UNIVERSITY OF KWAZULU-NATAL

FACTORS AFFECTING THE ADOPTION OF GREEN DATA CENTRES IN NIGERIA

By

Ojediran Oluwatosin Akinyele

216076372

A dissertation submitted in fulfilment of the requirements for the degree of Master of Commerce
(Information Systems and Technology)

School of Management, IT and Governance

College of Law and Management Studies

Supervisor: Mr Mudaray Marimuthu

2020

DISSERTATION

FACTORS AFFECTING THE ADOPTION OF GREEN DATA CENTRES IN NIGERIA

SUBMITTED BY

Ojediran Oluwatosin Akinyele

216076372

IN FULFILMENT OF THE DEGREE OF

Masters of Commerce (M.Com.) in Information Systems and Technology

School of Information Systems & Technology

Faculty of Management Studies

UNIVERSITY OF KWAZULU-NATAL

DATE OF SUBMISSION

JULY 2020

SUPERVISED BY

Mr Mudaray Marimuthu

As the candidate's supervisor, I have approved this dissertation for submission.

Signed: [redacted]

Name: M Marimuthu Date: 15 July 2020

DECLARATION

I, Oluwatosin A. Ojediran declare that:

The research reported in this thesis is my original work except where otherwise indicated.

This thesis does not include other person's information and writing, except acknowledged explicitly as being sourced from other persons or researchers. Where other written sources have been quoted, then:

i. Their words have been used but placed inside quotation marks and referenced.

ii. Their words have been re-written, but the primary information endorsed to them has been referenced.

iii. This thesis does not contain graphics, words or tables copied and pasted from the Internet, except it is exclusively acknowledged, and their origin being comprehensive in the thesis and the references solutions.

iv. Publications reproduced by me as the author, co-author or editor, I have indicated in specifying which part of the publication was genuinely written by myself alone and have fully referenced such publications.

This thesis has not been submitted for any degree or examination at any other university.

Signed: 

Oluwatosin Ojediran

ACKNOWLEDGEMENTS

Firstly, I would like to give all thanks to God for His Love and Grace to be able to embark on and complete this research study.

I will also like to express my deepest gratitude to my research supervisor Mr Ashley Marimuthu for his all-time support and guidance during the research study. His bright supervision will always be highly appreciated. I also wish to express my honest gratitude to Professor Adetiba for his encouragement to take up this research program.

I would also wish to venture my profound appreciation to Mr Babajide, Mr Abiodun, Mr Aduroja, Mr Filani, and other members of various organisations for their efforts, contact, and time spent during the collection of information for my research study. I would also like to express my most profound appreciation to my parents, Rev. and Deaconess Akinwoye Ojediran for their unconditional love, prayers, and supports. My immense gratitude also goes to my Uncle and his Family; Pastor and Pastor Mrs Adejimi and family. My heartfelt appreciation goes to my eldest brother and his family; Mr Samuel Akinwoye, Mrs Efe Akinwoye, and Master. Oluwatobi Akinwoye. I wish to express my distinguished appreciation to my immediate brother; Mr Oluwasegun Ojediran, for his academic supports and loves.

Many thanks to Zanele Nxumalo, Mr Segun Oladoyinbo and Dr Olaide Oladoyinbo, Anuoluwapo Aluko, Solomon Adeyemo, Femi Adeyemo, Jide Enigbokan, Mr Joshua Ibidokun and family, Mr Busayo Otunba 1, Mr John Olusanya and Dr Nokhuthula Mavela, Moyin Ajayi, Mrs Ofusori, and to my colleagues that provide their support and words of encouragement.

I say a big thank you to everyone, who have in one way or the other contributed to the success of this research.

ABSTRACT

Green technology adoption is a reasonable effort that organisations, which are into data centres, should endorse due to the environmental crisis in the world concerning electronic waste and emission of harmful gasses, amongst other environmental concerns. Countries worldwide, especially the developed countries like the United States of America, have improved their data centres for environmental sustainability. However, most organisations in developing countries are yet to improve the level of environmental sustainability in the area of Information Technology. The adoption of green data centres in Nigeria is essential because it influences the environment. Anecdotal evidence suggests that most organisations in developing countries lack efforts to go green; this may be attributed to a lack of knowledge on reducing land space and technological components, ultimately affecting productivity. Various factors influence the adoption of green technology, and this study aims to determine these factors in the context of green data centres.

This study discovered factors that affect the adoption of green data centres in Nigeria using a descriptive qualitative research approach. Interview questions were aligned to the technology organisational and environmental (TOE) framework. Thematic data analysis using NVivo software was used to find themes that show the factors affecting the adoption of green data centres in Nigeria. Results indicate a lack of awareness, technical difficultly, lack of management support and inadequate policies for green data centres, as predominant factors affecting green data centre adoption.

TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

LIST OF ACRONYMS

AC	Alternating Current
ASSA	Academy of Science of South Africa
CO	Carbon Monoxide
CRAC	Computer Room Air Conditioners
DC	Direct Current
DCIM	Data Centre Infrastructure Management
DTPB	Decomposed Theory of Planned Behaviour
ECA	Economic Commission of Africa
ENIAC	Electronic Numerical Integrator Computer
GDC	Green Data Centre
GDCP	Green Data Centre Program
IBM	International Business Machines
ICT	Information Computer Technology
IDT	Innovation Diffusion Theory
IEA	International Energy Agency
IS&T	Information Systems and Technology
IT	Information Technology
ITU	International Telecommunication Union
kV	Kilo Volts
LAN	Local Area Network
PBX	Private Branch Exchange
PDU	Power Distribution Units

PHCN	Power Holding Company of Nigeria
PPP	Proper Power Planning
PwC	Pricewaterhouse Coopers
SAN	Storage Area Network
TAM	Technology Acceptance Model
TIA	Technology Innovation Agency
TOE	Technological, Organisational, Environmental

CHAPTER ONE: INTRODUCTION

1.1 Introduction

Information technology (IT) is a tool that enables people to do things efficiently using computers or telecommunication devices, amongst others. Various physical and mental work that was not quickly done or impossible before are now easily achieved using IT systems (Aferdita, 2015). Organisations implement information technologies into their mode of operation to solve problems and increase operation efficiency, thus increasing organisational profit. However, information technology continues to play a positive role in the cause of reducing environmental pollution through the provision of eco-friendly products, operations and businesses (Bachour, 2012). Therefore, the introduction of green information technology (Green IT) is essential to tackle the issues caused by the emission of harmful gasses like carbon monoxide (CO) and the disposal of used computer equipment, which negatively affects the environment.

Data centres form the backbone of various services such as web hosting, internet services, e-commerce, as well as software services, amongst others (Krishna, 2009). However, an increase in demand for these services influences the continuous expansion of data centres, which leads to environmental problems when its power usage and disposal are not correctly managed. Hence, it is imperative to ensure that data centres are environmentally friendly with minimum harmful environmental impact. Green technology enables people to live in a more environmentally-conscious (greener) way that is environmentally friendly (Mueller, 2017).

1.2 Background of the Study

Over the years, the issue of global warming has been an essential factor that affects the entire world, including developed countries, developing countries, and under-developed countries. For this reason, governments around the globe are responsible for attaining significant compliance for the well-being of the environment. Consequently, the word ‘green’ is used to imply contemporary developments or advancements that do not pose a threat to life or future generations. According to Hart (1997), environmental sustainability is a broad concept that refers to meeting the needs of the present generation without compromising future generations. While technological advancement has improved the speed and mobility of electronic devices, Mata-Toledo & Gupta (2010) attest that electronic devices can also become toxic waste when

improperly disposed in the environment. Devices like decommissioned servers and old cooling systems, amongst other waste devices that become irrelevant due to new technologies, when properly disposed in the appropriate manner reduce the harmful environmental impact. Thus, it is essential to review and discuss the effects of technological devices on the environment from production to disposal of these devices.

Nigeria is the most populous country in Africa (Kay & Nagesha, 2016), with a low electrical power generation. However, this nation has clean electricity sources that are mainly hydroelectric power plants, and the largest of these is in Kogi State. Regrettably, the low power generation in Nigeria affects the advancement of technology from the sourcing of IT tools to the use of IT tools (Kennedy-Darling *et al*., 2008). Therefore, most industries in Nigeria depend on diesel generators to operate efficiently. For example, mobile communication operators rely on data centres to work efficiently, and these data centres depend on the electrical power source to function optimally. Thus, most industries have to power their communication devices with diesel generators resulting in increased air pollution (Ngene & Aviara, 2014).

According to Gowri (2005), data centres are utilised as storehouses for the storage, management, and dissemination of data. These data centres aid business processes, information management, communication functions and are found in various sectors of the economy (Daim *et al.*, 2009). These sectors include financial services, media, advanced technologies, universities, and government institutions. For individuals and organisations to fully benefit from the use of these data centres, it is essential to address the environmental impact of a data centre because a data centre should be eco-friendly; that is "green". A green data centre utilises technologies that are more energy-efficient and do not contain inactive or unused servers. Using low power servers, modular data centres, reusing waste heat, and many more other energy "green" approaches can achieve green data centres. (Pawlish *et al.*, 2010).

Although the awareness of greening in the area of information technology in Nigeria seems to have been less considered, the demand for technology continues to increase daily, as most organisations in Nigeria now require more business applications due to their business expansion. This increase will continue to put pressure on data centres for upgrades on their servers, storage components, and networking devices, whereby old devices will be decommissioned and disposed in the environment. Gartner (2008), states that the data centre industry will continue to evolve due to the need for higher intelligence, and this will directly

increase the level of power that is required to maintain the data centre. In addition to the increase in power usage, is the disposal of old devices resulting in e-waste.

1.3 Research Problem

Green IT naturally starts with IT and business leaders' sentiments towards climate change, business, and environmental sustainability (Info-Tech, 2008; Rao & Holt, 2005). Many individuals and organisations are often less concerned about global warming and acid rain caused by frequent emission of carbon dioxide into the atmosphere. Nonetheless, the adoption and implementation of green IT differ from one country to another, with most countries in Africa having a low adoption rate (Terry, 2012). Almost two decades ago from 2011, developed countries had the highest rate of toxic gas emissions. Yet, in recent times, toxic gas emissions from diesel generators, car exhaust fumes, and other pollutants from developing countries exceed those of the developed countries (IEA, 2011). Developing countries need to implement green IT due to the environmental benefits. The frequent demand for technologies has increased the capacity of data centres in the aspect of computing, space, and electrical power load because most people in developing and under-developed countries are being open to new technologies like the use of mobile communication such as the Internet.

Lagos State, a city located in the south-western part of Nigeria, has always been the most significant commercial consumer of electricity due to the large population density of about twenty-one million inhabitants (PwC, 2015). According to Etukudor (2015), the electricity transmission network is a significant challenge. In 2010, seven hundred and forty-eight electrical power outages occurred on the 330kV transmission circuit, while four thousand, one hundred and one electrical power outages were recorded on the 132kV circuit. Therefore, the status of Nigeria's electrical power generation and distribution is deficient, and this shows that the country's electrical energy issue continues to force industries into finding alternative power supply like electrical power generators (Chinwuko *et al.*, 2011). These generators are mostly powered by diesel fuel, and their gaseous emissions pose a great deal of danger to the ecosystem and public health. The construction of green energy-efficient data centres is not just a choice that organisations must make on their own; instead, the government also needs to be aware of the threat posed to the environment by information technology somewhat similar to chemical wastes. According to Rais (2014), greening a data centre is a technology of reducing the power or energy usage in a data centre. Therefore, strategic planning to manage electrical

power in a data centre is essential, while substantial improvement continues in data centre operations (Spafford, 2009).

