10-12 people usually attended

these workshops. In addition to this, site visits were conducted at the main campus where some of the SMEs are occupying offices to distribute paper questionnaires. During these site visits, face-to-face meetings took place whereby informal discussions were conducted regarding the research study.

These entrepreneurs use these office spaces on an as-needed basis and as a result, were not always readily available. Thus, the average number (three or four) of entrepreneurs to meet up with at the different locations varied due to their flexible working hours. Site visits were also conducted at the eKasiLabs which are located in townships whereby individual informal question-and-answer sessions related to the research study took place. These informal discussions were noted but not recorded but provided significant insight into aspects regarding the adoption of green ICT. The programme managers at the eKasiLabs also confirmed that the entrepreneurs don't visit these satellite branches every day (an average of three entrepreneurs a day) and only come by when they need to use any of the facilities supplied at these labs.

One hundred paper questionnaires throughout the interventions and site visits were completed by participants of which two were incomplete and could not be used. Of the 400 targeted participants, a total of n=100 answered the questionnaires successfully (both electronic and paper). However, a total of ten questionnaires could not be used because the participants only completed the first page or question 1 and left out the remaining sections of the questionnaire. This presents a response rate of 25% of usable questionnaires for the statistical analysis of data. Both the electronic and paper self-administered questionnaires were administered by the researcher. The data collected by means of these two strategies were transferred to a Microsoft Excel spreadsheet. The data was analysed using the IBM SPSS, Version 25, with the assistance of a statistician.

4.2.2 Demographic characteristics

The targeted population consisted of registered SMEs with The Innovation Hub located in Gauteng. This sample of SMEs comprised advanced technological infrastructures in

an innovative digital space. For this reason, The Innovation Hub was selected as it focuses on high-end innovative solutions that create a cutting-edge ICT platform for entrepreneurs. These participants were selected based on their job descriptions and involvement in ICT decision-making processes.

The questionnaire was thus distributed to SME owners and managers who are viewed as subject experts in high-technology enterprises. The participants' job function revolves around key decision matters and has the potential to impact decisions pertaining to the adoption of green ICT. Thus, the SME owners and managers were selected as primary participants based on their responsibilities and involvement in key business decisions. Attention is now drawn to the descriptive analysis of the demographics (the percentage values are indicated without decimals as the participants totalled 100).

4.2.2.1 Position of participants in company

The targeted population for the study consisted of owners and managers in high technology-based SMEs located in Gauteng. In Table 4.2 the results of the participants who completed the questionnaires are shown in percentage values (n=100).

Table 4.2: Position held in company

Position in company	**Percent (%) n=100**
Owner	60
Manager	38
Not specified	2
Total	**100**

From Table 4.2 it is evident that most of the participants were owners (60%) of SMEs and 38% represented managers. In addition, two of the participants did not specify their position held in the company but served as instrumental role players with the capacity to impact ICT decision-making processes.

These participants were considered as they occupied jobs that also involved key decision matters which potentially impacted decisions on green ICT adoption. They provided a high probability of validity as the data collected came from participants who had a certain level of knowledge and experience of ICT which is expected from subject experts in SMEs. However, the study primarily focused on the data analysis of the two main categories - owners and managers - as these two job functions require certain levels of knowledge and experience regarding ICT.

4.2.2.2 Age group of participants

Table 4.3 shows the distribution of the participants based on their age group as reflected in the different age brackets in percentage values (n=100).

Table 4.3: Age groups

Age groups	Percent (%) n=100
18-29	48
30-39	38
40-49	8
50-59	4
Not specified	2
Total	**100**

The largest age group of participants was represented by the age group 18-29 years (48%) while 38% came from the age group 30-39 years. Participants aged 40-49 (8%) and 50-59 (4%) years represented the lower percentages with regard to age. This indicates the likelihood that participants below the age of 40 are the biggest group contributing to the study.

The not-specified age group (2%) only constituted a small percentage which might not impact significantly the generalisability but contributes towards the perception of green ICT. The participants in all the age groups responded as the entire population was provided with the same opportunity to participate in the study.

4.2.2.3 Education level of participants

In Table 4.4, the different education levels of the participants are shown based on the qualification obtained in percentage values (n=100).

Table 4.4: Education levels

Education level	Percent (%) n=100
Matric or less	9
Diploma or certification	39
Degree	26
Postgraduate degree	25
Not specified	1
Total	**100**

From Table 4.4 it is evident that most of the participants had tertiary education ranging from diploma or certificate (39%), degree (26%) to postgraduate degree (25%). Only 9% of the participants had matric or less and only 1% did not specify a qualification. This indicates that the participants with a tertiary education (majority) are likely to impact the decisions regarding the adoption of green ICT.

4.2.2.4 Number of operational years of company

Table 4.5 shows the number of operational years of companies as indicated by the participants in percentage values (n=100).

Table 4.5: Number of operational years

Number of operating years	Percent (%) n=100
Less than a year	12
1-5 years	64
6-10 years	14
More than 10 years	8
Not specified	2
Total	**100**

As shown in Table 4.5, 64% of the participants have been operating their companies between 1 and 5 years. Those participants operating between 6 and 10 years comprise 14%, less than a year 12%, more than 10 years 8%, and 2% not specified. From the results, it is evident that the companies are relative newcomers to the marketplace. Thus, the likelihood of participants taking advantage of opportunities regarding green ICT adoption might be higher due to their companies still being at a start-up stage.

4.2.2.5 Number of employees in company

In Table 4.6, the number of employees in companies is shown based on the responses from participants in percentage values (n=100).

Table 4.6: Number of employees

Number of employees	Percent (%) n=100
<50	91
50-150	3
151-250	2
Not specified	4
Total	**100**

Table 4.6 indicates that 91% of the participants have less than 50 employees in their company. The minority of the number of employees for companies was represented by those ranging from 50-150 employees (3%), 151-250 employees (2%) and 4% not specified. This reveals that a majority of the enterprises are small and fall under the category of SMEs. As mentioned in Chapter 1, SMEs employ fewer than 50 employees (small-sized) and less than 250 employees (medium-sized) according to Adeniran and Johnston (2016:61).

Moreover, in a certain sense, the relatively small sample can be defended by the following argument. Firstly, the green ICT concept is still relatively new in South Africa as not all participants were familiar with the term. Hence, the study was conducted to test a collective perception of entrepreneurs who are more likely to adopt green ICT practices due to the high-technology environment they are operating in.

Secondly, the sample size exceeds or is comparative to research published on green ICT (IT/IS) such as a sample size = 61 (Buchalcevova & Gala, 2013:44), sample size = 64 (Chen & Chang, 2014:319), sample size = 43 (Buchalcevova, 2015:30) and sample size = 102 (Muafi, 2015:727). The sample size of the study exceeds the value of 50 which is normally regarded as the requirement for significance and exceeds the minimum acceptable value (30-40) for exploratory factor analysis (Hair *et al.*, 2014:115-116). The researcher made all reasonable efforts to obtain responses from all the SMEs registered with The Innovation Hub. After the responses were obtained, the IBM SPSS, Version 25 statistics software program was used to analyse the data.

4.3 MULTIVARIATE STATISTICS

In this section, a detailed discussion is provided on the statistics of the exploratory factor analysis and statistical summary of constructs.

4.3.1 Exploratory factor analysis

An exploratory factor analysis was used to determine the validity of the constructs perceived by SMEs. This analysis was also used to explore the data as it assists the researcher on how to derive and measure the factor loadings from the statistical results (Hair *et al.*, 2014:602-603). The Bartlett 's test of sphericity was considered significant ($p<0.05$) as it yielded a chi-square value of $X^2 = 1158.33$ (df =253, p=0.000). Thus, the chi-square distribution for this research indicated the significance of correlations in the data which is appropriate for factor analysis (Pallant, 2011:183). The KMO measure of sampling adequacy yielded a value of 0.722 which is greater than 0.6 and thus acceptable for factor analysis (Sreejesh *et al.*, 2014:217).

From Table 4.7 it is evident that the KMO and Bartlett's test are statistically significant as a value greater than the minimum ($p<0.05$) is deemed a valid factor analysis. The chi-square approximation is therefore significant for the barriers resulting in the low green ICT adoption.

Table 4.7: KMO and Bartlett's test

KMO measure of sampling adequacy		0.722
Bartlett 's test of sphericity	Approx. Chi-Square	1158.338
	Df	253
	Sig	0.000

**Df = Degree of freedom*

***Sig = Significance*

Cattell's scree test was used to plot the eigenvalues and identify a maximum number of factors greater than 1.0 extracted before the curve starts to straighten (Pallant, 2011:199). The eigenvalues of the components extracted only showed six values above 1 (5.85, 2.76, 2.53, 2.12, 1.62, 1.07) of which the total variance was 69.34%. In Figure 4.2 a screeplot with the variance between the components extracted is shown.

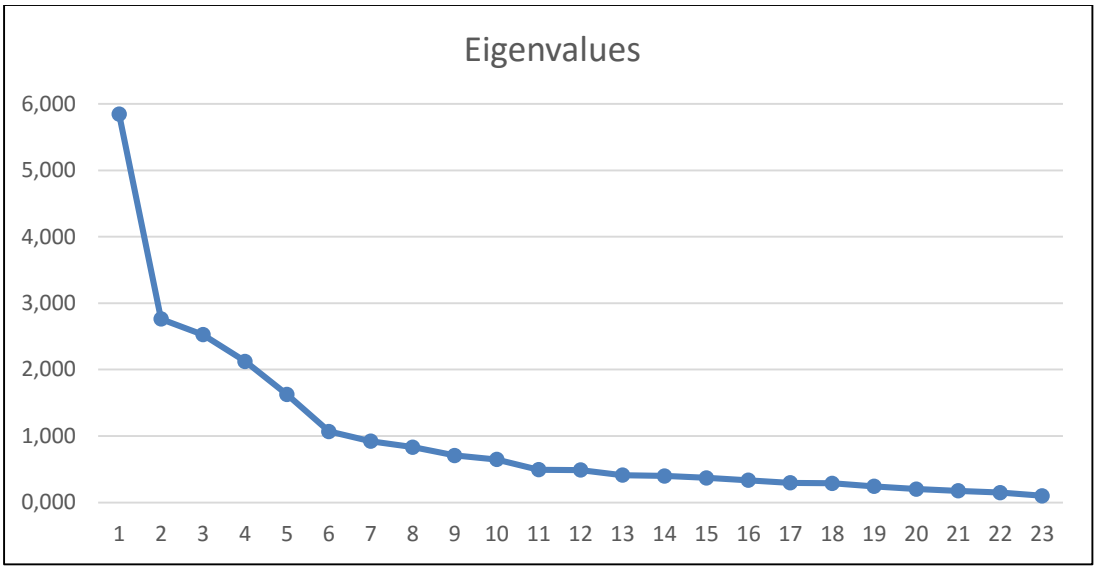

Figure 4.2: Scree test

Figure 4.2 shows a much greater variance between components 1 and 2 in comparison to the other components. A clear break is indicated on the plot between components 2, 3, 4, 5 and 6 which will be explored. Overall six factors were identified from Cattell's scree test to be retained for further exploration and validity.

The objective of a factor analysis is to group related variables together into a set of more manageable factors without reducing information through an interdependence technique (Hair *et al.*, 2014:14, 89). Hence, an exploratory factor analysis was conducted to determine the barriers resulting in the low adoption rate of green ICT. After all non-loading items were removed, the number of items decreased from 25 to 23. Six factor loadings were considered based on the eigenvalues of the components extracted. The proposed cut-off point for the loadings of the items was >0.60 and the Cronbach's alpha threshold was >0.70 as values ranged from 0.75 to 0.88. The items identified are closely related to factors and grouped according to communalities as extracted from the shared variance measured (Field, 2013: 675). High communalities are indicated as items correlate and load significantly on factors. Table 4.8 the items loaded for each construct are reported.

Table 4.8: Rotated factor matrix

Construct: Legislation	**Factor loadings**					
Items	**1**	**2**	**3**	**4**	**5**	**6**
Inadequate capabilities by government	0.894					
Insufficient government support for green initiatives	0.791					
Unclear government policies	0.779					
Unpredictable changes in government laws	0.774					
Insufficient government subsidies	0.769					
Construct: Skills	**Factor loadings**					
Items	**1**	**2**	**3**	**4**	**5**	**6**
Lack of skills to enhance green initiatives		0.873				
Inadequate technical capabilities		0.816				
Poor expertise in green ICT operation processes		0.795				
Lack of qualified employees		0.752				
Lack of green ICT training		0.646				
Construct: Funding	**Factor loadings**					
Items	**1**	**2**	**3**	**4**	**5**	**6**
Continuous investment required			0.770			
High initial investment required for operational costs			0.748			
Uncertainty about return on investment			0.742			
High research and development costs			0.677			
Insufficient capital			0.613			

Construct: Awareness	**Factor loadings**					
Items	**1**	**2**	**3**	**4**	**5**	**6**
Unawareness of green ICT in the marketplace				0.804		
Unawareness of green ICT to improve sustainability				0.779		
Unsureness about the implementation of green ICT				0.770		
Unawareness about green ICT operation processes				0.729		
Construct: Knowledge-complexity	**Factor loadings**					
Items	**1**	**2**	**3**	**4**	**5**	**6**
Too complex					0.890	
Risk of failure					0.766	
Construct: Knowledge-uncertainty	**Factor loadings**					
Items	**1**	**2**	**3**	**4**	**5**	**6**
Uncertainty about green ICT benefits						0.785
Lack of shared knowledge collaboration						0.776
Cumulative percentage variance explained	**29.79**	**40.64**	**48.76**	**56.31**	**62.83**	**67.65**

Factor loadings above the acknowledged threshold of ±0.50 are deemed significant on the basis of the specific power level and sample size (Hair *et al.*, 2014:115). As shown in Table 4.8, the factor loadings were >0.6 which are above the significant level and indicate that the internal consistency is acceptable. Five constructs were originally discussed in the literature, but the overall eigenvalues extracted six factors that were grouped into 23 items according to each factor. The items extracted are represented by the following six factors:

- Legislation (inadequate government capabilities, insufficient support, policies, laws, subsidies)
- Skills (lack of green initiatives, inadequate technical capabilities, expertise, qualified employees, training)
- Funding (insufficient and uncertainty about investments, capital and high costs)

- Awareness (unawareness of marketplace, improving sustainability, implementation and operation processes)
- Knowledge-complexity (too complex and risk of failure)
- Knowledge-uncertainty (uncertainty of benefits and lack of shared knowledge)

Table 4.8 indicates that the rotated factor matrix loadings grouped all the items well onto the constructs. The results from the exploratory factor analysis show that five items were grouped into the legislation, skills and funding factor. The items of these constructs therefore, corresponded directly to the measurement instrument used. Furthermore, four items were grouped into the awareness factor, thus one item was weaker and formed part of the non-loadings removed based on the eigenvalues. The knowledge factor was loaded into two separate factors, namely complexity and an uncertainty factor which each had two item loadings and indicated one non-loading. In general, the items of each factor evidently showed that the constructs are in line with the questionnaire and measured what it was supposed to measure. This confirms the questionnaire's validity for a more in-depth statistical analysis. It should also be noted that only the highest factor loadings were added and reported as shown in Table 4.8.

4.3.2 Statistical summary of constructs

The results regarding the barriers of green ICT presented in Section C (question 4.1 – 4.5) of the questionnaire are discussed based on univariate and bivariate analysis. These ratings of the six constructs identified as legislation, skills, funding, awareness, knowledge (complexity and knowledge) are also analysed to ensure the reliability of the questionnaire. According to Pallant (2011:210), Cohen's *d* is one of the most frequently used effect size statistics to determine the difference between the standard deviation (SD) units. A one-sample t-test was conducted to test the statistical (standardised) difference between the mean (M) and mid-value of the sample for the constructs whereby the effect size was calculated through Cohen's *d* formula and the values were interpreted as follows (Quantitative Specialists, 2016):

Effect size

$$\text{Cohen's } d = \frac{\text{mean difference}}{\text{Std. Deviation}}$$

Cohen's guidelines for *d*:

Small = .20, medium = .50, large = .80.

The effect size calculated for four of the constructs (legislation, skills, funding and awareness) was large and the values ranged between 1 to 1.41. However, the effect size calculated for knowledge (complexity) was small (0.18) and medium (0.72) for knowledge (uncertainty). This indicates that the magnitude of the difference in the means (SD units) for the majority of constructs is large.

4.3.2.1 Legislation

Table 4.9 shows a summary of the statistics of the legislation construct determined through the data collected.

Table 4.9: Statistics of legislation construct

Items **Cronbach's alpha = 0.88**	**SD %**	**D %**	**N %**	**A %**	**SA %**	**Item mean (sdev)**	**Construct mean (sdev)**
Q4.4.a: Insufficient government subsidies	5	4	25	31	35	3.87 (1.098)	3.88 (0.878)
Q4.4.b: Unpredictable changes in government laws	5	8	23	41	23	3.69 (1.070)	
Q4.4.c: Inadequate capabilities by government	4	6	23	39	28	3.81 (1.042)	
Q4.4.d: Unclear government policies	3	8	19	33	37	3.93 (1.075)	
Q4.4.e: Insufficient government support for green initiatives	3	5	18	28	46	4.09 (1.055)	
Average: Overall frequency for construct	**4**	**6**	**22**	**34**	**34**		

**SD=Strongly disagree; D=Disagree; N=Neutral; A=Agree; SA=Strongly agree*

***sdev=Standard deviation*

As shown in Table 4.9, the percentages of the statistical analysis revealed that most of the participants agreed with the statements. The *agree* and *strongly agree* ratings by the participants for the legislation criteria consist of the following:

- Insufficient government subsidies (31% agree and 35% strongly agree = 66%)
- Item M=3.87 and SD=1.098
- Unpredictable changes in government laws (41% agree and 23% strongly agree = 64%)
- Item M=3.69 and SD=1.070
- Inadequate capabilities by government (39% agree and 28% strongly agree = 67%)
- Item M=3.81 and SD=1.042
- Unclear government policies (33% agree and 37% strongly agree = 70%)
- Item M=3.93 and SD=1.075
- Insufficient government support for green initiatives (28% agree and 46% strongly agree = 74%)
- Item M=4.09 and SD=1.055

A one-sample t-test indicated that the overall construct mean of 3.88 (SD=0.878) is statistically significant from the mid-value of 3 [t(99)=10.006, p=0.000, two-tailed and large effect size=1.00]. The SD of both the items and constructs was below or slightly above 1, which indicates that the rating scores were fairly close to the mean scores. Furthermore, Cronbach's alpha was 0.88 and confirms the reliability of the questionnaire used to collect the data as values above 0.7 are considered reliable (Hair *et al.*, 2014:123).

Based on these ratings, SMEs are unclear about legislation on green ICT. This implies that all of the participants (n=100) appear to experience insufficient support regarding the

adoption of green ICT. This indicates that participants agreed with the statement that legislation was a barrier and hindered the adoption of green ICT.

Figure 4.3 shows the skewness related to the legislation construct regarding the barriers of green ICT as rated by SME owners/managers by means of a histogram. A histogram is used to graphically show the distribution of a single variable representing the frequency of data values within the categories of data (Hair *et al.*, 2014:33). The histogram shows a fairly normal distribution, though a somewhat skewed distribution toward higher score ratings. This indicates that the legislation construct regarding the barriers of green ICT received a relatively more than neutral rating towards an agreeable rating. Additionally, higher values on the scale in Figure 4.3 imply that participants are more in agreement about the lack of legislation being a barrier for green ICT adoption.

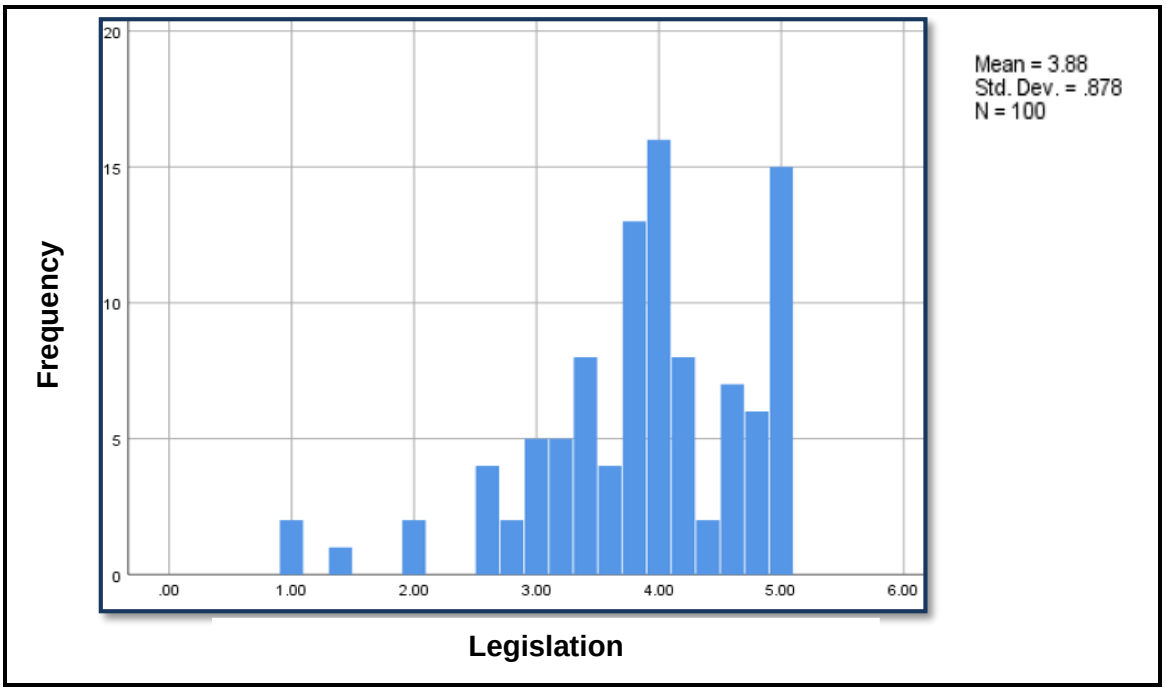

Figure 4.3: Histogram of legislation construct

4.3.2.2 Skills

Table 4.10 shows a summary of the statistics of the skills construct determined through the data collected.

Table 4.10: Statistics of skills construct

Items **Cronbach's alpha = 0.86**	**SD %**	**D %**	**N %**	**A %**	**SA %**	**Item mean (sdev)**	**Construct mean (sdev)**
Q4.3.a: Lack of qualified employees	3	7	28	39	23	3.72 (0.996)	3.78 (0.746)
Q4.3.b: Lack of skills to enhance green initiatives	3	7	12	58	20	3.85 (0.925)	
Q4.3.c: Inadequate technical capabilities	3	5	22	57	13	3.72 (0.866)	
Q4.3.d: Poor expertise in green ICT operation processes	3	7	29	48	13	3.61 (0.909)	
Q4.3.e: Lack of green ICT training	3	5	13	45	34	4.02 (0.974)	
Average: Overall frequency for constructs	**3**	**6**	**21**	**49**	**21**		

**SD=Strongly disagree; D=Disagree; N=Neutral; A=Agree; SA=Strongly agree*

***sdev=Standard deviation*

As shown in Table 4.10, the percentages of the statistical analysis revealed that most of the participants agreed with the statements. The *agree* and *strongly agree* ratings by the participants for the skills criteria consist of the following:

- Lack of qualified employees (39% agree and 23% strongly agree = 62%)
- Item M=3.72 and SD=0.996
- Lack of skills to enhance green initiatives (58% agree and 20% strongly agree = 78%)
- Item M=3.85 and SD=0.925
- Inadequate technical capabilities (57% agree and 13% strongly agree = 70%)

- Item M=3.72 and SD=0.866
- Poor expertise in green ICT operation processes (48% agree and 13% strongly agree = 61%)
- Item M=3.61 and SD=0.909
- Lack of green ICT training (45% agree and 34% strongly agree = 79%)
- Item M=4.02 and SD=0.974

A one-sample t-test indicated that the overall construct mean of 3.78 (SD=0.746) was statistically significant from the mid-value of 3 [t(99)=10.509, p=0.000, two-tailed and a large effect size=1.05]. The SD of both the items and constructs was below 1, which indicates that the rating scores were close to the mean scores. Furthermore, Cronbach's alpha was 0.86 and confirms the reliability of the questionnaire used to collect the data. Based on these ratings a lack of expert ICT for the adoption of green ICT is experienced by SMEs. From these percentages, it is evident that all of the participants (n=100) did not have the necessary skills for the adoption of green ICT.

Based on these ratings, a lack of skills for the adoption of green ICT is experienced by SMEs. From these percentages, it is evident that all of the participants (n=100) did not have the necessary skills for the adoption of green ICT. This indicates that the participants agreed with the statement that a lack of skills was a barrier and hindered the adoption of green ICT.

Figure 4.4 shows the skewness related to the skills construct regarding the barriers of green ICT as rated by SME owners/managers by means of a histogram. The histogram shows a fairly normal distribution, though a somewhat skewed distribution toward higher score ratings. This indicates that the skills construct regarding the barriers of green ICT was rated relatively higher than neutral. Additionally, higher values on the scale in Figure 4.4 imply that the participants agreed that a lack of skills was a barrier for green ICT adoption.

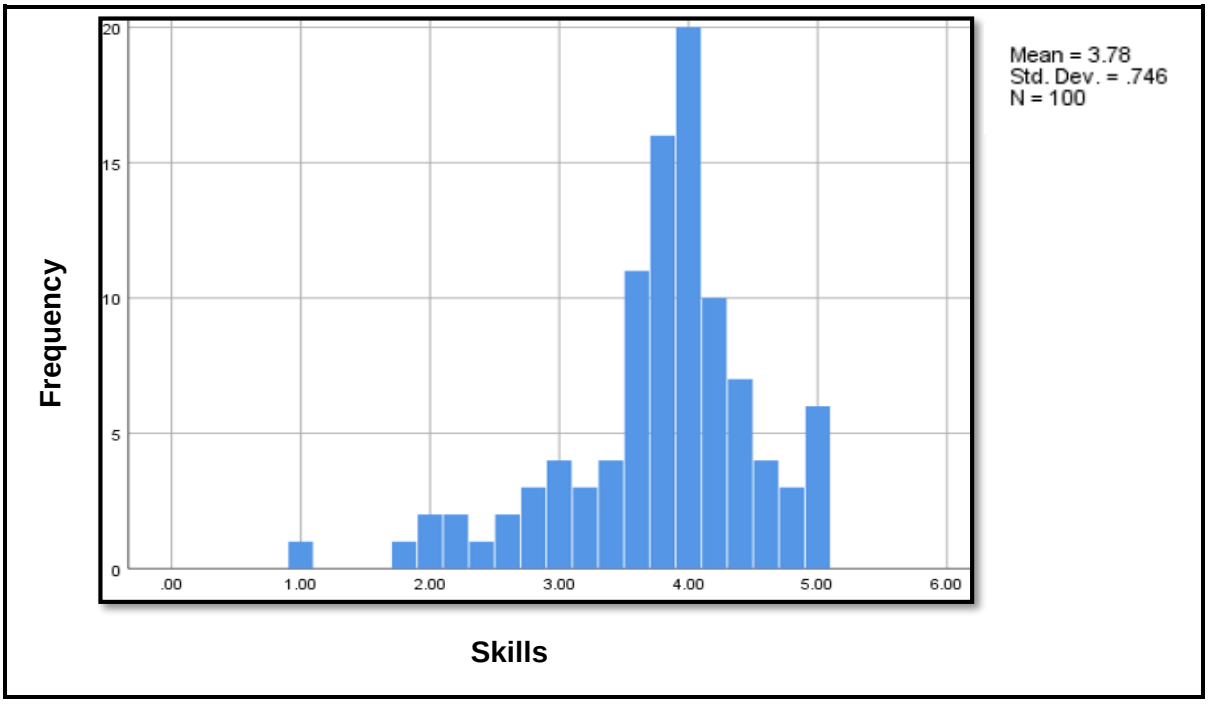

Figure 4.4: Histogram of skills construct

4.3.2.3 Funding

Table 4.11 shows a summary of the statistics of the funding construct determined through the data collected.

Table 4.11: Statistics of funding construct

Items Cronbach alpha's = 0.79	SD %	D %	N %	A %	SA %	Item mean (sdev)	Construct mean (sdev)
Q4.5.a: Insufficient capital	4	4	20	31	41	4.01 (1.068)	3.94 (0.760)
Q4.5.b: High research and development costs	3	6	23	37	31	3.87 (1.022)	
Q4.5.c: Uncertainty about return on investment	4	6	20	35	35	3.91 (1.074)	
Q4.5.d: Continuous investment required	2	5	28	37	28	3.84 (0.961)	
Q4.5.e: High initial investment required for operational costs	2	5	20	31	42	4.06 (1.003)	
Average: Overall frequency for constructs	**3**	**5**	**22**	**34**	**35**		

**SD=Strongly disagree; D=Disagree; N=Neutral; A=Agree; SA=Strongly agree*

***sdev=Standard deviation*

As shown in Table 4.11, the percentages of the statistical analysis revealed that most of the participants agreed with the statements. The *agree* and *strongly agree* ratings by the participants for the funding criteria consist of the following:

- Insufficient capital (31% agree and 41% strongly agree = 72%)
- Item M=4.01 and SD=1.068
- High research and development costs (37% agree and 31% strongly agree = 68%)
- Item M=3.87 and SD=1.022
- Uncertainty about return on investment (35% agree and 35% strongly agree = 70%)
- Item M=3.91 and SD=1.074
- Continuous investment required (37% agree and 28% strongly agree = 65%)
- Item 3.84 and SD=0.961

- High initial investment required for operational costs (31% agree and 42% strongly agree = 73%)
- Item M=4.06 and SD=1.003

A one-sample t-test indicated that the overall construct mean of 3.94 (SD=0.760) was statistically significant from the mid-value of 3 [t(99)= 12.343, p=0.000, two-tailed and a very large effect size=1.23]. The SD of both the items and constructs was below or slightly above 1, which indicates that the rating scores were fairly close to the mean scores. Furthermore, Cronbach's alpha was 0.79 and confirms the reliability of the questionnaire used to collect the data.

Based on these ratings, the SMEs experienced a lack of funding for the adoption of green ICT. This implies that the total participants (n=100) did not have the necessary funding for the adoption of green ICT. This indicates that the participants agreed with the statement that a lack of funding was a barrier and hindered the adoption of green ICT.

Figure 4.5 shows the skewness related to the funding construct regarding the barriers of green ICT as rated by SME owners/managers by means of a histogram. The histogram shows a fairly normal distribution, though a somewhat skewed distribution toward higher score ratings. This indicates that the funding construct regarding the barriers of green ICT was relatively more than the average score rating of 3 and beyond. Additionally, higher values on the scale in Figure 4.5 imply that the participants agreed that a lack of funding was a barrier for green ICT adoption.