According to Mueller (2017), green IT is the practice of environmentally friendly computing to reduce the negative impact of IT operations from its use to disposal on the environment. It has been observed that most organisations are showing unwillingness to adopt and implement green data centres due to lack of finances and the lack of IT specialists to handle the innovation and complexities in transitioning into green data centres (De Zoysa & Wijayanayake, 2013). Nevertheless, a data centre that wants to embrace green IT must store, manage, and disseminate data in a way that does not pose any environmental threats, through the demonstration of Green readiness. This demonstration is an application of environmental procedures through attitude, policy, practice, technology, and governance in information technology infrastructures (Molla *et al.*, 2009).

Most of the current literature focuses on green IT in general (Gholami *et al.*, 2016). Yet, there is limited research on these factors, affecting green data centres (Papadopoulos & Wurm, 2012). Therefore, determining factors affecting the adoption of a green data centre can provide an understanding of the lack of data centres adoption in Nigeria.

1.4 Research Questions

This study seeks to answer the following research questions:

1. What is the adoption level of green data centres in Nigeria?

2. What technological factors affect the adoption of green data centres adoption in Nigeria?

3. What organisational factors affect the adoption of green data centres adoption in Nigeria?

4. What environmental factors influence organisational adoption of green data centres in Nigeria?

1.5 Research Objectives

This research investigated the adoption of green data centres in Nigeria and objectives implemented to achieve the outlined research objectives are:

1. To identify the adoption level of a green data centres in Nigeria.

2. To identify technological factors affecting the adoption of green data centres in Nigeria.

3. To identify the organisational factors affecting the adoption of green data centres in Nigeria.

4. To identify the environmental factors affecting the adoption of green data centres in Nigeria.

1.6 Overview of Research Methodology

According to Brannick & Roche (1997), several elements influence the methodology in which a researcher chooses to conduct a particular study. These include the nature of the research problem and the research paradigm. In this study, different organisations that own a data centre in Nigeria were approached for the collection of primary data. Lagos State in Nigeria was the preferred geographical area as Lagos state is home to the highest number of internet users in Nigeria and where expert data centre organisations are located. Paul (2008) states that population can be defined as the totality of the units, individuals, or people in a given geographical area in which a study would be conducted.

There are two types of research approaches; qualitative and quantitative. Quantitative research is the type of research approach that uses numerical data as its origin for creating a complete understanding of a fact. Qualitative research approach provides in-depth detail of non-numerical data on the phenomena under study. Therefore, social phenomena such as the emotions, feelings, opinions, and personality attached to the collection of data can be expressed (Christopher, 2014). The qualitative approach method will be preferred in this study because it allows the researcher to have an in-depth understanding of the phenomenon. Christopher (2014) established that qualitative methods are not merely 'soft' and unscientific, but have questions that only allow in-depth analysis because it can explain ambiguous data and offer insights into respondent's point of view, considered intangible by quantitative methods. Data from the questionnaire (interview guide) was transcribed manually by the researcher. NVivo software was utilised for data analysis. NVivo is a qualitative data analysis software tool that is meant to aid a researcher from 'time-consuming' vast arrays of data, which will help to increase the accuracy and the speed of the analysis process (Zamawe, 2015). According to

Hoover & Koerber (2009), efficiency, multiplicity, and transparency are benefits gained from using NVivo in a research study. Nevertheless, NVivo also assist the researcher in generating themes and sub-themes for an in-depth understanding of the research findings (Houghton *et al*., 2017).

1.7 Contribution to this study

The factors affecting the adoption of green data centres have attracted minimal attention. According to IBM (2007), the attention of the government and organisations towards the reduction of greenhouse gas emissions is improving. However, the improvement is yet to resolve the environmental crisis. Hence, this study will contribute to green data centre adoption and determine the factors affecting the adoption of green data centres in developing countries like Nigeria. It will also help organisations and governments, not only in Nigeria but in other developing countries, to embrace eco-sustainability. According to Terry (2012), green revolution technology and its impact have been outside Africa, and relatively little empirical evidence exists within African communities.

1.8 Structure of the Dissertation

This thesis consists of five chapters:

Chapter 1 - Introduction: This chapter shows a summary of the research dissertation. This chapter explains the issues surrounding the adoption of green IT, especially in the area of a data centre. The research objectives, research questions, research approach, research limitations, and the problem statement are presented in this chapter.

Chapter 2 - Literature review: This chapter reviews the literature on the adoption of green data centres. It explains further on data centre infrastructure, the various sections that make up a data centre, data centre management, and the adoption of green data centres.

Chapter 3 - Research design and methodology: This chapter explains the research methodology carried out in the study. It also expatiates further on the method of data collection, the targeted population, and the sampling method used for this study. Furthermore, this chapter presents the data analysis technique implemented in the study.

Chapter 4 - Data presentation and discussion of findings: This chapter offers general insight into the data collected via the audio device, which was transcribed and then analysed

using NVivo software. Results were presented to identify factors affecting green data centre adoption in a developing country – Nigeria.

Chapter 5 - Conclusion and recommendations: This chapter provides the overall summary of the study, conclusions derived from the results, and future study and recommendations.

1.9 Summary

This chapter provided the background on green data centres. Many organisations in Nigeria have been found to face common challenges in setting up of green data centres. These common challenges influence the lack of eco-sustainability in organisations. Data centres are the backbone of today's information system technology advancement because they provide the primary support for the mobile connections and storage needed for today's social networking and application development. This chapter also discusses the research questions, research aim, objectives, the problem statement and research limitations.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Information technology (IT) positively influences environmental sustainability, and its benefits have improved other aspects of science and technology. For example, IT innovations have played a vital role in reducing harmful gases from vehicle exhaust pipes with the emergence of eco-friendly vehicle technologies. As well as reduction of energy consumption by means of, dematerialisation, emission management systems, limiting of carbon-emitting business practices such as travel by opting for other mediums of connecting like video-conferencing and other online collaboration facilities. The implementation of information technology continually supports dynamic routing of vehicles and machines (Jones & Mingay, 2008; Esty & Winston, 2006).

Global warming has been an indisputable fact that affects all living entities in the ecosystem. It has been shown to have a revolving cycle of operation that affects living and non-living components in the ecosystem. There is an increase in ecological initiatives on global warming due to global ecosystem degradation. The interventions to curb, reduce and manage global warming have had a positive impact on the entire globe; however, some areas continue to face a daunting array of environmental problems (Schroeder, 2009). Thus, organisations that invest in green technology have been encouraged to support environmental innovations that help to reduce the causes of global warming (Hart, 1997).

Moreover, green technology continues to solve problems using application development, software, networking, cooling systems, and data storage while maintaining green compliance. According to Uddin & Rahman, (2010), 30% of servers in a data centre are less functional because they are considered obsolete. Therefore, old electronic devices become waste; when they are not recycled or in use and organisations are encouraged to manage electronic waste appropriately. Furthermore, Akuru & Okoro (2014) attest to green compliance achievement when IT tools are appropriately utilised. This attestation indicates that green data centres are more efficient when new and old electronic devices in a data centre are managed appropriately.

2.2 Data Centre

Seventy years ago, Electronic Numerical Integrator Computer (ENIAC) facilities were designed in the United States of America to store codes for the support of weaponry. This

weaponry was explicitly made for the United States Army Ballistic Research laboratory in the year 1946, and these facilities serve as the foundation of data centres (Arif & Murat, 2015). About 30 years ago computers came into public interest, and the initial interest of computer usage by industries had a low turn-out because most electronic-based sectors and the traditional computer industry were quite distinct with minimal cross over between them (Campbell-Kelly & Aspray, 2004). However, in the late eighties the advancement in technology brought about the invention of microcomputers that resulted in a significant increase in computer usage by organisations. According to Balodis & Opmane (2012), the rise in demand for personal computers resulted in the development of the Internet and other extensive information technology resources. These information technology resources provide adequate services for businesses, personal purposes, and data centres support these entities.

According to Anderson (2010), a data centre is a facility or a place that houses websites and provides data storage. Therefore, a data centre offers uninterrupted services and has specific features such as uninterrupted power supply, network security, physical security, network communications, controlled environment, fire suppression emergence, amongst others. Although, to a layman, a data centre is a room or some kind of a building that stores large information for an organisation, while some describe a data centre as a central system that enables internet communication (Benson *et al.*, 2010; Nathuji & Schwan, 2007). Likewise, a data centre is a hardened facility that is devoted to providing continuous services to business data operations (Anixter, 2012). This facility contains the storage, computational power, and the fundamental support for a business service. However, these business services (especially, Information Technology) must maintain sustainable environmental operations to reduce the negative impact of IT on the environment. Therefore, technology is green when it is environmental friendly in the way it is developed, operated, and disposed of, thereby protecting and conserving natural resources (Bhardwaj & Neelam, 2015).

2.2.1 Types of Data Centres

All over the world, data centres have become a significant infrastructure for corporations, institutions, government, non-governmental organisations (Pawlish *et al.*, 2010). These data centres are designed for specific reasons to solve particular operational problems and issues. Data centres are in two major categories, being Corporate Data centres and Colocation Data Centres (Legrand *et al*., 2016). These categories of data centres are determined by the type of network technology, tools used, and the magnitude of services performed in the data centre.

Corporate data centres are known to serve numerous applications. They are mostly owned and operated by private organisations and government agencies (Anixter, 2012). These corporate data centres are also known to provide IT services to oil companies, banks and many more. However, the servers in corporate data centres are mainly established to support the internal operation of an organisation through data storage, data processing, and web services, though the web service maintains both internal and external bandwidth for their applications.

A colocation data centre is a large data centre that offer space to servers for a different organisation. This category of a data centre is outsourced, and the security level of such a data centre is very high. Colocation can also be described as a storage pattern that enables clients to store hardware, provides highly reliable security, cooling system, technical expertise, and compliance support to the client's data and hardware (EATEL, 2017).

2.3 Data Centre Infrastructure Management

Data centre infrastructures contain various assets like servers, storage area networks, network devices, electrical power, and cooling units. The infrastructures in the data centre can be physical or virtual. The physical and virtual views provide the necessary information needed to operate and maintain the devices in the data centre. Brent (2015) emphasised the importance of infrastructural management through planning and design for the green economy. Thus, a data centre that is owned by large organisations such as Google need to embrace, prioritise, and utilise a large number of renewable power sources such as solar energy in their data centres (Grant, 2018). Google continues to support global sustainability programs as inappropriate production, use, and disposal of technologies may harm the environment (Murugesan, 2008). Although, rapid growth in organisations has contributed massively to the positive influence of ICT, however, its negative impact increases the amount of electronic waste (e-waste) due to frequent disposal of ICT products (Papadopoulos & Wurm, 2012). This increasing amount of electronic waste will also continue to escalate because of the short lifetime of most ICT devices (Herat & Bahadir, 2007). For this reason, inappropriate disposal of ICT technology continues to have a negative impact on the environment (Holmner *et al.*, 2012).