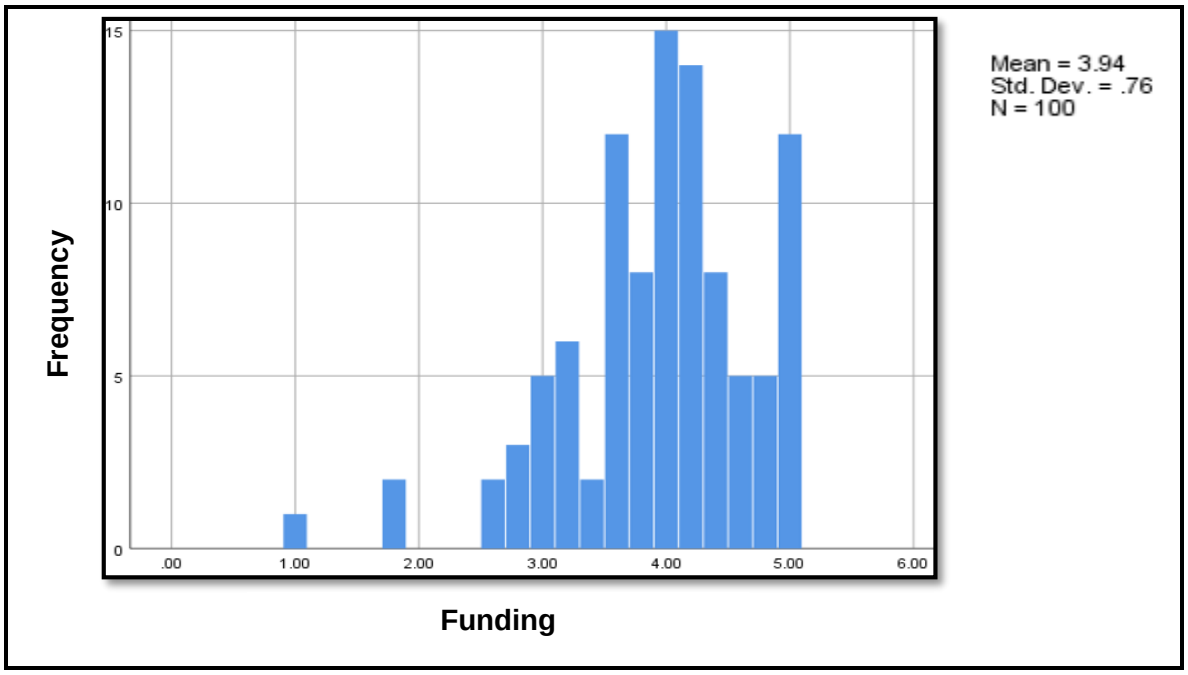

Figure 4.5: Histogram of funding construct

4.3.2.4 Awareness

Table 4.12 shows a summary of the statistics of the awareness construct determined through the data collected.

Table 4.12: Statistics of awareness construct

Items **Cronbach's alpha = 0.81**	**SD %**	**D %**	**N %**	**A %**	**SA %**	**Item mean (sdev)**	**Construct mean (sdev)**
Q4.1.a: Unsureness about the implementation of green ICT	1	3	28	46	22	3.85 (0.833)	3.94 (0.667)
Q4.1.b: Unawareness of green ICT to improve sustainability	0	5	21	47	27	3.96 (0.828)	
Q4.1.d: Unawareness of green ICT in the marketplace	0	5	26	37	32	3.96 (0.887)	
Q4.1.e: Unawareness about green ICT operation processes	0	3	23	45	29	4.00 (0.804)	
Average: Overall frequency for constructs	**0**	**4**	**25**	**44**	**28**		

**SD=Strongly disagree; D=Disagree; N=Neutral; A=Agree; SA=Strongly agree*

***sdev=Standard deviation*

As shown in Table 4.12, the percentages of the statistical analysis revealed that most of the participants agreed with the statements. The *agree* and *strongly agree* ratings by the participants for the awareness criteria consist of the following:

- Unsureness about the implementation of green ICT (46% agree and 22% strongly agree = 68%)
- Item M=3.85 and SD=0.833
- Unawareness of green ICT to improve sustainability (47% agree and 27% strongly agree = 74%)
- Item M=3.96 and SD=0.828
- Unawareness of green ICT in the marketplace (37% agree and 32% strongly agree = 69%)
- Item M=3.96 and SD=0.887
- Unawareness about green ICT operation processes (45% agree and 29% strongly agree = 74%)
- Item M=4.00 and SD=0.804

A one-sample t-test indicated that the overall construct mean of 3.94 (SD=0.667) is statistically significant from the mid-value of 3 [t(99)=14.120, p=0.000, two-tailed and a very large effect size=1.41]. The SD of both the items and constructs was below 1, which indicates that the rating scores were close to the mean scores. Furthermore, Cronbach's alpha was 0.81 and confirms the reliability of the questionnaire used to collect the data.

Based on these ratings, the SMEs experienced a lack of awareness for the adoption of green ICT. From these percentages, it is evident that all the participants (n=100) were mainly not aware of green ICT adoption. This indicates that the participants agreed with the statement that a lack of awareness was a barrier and hindered the adoption of green ICT.

Figure 4.6 shows the skewness related to the awareness construct regarding the barriers of green ICT as rated by SME owners/managers by means of a histogram. The histogram shows a fairly normal distribution, though a somewhat skewed distribution towards the higher score rating. This indicates that the awareness construct regarding the barriers of green ICT was relatively much more than the average score rating of 3 and beyond. Additionally, higher values on the scale in Figure 4.6 imply that the participants agreed that a lack of awareness was a barrier for green ICT adoption.

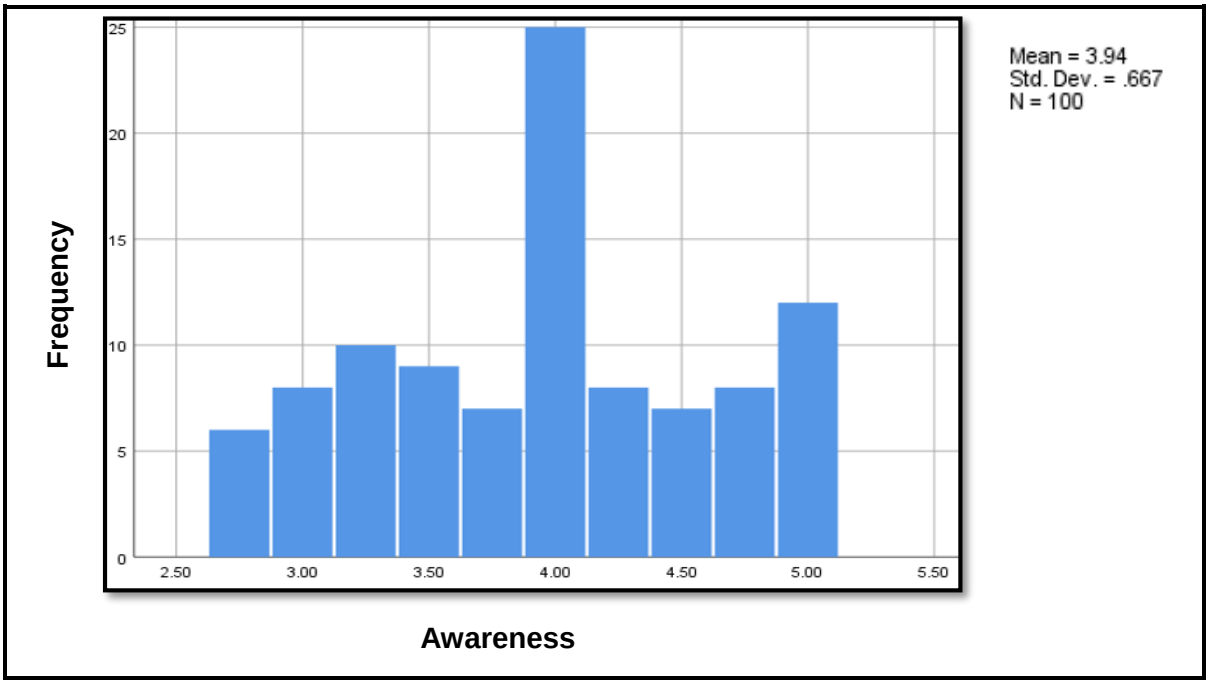

Figure 4.6: Histogram of awareness construct

4.3.2.5 Knowledge-complexity

Table 4.13 shows a summary of the statistics of the knowledge-complexity construct determined through the data collected.

Table 4.13: Statistics of knowledge-complexity construct

Items Cronbach's alpha = 0.75	SD %	D %	N %	A %	SA %	Item mean (sdev)	Construct mean (sdev)
Q4.2.a: Too complex	5	23	29	31	12	3.22 (1.088)	3.18 (0.999)
Q4.2.b: Risk of failure	6	27	28	25	14	3.14 (1.146)	
Average: Overall frequency for constructs	**6**	**25**	**29**	**28**	**13**		

**SD=Strongly disagree; D=Disagree; N=Neutral; A=Agree; SA=Strongly agree*

***sdev=Standard deviation*

As shown by Table 4.13, the percentages of the statistical analysis revealed that most of the participants agreed with the statements. The *agree* and *strongly agree* ratings by the participants for the knowledge-complexity criteria consist of the following:

- Too complex (31% agree and 12% strongly agree = 43%)
- Item M=3.22 and SD=1.088
- Risk of failure (25% agree and 14% strongly agree = 39%)
- Item M=3.14 and SD=1.146

A one-sample t-test indicates that the overall construct mean of 3.18 (SD=0.999) is statistically significant from the mid-value of 3 [t(99)=1.802, p=0.075, two-tailed and a small effect size=0.18]. The SD of both the items and constructs was below or slightly above 1, which indicates that the rating scores were fairly close to the mean scores. Furthermore, Cronbach's alpha is 0.75 and confirms the reliability of the questionnaire used to collect the data.

Based on these ratings, there appears to be a lack of knowledge regarding the complexity for the adoption of green ICT by SMEs. This implies that all the participants (n=100) don't have the necessary knowledge based on the complexity to adopt green ICT. This indicates that the participants agreed with the statement that a lack of knowledge based

on the complexity of green ICT was a barrier and hindered the adoption. It is also notable that the *disagree* (27%) and *agree* (25%) rating by SMEs on the risk of failure was almost perceived relatively fairly.

Figure 4.7 shows the skewness related to the knowledge-complexity construct regarding the barriers of green ICT as rated by SME owners/managers by means of a histogram. The histogram shows a fairly normal distribution, though a somewhat skewed distribution toward the higher score ratings. This indicates that the knowledge-complexity construct regarding the barriers of green ICT was relatively more than neutral towards an *agreed* rating. Additionally, higher values on the scale in Figure 4.7 imply that the participants were slightly more in agreement that a lack of knowledge based on the complexity of green ICT was a barrier for the adoption.

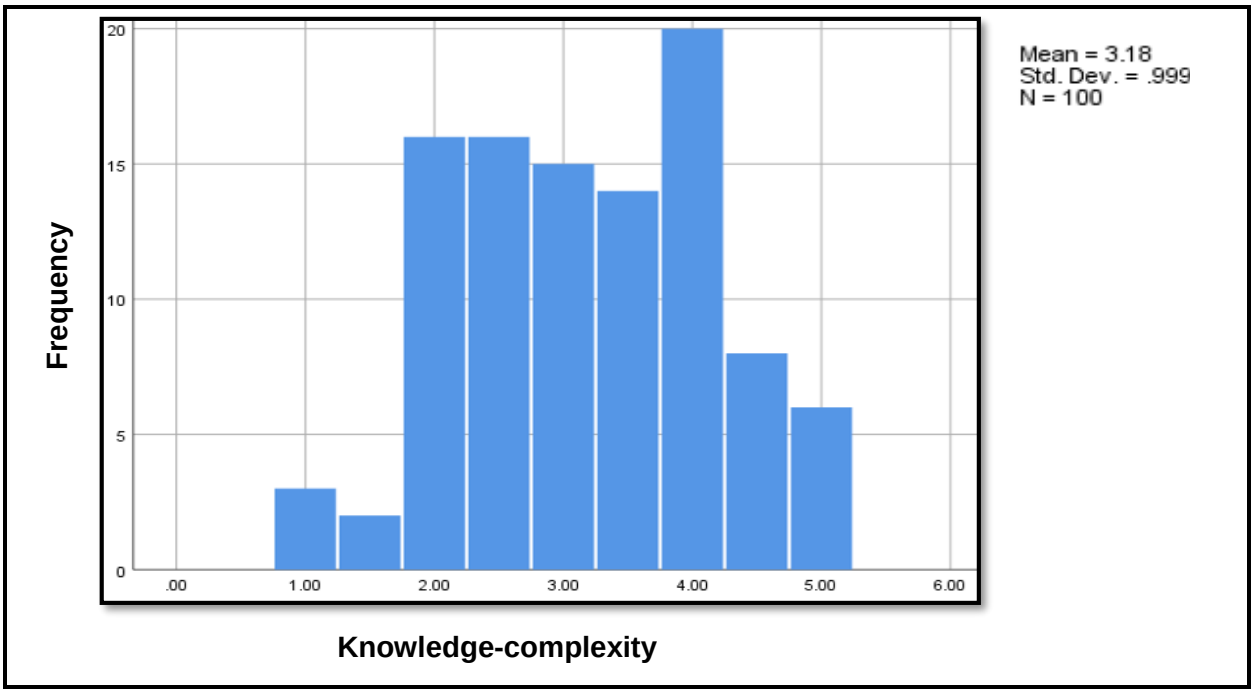

Figure 4.7: Histogram of knowledge-complexity construct

4.3.2.6 Knowledge-uncertainty

Table 4.14 shows a summary of the statistics of the knowledge-uncertainty construct determined through the data collected**.**

Table 4.14: Statistics of knowledge-uncertainty construct

Items **Cronbach's alpha = 0.79**	**SD %**	**D %**	**N %**	**A %**	**SA %**	**Item mean (sdev)**	**Construct mean (sdev)**
Q4.2.d: Lack of shared knowledge collaboration	6	5	26	47	16	3.62 (1.013)	3.68 (0.936)
Q4.2.e: Uncertainty about green ICT benefits	3	11	20	42	24	3.73 (1.043)	
Average: Overall frequency for constructs	**5**	**8**	**23**	**45**	**20**		

**SD=Strongly disagree; D=Disagree; N=Neutral; A=Agree; SA=Strongly agree*

***sdev=Standard deviation*

As shown in Table 4.14, the percentages of the statistical analysis revealed that most of the participants agreed with the statements. The *agree* and *strongly agree* ratings by the participants regarding the knowledge-uncertainty criteria consist of the following:

- Lack of shared knowledge collaboration (47% agree and 16% strongly agree = 63%)
- Uncertainty about green ICT benefits (42% agree and 24% strongly agree = 66%)

A one-sample t-test indicated that the overall construct mean of 3.68 (SD=0.936) is statistically significant from the mid-value of 3 [t(99)=7.213, p=0.00, two-tailed and a medium effect size=0.72]. The SD of both the items and constructs was below or slightly above 1, which indicates that the rating scores were fairly close to the mean scores. Furthermore, Cronbach's alpha is 0.79 and confirms the reliability of the questionnaire used to collect the data.

Based on these ratings, a lack of knowledge about the uncertainty regarding the adoption of green ICT is experienced by SMEs. From these percentages, it is evident that most of the participants (n=100) did not have the necessary knowledge based on the uncertainty of green ICT adoption. This indicates that participants agreed with the statements that a lack of knowledge based on the uncertainty of green ICT was a barrier and hindered the adoption.