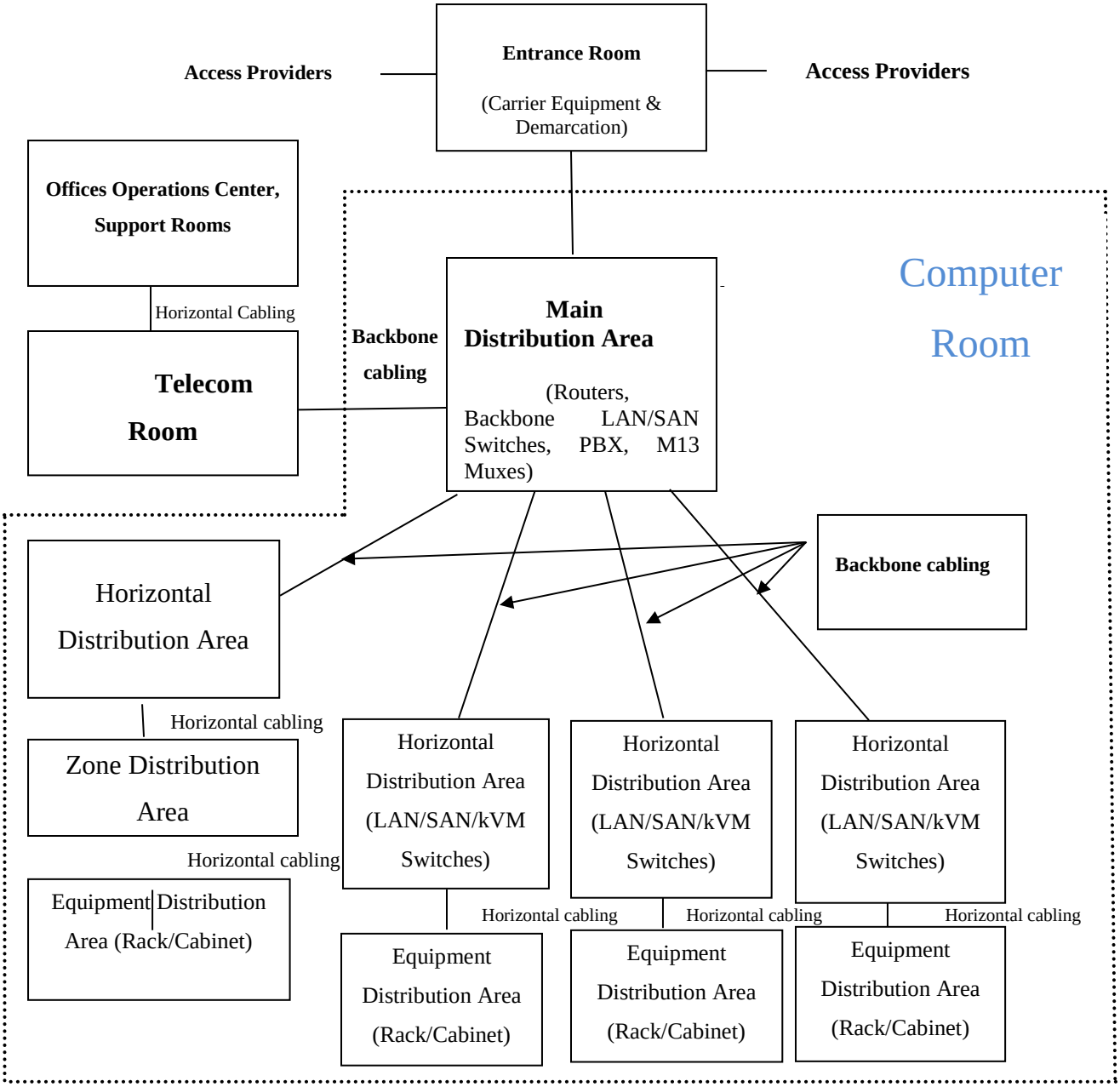

Figure 2-1: Example of basic data centre topology (TIA-942, 2005)

Figure 2-1 is a standard telecommunications infrastructure for a data centre in early 2005, and the first standard to address data centre infrastructure management. Data Centre Infrastructural Management (DCIM) is the use of IT tools and energy resourcefully in a data centre by an IT professional. These tools also enable IT experts to handle the complexity of a data centre environment. DCIM is a combination of different devices, mainly servers, storage, and network switches for monitoring, designing/computerisation, planning, and implementation. However, some components, such as the design section, operation section, monitoring section, predictive

analysis, and planning section of a data centre, must be considered before a data centre is constructed (Cole, 2012).

Figure 2-2: Data Centre Management Components (Cole, 2012)

1. ***Planning Section***: This section is used to evaluate situations adverse impact of information or physical equipment in a data centre (Cole, 2012). According to Amity (2017), evidence has shown that embracing green technology can save resources such as energy, finances and reduce pollution.

2. ***Design Section***: This section described the infrastructural design (server arrangement, power, cooling, networking, and physical security) needed for a specific data centre (Cole, 2012). It is therefore crucial for a data centre to incorporate cautious design to reduce energy consumption in a data centre because cooling system consume 50% of the energy in a data centre (Sharma *et al.*, 2017). According to Rick (2008), designing a green data centre can be challenging. As a result, it is necessary to create a sustainability factor in energy efficiency and recycling of the data centre design.

3. ***Monitoring Section***: Though, there is massive investment in the designing of a data centre. Yet, the monitoring section of DCIM is a critical aspect of the green data centre

because of its energy-saving management. This key aspect requires the smooth operation of the data centre environment through the management of humidity, air/cooling flow, power distribution, and dirt control. Nevertheless, this section also reduces the cost of damages in a data centre due to its alertness via alarm systems or text message (Cole, 2012).

4. ***Predictive Analysis Section:*** This section analyses the previous and present performance of tools in the data centre. It also gives the data management team enough time to measure, avoid and reduce the impact of the failure that may occur in a data centre (Majumder *et al.*, 2017).

2.3.1 Computer Servers

The word “server” in computing originated from 'Queuing Theory'; which dates back to the mid-twentieth century (Kendall, 1953). A server is known as a computer device that enables functionality for other computer programs or devices called 'Clients' because of its ability to manage resource files, programs, and process requests that delivers data to other computers via a network. Yet, it is essential also to analyse the impact of servers on the environment, using the embedded carbon content of the server, from maintenance, decommissioning, and disposal of the server (Hilty *et al.*, 2013). This impact caused by servers is brought up the introduction of virtualisation in a data centre, and it helps to reduce the heat generated from a data centre due to the use of fewer servers. Campbell & Jeronimo (2006) described virtualisation as a process of utilising virtual machines for the virtualised representation of a physical device, through the help of virtualisation software.

2.3.2 Racks

A rack is “an empty closet that can hold different types of thickness and heavy components when mounted" (Mikalsen, 2009, p. 12). Most data centres are massive in size, and they are compared to a large room of a building or the whole building. In a data centre facility, IT equipment is organised in various sections, ranging from the underground cabling to the overhead lighting. Another section that looks similar to a set of refrigerators or a cabinet is a place to mount and arrange computer servers. These cabinets are arranged in rows and columns to form different corridors. The arrangement of the cabinets enables IT personnel to access each server from the front or rear aisle. However, racks are not only reserved for servers,

computer screens, or storage devices. Still, a rack layout intends to provide housing for cooling distribution because of the increasing heat from modern high-density server technology (Kadhim, 2018).

Figure 2-3: An image of a rack, and a Dell Rack server (Mikalsen, 2009)

Some data centres are installed in ship-like containers instead of block buildings. These types of ship-like containers are common among large data centre facilities. Thus, when there is a need for repairs, upgrades, or decommission of servers, the entire ship-like container can be replaced with another, including installed servers and IT equipment. This process makes it easier to temporarily deploy data centre facilities (Bramfitt & Coles, 2011).

2.3.3 Physical Security

Property protection is an essential aspect of a successful business establishment. For example, most private properties with expensive and sensitive facilities require fencing. Consequently, a data centre needs to be secured because it houses IT tools and equipment such as the servers, laptops, air conditioning system, and data. It is naturally challenging to counter all potential security breaches in life, and that is why a data centre must be in a controlled facility with

limited access. The vulnerability could arise in a data centre, so there is a need to secure data, IT specialists and all telecommunication assets (Janpitak & Sathitwiriyawong, 2011). Nevertheless, it is the responsibility of IT service providers to ensure IT hardware such as routers, servers, cables, and amongst others are kept safe (Mahesh, 2016).

2.3.4 Cooling System

The level of energy consumed by information technology equipment in a data centre facility has increased the number of data centres. This increasing number of servers in a data centre requires more cooling surrounding while escalating the total operational cost of data centres (Pelley, 2009), due to the rising heat from devices in a data centre. Therefore, a more cooling system is needed to stabilise the temperature of a data centre (Webber & Wallace, 2009). Thus, high demand for cooling systems requires more electrical power energy and this energy source should be eco-friendly before a data centre is considered eco-friendly.

Furthermore, data centres continue to increase yearly due to the demand for new technology. This increase influences the demand for a bigger data centre storage facility, and this has practically increased the need for IT equipment such as cooling systems, which operates daily due to everyday use of data centre tools (Wang *et al.*, 2011; Mikalsen, 2009). For example, the electricity cost of cooling systems accounts for 30% of the total electricity bill for operating a data centre (Wang *et al.*, 2011). However, due to this expense, heat pumps are installed to transfer heat to a different part of a data centre facility, where heat is needed.

Furthermore, large data centres are known to consume lots of cooling costs for sustenance. Thus, it is crucial to strategically collect and discard a large amount of waste heat (Lucchese, 2019). The introduction of strategies such as air management and cooling management, can aid the reduction of "cooling air" evaporation and the re-circulation of heat in a data centre through large evaporators and water temperature condensers (Lykou *et al.*, 2017). Nevertheless, excess heat generated from the data centre is reused to warm up offices in other facilities around the data centre, during winter (Monroe, 2016).

2.3.5 Power System and Lighting

IT tools such as servers, SAN system, networking system, amongst others, consume more energy due to the constant lighting and air-conditioning of a data centre (Jin *et al.*, 2013). Therefore, the energy usage is an essential part of establishing a data centre because it forms

the power that kick starts and sustains the operation of a data centre. If non-essential applications are removed from specific servers; a lesser amount of servers would be required, and this could encourage less power consumption across the data centre (Gerald & Ramzi, 2008). Hence, it is crucial to take the distribution of electrical power found in a data centre, seriously. Under strict safety requirements, the electrical unit powers 90% of equipment in a data centre. Thus, the power distribution unit meant for a data centre must meet all the necessary safety requirements. Besides, financial management of a data centre is important because the electricity cost of a server can outrun the cost of buying the server (Gerald & Ramzi, 2008).

Data centres account for more than 2% of global electricity usage (Koomey, 2011), and it is expected to increase to 4.4% by 2040 (Tatchell-Evans, 2017). A typical data centre consumes about one hundred times more energy per square meter than a standard office building. Therefore, Proper Power Planning also known as PPP is performed before installing electricity in a data centre. For example, a business that involves streaming of videos over the Internet requires a data centre to operate efficiently, at all times, and this demands more power energy for cooling a data centre (Velte *et al.*, 2008). This proper power planning also demands an in-depth understanding of the data centre power-consumption and its redundancy requirements (that is the management of excessive/surplus electrical power). If all these requirements are excluded, frequent power failures or downtime might occur in the data centre. Furthermore, the energy produced by solar and wind power generation is unreliable due to their high dependence on the weather, which is impossible to control (Ketter & Koolen, 2017).

The chief executive officer of Google identified the level of energy consumption by electrical power plants in a data centre as a leading issue affecting computer designers (Pruhs, 2019). This energy consumption has always been a critical challenge for IT industries all over the world (Arwa, 2018). However, the cost of electricity is increasing speedily (Harris, 2011), and this negatively impacts power saving in data centre operations due to the rise in energy and cooling price (Bader, 2013). For example, the increasing power density of servers and other IT components in a data centre requires a proper distribution of electricity in the data centres (Ebrahimi *et al.*, 2013). This demand continually put the burden on power sources of data centres and greenhouse gas emissions due to the erratic power supply (Murugesan, 2008).

According to Pelley et al. (2009) servers in a data centre consumes 56% of electrical energy while other 44% goes to data centre infrastructures, such as cooling, lighting, amongst others.

Maintaining this electrical power supply demands a reliable energy source. IT equipment such as servers is expected to function fully, unlike regular computers that can be put to sleep mode. Lighting has been a prominent part of the data centre infrastructure, which is essential for setting up an efficient data centre. Therefore, a data centre that requires lights to be on throughout the day and night needs to put up a more considerable lighting system that consumes less electrical energy (Commscope, 2014).