Figure 4.8 shows the skewness related to the knowledge-uncertainty construct regarding the barriers of green ICT as rated by SME owners/managers by means of a histogram. The histogram shows a fairly normal distribution, though a somewhat skewed distribution toward the higher score rating. This indicates that the knowledge-uncertainty construct regarding the barriers of green ICT was relatively more than neutral towards an *agreed* rating to a certain extent. Additionally, higher values on the scale in Figure 4.8 imply that the participants generally agreed that a lack of knowledge based on the uncertainty of green ICT was a barrier for the adoption.

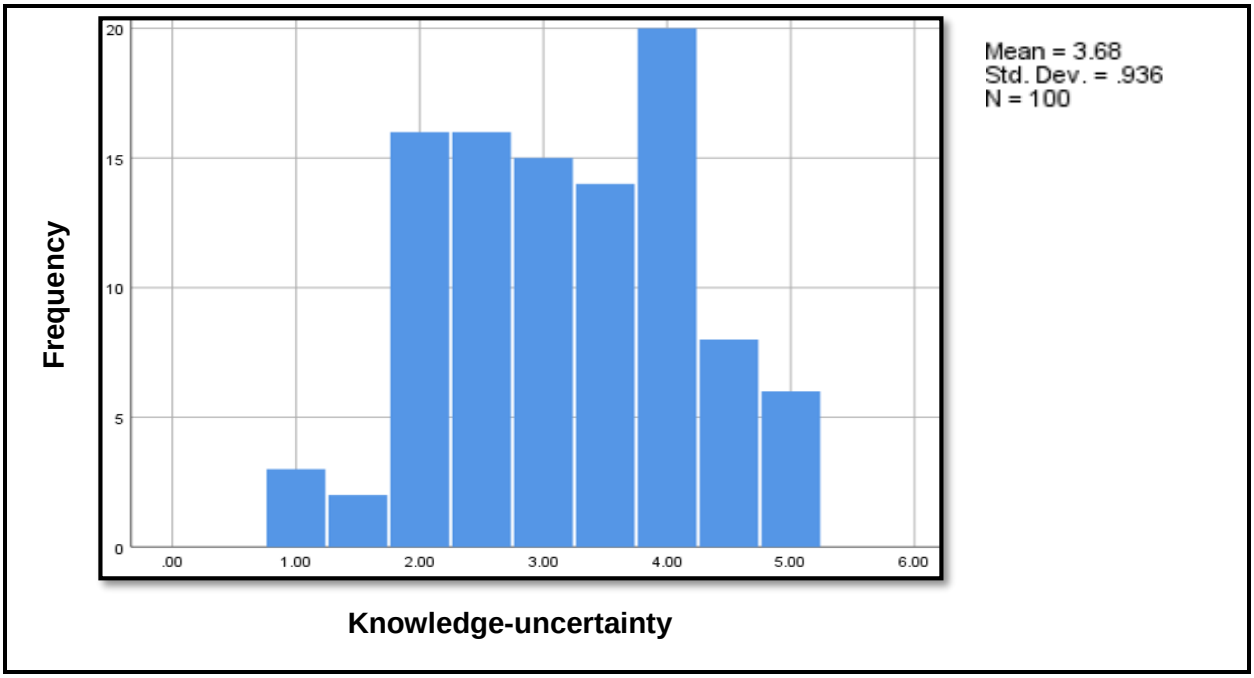

Figure 4.8: Histogram of knowledge-uncertainty construct

From these results, it was evident that the statement most agreed on was a lack of funding hindering the green ICT adoption rate (mean score of 3.94 and standard deviation of 0.760). The results also imply that barriers identified in the literature (Chapters 1 and 2) are indeed viewed as hindrances by SMEs for the adoption of green ICT.

4.4 INFERENTIAL STATISTICS

In this section a detailed discussion is provided particularly on the statistics of the group differences and correlation analysis.

4.4.1 Group differences

A description of the statistics related to group differences will be explained in this section. These group differences are based on the biographical information presented in Section D (questions 1 to 5) of the questionnaire which included position in company, grouped ages, education level and operational years. The total responses received by participants were analysed from the data collected to assess group differences. The level of significance value between the two groups was set at 0.05 for the independent-samples t-test (Field, 2013:378). According to Pallant (2011:242), if the significance value of Leven's test results is $p \leq 0.05$ the groups are significantly different but if $p \geq 0.05$ the groups are not significantly different. The effect size was calculated by the eta squared formula and values were interpreted as follows (Pallant, 2011:243):

$$\text{Eta squared} = \frac{t^2}{t^2 + (N1 + N2 - 2)}$$

.01=small effect
.06=moderate effect
.14=large effect

4.4.1.1 Position in company

Table 4.15 shows the results of the group statistics based on the position held by owners and managers in SMEs.

Table 4.15: Grouped statistics of positions in company

Construct	Position in company	n	Mean	Std. Deviation	t-value (df)	p-value	Effect size
Legislation	Owner	60	3.81	1.016	-1.169 (96)	0.245	0.01
	Manager	38	4.01	0.609			
Skills	Owner	60	3.78	0.810	0.062 (96)	0.951	0.00
	Manager	38	3.77	0.663			
Funding	Owner	60	3.87	0.849	-1.095 (96)	0.276	0.01
	Manager	38	4.05	0.614			
Awareness	Owner	60	3.93	0.692	-0.300 (96)	0.765	0.00
	Manager	38	3.97	0.653			
Knowledge-complexity	Owner	60	3.28	0.989	1.454 (96)	0.149	0.02
	Manager	38	2.99	0.976			
Knowledge-uncertainty	Owner	60	3.62	1.002	-0.746 (96)	0.457	0.01
	Manager	38	3.76	0.852			

Table 4.15 indicates that there was no significant difference in the scores between owners and managers based on the position in the company. The results of the independent-samples t-test are as follows:

- Legislation – for owners (M=3.81, SD=1.016) and managers (M=4.01, SD=0.609); t(96)=-1.169; p=0.245 and a very small magnitude in the mean differences (effect size=0.01).
- Skills – for owners (M=3.78, SD=0.810) and managers (M=3.77, SD=0.663); t(96)=0.062; p=0.951 and no effect size (0.00).
- Funding – for owners (M=3.87, SD=0.849) and managers (M=4.05, SD=0.614); t(96)=-1.095; p=0.276 and a very small magnitude in the mean differences (effect size = 0.01).

- Awareness – for owners (M=3.93, SD=0.692) and managers (M=3.97, SD=0.653); t(96)=-0.300; p=0.765 and no effect size (0.00).
- Knowledge-complexity – for owners (M=3.28, SD=0.989) and managers (M=2.99, SD=0.976); t(96)=1.454; p=0.149 and a very small magnitude in the mean differences (effect size = 0.02).
- Knowledge-uncertainty - for owners (M=3.62, SD=1.002) and managers (M=3.76, SD=0.852); t(96)=-0.746; p=0.457 and a very small magnitude in the mean differences (effect size = 0.01).

Figure 4.9 shows the mean scores graphically in accordance with the independent-samples t-test that was conducted to differentiate between the perceptions of the two groups. On average the data revealed that owners and managers rated the five constructs investigated relatively at the same level (ranging between 3.62 and 4.05) which exclude the knowledge-complexity construct which was rated lower than 3.30. These findings indicate that both groups perceived the lack of legislation, skills, funding, awareness and knowledge link to uncertainty more as barriers than knowledge based on complexity. The majority of the participants who indicated their level of position in the company were owners.

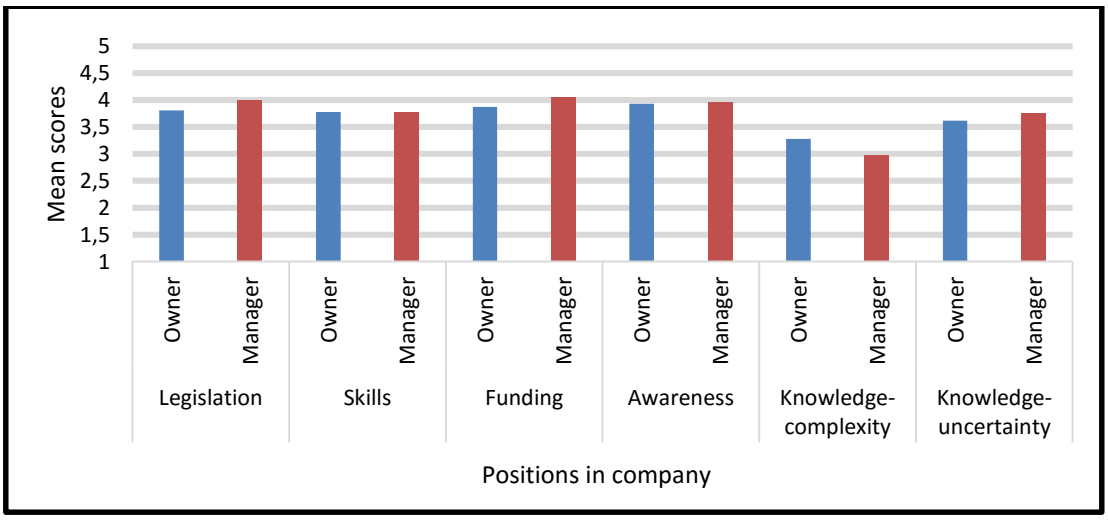

Figure 4.9: Mean scores of positions in company

4.4.1.2 Grouped ages

Table 4.16 shows the results of the statistics based on the grouped ages of 18-29 and 30+ in SMEs.

Table 4.16: Grouped statistics of grouped ages

Construct	Age group	n	Mean	Std. Deviation	t-value (df)	p-value	Effect size
Legislation	18-29	48	3.81	0.813	-0.826 (96)	0.411	0.01
	30+	50	3.96	0.942			
Skills	18-29	48	3.73	0.659	-0.492 (96)	0.624	0.00
	30+	50	3.81	0.829			
Funding	18-29	48	4.00	0.634	0.734 (96)	0.465	0.01
	30+	50	3.89	0.856			
Awareness	18-29	48	3.96	0.626	0.026 (96)	0.979	0.00
	30+	50	3.96	0.697			
Knowledge-complexity	18-29	48	3.15	0.962	-0.463 (96)	0.644	0.00
	30+	50	3.24	1.046			
Knowledge-uncertainty	18-29	48	3.65	0.967	-0.127 (96)	0.899	0.00
	30+	10	3.67	0.913			

Table 4.16 indicates that there was no significant difference in the scores between the grouped ages (18-29 and 30+). The results of the independent-samples t-test are as follows:

- Legislation – for age 18-19 (M=3.81, SD=0.813) and age 30+ (M=3.96, SD=0.942); t(96)=-1.669; p=-0.411 and a very small magnitude in the mean differences (effect size = 0.01).
- Skills – for age 18-19 (M=3.73, SD=0.659) and 30+ (M=3.81, SD=0.829); t(96)= -0.492; p=0.624 and no effect size (0.00).

- Funding – for age 18-19 (M=4.00, SD=0.634) and 30+ (M=3.89, SD=0.856); t(96)=0.734; p=0.465 and a very small magnitude in the mean differences (effect size = 0.01).
- Awareness – for age 18-19 (M=3.96, SD=0.626) and 30+ (M=3.96, SD=0.697); t(96)=0.026; p=0.979 and no effect size (0.00).
- Knowledge-complexity – for age 18-19 (M=3.15, SD=0.962) and 30+ (M=3.24, SD=1.046); t(96)=-0.463; p=0.644 and no effect size (0.00).
- Knowledge-uncertainty – for age 18-19 (M=3.65, SD=0.967) and 30+ (M=3.67, SD=0.913); t(96)=-0.127; p=0.899 and no effect size (0.00).

Figure 4.10 shows the mean scores graphically in terms of the independent-samples t-test that was conducted to differentiate between the perceptions of the two groups. On average the data reveals that the grouped ages 18-29 and 30+ rated the five constructs investigated fairly at the same level (ranging between 3.65 and 4.00) which excludes the knowledge-complexity construct which was rated lower than 3.30. These findings indicate that both groups perceived the lack of legislation, skills, funding, awareness and knowledge link based on uncertainty more as barriers than knowledge based on complexity. Most of the participants who indicated their age group came from the age group 18-29.

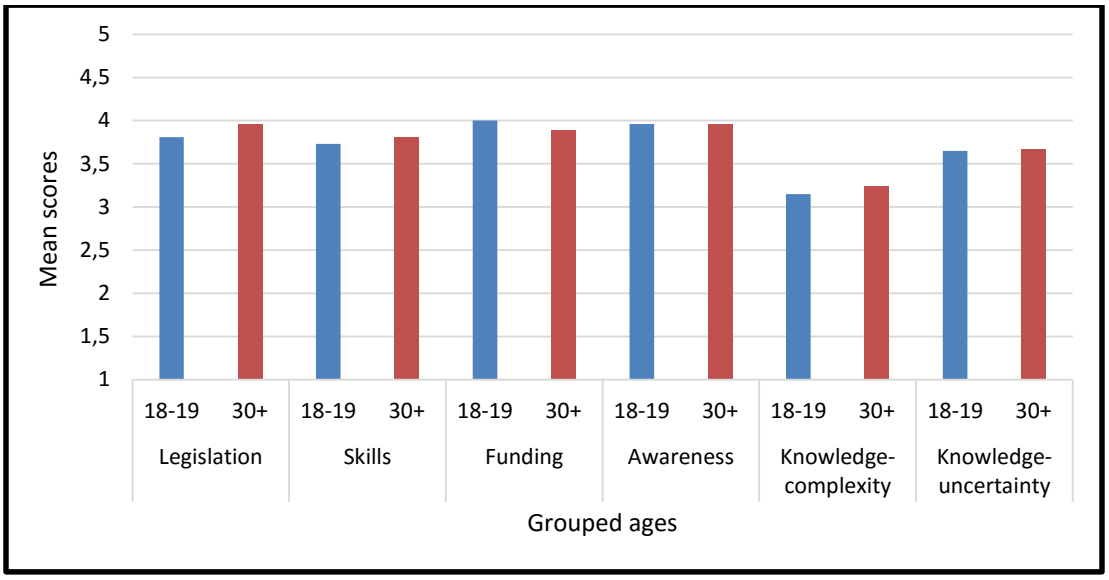

Figure 4.10: Mean scores of grouped ages

4.4.1.3 Education level

Table 4.17 shows the results of the statistics based on the grouped education levels in SMEs.

Table 4.17: Grouped statistics of education levels

Construct	Education level	n	Mean	Std. Deviation	t-value (df)	p-value	Effect size
Legislation	Matric or less	48	3.78	0.927	-1.141 (97)	0.257	0.01
	Degree or postgraduate degree	51	3.98	0.825			
Skills	Matric or less	48	3.69	0.784	-1.138 (97)	0.258	0.01
	Degree or postgraduate degree	51	3.86	0.712			
Funding	Matric or less	48	3.94	0.697	-0.179 (97)	0.858	0.00
	Degree or postgraduate degree	51	3.96	0.807			

Construct	Education level	n	Mean	Std. Deviation	t-value (df)	p-value	Effect size
Awareness	Matric or less	48	3.75	0.646	-3.123 (97)	0.002	0.09
	Degree or postgraduate degree	51	4.15	0.619			
Knowledge-complexity	Matric or less	48	3.05	1.017	-1.251 (97)	0.214	0.02
	Degree or postgraduate degree	51	3.30	0.985			
Knowledge-uncertainty	Matric or less	48	3.41	1.060	-2.704 (82)	0.008	0.07
	Degree or postgraduate degree	51	3.90	0.721			

Table 4.17 indicates that there was no significant difference in the scores between the educational levels of matric or less and degree or postgraduate degree for the legislation, skills, funding and knowledge-complexity. The results of the independent-samples t-test are as follows:

- Legislation – for matric or less (M=3.78, SD=0.927) and degree or postgraduate degree (M=3.98, SD=0.825); t(97)=-1.141; p=0.257 and a very small magnitude in the mean differences (effect size = 0.01).
- Skills – for matric or less (M=3.69, SD=0.784) and degree or postgraduate degree (M=3.86, SD=0.712); t(97)=-1.138; p=0.258 and a very small magnitude in the mean differences (effect size = 0.01).
- Funding – for matric or less (M=3.94, SD=0.697) and degree or postgraduate degree (M=3.96, SD=0.807); t(97)=-0.179; p=0.858 and no effect size (0.00).
- Knowledge-complexity – for matric or less (M=3.05, SD=1.017) and degree or postgraduate degree (M=3.30, SD=0.985; t(97)=-1.251; p=0.214 and a very small magnitude in the mean differences (effect size = 0.02).