2.4 Green Information Technology

In Africa, electronic waste is increasing. Green IT is a solution to consider in the IT sector in Africa? (Nganji & Brayshaw, 2010). Information technology influence is remarkably significant to social life, economy and other human wants. Unfortunately, IT tools encounter inadequacies due to a rise in the level of IT waste, also known as "e-waste". Khurrum *et al.* (2011) established that e-waste increases due to the use of IT device such as laptop, mobile phone, etc. and their short life span had caused two significant problems which are high energy consumption of power by most of these IT devices and the generated wastes from these devices when they are discarded (Juthathip *et al.*, 2013). However, most of these devices contains chemical components that pose a serious health challenge to the globe.

Green computing evolves continuously due to the pressure from the increasing use of IT tools (Kansal & Chana, 2012). Consequently, IT experts continue to produce and operate IT tools in an eco-sustainable way. Hence, the main reason for green IT is to practice Information technology in an environment whereby the IT tools do not cause environmental hazards, such as carbon monoxide, lead, and mercury (from heavy metals). Green IT life cycle is about the invention of energy-efficient IT tools, which are environmentally friendly. According to Murugesan (2008), green IT life cycle starts from the manufacturing to disposal of IT tools, in an efficient way that does not pose a negative impact on the environment.

Green data centre came into the limelight through the introduction of eco-sustainability and energy efficiency in the operation and management of computer-related equipment. Therefore, it is essential to be aware of Green IT adoption. Arif & Murat (2015) states that the productivity of a data centre continues to increase due to the influence of green information technology. Most organisations are now aware of the word Green IT, but few have adopted green IT into their organisational system. Researchers have also proposed various explanation on factors influencing the adoption of green IT in an organisation (Argon-Correa *et al.*, 2004). Thus,

innovative ideas shared within an organisation can improve the state of finance with effective environmental management of the organisation (Etzion, 2007). As a result, some organisation might be discouraged from adopting new ideas because, knowledge sharing within an organisation that perceives innovation as complicated phenomena require employees to gain more knowledge (Kousar *et al.*, 2017; Dwivedi *et al.*, 2009).

According to Porter & Van der (1995), Green IT refers to the use of environmentally friendly information technology tools to solve personal, business or various environmental challenges. These IT tools are considered green because the energy needed for operation is low while it renders optimal service. Besides, efficient energy usage by these IT tools, are disposed of in an environmentally friendly way. For this reason, Molla (2009) states that the goal of Green IT is to accomplish a sustainable environment, optimal energy utilisation and sustainable developments, while maintaining the primary importance of information technology, such as mobility (Kuhlman & Farrington, 2010). Green information technology or initiatives also involve the reduction of electrical power usage (Mines, 2008). Financial investment is also vital to the development of renewable energy technologies (Ding *et al.*, 2012). For example, in the year 2017, more than seven hundred and twenty billion rands was spent to cut down the use of oil and to develop renewable energy (green power) in Saudi Arabia change (DiPaola, 2017).

Furthermore, the impact of unreliable and unsuitable electrical power source on green data centre technology negatively affects IT tools. The IT tools in a data centre are mainly electronic devices such as computers, routers, servers, and amongst others. These electronic components, such as computers, are made from chemicals substances like arsenic, chromium, or mercury, and they intoxicate drains and pollutes groundwater when they are improperly disposal (Linda, 2010; Timothy, 2004). Therefore, green adoption must be put into consideration from the construction stage to the decommissioning phase of a data centre.

2.5 Adoption of Green Data Centres

Green information systems and technology is partially the influence of information technology tools on the reduction of environmental hazards, which is caused by different IT hardware. According to Kanmdar (2008), a green data centre surpasses a traditional data centre because of its primary objective of eco-sustainability. However, a traditional data centre centralises only on data access and storage space. An information system is called “green information system”

when the method of operation in an organisation is meeting environmental sustainability development goals (Sayeed & Gills, 2010), through the implementation of green policies that are intended to reduce the cost of energy (Sobotta *et al.*, 2010).

According to Arif & Murat (2015), attaining a result that is resourceful in environmental protection, needs to operate a green data centre efficiently by creating eco-friendly energy for the environment (Thornsteinson & Ganesh, 2003). Creating an eco-friendly data centre should not only be measured by operational cost, but it should also involve green initiatives such as virtualisation and cloud computing. Cloud computing refers to the use remote computing resources via broadband connections such as via the internet, software, storage and even infrastructure, with the goal of maximizing computing and minimizing cost. It can be simplified further as storing of information away from a physical location and when the need arises to use that information or reference that information, access is obtained through the Internet (Goundar, 2012), and its use has a significant advantage in saving cost during business operation and expansion. It also boosts data storage through the application of intelligent internet computing via quick solutions such as multitask capacity for better energy conservation across cities (Hopper, 2008).

The consciousness of "green" is becoming an essential part of industrialisation due to the increasing need for eco-friendly solutions (Twanda, 2014). Hence, the amount of electronic waste will continue to increase if organisations do not put in place technologies that reduce a large amount of toxic waste from electronic devices (Kaestner, 2009). These electronic devices, such as computer panels, contain acidic contents and end up in dump yards instead of recycling facilities (Berthon *et al.*, 2010). For this reason, Dell encourages the return of used electronic devices such as laptops and printer (Twanda, 2014). Likewise, Dell and other electronic organisations can help developing countries achieve green technology adoption by involving their agents to educate technology users about the importance of proper electronic device recycling (Twanda, 2014).

2.6 Current adoption of green data centres across the world and Africa

Green activities mainly include green technology innovation, green management innovation, green marketing innovation, and these activities are related to technology, product, and service (Schiederig *et al.*, 2012). For example, adoption of green innovations such as the

implementation of clean energy can reduce the cost of production (Florida & Davison, 1999). Oyebanji (2017) revealed that green innovation is triggered by green initiatives.

United States of America (USA) and China were known to be the two countries that emit the largest amount of carbon dioxide in the world (Ding *et al.,* 2012) and they both face the challenge and opportunity of environmental protection. These countries are at different phases of sustainable development which has been pointed out by environmental performance index scores. For example, China: 65.10 vs the USA: 84.72 and ranks China: 109th vs the USA: 26th in the world (Index, 2016). This environmental performance index also enables a competitive advantage that creates a "green image", which results in environmental effectiveness (Chen, 2008; Gholami *et al.*, 2016).

Due to increasing climate change; green technology initiatives have been introduced (Okewu *et al.*, 2017) and this introduction encourages the movement of data centres to locations, where renewable energy sources are readily available. For example, an organisation such as Facebook built a new data centre in Oregon, for easy access to solar power and efficient electrical distribution system (Kurp, 2008; Heilliger, 2011). Studies show that regardless of information technology growth in Africa, there is a low level of green technology awareness that still exists (Okewu *et al.,* 2017).

2.7 Factors influencing Green adoption

Climate change is one of the most critical global issues, and everyone need to tackle the ongoing global problems through green adoption (Holmner *et al*., 2012). Regrettably, insufficient research in developing countries has caused a lack of adoption of green innovations. Researchers are curious about African countries using IT innovation to enhance their development (Woherem, 1991). Therefore, it will cause them to recognise several factors that affect this type of IT innovation, especially on factors affecting the adoption of green innovation (Mishra *et al.,* 2014). For example, fish farming industries consider technology factors, financial factors, organisational factors, infrastructural factors, and management factors as main factors affecting the adoption of green innovations (Tejaswi & Vignesh, 2019). Therefore, technological, organisational, and environmental factors seem to be predominant factors affecting IT innovation.

The technological factor is simply the influence of technologies on the adoption of innovations (Arwa, 2018). According to Florida *et al*. (2001), organisational factors include "organisational resources, organisational innovations, and organisational performance monitoring system." Meanwhile, environmental factors include environmental indecision and external resource affecting innovation (Omamo, 2012). According to Lin & Ho (2010), technology factors, organisational factors, and environmental factors are significant factors influencing the adoption of innovation. Therefore, it is essential to consider several phenomena before creating and managing a green data centre. According to Hu *et al.* (2016), organisations should strategise their distribution of resources towards green IT and also aligned with internal and external awareness of environmental protection. By doing this, organisations will achieve environmental benefits through green IT practices.

2.8 The ways green data centres are achieved

In the late twentieth century, industry and business leaders have recognised the importance of incorporating environmental sustainability in their business practices (Nath *et al.*, 2014). For this reason, different groups have united to put together goals that reduce the consumption of energy in facilities (Anderson, 2010). Therefore, organisational guidelines have improved the adoption of green information technology on environmental development. Thus, a data centre needs to maintain optimal performance for a productive business in which the data centre is involved, and the guidelines must be of optimum service provision.

The adoption of energy-efficient practices, such as virtualisation, has improved the global competitiveness and sustainability of data centres in India (Raje *et al*., 2015). The introduction of virtualisation reduces the number of physical servers and the amount of energy usage in a data centre because multiple software operations in numerous physical servers are moved to a smaller number of virtual servers (Sean & Michael, 2006). Therefore, a green data centre is expected to operate efficiently by utilising the maximum amount of energy while causing minimum impact on the environment (Belvis, 2007). For example, the Malaysian government introduced policies to reduce the emission of harmful gases into the atmosphere (Shahrul *et al.*, 2013).

Furthermore, a data centre adopting green technology must discard a few devices (such as solid waste) to achieve a friendly environment. According to Linda (2010), solid waste is defined as garbage, refuse, or other discarded materials. Therefore, laid down guidelines for waste

management must be implemented. For example, the Resource Conservation and Recovery Act (RCRA) in the United States of America established standards for managing solid wastes, and these standards are meant to define if a device is a hazardous waste or not (Linda, 2010).

2.9 Theoretical Framework

Osanloo & Grant (2016) describe a theoretical framework as a foundation that set information together metaphorically and factually for a research study. This research study section explains a few frameworks and models that created the foundation of this research methodology. The theoretical framework is the blueprint of a dissertation analysis Osanloo & Grant (2016). For that reason, a suitable framework analysis is adopted because this research study answers explicitly the research questions (Srivastava & Thomson, 2009) on factors affecting green data centre adoption.

Framework analysis is the preferable tool in qualitative research method because it does not only generate theories but also interprets the actual "What" question happening in a distinct setting (Ritchie & Spencer, 1994). Therefore, this answer to "what" factors affect the adoption of a green data centre in Nigeria. These theories associated with the adoption process starts when an individual change from a state of ignorance to a state of understanding (Prochaska *et al*., 1992). According to Carr (1999), adoption is a technology an individual or organisation selects for a particular use. Hence, it is crucial to understand the elements of information technology adoption and the various theories used for examining the adoption level of an organisation.

According to Kerlinger (1966), a theory is a set of interrelated constructs, definitions, and propositions that present a systematic view of phenomena by specifying relations among variables to explain and predict phenomena. While MacMillan Education limited (2020) stated that a framework is a set of ideas that you use when you are forming your decisions and judgments. Likewise, LoBiondo-Wood & Judith (2014) describe a framework as a strategy that articulates the research intention, research question, literature review, and help with the processing of the design.

There is no ideal theory to generalise a study. However, a specific theory such as theoretical framework can be used for different fields of study. Theoretical Framework is a critical phase of a research study, and also useful in advance academic coursework (Osanloo & Grant, 2016).

Eisenhart (1991, p. 205) defined theoretical framework as "a structure that guides research by relying on a formal theory", while Fain (2004) described the theoretical framework as a structured set of unified theories that recognise the relationship between two or more variables for identifying problems or nature of things. The theoretical framework expresses different theories that brace the thoughts in the matter of how the research topic is planned and understood, alongside ideas and definitions from that theory that are relevant to the problem (Lovitts, 2005). Various theoretical models specifically clarify technology acceptance and adoption. These theories include Theory of Reasoned Action (TRA), Diffusion of Innovation (DOI), Technology, Technology Acceptance Model (TAM), Unified Theory of Acceptance and Use of Technology (UTAUT), Technology, Organisational and Environmental (TOE) and many more.

2.9.1 Theory of Reasoned Action (TRA)

TRA (Theory of Reasoned Action) was established in social psychology context, which attests to the behavioural intention of an individual's attitude and subjective norms (Fishbein & Ajzen, 1975). These intentions are prospects of a person's behaviour in a way that is fashioned through the attitudes and subjective norms of the person, and this individual intention results in action if the approach is inflexible (Sharma & Mishra, 2014).

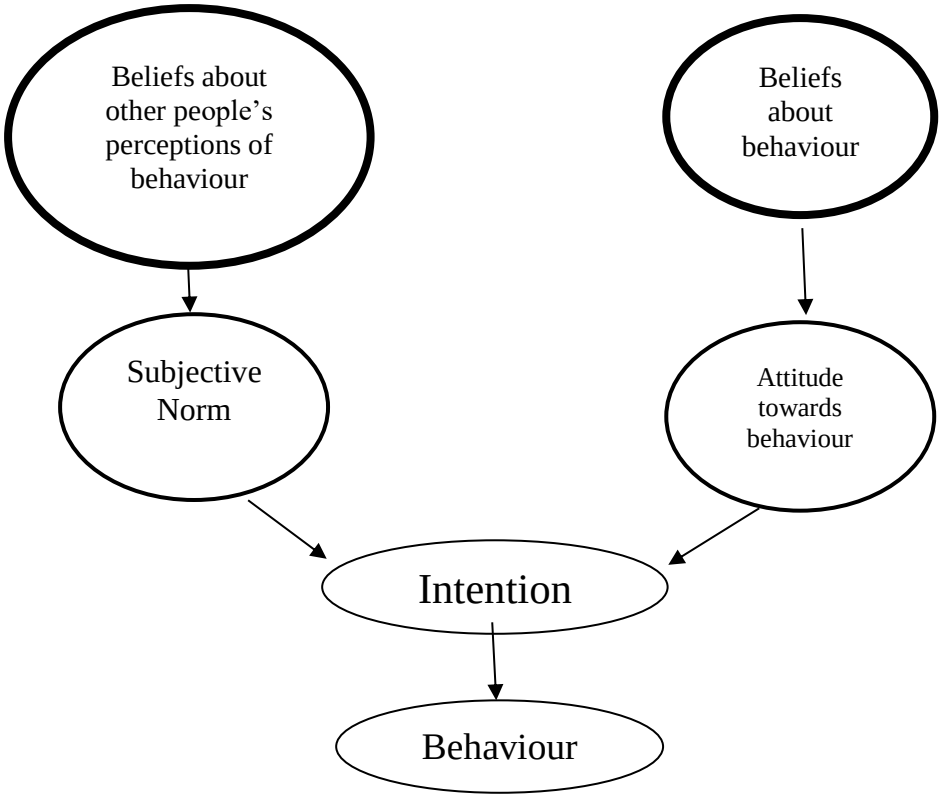

Figure 2-4: Representation of the Theory of Reasoned Action (Parminter & Wilson, 2003)

1. **Behavioural Intention**: This is an individual behavioural approach towards a task. This representation of TRA shows the mentality of individuals or organisational approaches towards environmental sustainability in Africa. According to Fishbein & Ajzen (1975, p. 888) "A person's intention is in turn, a function of his attitude toward performing the behaviour and of his subjective norm".

2. **Attitudes**: This is the ability to practically adopt innovation over some time through the initial attitude shown to the invention. This attitude shown influences the choice of accepting or rejecting the innovation. According to Botha & Atkins (2005), attitude is the evaluation of an individual belief about the outcome of a particular behaviour.

3. **Subjective Norms**: Fishbein & Ajzen (1975) also describe subjective norms as the influence of people behavioural intention in a social environment. Thus, the opinion that

will influence a person's behavioural intention is people's belief, which is subjective to the importance of a person's attribute.

Relating three attributes that formed TRA; Ajzen & Fishbein (1975) states that the behavioural belief component is expected to be positively correlated with attitude, while the normative belief component is expected to be positively correlated with the subjective norm. Therefore, this theory is not suitable to determine the factors affecting the adoption of green data centres in Nigeria because TRA depends mainly on the respondent's personal beliefs and not the factors associated with green adoption in Nigeria.

2.9.2 Technology Acceptance Model (TAM)

In the adoption of a technology research study, TAM is one of the most used theories and one of the earliest traditional adoption theory in the Information Technology sector (Davis, 1989; Benbasat & Barki, 2007; Silva, 2007). There are four constructs in TAM, which are perceived usefulness, perceived ease of use, behavioural intention to use, and actual system use (Davis, 1989). Perceived usefulness and perceived ease of use reveal more attention to the predicting degree of adopting new technology. Davis (1989, p. 320) also established perceived usefulness as the "degree at which using a particular system would be beneficial or promote job performance."

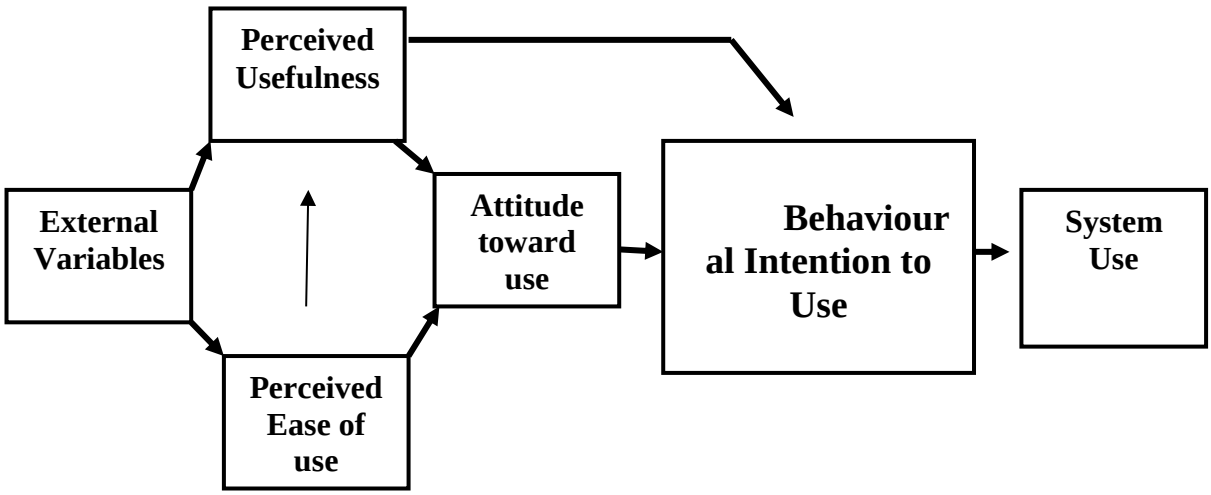

Figure 2-5: Perceived Usefulness, Perceived Ease of Use and User Acceptance of Information Technology (1989)

2.9.3 Unified Theory of Acceptance and Use of Technology (UTAUT)

The Unified Theory of Acceptance and Use of Technology (UTAUT) is a trial for merging the terminology of variables of different models and theories of Technology Acceptance (Ahmad, 2015). Therefore, UTAUT is unreliable due to complexity, imprecise approach, and its lack of ability to give pertinent details of individual behaviour (Casey & Wilson-Evered, 2012). On the other hand, UTAUT is assumed to be better than other theories because it identifies more than two-thirds of variance in the adoption behaviour (Venkatesh *et al.*, 2003). The variances, include gender, age, experience, the voluntariness of use, and they determine four constructs of UTAUT, namely; performance expectancy, effort expectancy, social influence, and facilitating conditions.

1. **Performance Expectancy**: This is the level at which an individual or group believe the use of a system will help to attain a better job performance (Venkatesh *et al.,* 2003) and this belief originates in five different derivatives that form other theories. The derivates are Perceived Usefulness, Relative Advantage, Job-Fit, and Extrinsic Motivation and Outcome Expectations (Davis et al., 1992; Moore & Benbasat, 1991; Thompson *et al*., 1991; Compeau *et al*., 1999).

2. **Effort Expectancy (EE**): This is the level of ease imparted with the use of the system (Venkatesh *et al.*, 2003). The three derivatives that form EE include ease of use, perceived ease of use, and complexity (Moore & Benbasat, 1991; Davis *et al*., 1992).

3. **Social Influence**: This is the level that an individual or group perceives the importance of others and the reason why a new system should be used (Venkatesh *et al.,* 2003). There are three derivatives developed from social influence, which are; subjective norm, image, and social factors (Davis *et al.,* 1992; Moore & Benbasat, 1991; Thompson *et al.,* 1991).

4. **Facilitating Conditions**: This is the level an individual or a group rely on the presence of an infrastructure that supports the use of a system (Venkatesh *et al*., 2003). There are three derivatives developed from facilitating condition, including perceived behavioural control, facilitating conditions and compatibility (Mathieson, 1991; Taylor & Todd, 1995; Thompson *et al.*, 1991; Moore & Benbasat, 1991).

Nonetheless, different authors highlight various theoretical models to verify UTAUT. Venkatesh *et al.* (2003) suggested UTAUT theory through a thorough assessment of these other theoretical Models (TRA – Theory of Reasoned Action, DOI – Diffusion of Innovation, TPB – Theory of Planned Behaviour, TAM – Technology Acceptance Model, etc.). Therefore, the complexity and indefinite approach of UTAUT is not appropriate for this study because this study aims to identify an individual and organisational perspective factors affecting the adoption of a green data centre in Nigeria.

2.9.4 Adoption and Diffusion Theory

The Theory of diffusion demonstrates how facts and ideas from various practices are being drawn together (Nutley *et al*., 2002; Rogers, 1995). Diffusion theory is not a single, all-inclusive theory; instead, it identifies various ideas for diffusion theory. By these identifications, the adoption of innovation through the recognition of the invention, exchange information procedure, is used to distribute innovative information quickly to a particular environment (Rogers, 1995).

Diffusion and adoption theory are both suppositions for an idea, practice, or object perceived as new (Rogers 1995). Even though diffusion and adoption theories are both interrelated, yet, they differ in their approach to innovation. According to Paul & Bas (2002), diffusion theory emphasises the extent an individual or group accepts innovation, and in most cases, it is characterised by a quantitative modelling approach. Bass (1969) also states that diffusion of innovation depends on two different effects. This innovation impacts how quickly a small group of innovators accepts an invention and the simulated effect that shows how quickly other categories of adopters copy the behaviour of the innovators.

Adoption theory focuses more on the decision an individual has towards the use of an innovation (Rogers, 1995). Therefore, understanding adoption is fundamental to the advancement of knowledge, which is derived from the diffusion of green innovation (Paul & Bas, 2002). Thus, adoption theory is suitable to explain the adoption of green innovation because of its emphasis on the use of innovation and the reduction of negative impact caused by innovation on the environment (Paul & Bas, 2002). Rogers (1995) stated five distinct methods that explain the adoption process of innovation, respectively. These methods include knowledge, persuasion, decision, implementation, and confirmation procedure. However, they

are narrowed down into three adoption processes, which are information, attitude, and behaviour and established the fact that they do not necessarily follow a specific order.