However, Table 4.17 revealed that there was a significant difference in the scores between the educational levels of matric or less and a degree or postgraduate degree for awareness and knowledge-uncertainty ($p<0.05$). The results of the independent-samples t-test are as follows:

- Awareness – for matric or less (M=3.75, SD=0.646) and degree or postgraduate degree (M=4.15, SD=0.619); t(97)=-3.123; p=0.002 and a moderate magnitude in the mean differences (effect size = 0.09).
- Knowledge-uncertainty – for matric or less (M=3.41, SD=1.060) and degree or postgraduate degree (M=3.90, SD=0.721); t(82)=-2.704; p=0.008 and a moderate magnitude in the mean differences (effect size = 0.07).

Figure 4.11 shows the mean scores graphically in terms of the independent-samples t-test that was conducted to differentiate between the perceptions of the two groups. On average the data reveals that matric or less and degree or postgraduate degree rated the five constructs investigated fairly at the same level (raging between 3.41 and 4.15) which excludes the knowledge-complexity construct rated 3.30 and lower. These findings also indicate that the educational level of matric or less (mean score of 3.75) towards green ICT adoption were lower compared to a degree or postgraduate degree (4.15) for awareness. Only 9% (eta squared = 0.09 multiplied by 100) of the awareness was explained by the educational level. The educational level of matric or less (mean score of 3.41) towards green ICT adoption was lower compared to a degree or postgraduate degree (3.90) for knowledge-uncertainty. Only 7% (eta square = 0.07 multiplied by 100) of the knowledge-uncertainty was explained by the educational level. Most of the participants who indicated their level of education had a tertiary qualification.

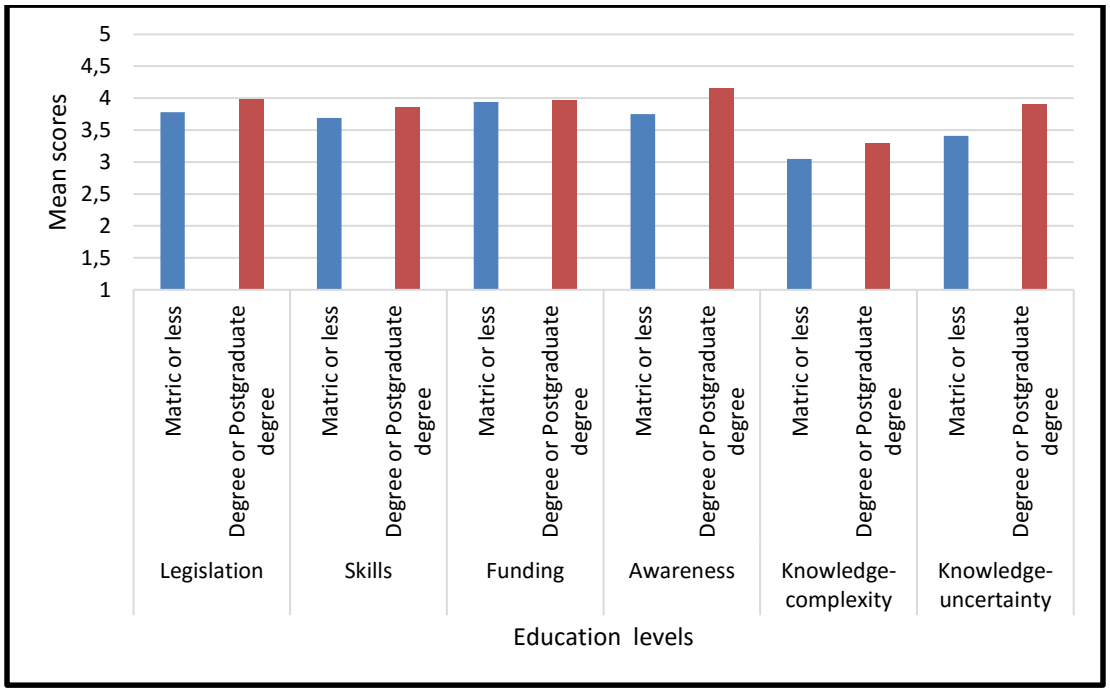

Figure 4.11: Mean scores of education levels

4.4.1.4 Operational years

Table 4.18 shows the results of statistics based on the grouped operational years differentiated between less than 5 years and more than 5 years of SMEs.

Table 4.18: Grouped statistics of operational years

Construct	Operational years	n	Mean	Std. Deviation	t-value (df)	p-value	Effect size
Legislation	Less than 5 years	76	3.97	0.847	1.670 (96)	0.098	0.03
	More than 5 years	22	3.62	0.958			
Skills	Less than 5 years	76	3.73	0.764	-1.308 (96)	0.194	0.02
	More than 5 years	22	3.96	0.695			
Funding	Less than 5 years	76	3.96	0.788	0.152 (96)	0.879	0.00
	More than 5 years	22	3.93	0.646			
	More than 5 years	22	3.59	1.008			

Construct	Operational years	n	Mean	Std. Deviation	t-value (df)	p-value	Effect size
Awareness	Less than 5 years	76	3.98	0.659	0.654 (96)	0.515	0.00
	More than 5 years	22	3.88	0.685			
Knowledge-complexity	Less than 5 years	76	3.20	0.994	0.532 (96)	0.596	0.00
	More than 5 years	22	3.07	1.038			
Knowledge-uncertainty	Less than 5 years	76	3.67	0.915	0.354 (96)	0.724	0.00
	More than 5 years	22	3.59	1.008			

Table 4.18 indicates that there was no significant difference in the scores between the operation years (less and more than 5 years) of SMEs. The results of the independent-samples t-test are as follows:

- Legislation – for less than 5 years (M=3.97, SD=0.847) and more than 5 years (M=3.62, SD=0.958); t(96)=-1.670; p=0.098 and a small magnitude in the mean differences (effect size = 0.03).
- Skills – for less than 5 years (M=3.73, SD=0.764) and more than 5 years (M=3.96, SD=0.695); t(96)=-1.308; p=0.194 and a small magnitude in the mean differences (effect size = 0.02).
- Funding – for less than 5 years (M=3.96, SD=0.788) and more than 5 years (M=3.93, SD=0.646); t(96)=0.152; p=0.879 and no effect size (0.00).
- Awareness – for less than 5 years (M=3.98, SD=0.659) and more than 5 years (M=3.88, SD=0.685); t(96)=0.654; p=0.515 and no effect size (0.00).
- Knowledge-complexity – for less than 5 years (M=3.20, SD=0.994) and more than 5 years (M=3.07, SD=1.038); t(96)=0.532; p=0.596 and no effect size (0.00).
- Knowledge-uncertainty – for less than 5 years (M=3.67, SD=0.915) and more than 5 years (M=3.59, SD=1.008); t(96)=0.354; p=0.724 and no effect size (0.00).

Figure 4.12 shows the mean scores graphically in terms of the independent-samples t-test that was conducted to differentiate between the perceptions of the two groups. On average the data reveals that less than 5 years and more than 5 years rated the five constructs investigated fairly at the same level (ranging between 3.62 and 3.98) which excludes the knowledge-complexity construct rated 3.20 and lower. These findings indicate that both groups perceived the lack of legislation, skills, funding, awareness and knowledge link to uncertainty more as barriers than knowledge based on complexity. Most of the participants who indicated the operational years of their enterprise had been operating between 1 and 5 years.

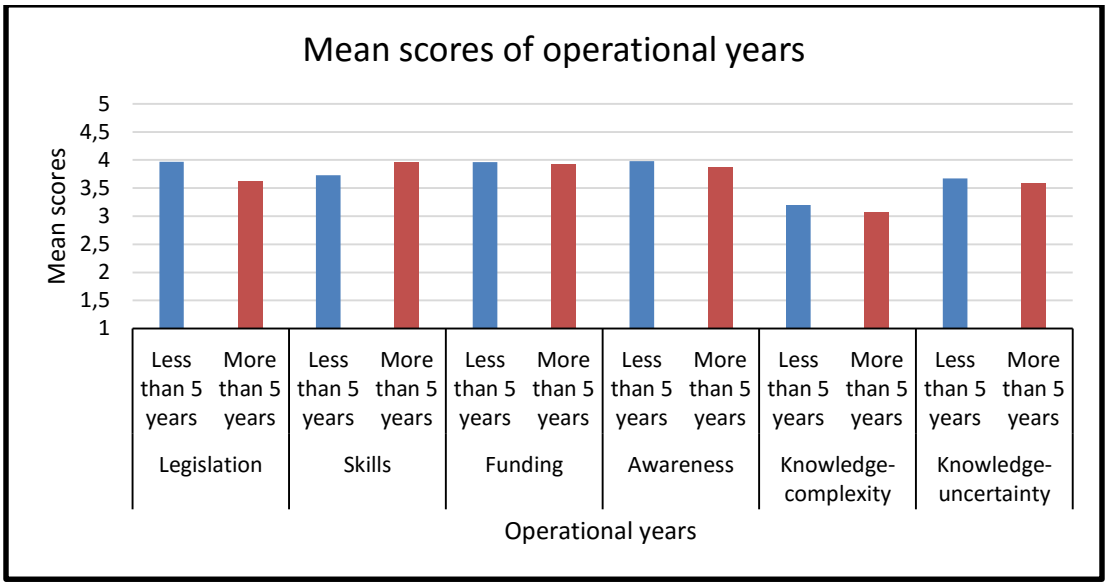

Figure 4.12: Mean scores of operational years

From these results, it can be seen that a lack of legislation, skills, funding, awareness and knowledge (complexity and uncertainty) are indeed perceived as barriers based on the statistics between these two groups (owners and managers). Lastly, an independent-samples t-test was not conducted for the group statistics based on the number of employees – 91% of SMEs employed less than 50 employees and the remaining groups were too small to compare (see section 4.2.2.5).

4.4.2 Correlation analysis

A Pearson product-moment coefficient can be used to determine the direction and strength of a linear relationship amongst two random variables (Pallant, 2011:128). The strength of a relationship among two constructs can be measured as r=0.10 to 0.29 (small effect size), r=0.30 to 0.49 (medium effect size) and r=0.50 to 1.0 (large effect size) (Field, 2013: 83; Pallant, 2011:134). A Pearson's correlation value of -1 indicates a perfect negative correlation, +1 indicates a perfect positive correlation and 0 indicates no correlation. In Table 4.19 the correlations between the six constructs are shown to indicate the correlation coefficient for legislation, skills, funding, awareness, knowledge-complexity and knowledge-uncertainty.

Table 4.19: Pearson's correlation

Pearson's Correlation Coefficient n=100						
Constructs	**Legislation**	**Skills**	**Funding**	**Awareness**	**Knowledge-complexity**	**Knowledge-uncertainty**
Legislation	1					
Skills	0.26**	1				
Funding	0.33**	0.30**	1			
Awareness	0.16	0.23*	0.18	1		
Knowledge-complexity	0.14	0.08	0.06	0.24*	1	
Knowledge-uncertainty	0.28**	0.36**	0.13	0.38**	0.33**	1

*** Correlation is significant at the 0.01 level (2-tailed)*

** Correlation is significant at the 0.05 level (2-tailed)*

Table 4.19 shows the following significant relationship between the correlation of constructs:

- There was a small positive relationship between legislation and skills, r=0.26, n=100, p≤0.05, with legislation positively affecting skills.

- There was a medium positive relationship between legislation and funding, r=0.33, n=100, p≤0.05, with legislation positively affecting funding.
- There was a small positive relationship between legislation and knowledge-uncertainty, r=0.28, n=100, p≤0.05, with legislation positively affecting knowledge-uncertainty.
- There was a medium positive relationship between skills and funding, r=0.30, n=100, p≤0.05, with skills positively affecting funding.
- There was a small positive relationship between skills and awareness, r=0.23, n=100, p≤0.05, with skills affecting awareness.
- There was a medium positive relationship between skills and knowledge-uncertainty, r=0.36, n=100, p≤0.05, with skills affecting knowledge-uncertainty.
- There was a small positive relationship between awareness and knowledge-complexity r=0.24, n=100, p≤0.05, with awareness affecting knowledge-complexity.
- There was a medium positive relationship between awareness and knowledge-uncertainty, r=0.38, n=100, p≤0.05, with awareness affecting knowledge-uncertainty.
- There was a medium positive relationship between knowledge-complexity and knowledge-uncertainty, r=0.33, n=100, p≤0.05, with knowledge-complexity affecting knowledge-uncertainty.

Based on these correlations, it can be deduced that there is a perfect positive correlation between constructs. This inspection of the correlation coefficient revealed that these constructs are significant and explain the variance in each other either with a small effect size (between 0.23 and 0.28) or medium effect size (between 0.30 and .38). This implies that these constructs are barriers and hinder the adoption of green ICT. In addition, the remaining correlation coefficients (0.06, 0.08, 0.13, 0.14, 0.16 and 0.18) between constructs in Table 4.19 show that no significant relationship exists. This does not by any means imply causation but shows that there is no linear relationship between these constructs.

4.4.3 Summary of shared views

In addition to the close-ended questions, a set of open-ended questions was also presented to the participants. These questions appeared in Section E and were aimed at obtaining general views on green ICT from the participants. They were thus given the opportunity to list and explain barriers based on their requirements for the adoption of green ICT.

Word Cloud® was used to extract keywords identified from the open-ended questions that were asked. This visual presentation of data was used to indicate the most prominent words that occurred most frequently from the statements. The word cloud generator was deemed a suitable and efficient method to determine important issues as perceived as barriers for the adoption of green ICT. A combined word list was created through word cloud which consisted of additional views on green ICT perceived by SMEs in Section E. Moreover, to enhance the understanding regarding barriers, SMEs owners and managers were also provided with the opportunity to add any additional information they viewed as important. Figure 4.13 shows the word cloud created and the issues that emerged based on the content received from the open-ended questions.

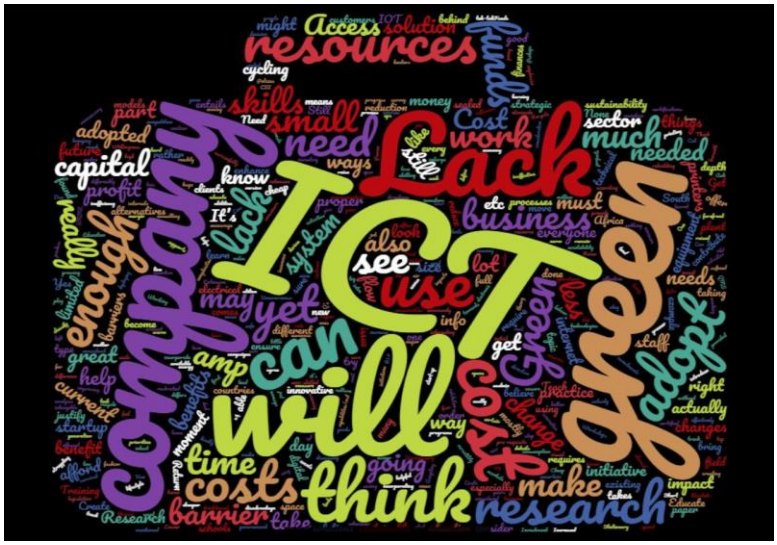

Figure 4.13: Word Cloud
Source: Author's own composition (2019)

Figure 4.13 shows the green ICT issues viewed as most relevant and include the following aspects:

- Access to resources
- Uncertainty regarding costs
- Lack of funding or capital
- Uncertainty regarding benefits and profit
- Time constraints linked to the adoption
- Skills and knowledge needed
- Green ICT is much needed and requires more research

Based on these key aspects that were identified, it is evident that SMEs experienced similar barriers as the ones found in the answers to the close-ended questions. These aspects are based on the experiences that SME owners or managers encounter daily in SMEs. Moreover, it appeared that the participants were in favour of green ICT adoption even though they experienced certain barriers.