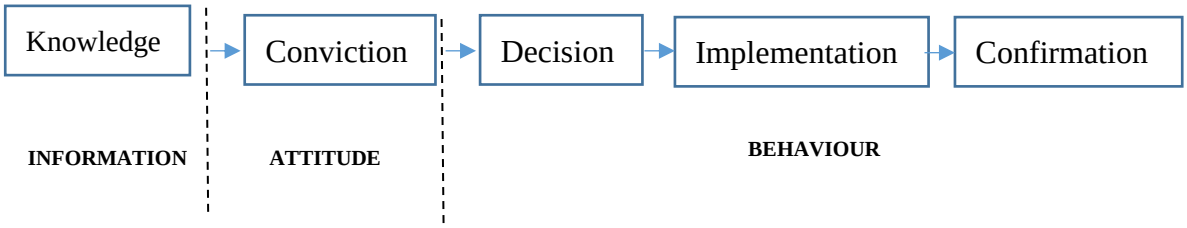

Figure 2-6: **Adoption Process (Gatignon, 1991)**

According to Figure 2-6, the three adoption processes mentioned by Gatignon are information, attitude, and behaviour. According to Gatignon (1991), information sources are significant in the process of adoption, but non-personal information is unimportant in its first stage. The reliability of this information source can enhance the transformation of a positive attitude towards the performance of green innovation (Osterhus, 1997). Therefore, the reliability of the information source is essential to green innovations (Driessen & Verhallen, 1997). Nevertheless, an adoption process does not guarantee the acceptance or rejection of an innovation. Hence, this study asks the question of "what factors affect the adoption of a green data centre in Nigeria". At the same time, it attains the understanding of an individual or organisational impact on green data centre technology adoption.

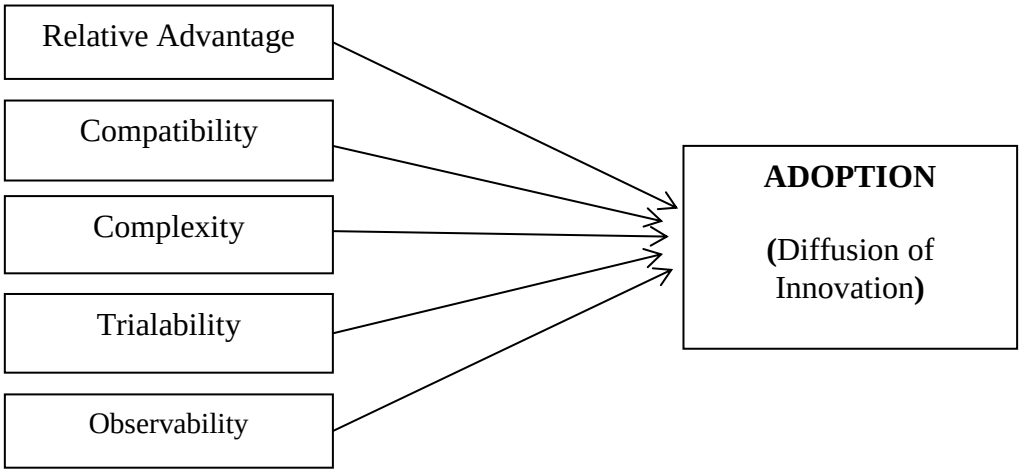

Figure 2-7: Diffusion of Innovation (Rogers 1983)

The main factors (*according to Figure 2.7*) within the DOI framework are:

1. **Relative Advantage:** When innovation is perceived to be better than the idea it replaces.
2. **Compatibility:** This is how reliable an innovation is with the current need.
3. **Complexity:** When innovation is complex; the invention is difficult to use.
4. **Trialability:** The level to which an innovation is tried before it can be guaranteed for adoption.
5. **Observability:** When an innovation can provide real results.

2.9.5 Technology, Organisation, and Environment (TOE)

Around 1990, Tornatzky & Fleischer (1990) proposed the TOE theoretical framework for the adoption of technology. Ever since the TOE framework has been used as a pattern to follow, when studying the adoption of Information Technology in various levels. For example, the identification of technological, organisational and environmental factors affecting the adoption of a green data centre technology in Nigeria. Thus, the TOE framework established a strong theoretical foundation to achieve an understanding of the factors that affect the adoption of a green data centre in Nigeria. According to Zhu *et al.* (2010), technological factors of TOE include information system features, such as functional capabilities and technical infrastructure within an organisation, Chau & Tam (1997), stated that the organisational factor of TOE reflects the characteristics of a firm. Characteristics, such as structure, size, readiness, and climate. Zhu *et al.* (2010) also stated that the environmental factor reflects external characteristics towards an organisation, which include competition, market forces, and regulatory forces.

There are several approaches to identify the factors influencing the adoption of existing information technology (Jeyaraj *et al*., 2006; Kurnia & Johnston, 2000). These factors include relative advantage, compatibility, organisational readiness, top management support, knowledge, subjective norm, government regulations, amongst others. They have been identified at a particular time to "determine the adopting decisions of an organisation" (Thiesse

et al., 2011). Therefore specific characteristics are sub-categorised into the TOE factors, which include relative advantage, compatibility, organisational readiness, top management support, training, education, internal pressure, and government regulations (Baker *et al*., 2012; Zhang & Dhaliwal, 2009).

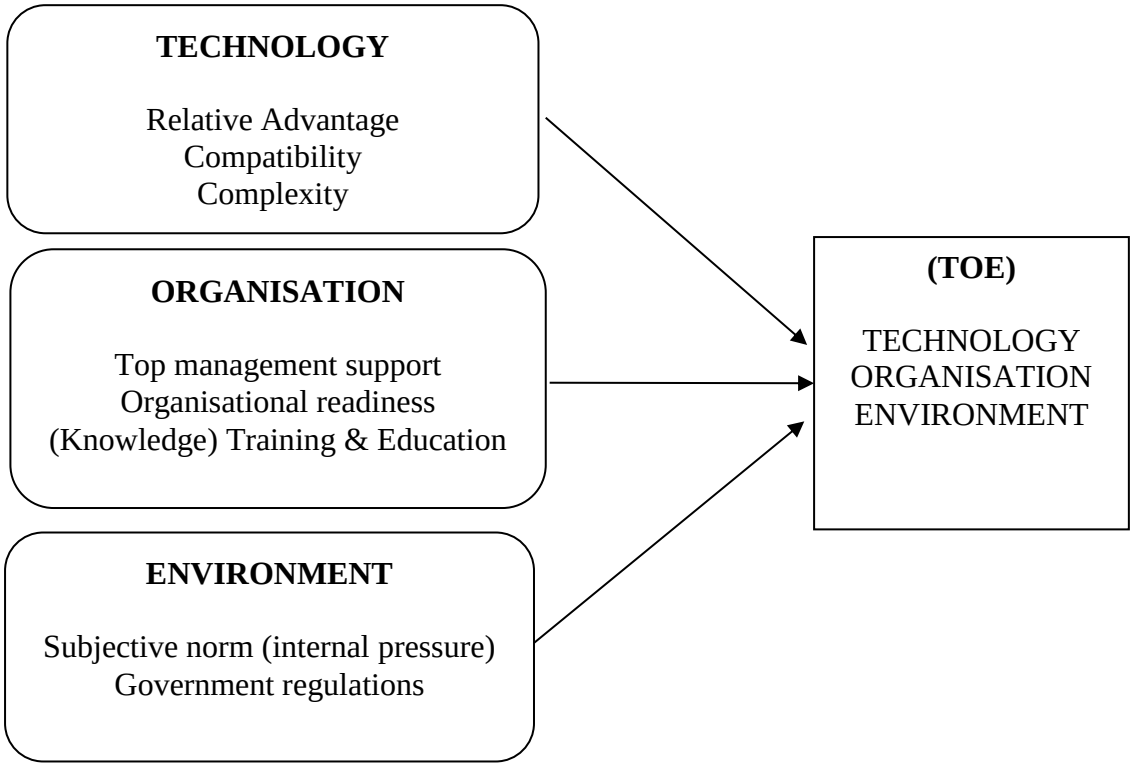

Figure 2-8 TOE framework, Tornatzky and Fleischer (1990)

Individuals and organisations must identify that the adoption of innovation will either solve existing problems or increase productivity (Zhu *et al*., 2003). Compatibility is the rate a technological innovation is perceived to be dependable with the current standard of operation, beliefs, values, previous experiences, and needs (Rogers, 2003). The more compatible an innovation is to the current need; the faster the diffusion rate (Nomsa, 2013). Therefore, compatibility is an essential determinant for IT adoption because organisations do not want difficulties during the implementation of IT (Lee & Kjm, 2007).

According to Tornatzky & Klein (1982), top management support is positively interrelated to the adoption of innovations in an organisation. Various research studies revealed that innovation adoption is easy, with support from an organisation's management because

information technology relates positively to organisational readiness (Ramadani & Kawalek, 2007; Mumtaz, 2017). Organisational readiness is the level an organisation acquires resources, knowledge, commitment, and governance to adopt new ideas (Hameed *et al*., 2012). According to Ramdani & Kawalek (2007), organisations with limited resources do not adopt new technology because they are not responsive to the readiness of adopting new technology. Therefore, organisational resource increase has a strong impact on the adoption of innovation (Ramadani & Kawalek, 2007) due to the knowledge acquired. The knowledge acquisition is a vital determinant in the adoption of innovations because the adequate knowledge of information system security and expertise of information system security within an organisation helps the adoption of information system security (Fichman & Kemerer, 1997; Mumtaz, 2017).

Subjective norm is the collective pressure put on employees of an organisation by top management or colleagues (Mumtaz, 2017). Therefore, the internal pressure within an organisation affects the decision of an employee on innovation. Likewise, many researchers identify the impact of government regulation on a nation's decision to either accept or reject new technology (Hameed *et al.*, 2012). Thus, support from government regulations and policies may positively influence technology adoption (Mumtaz, 2017).

2.9.5.1 Technological Factors

According to Thiesse *et al*. (2011), the technological factor identifies existing technologies and technical skills in an organisation. Therefore, it is essential to determine what new technology would achieve to make a difference. Although there are contentions that software diffuses faster than the hardware (Meade & Islam, 2006), yet, hardware facilities should not be underestimated, and existing technology must go through the adoption process by setting a broad limit on the scope and pace of technological change that an organisation can undertake (Collins *et al*., 1988).

The technology that causes a discontinuous change indicates that organisations must confirm the "competence-enhancing" to "competence-destroying" of a technology (Tushman & Anderson, 1986). Therefore, organisations that are entirely into technological innovations must be committed to making rapid and significant adoption that preserves and improves their competitive advantage. Thus, managing technology under a proper scientific and engineering practice begins with initiatives from a broad horizon. Technology management commences

with idea generation when an "idea transit into the wide end of a funnel and its screened along the funnel to identify, select, and economically exploit innovations, through scientific and engineering performance criteria" (Brent 2015, p. 5). For example, the introduction of virtualization technology promoted energy saving by setting up virtual machine templates on available server configuration, and this makes it faster than installing new operating systems on new servers (Bery & Lamers, 2009).

2.9.5.2 Organisational Factors

According to Jeff (2011), organisational factors refer to the characteristics and resources of an organisation. Organisations differ in the foundation of their internal resources and their way of doing things. As a result, their general performances are due to reaction from internal and external challenges (Hwang *et al*., 2010). Due to the number of slack resources from internal complexities of an organisation's managerial structure, the impact on technology adoption, scope, informal electronic linkage, and communication challenges is affected negatively (Low *et al*., 2011; Teo *et al*., 2009).

According to Jafri (2015), cost management is one of the organisation's primary ideas to adopt green technology, but Isaksson (2014) described the investment cost and uncertain profit margin as significant issues affecting organisations from adopting green technology. However, achieving cost reduction in the area of business operation, through environmental sustainability measures, has given the decision-makers of an organisation the continuity to embrace green-related standards (Ainin *et al*., 2015). These decision-makers or top management of an organisation have discovered unsuccessful green adoption due to their lack of support because the encouragement employees receive from top management positively influences the adoption of new technological innovations (Isaksson, 2014; Froehle *et al.*, 2000).