4.5 CONCLUSION

In this section, a comprehensive description is provided on the interpretation of the data analysed.

4.5.1 Concluding remarks

As mentioned in section 4.1, the primary objective of the research study was to identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs. Six constructs extracted from the exploratory factor analysis confirmed the barriers identified in the literature and were found to result in a low green ICT adoption rate. Although five constructs were originally discussed in the literature, the overall

eigenvalues extracted showed six components whereby knowledge is divided into complexity and uncertainty. Having analysed the data collected, the mean scores indicate the prominence of each barrier perceived by SMEs.

In Table 4.20, the ranking of mean scores for barriers resulting in the low adoption of green ICT is shown.

Table 4.20: Mean scores of barriers for green ICT

Ranking	Barrier	Mean	Std. Deviation
First	Funding	3.94	0.760
Second	Awareness	3.94	0.667
Third	Legislation	3.88	0.878
Fourth	Skills	3.78	0.746
Fifth	Knowledge-uncertainty	3.68	0.936
Sixth	Knowledge-complexity	3.18	0.999

Table 4.20 indicates that participants rated lack of funding as the foremost barrier in hindering the adoption of green ICT with (M=3.94 and SD=0.760). The lack of funding was followed by the following:

- Awareness was ranked as the second-most prominent barrier (M=3.94 and SD=0.667).
- Legislation was ranked as the third-most prominent barrier (M=3.88 and SD=0.878).
- Skills were ranked as the fourth-most prominent barrier (M= 3.78 and SD=0.746).
- Knowledge-uncertainty was ranked as the fifth-most prominent barrier (M= 3.68 and SD=0.936).
- Knowledge-complexity was ranked as the sixth-most prominent barrier (M=3.18 and SD=0.999).

This implies that the participants (owners and managers of SMEs) perceived a lack of funding as the key barrier preventing the adoption of green ICT. Hence, SMEs should consider collaborating with other stakeholders such as venture capitalists to obtain additional funding to adopt green ICT operation practices. The barrier (knowledge-complexity) with the lowest mean score was perceived as the least important factor contributing to a low adoption rate of green ICT.

The first secondary objective of the research study was to determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs. Table 4.19 shows positive correlations of legislation with skills (0.26 - small), funding (0.33 - medium), and knowledge-uncertainty (0.28 - small). This indicates that these constructs affect one another when deciding to adopt green ICT in SMEs. The positive correlation of skills with funding (0.30 - medium), awareness (0.23 - small) and knowledge-uncertainty (0.36 - medium) indicates that these constructs affect one another when deciding to adopt green ICT in SMEs. This implies that the effect of funding and knowledge-uncertainty is higher than awareness when decisions on adopting green ICT are made. The positive correlation of awareness with knowledge-complexity (0.24 - small) and knowledge-uncertainty (0.38 - medium) indicates that these constructs affect one another when deciding to adopt green ICT in SMEs. This implies that the uncertainty based on knowledge has a higher effect than knowledge based on complexity when deciding on whether to adopt green ICT. Overall, it can be deduced that knowledge-uncertainty and lack of awareness correlate and run parallel with each other which indicates that if the one hinders the adoption of green ICT the other will most likely also hinder it. Hence, the uncertainty and unawareness about green ICT (benefits and shared knowledge) greatly impact on the decision-making process by SMEs regarding green ICT adoption.

The second secondary objective of the research study was to recommend strategies on how to improve the adoption rate of green ICT in South African SMEs. Based on the barriers identified is it clear that the participants believed that they experienced a lack of funding, awareness, legislation, skills and knowledge based on uncertainty and

complexity with regard to the adoption of green ICT. Considering this, a list of some practical advice to SME owners is provided (as the majority of participants were owners) in Table 4.21 on how to improve the adoption rate of green ICT.

Table 4.21: Practical advice for SME owners

Practical advice to improve the adoption rate of green ICT	
Actions	**Rationale**
Promote training workshops	Provide training and development to initiate green ICT practices in the workplace to raise awareness among employees.
Commit and implement green ICT strategies	Engagement in different environmental activities that can create a more green-conscious culture in the workplace.
Prioritise the adoption of green ICT practices	By actively involving all employees, valuable insight could be gained in order to make decisions about green ICT adoption practices
Develop a knowledgeable culture about green ICT practices	Provide information on environmental management systems to pioneer environmentally friendly operation practices in the workplace.

4.5.2 Chapter summary

Chapter 4 presented the findings of the study with regard to the barriers resulting in the low adoption rate of green ICT in South African SMEs. It began with a discussion on the response rate which was followed by a description of the demographics characteristics. Next, an explanation was provided on the factor analysis to confirm the validity of the questionnaire. An overall summary of the results of the constructs identified followed by group differences between participants was given. The correlations between barriers were presented and then the views regarding green ICT were reported. A discussion on the specific outcomes of the research objectives was also presented. This chapter sums up the key points of the discussion regarding the analysed data and the interpretation. The next chapter will focus on the conclusions and recommendations of the research study.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

In this chapter, the conclusions and recommendations are presented on the low green ICT adoption rate in South African SMEs based on the data and the results outlined in Chapter 4. Below is a flow diagram (see Figure 5.1) to show the structure of the chapter.

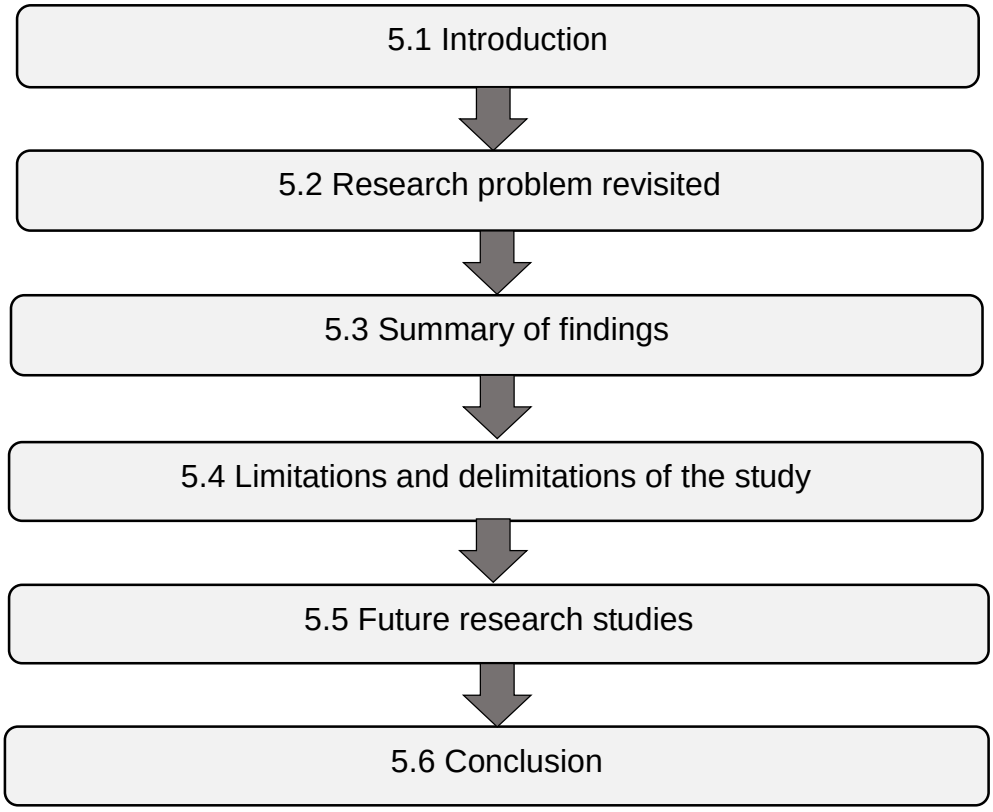

Figure 5.1: Flow diagram of Chapter 5
Source: Author's own composition (2019)

Chapter 5 is structured as follows:

- Firstly, it reviews the research process followed for this study in section 5.1.
- In section 5.2 the research problem is revisited.
- A summary of the findings is provided in section 5.3.
- In section 5.4 the limitations and delimitations of the study are discussed.
- Future research studies are discussed in section 5.5.
- Lastly, a conclusion is presented in section 5.6.

By reflecting on the chapters in this study, it is important to point out once again what the overall objectives were and what was accomplished by addressing the research problem. Chapter 1 provided an introduction to the study based on a synopsis of the literature which in turn highlighted the research problem and importance of the study. The research problem, questions, objectives were aligned with the literature. Chapter 2 described the research area and the key factors resulting in the low green ICT adoption rate in operation practices of SMEs. After the literature review, a questionnaire was drafted in line with what was found in the literature. In Chapter 3, the research method used to achieve the research objectives of the study were outlined. Chapter 4 examined the data collected, provided statistical analysis and interpreted the results based on the research objectives. Finally, the conclusions and recommendations are presented based on the analysis of results.

The study thus intended to seek a greater understanding regarding the low green ICT adoption rate in South African SMEs. A summary of the study as shown in Chapter 1 is reiterated in Table 5.1.

Table 5.1: Summary of the study

Research problem	Objectives	Research questions	Motivation for the study
• The problem is the low green ICT adoption rate in South African SMEs	Primary objectives: • To identify the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs *Secondary objectives:* • To determine the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs • To recommend strategies on how to improve the adoption rate of green ICT in South African SMEs	*Primary research question:* • What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs? *Secondary research questions:* • What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs? • What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?	• The motivation for the study can be found in the fact that the findings might contribute to the body of knowledge on the low adoption rate of green ICT in South Africa. • The research study envisaged to fill the void in the literature regarding the limited research on the low adoption rate of green ICT (Bekaroo *et al.*, 2016:1592). • A literature review revealed that the reasons for the low adoption rate of green ICT should be investigated in more detail to determine why green initiatives such as cloud computing are adopted at a low rate in sub-Saharan Africa (Yeboah-Boateng & Essandoh, 2014:13-14). • This study will also examine the green ICT principles that may influence the low rate of adopting green technology into regulations to protect the environment (Radu, 2016:743). • South Africa is the largest emitter of carbon dioxide in Africa producing 24% of all Africa's emissions *(*Radu, 2014:434). It is therefore imperative to understand the reasons for the reluctance of South African SMEs to adopt green ICT practices to address this problem. • Many researchers are also inviting more research on the development of greener technologies (Tuskeentushi *et al.*, 2013:11; Baggia *et al.*, 2019:1589; Capasso *et al*., 2019:400).

Source: Author's own composition (2019)

5.2 RESEARCH PROBLEM REVISITED

The problem is the low adoption green ICT adoption rate in South African SMEs. As mentioned in Chapter 1, the literature shows that there is a lack of research regarding the low adoption rate of green ICT in developing countries (Radu, 2016:743; Bekaroo *et al.*, 2016:1589, 1592; Yeboah-Boateng & Essandoh, 2014:13-14; Zhang & Liang, 2012:1010). The focus of the study was to examine the fundamental aspects contributing to the low adoption rate of green ICT. Moreover, specific barriers resulting in the low adoption rate of green ICT in operation practices were examined. South Africa is viewed as the 13th largest emitter globally with an estimated 468 metric tonnes of CO_2 emitted in 2016 (Global Carbon Atlas, 2017). There is thus a need to investigate the barriers identified in the literature influencing the low adoption rate of green ICT.

5.3 SUMMARY OF FINDINGS

This section summarises the findings of the study. Conclusions will be made. Sections C, D and E of the questionnaire focused on the specific objectives of this study. Sections A and B included observable factors for this study related to the adoption and drivers associated with the adoption of green ICT. The barriers investigated were referred to as hindrances preventing the adoption of green ICT in South African SMEs. Participants were asked to rate their perceptions on pre-determined barriers identified in the literature review (Chapter 1 and 2). They had to rate the extent to which they agreed with the statements regarding the low adoption of green ICT. The rating scale was based on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

Figure 5.2 shows the key barriers (with mean and standard deviation values) hindering the adoption of green ICT in SMEs. This study found through the exploratory factor analysis that the barriers regarding the low green ICT adoption rate for SMEs correspond with the barriers mentioned in the literature. All constructs, namely funding, awareness, legislation and skills, are aligned with the factors mentioned in the literature (see Table 3.5 above) as presented in Chapter 3. The remaining knowledge factor is divided into

two separate factors, namely knowledge-uncertainty and knowledge-complexity (Figure 5.2). The latter finding slightly deviates from what Lundfall *et al.*, (2015:74) found.

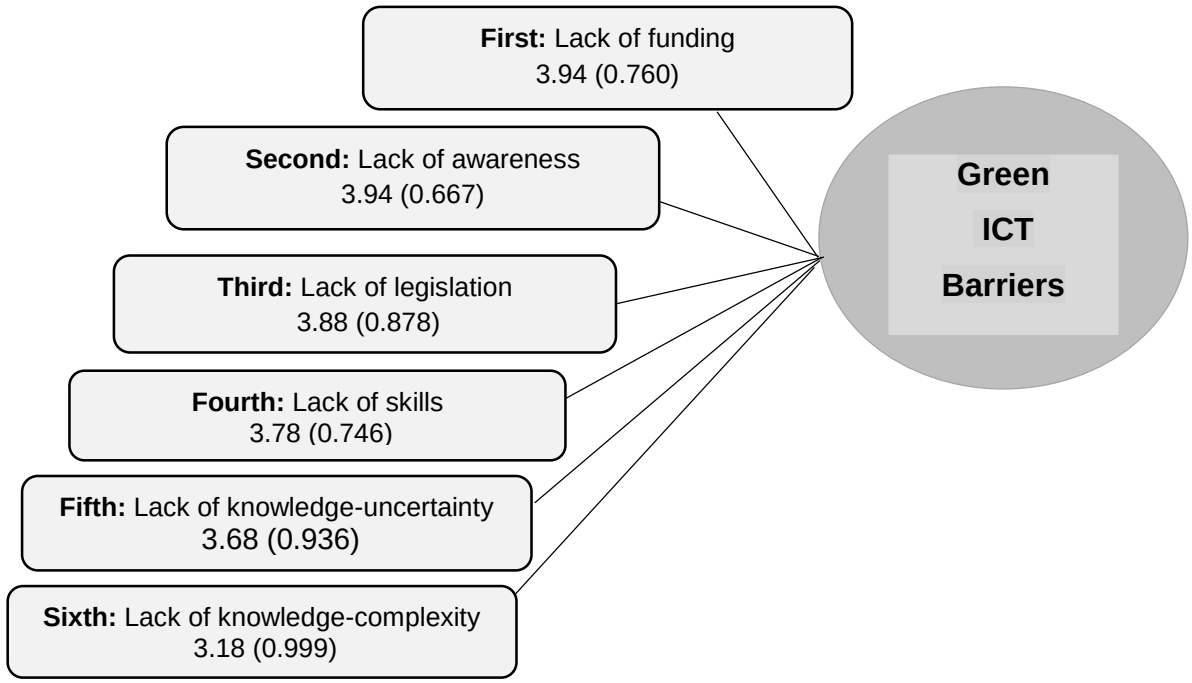

Figure 5.2: Conceptual representation of key green ICT barriers
Source: Author's own composition (2019)

5.3.1 Conclusion – Research question 1: What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs?

In identifying the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs the following was found. The findings indicated that a lack of funding, awareness, legislation, skills, knowledge based on uncertainty and complexity are the reasons why SMEs are reluctant to adopt green ICT. The participants rated the six constructs based on the mean scores to indicate the prominence of the barriers perceived. Lack of funding (M=3.94, SD=0.760) and lack of awareness (M=3.94, SD=0.667) were rated as the most prominent barriers hindering the adoption of green ICT. Lack of legislation was ranked as the third-most prominent barrier (M=3.88,

SD=0.878) followed by a lack of skills in fourth place (M=3.78, SD=0.746). Lack of knowledge based on uncertainty (M=3.68, SD=0.936) and complexity (M=3.10, SD=0.999) were ranked fifth and sixth respectively.

In general, the participants indicated that they agreed with statements about the barriers of green ICT. The results of the overall ratings illustrated in Figure 5.2 are as follows:

- Lack of funding – the participants mostly agreed (34%) or strongly agreed (35%) which amounted to 69% of them agree with this statement. The barrier regarding the lack of funding corresponds with what was found in the literature in this regard (Welfens & Lutz, 2012:159; Fatoki, 2019:10).
- Lack of awareness – the participants agreed (44%) or strongly agreed (28%) which amounted to 72% of them agree with this statement. This barrier corresponds with what (Wabwoba *et al.*, 2013:100; Khan, Aljaberi & Muammar, 2019:45-46) found.
- Lack of legislation – the participants agreed (34%) or strongly agreed (34%) which amounted to 68% of them agree with this statement. This barrier is also mentioned by Buchalcevova and Gala (2013:44-48); and Qing (2019:4467).
- Lack of skills – the participants agreed (49%) or strongly agreed (21%) which amounted to 70% of them agree with this statement. The barrier is also mentioned by Abdullah *et al.*, 2016:689; Álvarez Jaramillo, Zartha Sossa & Orozco Mendoza, 2019:521).
- Lack of knowledge-uncertainty – the participants agreed (45%) or strongly agreed (20%) which amounted to 65% of them agree with this statement. The barrier which is mentioned in the literature (Lundfall *et al.*, 2015:74; Fatoki, 2019:4) was found to present slightly differently in the current study and was divided into two constructs: the lack of knowledge-uncertainty and knowledge-complexity.
- Lack of knowledge-complexity – the participants agreed (28%) or strongly agreed (13%) which amounted to 41% of them agree with this statement. Although this rating is below 50% it still amounted to more participants agreeing with this than

those who disagreed (6%) or strongly disagreed (25%) (total of 31%). However, 29% of the participants tended towards a neutral rating. This barrier identified in the literature (Lundfall *et al.*, 2015:74; Álvarez Jaramillo *et al.*, 2019:519-520) was divided into two constructs in the current study: the lack of knowledge-uncertainty and knowledge-complexity.

Moreover, an opportunity was given to the participants to add any additional information they thought was important for the adoption of green ICT (Section E). The aspects highlighted were similar to the above-listed barriers and those mentioned in the literature. No specific major barriers were pointed out aside from the time constraints and that green ICT was viewed as a favourable practice.

In terms of these findings, research question 1 was answered and objective 1 was met. The following sections present the theoretical implications, managerial implications and recommendations.

5.3.1.1 Theoretical implications

The study found that the barriers (constructs) in this study are reflected in the literature, except the lack of knowledge (complexity versus uncertainty). The study also empirically proved that a lack of funding is the most prominent barrier and awareness comes in second, both of which thus play a role in the low green ICT adoption rate in South African SMEs. The study contributed to the body of knowledge in the area of green operation practices, namely green ICT, by identifying and prioritising the constructs indicating the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs. Thus, the study filled the void in the literature and can serve as a source of reference for future research in the area of green ICT. The empirical results of the study provided new insight into the understanding of the low green ICT adoption rate in South African SMEs. Moreover, six barriers were identified from the research study as hindrances for the adoption of green ICT. However, five constructs were originally

identified in the literature, but the overall eigenvalues extracted showed six components whereby knowledge is divided into complexity and uncertainty.

5.3.1.2 Managerial implications

The empirical results can provide SME owners and managers with an understanding of the low green ICT adoption rate in South African SMEs. According to the findings, SME owners and managers should be supportive and champion an environmentally friendly culture that can contribute towards advancing effective strategies for adopting green ICT. The empirical results proved that six barriers (lack of funding, awareness, legislation, skills, knowledge based on uncertainty and complexity) do indeed prevent the adoption of green ICT and the focus of SMEs should be on addressing these barriers. Managers are advised to introduce strategies on how to overcome these barriers hindering the low green ICT adoption rate.

5.3.1.3 Recommendations

Based on the findings of the first objective, the following recommendations, if adopted by SMEs, may enhance green ICT operation practices.

Owners and managers of SMEs should consider the following:

- Familiarise themselves with green ICT irrespective of the size of their enterprise; for example, becoming more aware of energy conservation.
- Undertake practical steps to determine the cost of adopting green operation practices as certain practices may require more resources, capital and time.
- Employ green ICT experts to help create an environmental awareness culture in the workplace.
- Consider collaboration with other enterprises to reduce costs and achieve sustainable green ICT operation practices.

- Adopt green ICT to gain a competitive advantage over competitors who have not yet adopted green ICT practices.
- Consider collaboration with venture capitalists to obtain additional support for funding.

Policy makers should consider the following:

- Government should strive towards increasing support of SMEs for the adoption of green ICT; examples are investing in green ICT operation processes.
- Sustainable development programmes should be offered to SMEs to enhance green ICT operation practices.
- The framework regulating green ICT practices should be reviewed to improve policies governing the SME sector.
- They should consider playing an active role in the adoption practices through the formulation of national green ICT policies.
- Collaborations with SMEs should be promoted so that green ICT policies can be integrated into all business practices and thereby reduce carbon emissions.
- The Innovation Hub should support and implement as many as possible high impact actions continuously to help enterprises to overcome hindrances in the adoption of green ICT.

5.3.2 Conclusion - Research question 2: What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs?

The following was found about the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs. Pearson's product-moment coefficient was used to determine the correlation between a lack of legislation,

skills, funding, awareness, and knowledge based on complexity and uncertainty. A perfect positive correlation was found between the constructs. This implies that these constructs are significant and influence each other either with a small or medium effect size.

The small positive relationship between legislation and skills, legislation and knowledge-uncertainty, skills and awareness, and awareness and knowledge-complexity indicate that an increase in one construct will lead to an increase in the other. The medium positive relationship between legislation and funding, skills and funding, skills and knowledge-uncertainty, awareness and knowledge, and knowledge-complexity and knowledge-uncertainty indicate that a relatively moderate increase in one construct will have the same effect in the other. This implies that the constructs with positive medium correlations have a higher effect on each other when decisions are made on green ICT adoption in comparison to positive small correlations. In general, the findings indicated that awareness based on knowledge-uncertainty regarding green ICT adoption significantly impacted SME's decision-making processes. Based upon the collective views of the participants, the significant relationship between awareness and knowledge-uncertainty was indicated as the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT. In general, it can be deduced that the positive correlations between the preceding constructs go hand in hand with each other which implies that if one construct results in the low adoption of green ICT the other will most probably also be similarly affected. Hence, SMEs need to be more aware of green ICT to overcome uncertainties and also work at enhancing the development of knowledge, skills and acquire the necessary funding through continuous actions.

In terms of these findings, research question 2 was answered and objective 2 was met. The following sections present the theoretical implications, managerial implications and recommendations.

5.3.2.1 Theoretical implications

The study empirically proved that the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs is the positive relationship between lack of awareness and knowledge-uncertainty. The results revealed that a lack of awareness has the greatest effect on knowledge-uncertainty based on the highest positive correlation (r=0.38) between these constructs. This implies that the uncertainty based on knowledge has a higher effect than knowledge based on complexity when decisions need to be made on whether to adopt green ICT or not. Thus, lack of awareness positively and significantly impacts the uncertainty of knowledge; they run in parallel with each other which indicates that if the one hinders the adoption of green ICT the other will most likely also.

5.3.2.2 Managerial implications

It was also found that a lack of specific resources essential for the adoption of green ICT could hinder environmental sustainability and contribute towards the increase of carbon emissions. In mobilising resources and supportive environmental mechanisms SMEs could obtain the necessary knowledge and awareness to maximise the advantages of green ICT adoption. Owners and managers should also focus on the requirements of SMEs when considering key strategic decisions related to green ICT as underlying factors may become disruptive if not monitored properly. Furthermore, the data implies that awareness associated with the uncertainty of knowledge greatly impacts the decision-making processes related to green ICT adoption in SMEs.

5.3.2.3 Recommendations

Based on the findings of the first secondary objective, the following recommendations are made for SMEs to enhance green ICT operation practices.

Owners and managers of SMEs should consider the following:

- Prioritise training specifically designed for SMEs to upskill employees on green ICT adoption operation processes.
- Invest in educating employees about green ICT and its advantages.
- Create a knowledgeable green ICT culture in the workplace by enforcing the attendance at green initiatives.
- Intensify green ICT awareness campaigns to ensure return on investment in the long run.
- Develop a culture that is innovative and favourable towards green ICT adoption and which promotes a positive change in operation processes, e.g. green disposal practices.

Policy makers should consider the following:

- In supporting SMEs, the following should be prioritised by the government when offering green ICT development programmes: awareness, knowledge focused on complexity and uncertainty, skills and funding (constructs with higher correlations deduced).
- Provide sufficient resources to support the funding of green ICT initiatives such as cloud computing.
- Educate government officials about the advantages of adopting green ICT practices.
- Enforce the adoption of environmental certification practices to pioneer the greening of ICT.
- The Innovation Hub as the leading technological science park in sub-Saharan Africa should take the lead in incorporating green ICT best practices by advising

SMEs on the appropriate changes to ensure the effectiveness of successful green ICT adoption processes.

5.3.3 Conclusion - Research question 3: What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?

The recommended strategies on how to improve the adoption rate of green ICT in South African SMEs are based on the following findings. An independent-samples t-test was conducted to compare the mean scores between the two groups of participants. This test indicated no significant difference in the mean scores between owners and managers based on the position in the company. There was no significant difference in the mean scores between the grouped ages (18-29 and 30+). The independent-samples t-test based on the educational level indicated no significant difference between the educational levels of matric or less and degree or postgraduate degree for legislation, skills, funding and knowledge-complexity. However, it did indicate that there is a significant difference in the scores between the educational levels of matric or less and a degree or postgraduate degree for the awareness and knowledge-uncertainty constructs ($p<0.05$). There was no significant difference in the mean scores between the operation years (less and more than 5 years) listed.

Overall, the independent-samples t-test statistics of the group differences between participants indicated that all the barriers were fairly rated at the same level (no significant difference), except for the significant group differences between matric or less and degree or postgraduate degree for education level with a small (awareness) and moderate (knowledge-uncertainty) effect size. The awareness of green ICT adoption was lower in the group who had an educational level of matric or less (mean score of 3.75) than those who had a postgraduate degree (4.15). Furthermore, only 9% of the variance in awareness was explained by the educational level (effect size = 0.09). The group with an educational level of matric or less (mean score of 3.41) scored lower on knowledge-uncertainty regarding green ICT adoption compared to the group with a postgraduate

degree (3.90). In addition, only 7% of the variance in knowledge-uncertainty was explained by the educational level (effect size = 0.07). This indicates that the group of SME owners and managers with a lower educational level felt more impartial towards green ICT adoption than owners and managers with higher qualifications (require more information on benefits).

In terms of these findings, research question 3 was answered and objective 3 was met. The following sections present the theoretical implications, managerial implications and recommendations.

5.3.3.1 Theoretical implications

In the past, research studies did not examine the reasons for the reluctance of South African SMEs to adopt green ICT practices. The current study however, examined these and recommendations are made regarding strategies to improve the adoption of rate green ICT in SMEs. Thus, this study also aimed at contributing to the research by understanding green ICT and regulations in this regard to protect the environment (Radu, 2016:743).

The findings present a greater understanding and detailed information that is important for entrepreneurs, government and other stakeholders in terms of their roles in ensuring environmental sustainability when green ICT is adopted. These findings may therefore, promote green initiatives in South Africa and motivate the government to review policies related to environmental regulations. It is therefore proposed that the application of these policies should be strategically aligned with regulatory instruments governing the SME sector.

5.3.3.2 Managerial implications

The barriers play an instrumental role in strategising decisions when adopting green ICT as SMEs need to contextualise their strategic goals to enhance efficiency. The context of

green ICT must be clearly defined beforehand to ensure the correct decisions are made and appropriate processes are adopted by SMEs. Green ICT may play a supportive function in operational processes and may provide enterprises with both profitable and competitive advantages. It is therefore suggested that SMEs enhance their awareness, knowledge and skills to establish procedures for the adoption of green ICT to become general practice over time without compromising future legislation and funding prospects. Additionally, SMEs could overcome these barriers by improving their awareness, knowledge and skills and familiarising themselves with green ICT.

5.3.3.3 Recommendations

With regard to the second secondary objective, the following recommendations are made if SMEs wish to adopt and enhance green ICT operation practices.

Owners and managers of SMEs should consider the following:

- Consider a shift from converting ICT to green ICT in operation practices, e.g. re-using or recycling electronic equipment.
- Align green ICT initiatives with strategic goals (vision and mission) of the enterprise.
- Strive to adopt green ICT strategies to reduce emissions and achieve a sustainable environment.
- Focus on the requirements of the SMEs to ensure that the right green ICT tools and green ICT practices are used to achieve the aims of green ICT.
- Establish a functional area in the enterprise for green ICT similar to marketing and finance functional areas to enhance awareness and knowledge strategies aligned with green ICT.

Policy makers should consider the following:

- Establish a platform to discuss policies and future changes to environmental regulations such as carbon tax.
- Join forces with SMEs and implement support mechanisms to achieve green ICT strategies.
- Ensure that development programmes are properly directed to reach all SME owners and managers in support of green ICT aims.
- Ensure that green ICT is integrated at strategic levels and adopted through policies and strategic documentations.
- Take cognisance of the role academia plays. Academic institutions offer a valuable research and development platform to translate policies into feasible projects.
- The Innovation Hub should promote change programmes by appointing change managers or teams to ensure the sustainability of projects or programmes and promote a culture change towards green ICT adoption.

5.5 LIMITATIONS AND DELIMITATIONS OF THE STUDY

The study has some limitations and delimitations even though strong evidence was presented in terms of the applicable requirements for the research instrument having been met including the credibility of the study. The following are some of the limitations and delimitations of the study:

- Only SMEs registered with The Innovation Hub and located in Gauteng were examined. As a result, the findings cannot be generalised but are deemed sufficiently representative to be applied to economies similar to South Africa. The Gauteng region was selected as it has the largest number of South African SMEs with advanced technological infrastructure and plays an important role in the South African economy.

- The low response rate of the online survey presented a delimitation for the study as only a small number of participants responded. However, additional strategies were followed which included the distribution of paper questionnaires to increase the response rate.
- Some participants were not easily accessible as the office spaces at The Innovation Hub are used on an as-needed basis. To address this delimitation, the researcher made appointments with these entrepreneurs.
- The site visits made at satellite branches were also limited to a small number of participants as the entrepreneurs only visit the sites occasionally to use the facilities. To address this delimitation, the researcher also attended training interventions.
- Lastly, budget and time constraints as well as limited population particularly presented limitations for this study.