2.9.5.3 Environmental Factor

Sophonthummapharn (2009) describes the environmental context as the impact of external factors, which influence an organisation. These external factors are environmental protection law that enforces the elimination of factors affecting the environment (Ogbo *et al*., 2017). The environmental factor of the TOE is significant because it generates green information technology importance for creating a favourable and accommodating environment. Low *et al*.

(2011) states that competition and pressure from trading partners has a significant effect on the adoption of information technology.

This study adopted the TOE framework to present a clear model for this study. The TOE framework is an observable and reliable theoretical foundation, although some parameters specified within the three factors vary in some studies. Weng & Lin (2011) established that the TOE framework is utilized to analyse the factors influencing the adoption of green practices by small and medium-sized companies. Oliveira & Martins (2010) describe the technology factors of TOE on the relevance of new technologies to an organisation. Therefore, the TOE framework is valid for the adoption of different IT innovative technologies (Ramadani & Kawalek, 2007). Nevertheless, the TOE framework is more suitable than other theoretical frameworks, meant to identify technological, organizational, and environmental factors (Wen & Chen, 2010). TOE framework is also more practical in supporting information systems technology than other theoretical frameworks like UTAUT or TAM (Zheng *et al*., 2011; Henriksen, 2006; Hong *et al*., 2006; Zhu *et al.*,2003; Kuan & Chau, 2001).

2.10 Summary

This chapter presents a general overview of the literature that covers the history of a data centre, data centre infrastructure, green information technology and green data centre. It further identifies the adoption factors of a green data centre, the current status quo of adoption of a green data centre, and ways a green data centre can be achieved. This chapter also revealed the importance of a data centre to a growing business economy and the threats facing the operation and expansion of the data centre in the environment. The chapter also highlights the effects of greening a data centre on the ecosystem. It also extends to reviewing renewable energy, which contributes to green environmental benefits. Different types of theoretical models were discussed, and TOE was selected as the theoretical framework in the study.

The next chapter presents the research methods, design and data analysis used to achieve the objectives of this study.

CHAPTER THREE: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

This chapter identified the research methodology employed to achieve the objectives of this study. This chapter also states the appropriate research design for this study, which includes the data collection methods, sampling techniques, and the other suitable techniques used for the analysis of collected data.

3.2 Research Design

The main reason for this research is to understand the factors affecting the adoption of green data centres in Nigeria. Therefore, this research articulates the initial belief of acquiring data and analyzing collected data. According to Creswell (2009), research design refers to the plans and procedures that cover the entire decisions from high-level assumptions to the methods used for gathering and analysing data. Research design is a method of obtaining data from respondents in a well-structured manner, whereby a researcher understands the research problem, with less ambiguity (Wyk, 2012). There are different types of research designs, which are descriptive and explanatory. These research designs also explain two fundamental types of research questions.

The descriptive research design answers what, where, and when about an observable fact. According to Polit & Beck (2004), a descriptive research design allows easy collection of participant's opinions based on their general involvement with the research under study. In contrast, explanatory research only explains the relationship between "why", "how" and "when" variables of the investigation. Descriptive research is more focused than the explanatory research because the descriptive research focused on the "what" variables (Borg & Gall, 1989) of the factors affecting the adoption of green data centres in Nigeria. Meanwhile, explanatory research focus on 'why, how and when" of research. An explanatory research design will distract a researcher from the main research question of "what" factors affect the adoption of a green data centre in Nigeria.

However, descriptive research can accommodate the why, how, and when of the explanatory research, all together, because a research result obtained from a descriptive study of two or more different individuals concerning the level of their awareness of green data centres could be subjective. The descriptive research design is used to gain in-depth detail on factors affecting

the adoption of green data centres in Nigeria. This research design will highlight the specific factors influencing the adoption of greening in data centres across Nigeria, and also identify the crucial reason for data centres adoption in Africa. Besides, the analysed information will also be useful to future researchers that are trying to comprehend the rate at which green data centre adoption is increasing in other developing countries.

3.3 Study Site

Ritchie (2013) describes a study site as the physical location where a research study is conducted. Interviews were performed with staff from companies situated in Lagos, mainly large organisations such as banks, which support a large population of mobile banking customers in Africa (Odumern, 2013). This immense demand for mobile banking has enhanced the expansion of information technology in Nigeria (Oluwagbemi *et al*., 2011).

In Nigeria, Internet users increased from two hundred thousand in the year 2000 to above ninety-eight million users in the year 2017 (Miniwatts Marketing Group, 2018). This expansion comes with innovations that might cause havoc to the environment if appropriate eco-sustainability measures are not enforced. For example, the cooling systems of a data centre accounts for 30% to 40% of the total energy consumption of a data centre. Singapore generally has cold weather throughout the year (Singapore, 2014), as compared to Nigeria which has a hotter temperature for more than six months in a year and requires more cooling systems compared to most countries with cold weather. Unfortunately, low outage from electric grids cause organisations to depend on diesel generators, and the gases emitted from these generators pollutes the environment.

3.4 Research Approach

A qualitative research method was adopted in this study. According to MacDonald & Headlam (2008), qualitative research methodology provides a rich and reliable outcome through the presentation of ideas, insights and concepts to simplify the facts under study. The appropriate standard of qualitative research is the understanding of compounded relationships rather than the clarifications of a single relationship. Open-ended inquiry style is utilized, as the qualitative data result is continually subjective, affluent, and comprises of profound data that is usually accessible in a detailed word format (Flick *et al*., 2004).

This research identified a specific set of people that are into data centre management. Therefore, an in-depth interview was carried out using a qualitative based interview schedule. In a qualitative research methodology, the investigator listens and also records a respondent's contribution (Creswell, 2012). During a research study, both qualitative and quantitative research approaches provide valuable data for the designing of important information. However, this study adopted a qualitative research approach during the interview because it enable the researcher to be flexible with the research questions. In contrast, the quantitative research approach requires a fixed research questionnaire for statistical comparison regardless of the respondent's profound and detailed responses (Madrigal & Bryan, 2012).

3.5 Research Population

Burns & Grove (1997) explains the target population to be an entire aggregation of units, individuals, or people in a specific area or space with great interest to an investigator due to particular criteria they possess. The targeted population were organisations in Nigeria that operate and manage data centres. They were contacted by email and a letter of informed consent were forwarded to them which indicated the purpose of this research study (Appendix A). Over the years, transformation in the area of information technology took place in every sector of the Nigerian economy. Given that, data centres in Nigeria play an essential role as a backbone to most sectors in Nigeria (Awoyemi & Awoyemi, 2017). Therefore, the target population were individuals who work and make decisions on the operation and management of their respective data centres.

3.6 Sampling

Webster (1983) states that sampling is a subset of the target population with characteristics that gain a general view of the target population. Sekaran & Bougie (2016) also defines sampling as the process of selecting an adequate number of specific elements from the population. The two types of sampling techniques are probability and non-probability. Probability sampling involves the random selection of participants mostly used in quantitative research, whereas non-probability sampling involves a non-random selection of participants and is mostly used in qualitative research studies (Abedsaeidi & Amiraliakbari, 2015). Therefore, in this study, a non-probability sampling technique was used.

3.6.1 Sampling Techniques

The standard non-probability method is purposive sampling, snowball sampling, and convenience sampling. The selected sampling method utilized in this study was purposive sampling technique. Purposive sampling is a sampling technique that relies on a research participant's specific characteristics. Since this study focused on investigating the factors affecting the adoption of green data centres in Nigeria, it was paramount that the participants are knowledgeable with data centres and green data centres within an organisation.

3.6.2 Sampling Frame and Size

A qualitative research analysis does not require a larger sample size, unlike the quantitative research design. Morse (1999), suggested thirty to fifty participants while Creswell (1994) suggested twenty-five or fewer participants, and this shows that there is no precise imperative numerical value suggestive of standard acceptable sample size in qualitative research. A sample size of six participants is sufficient to enable the development of meaningful themes and useful interpretations, for studies with a high level of homogeneity amongst the population (Greg *et al*., 2016). This study targeted twenty participants that have knowledge and experience of data centres in their organisations. A letter of informed consent (Appendix A) was sent requesting their assistance for an interview.

3.7 Data Analysis

In this study, a qualitative research approach was used to derive meaning from people's attitudes, perceptions and experiences. According to Woods (2011), interviews are usually conducted on a one on one basis and they are generally used to support or extend an investigator's knowledge on thoughts, attitudes, and meanings of phenomena from people. These interviews can either be structured, semi-structured or unstructured interviews (MacDonald & Headlam 2008). A semi-structured interview guide was chosen as the data collection tool. It allows the interviewer to ask further open-ended questions for rich data collection. For the interviews to achieve the objectives of this study, the researcher followed Kvale (1996) seven stages for conducting in-depth interviews. These stages are:

1. ***Thematizing,*** which is the principal formulation of the investigation that explain the "How, Why, and What" of the research elements.

2. ***Designing*** is simply the creation of a plan for the research study.

3. ***Interviewing*** is given an understanding approach to the observable fact in outlines being researched.

4. ***Transcribing*** is the process of preparing the interviewed data collected for analysis by transcribing the data.

5. ***Analysing*** involves a critical analysis of the data.

6. ***Verifying*** establishes the validity and reliability of the results attained from the interview.

7. ***Reporting*** discloses the data and outcomes of the research study by publishing the result.

Harrell & Bradley (2009), state that when a researcher adopts a semi-structured interview guide (Appendix D); this allows researchers to go deeper into the research area for better understanding, and it also allows the researcher to adjust the questions based on the respondent's reply. An audio recorder was used to capture data from the participants during the interview. However, each participant was given the interview questions to help them familiarise with the questions before the interview was performed. This procedure is important because respondents have to relay their thoughts without leaving out important information during the interview. Then, the audio file from the interview was transferred into the computer, for manual transcription into readable format before data analysis.

3.8 Ethical Considerations

The Ethical Committee of the University of KwaZulu-Natal (UKZN) approved the interview questions before data was collected from organisations. The researcher was granted approval to conduct this study by the UKZN (Appendix B) research office. Ethical approval preserves the rights and integrity of the human respondents involved in the research study (Gilbert, 2008). Researcher and respondent signed and agreed to the copy of the letter of informed consent (Appendix A). This agreement prepares the respondents on the time frame for the interview and explains the study in question.

3.9 Interview

According to Wallen & Fraenkel (2013), an interview is a method of oral questioning. The data collection method involved the recording of data with the use of an electronic voice recorder, verbatim transcription was utilized, and the data was analysed using NVivo software.

1. **RECORDING OF DATA**: This was achieved by means of audio recording with an electronic voice recorder. A backup tape was also kept as technical glitches may occur with electronically stored data on a device. It is critical to ensure recordings are audible and clear. This clarity is important to facilitate the ease of comprehending the data and appropriate transcription.

2. **VERBATIM TRANSCRIPTION**: This is done after recording is finished and mostly performed by an expert in a situation whereby the recordings are not clear or due to different language barriers. The recording was listened to over and over again to enable proper interpretation. In the case of this study, the recordings were transcribed by the researcher manually, and NVivo software was used to analyse the transcribed data.

3.10 Thematic Analysis

The research design used in this study was descriptive because of the question of "what" factors affect the adoption of a green data centre in Nigeria. For this purpose, a thematic analysis was suitable for organizing and analysing the information gathered. Thematic analysis is the most utilized qualitative method to analyse qualitative interviews (Jugder, 2016). This type of analysis is also preferred because the research study involved the coding of transcribed data to form themes and sub-themes (i.e. nodes). Wong (2008) describes nodes as being equivalent to the sticky notes that researchers fixed on a document for a specific passage that belong to a topic.

Before the induction of thematic analysis, copies of interview transcripts are made. All the descriptions that apply to the topic and research questions are highlighted to form various nodes. By doing this, the entire highlighted portion is coded, and this preserves the relevant information in tune with the research study. These highlighted codes are put out into different nodes or sets according to their similarities. Each node is named with headings that explain the

highlighted codes. After which, a thorough read-through was performed to know if the nodes were selected appropriately. A further presentation of main themes and sub-themes were interpreted with the use of the six steps mentioned below (Braun & Clarke, 2006):

1. ***Familiarizing*** yourself with your data by reading through the whole data.