5.6 FUTURE RESEARCH STUDIES

The study has provided insight into the green ICT adoption rate in South African SMEs. Possible future research areas include the following:

- The study excluded large enterprises and multinational companies. Thus, further research could be conducted to determine how these green ICT adoption barriers impact larger businesses.
- The study addressed the barriers related to green ICT in SMEs though the research could be extended to focus only on the drivers impacting green ICT.
- The study was limited to the selected SMEs located in Gauteng and future research could focus on the other provinces in South Africa.
- An in-depth study on each of the barriers identified or the advantages of integrating green ICT adoption presents another area for further research.

- A comparison could be made regarding the low green ICT adoption rate in SMEs between different sub-Saharan African countries.
- Applicable environmental training related to green ICT adoption could be offered to owners and managers of South African SMEs and the effectiveness of the training provided could be investigated.
- Future research could focus on a larger sample size to present more statistically significant findings and/or a longitudinal study could be carried out to determine whether the findings differ over a longer period or whether there are different trends.
- The difference between owners and managers with higher education levels and those with lower educational qualifications and who are involved in decision-making processes regarding green ICT adoption in SMEs could be investigated.
- Further research could be conducted to determine the impact of collaboration between different enterprises, governments and other stakeholders to promote the adoption of green ICT operation practices.

5.7 CONCLUSION

Chapter 5 presented a comprehensive summary of the conclusions and recommendations based upon the analysis of results as outlined in Chapter 4. In this chapter, the research problem was revisited, and the findings regarding the three research objectives and implications were discussed. The recommendations, limitations and delimitations, and future research studies regarding the adoption of green ICT were examined.

The findings of the study confirmed the importance of green ICT adoption in operation processes in South African SMEs. It is imperative for SMEs to strive towards environmentally sustainable practices and to gain advantages through the adoption of

green ICT. The main reasons for not adopting green ICT were related to a lack of funding, awareness, legislation, skills, knowledge based on uncertainty and complexity.

The objectives of the study were met as the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs were identified. Lack of funding was rated as the predominant barrier hindering the adoption of green ICT. Lack of awareness was ranked second, lack of legislation third, lack of skills fourth, lack of knowledge based on uncertainty and complexity were ranked fifth and sixth respectively. Based upon the collective responses, the significant relationship between awareness and knowledge-uncertainty was indicated as the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT. Ultimately there was a significant difference between owners and managers with higher education levels and those with lower qualifications about their rating on awareness and knowledge based on the uncertainty of green ICT adoption. Recommendations were provided to guide and assist SMEs and policy makers in adopting sustainable green ICT practices.

The research sought to make a significant contribution to the body of knowledge on the low adoption rate of green ICT in South Africa and to fill the void in the literature regarding the limited research field. Moreover, it sought to create an awareness of the opportunities for future research in green ICT adoption among various stakeholders concerned with environmentally sustainable practices.

Table 5.2 summarises the research problem investigated, and research questions answered together with a summary of the theoretical and managerial implications based on the findings.

Table 5.2: Summary of implications

Research problem	Research questions	Theoretical and Managerial implications
• The problem is the low green ICT adoption rate in South African SMEs	*Primary research question:* • What are the most prominent barriers resulting in the low adoption rate of green ICT in South African SMEs? *Secondary research questions:* • What is the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs? • What are the recommended strategies to improve the adoption rate of green ICT in South African SMEs?	*Theoretical implications:* • The study empirically proved that a lack of funding was the most prominent barrier and with a lack of awareness following closely in the low adoption rate of green ICT in South African SMEs. • The study empirically proved that the barrier with the strongest underlying correlation resulting in the low adoption rate of green ICT in South African SMEs is the positive relationship between lack of awareness and knowledge-uncertainty. • The findings may provide a greater understanding and more detailed information for entrepreneurs, government and other stakeholders in terms of their role towards environmental sustainability through the adoption of green ICT. *Managerial implications:* • The findings indicated that SME owners and managers should be supportive and champion an environmentally friendly culture that can contribute towards advancing effective strategies for green ICT adoption. • Owners and managers should focus on the requirements of SMEs when considering key strategic decisions related to green ICT as underlying factors may become disruptive if not monitored properly. • The context of green ICT must be clearly defined beforehand to ensure the correct decisions and processes are adopted by SMEs.

Source: Author's own composition (2019)

Table 5.3 presents a summary of the recommendations using a strategy framework based on the results of the research findings. The recommendations apply to both owners/managers of the SMEs and policy makers.

Table 5.3: Strategy Framework

Adoption of Green ICT by SMEs Strategy Framework	
SMEs (Owners and managers)	**Policy Makers (Government and The Innovation Hub)**
• Familiarise themselves with green ICT irrespective of the size of their enterprise; for example, becoming more aware of energy conservation. • Undertake practical steps to determine the cost of adopting green operation practices as certain practices may require more resources, capital and time. • Employ green ICT experts to help create an environmental awareness culture in the workplace. • Consider collaboration with other enterprises to reduce costs and achieve sustainable green ICT operation practices. • Adopt green ICT to gain a competitive advantage over competitors who have not yet adopted green ICT practices. • Consider collaboration with venture capitalists to obtain additional support for funding. • Prioritise training specifically designed for SMEs to upskill employees on green ICT adoption operation processes. • Invest in educating employees about green ICT and its advantages.	• Government should strive towards increasing support of SMEs for the adoption of green ICT; examples are investing in green ICT operation processes. • Sustainable development programmes should be offered to SMEs to enhance green ICT operation practices. • The framework regulating green ICT practices should be reviewed to improve policies governing the SME sector. • They should consider playing an active role in the adoption practices through the formulation of national green ICT policies. • Collaborations with SMEs should be promoted so that green ICT policies can be integrated into all business practices and thereby reduce carbon emissions. • The Innovation Hub should support and implement as many as possible high impact actions continuously to help enterprises to overcome hindrances in the adoption of green ICT. • In supporting SMEs, the following should be prioritised by the government when offering green ICT development programmes: awareness, knowledge focused on complexity and uncertainty, skills and funding (constructs with higher correlations deduced).

SMEs (Owners and managers)	Policy Makers (Government and The Innovation Hub)
• Create a knowledgeable green ICT culture in the workplace by enforcing the attendance at green initiatives. • Intensify green ICT awareness campaigns to ensure return on investment in the long run. • Develop a culture that is innovative and favourable towards green ICT adoption and which promotes a positive change in operation processes, e.g. green disposal practices. • Consider a shift from converting ICT to green ICT in operation practices, e.g. re-using or recycling electronic equipment. • Align green ICT initiatives with strategic goals (vision and mission) of the enterprise. • Strive to adopt green ICT strategies to reduce emissions and achieve a sustainable environment. • Focus on the requirements of the SMEs to ensure that the right green ICT tools and green ICT practices are used to achieve the aims of green ICT. • Establish a functional area in the enterprise for green ICT similar to marketing and finance functional areas to enhance awareness and knowledge strategies aligned with green ICT.	• Provide sufficient resources to support the funding of green ICT initiatives such as cloud computing. • Educate government officials about the advantages of adopting green ICT practices. • Enforce the adoption of environmental certification practices to pioneer the greening of ICT. • The Innovation Hub as the leading technological science park in sub-Saharan Africa should take the lead in incorporating green ICT best practices by advising SMEs on the appropriate changes to ensure the effectiveness of successful green ICT adoption processes. • Establish a platform to discuss policies and future changes to environmental regulations such as carbon tax. • Join forces with SMEs and implement support mechanisms to achieve green ICT strategies. • Ensure that development programmes are properly directed to reach all SME owners and managers in support of green ICT aims. • Ensure that green ICT is integrated at strategic levels and adopted through policies and strategic documentations. • Take cognisance of the role academia plays. Academic institutions offer a valuable research and development platform to translate policies into feasible projects. • The Innovation Hub should promote change programmes by appointing change managers or teams to ensure the sustainability of projects or programmes and promote a culture change towards green ICT adoption.

Source: Author's own composition (2019)

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ANNEXURE A: PARTICIPATION INFORMATION SHEET

Participation Information Sheet

GREEN INFORMATION COMMUNICATION TECHNOLOGY QUESTIONNAIRE FOR SELECTED SOUTH AFRICAN SMEs

Dear Prospective Respondent

My name is Elizma Bok, a Masters student in Business Management at the University of South Africa (UNISA). I would like to invite you to participate in a survey entitled “Green Information Technology” in which you will be asked to answer a questionnaire.

The research study seeks to investigate and describe how the green ICT adoption rate in South African SMEs is influenced by certain barriers. By taking part in this survey, you will be making a valuable contribution to green ICT research in South Africa and assist in protecting the environment along with the creation of jobs in green environment. The Innovation Hub was selected as it’s a well-managed institution that operates in an innovative digital space to promote economic development.

Please note that your participation in this research study is voluntary. All the data received will be treated anonymously and with strict confidentially. Clear instructions are provided below for the completion of the questionnaire which will take approximately 10 minutes to complete.

Please note that there are no right or wrong answers and the study is purely for academic research purposes. There are no rewards or payments associated with the participation in this study. If you feel uncomfortable at any stage during the questionnaire, you are free to stop and you do not need to provide an explanation for doing so. Kindly be informed that no potential risk is foreseen and that participants interest will be protected at all times.

The results obtained will be securely stored by protected passwords and records will be retained for five years and disposed thereafter. The information will only be used for research purposes, including publications and conference proceedings while protecting participant’s privacy. If you would like to know about the findings of the final research results or need any additional information, please do not hesitate to contact me, Elizma Bok, on 012 429-3621.

Thank you for taking the time to read this information sheet and for taking part in the research study.

Elizma Bok

ANNEXURE B: QUESTIONNAIRE

INTRODUCTION

In recent years, the rise in global ecological problems has evidently become more of a concern. The increase in greenhouse gasses such as carbon dioxide (CO2) emissions are viewed as one of the contributors. As a result, Green ICT surfaced as a main issue to reduce the ecological impact on the environment. Green ICT adoption therefore serves as a solution to minimise the energy and waste consumption of natural resources to protect the environment.

Green ICT refers to the *"Pioneering way of using ICT that consists of policies and practices which deal with environment sustainability by minimizing carbon footprint, ICT waste and by optimising energy consumption and by conserving natural resources for cost-effectiveness, sustenance of ICT and to save planet".*

Kindly sign the following consent form before completing the questionnaire:

Consent to participate in this study

- I herewith consent to participating in this research study.
- I understand that the study is conducted on a voluntary basis.
- I understand that the data collected for the study will be strictly confidential.
- I understand that the data gathered will only be used for academic research.
- I am aware that the final results of the research study will be accessible on request.

I acknowledge and accept the above terms for participating in the study.

_____ _____

Signature Date

Please take special note of the participation information sheet regarding the research study.
Your contribution towards the results of this research study is of significant value.

SECTION A – ADOPTION

Rate your level of agreement with the following statements in *each row*:

Question 1: When I adopt green ICT it will be...	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
a) voluntarily.					
b) to comply with regulations.					

c) under pressure from customers.					
d) under pressure from competition.					

Question 2: I believe that green ICT …	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
a) reduces the negative impact of packaging.					
b) reduces the negative impacts of producing finished goods.					
c) reduces the negative impact of the user phase.					
d) promotes a product that can be recycled.					

SECTION B – DRIVERS

Question 3: My understanding is that green ICT can…	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
3.1 Cost					
a) enhance operational efficiency.					
b) decrease operational costs.					
c) enhance innovative manufacturing processes.					
d) increase the development of eco-friendly practices.					
e) improve the company's performance.					
3.2 Competitive advantage					
a) offer products with less impact on the environment.					
b) distinguish the company from its competitors.					
c) allow the company to adjust easily to markets.					

d) increase the cost-effectiveness of the company.					
e) enhance market entrance.					
3.3 Product life cycle					
a) contribute towards the reduction of waste.					
b) carry out life cycle assessment for products.					
c) increase the use of recyclables.					
d) extend the product life.					
e) increase the reusability of products.					
3.4 Environmental conditions					
a) reduce carbon emission.					
b) grow profit by environmental management systems.					
c) improve the competitiveness of environmental investments.					
d) enhance the rebuilding of the natural environment.					
e) decrease energy usage.					

SECTION C – BARRIERS

Question 4: I believe that the following constructs might hinder the adoption of green ICT:	1 Strongly disagree	2 Disagree	3 Neutral	4 Agree	5 Strongly agree
4.1 Awareness					
a) Unsureness about the implementation of green ICT					
b) Unawareness of green ICT to improve sustainability					
c) Inadequate awareness of environmental policies					
d) Unawareness of green ICT in the marketplace					

e) Unawareness about green ICT operation processes					
4.2 Knowledge					
a) Too complex					
b) Risk of failure					
c) Unclear perceptions of change towards green ICT					
d) Lack of shared knowledge collaboration					
e) Uncertainty about green ICT benefits					
4.3 Expert ICT skills					
a) Lack of qualified employees					
b) Lack of skills to enhance green initiatives					
c) Inadequate technical capabilities					
d) Poor expertise in green ICT operation processes					
e) Lack of green ICT training					
4.4 Legislative regulations					
a) Insufficient government subsidies					
b) Unpredictable changes in government laws					
c) Inadequate capabilities by government					
d) Unclear government policies					
e) Insufficient government support for green initiatives					
4.5 Funding					
a) Insufficient capital					
b) High research and development costs					
c) Uncertainty about return on investment					

d) Continuous investment required					
e) High initial investment required for operational costs					

SECTION D – BIOGRAPHICAL INFORMATION

Please place a cross in the appropriate box:

(1) Position in company

a) Owner	
b) Manager	

(2) Your age group

a) 18-29 years	
b) 30-39 years	
c) 40-49 years	
d) 50-59 years	
e) 60-65 years	

(3) Education level

a) Matric or less	
b) Diploma or certification	
c) Degree	
d) Postgraduate degree	

(4) Number of operational years of your company

a) Less than a year	
b) 1-5 years	
c) 6-10 years	
d) More than 10 years	

(5) Number of employees in your company

a) Fewer than 50	
b) 50-150	
c) 151-250	
d) Unsure	

SECTION E – OPEN-ENDED QUESTIONS: GENERAL VIEWS ON GREEN ICT

(1) What is a major barrier for your company in adopting green ICT?

(1.1) Why do you see this as a barrier for your company?

(2) Why do you think the adoption of green ICT may be a problem for your company?

(3) What strategies would you recommend to improve the adoption of green ICT in your company?

(4) Is there any additional information that you would like to add?

End of survey.

Thank you for completing the survey.

ANNEXURE C: ETHICAL CLEARANCE CERTIFICATE

UNISA university of south africa

COLLEGE OF ECONOMIC AND MANAGEMENT SCIENCES
DEPARTMENTAL ETHICS REVIEW COMMITTEE
OPERATIONS MANAGEMENT

Date: 4 February 2019

NHREC Registration # : (if applicable)
ERC Reference # : OPS/2019/002

Name : Elizma Bok

Student #: 90266838

Dear Ms Elizma Bok

Decision: Ethics Approval from
4 February 2019 - 4 February 2024

Researcher(s): Elizma Bok
Department of Operations Management
College of CEMS
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Adopting Green Information Communication Technology (ICT): Barriers for South African SMEs

Qualification: DPEMS02

Thank you for the application for research ethics clearance by the Unisa Department of Operations Management Ethics Review Committee for the above mentioned research. Ethics approval is granted for 5 years (**see period mentioned above**).

*The **low risk application** was **reviewed** by the Department of Operations Management:*

The proposed research may now commence with the provisions that:

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