2. ***Generate Initial codes*** is the first stage of highlighting codes manually with the use of a coloured pen or NVivo software. At this stage, the researcher can highlight lots of codes for sets of themes.

3. ***Searching for themes*** by sorting out possible themes and sub-themes. This can be sorted using visuals like mind-map.

4. ***Reviewing themes*** is the stage of breaking down themes or refining themes into one another.

5. ***Defining and naming themes*** is the stage whereby themes are well narrated and given a definite name or title.

6. ***Producing a report*** is the stage where the researcher finally analyses the results drawn from the data and uses the themes to provide enough evidence to support the research objective.

3.11 Ensuring Reliability and Validity

Reliability and validity are two aspects of research regarding the design, analysed results, and quality evaluation of the study (Patton, 2002). According to Brink (1993, p. 35), reliability and validity are a "significant piece in a research study, and they distinguish between good or poor research" (Altheide & Johnson, 1998).

According to Morse (1999), in some instances, the importance of reliability and validity in qualitative methods is rejected because qualitative methods unintentionally support the default notion, which is unreliable, invalid, lacking in rigour, and unscientific. Therefore, various researchers use different terms to identify validity and reliability in a qualitative research study. These terms include quality, rigour, trustworthiness, validity and dependability. Due to specific

measures for evaluating the scientific merit of qualitative research, many researchers use terms such as credibility, truth, trustworthiness, value, applicability, conformability, and consistency instead of Validity and Reliability (Leininger, 1991; Lincoln & Guba, 1986; Glaser & Strauss, 1967). In qualitative research, several research studies use terms such as quality, rigour or trustworthiness, as a replacement for validity, while dependability is used instead of reliability (Davies & Dodd, 2002; Stenbacka, 2001; Seale, 1999). However, a quality case from trustworthiness can be improved, and validated through fairness, knowledge sharing and social actions (Lincoln & Guba, 1986; Creswell, 1997).

3.11.1 Triangulation

According to Shenton (2004), triangulation is established when the researcher cross-references the same data through various data sources. Therefore, results from each respondent were cross-referenced against each other to obtain validity because all the respondents are from different organisations that operate data centres in Nigeria.

3.11.2 Credibility (Internal Validity)

Credibility is ensured when research findings are a true reflection or representation of reality (Brink, 1993). Credibility was included in this research study by targeting organisations in Nigeria, where IT is developing. These organisations were selected because they own a data centre and also operate these data centres in Nigeria. As such, a research study is credible when the research population is significant to an expected research result (Wahyuni, 2012).

3.11.3 Transferability (External Validity)

The transferability of a qualitative research design indicates the extent to which the conclusion of a study is generalised to similar studies (De Vaus & de, 2001). Transferability is also a representation or reflection of reality when it is legitimately applicable across a group or unit of individuals (Brink, 1993). The researcher provided information on the type of organisation that the respondents were employed in and their years of experience.

3.11.4 Dependability (Reliability)

According to Seltiz *et al.* (1976, p. 182) “reliability is concerned with the consistency, stability, and repeatability of the informant’s accounts as well as the investigators’ ability to gather and

record information correctly". This consistent and stable outcome is accurately yielded to evaluate the quality of a qualitative research study (Rubin & Babbie, 2016; Stenbacka, 2001). The respondents were selected based on their similar experiences in data centre operation.

3.11.5 Confirmability (Objectivity)

Due to confirmability, other researchers or individuals can confirm the authenticity of the research results. However, the progress of a research record is kept as an audit trail for examination (Wahyuni, 2012). According to Wahyuni (2012), the results of a research study is the true reflection of the respondent and not the researcher. Therefore, all the information recorded during the research study is submitted to the School of Management, IT, and Governance, which will then be securely archived for five years and disposed of accordingly.

3.12 Summary

This chapter lays out the research design, research population, study site, research method used, sampling technique, data collection, the reliability and validity (*triangulation, credibility, transferability, dependability and confirmability*) of the data analysed. The interview was prepared to get an in-depth understanding of the research question and to establish factors affecting the adoption of a green data centre in Nigeria. The next chapter would proceed to the research data presentation and discussion of findings.

CHAPTER FOUR: DATA PRESENTATION AND DISCUSSION OF FINDINGS

4.1 Introduction

The previous chapter provided details of the research methodology that was applied in this research study, it also unpacked the factors affecting the adoption of green data centres in Nigeria. Respondents selected were from different organisations in Nigeria, who have ample knowledge of data centres and or green technology. The respondents to this study were in positions that influence decisions that affect changes in their respective data centre. This chapter presents the findings and discussion of factors affecting the adoption of green data centres in Nigeria.

4.2 Demographic Analysis

Seven participants from seven different organisations in Nigeria responded to the researcher's email for an interview that initially targeted twenty respondents. All respondents were individuals who influence the operation of Information Technology services in their organisation. The table below (Table 4-1) presents the profile of each participant, including the extent of their experience, job position and department. Some respondents were top management staff, while others influenced the decisions made towards the operations of their data centres in one way or another. The organisations of respondents 1 and 2 were adopters of green data centres. This information gathered during the interview process identified respondent one (1), respondent two (2) as being aware of green data centres, and they reported green data centre practice in their organisation.

Table 4-1 Biographic Analysis

RESPONDENTS	JOB POSITION	DEPARTMENT	LENGTH OF WORK EXPERIENCE (years)
Respondent 1	Team Lead (Data Centre)	Computer & Telecommunication Servicing Company	10
Respondent 2	Head of project management & Senior IT consultant	Project Management	5
Respondent 3	Team Lead (IT/Network Administration)	Lotto company	9
Respondent 4	Head of Department (Human Resources & Window Server Support)	Computer servicing Company	6
Respondent 5	Supervisor (All services; including the IT department)	Information technology company	7

Respondent 6	Assistant facility manager (Mechanical & electrical department)	Information technology service	15
Respondent 7	IT consultant	Information technology service	6

The rest of this chapter presents the results of the thematic analysis. Figure 4.1 illustrates the structure of how the thematic analysis is presented and discussed the research objectives below:

1. To identify the level of adoption of green data centres in Nigeria.

2. To identify technological factors affecting the adoption of green data centres in Nigeria.

3. To identify the organisational factors affecting the adoption of green data centres in Nigeria.

4. To identify the environmental factors affecting the adoption of green data centres in Nigeria.

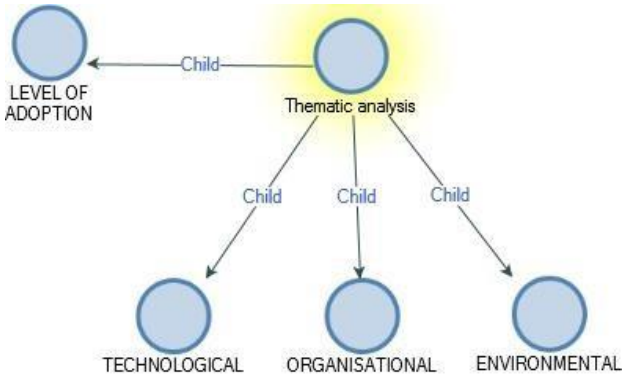

Figure 4-1: Thematic Analysis of factors affecting green data centres in Nigeria

4.3 LEVEL OF ADOPTION

According to (Bhardwaj & Neelam, 2015) who stated that we are all responsible for the survival of this world because the most significant benefit to everyone is enhancing the quality of life through an eco-friendly environment. Unfortunately, developing countries continue to encounter technological, organisational, and environmental issues that prevent them from migrating into green innovations. Fay (2012) suggested that green growth is of great importance in a developing country and to increase public awareness of environmental issues (Shahrul *et al.*, 2013). Therefore, it is necessary for individuals and organisations from developing countries such as Nigeria to identify factors affecting the adoption of green technology before embarking on the green adoption process. Respondents were interviewed to determine specific issues affecting their organisations from adopting green technology issues such as an inconsistent supply of electricity and lack of awareness are two sub-themes that emerged during the interviews.

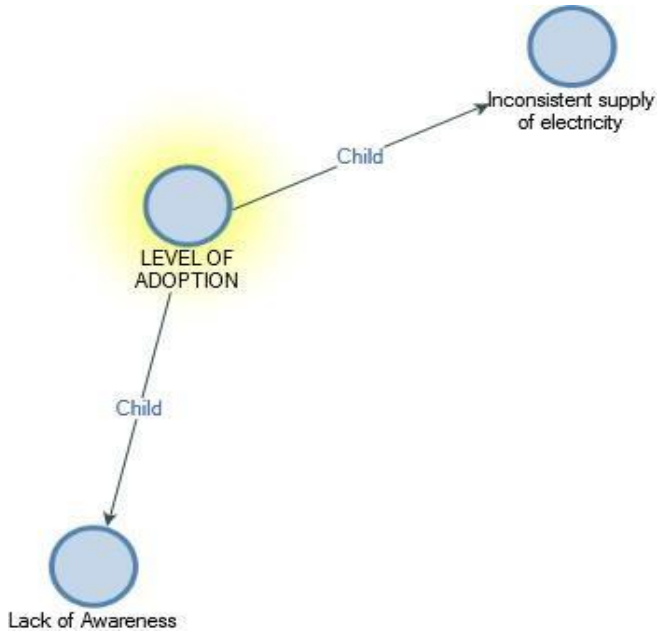

Figure 4-2: LEVEL OF ADOPTION

4.3.1 Lack of awareness

Slattery & Rapp (2003) describe environmental consciousness as a fundamental goal, and this is significant in the adoption of a green data centre. It is essential to identify each respondent's

familiarity to achieve the primary objective, with green technology. According to ASSAf (2014), it is paramount that an adopter of the targeted technology is aware that the technology exists, and acknowledge that the technology may have a positive impact. As indicated by the verbatim extracted below respondent (1), respondent (2) and respondent seven (7) stated their level of green awareness, respectively:

"We do have various platforms that promote green technology here in our company."

"We follow various guidelines that support the reduction of harmful gas emission."

"I am aware of what green technology is all about."

However, Respondent three (3) and respondent five (5) established their insufficient knowledge of green technology, respectively:

"I have an idea of what green technology stands for in the recent world, but we sincerely do not have such awareness in our company as a whole."

"I do but little knowledge about green technology even though I have heard of the green world."

Environmental awareness is understanding the relationship between an individual or organisation and the environmental issues (Yannis & Michael, 2013). However, respondent four (4) and respondent six (6) indicated that they do not have any knowledge of green technology. Therefore, organisations must encourage their innovators to embrace green technology solutions in the area of their research, development and commercialization (Lohse, 2014). Thus, adopting green innovation is enabling innovations to be productive and eco-friendly.

Nevertheless, there is an assumption that people will adopt an innovation if they assume their productivity or service will increase (Rogers, 1995). Respondent one (1) elaborated on the adoption of the green data centre by his organisation because the exposure and awareness of innovations prompted his organisation to adopt a green data centre. Karanasios *et al.* (2010) states that an organisation that has an awareness of the environmental concerns relating to energy development would adopt practices to green their data centres. Respondent one (1) reported the following:

"it all started with the news and information received from other sources of data centres in developed countries. So the idea of greening came to our mind. Exposure to innovations also tends to support green data centres. Things like virtualization and use of solar powers in terms of generation of electrical power. Reducing energy cost became a big part of cost-cutting, and we had to start with that by introducing solar panels for electrical purposes and use introduced virtualization which helps a lot in the greening of a data centre. Nevertheless, green awareness became a blueprint in the policies made in our company."

The above report from respondent one (1) indicates that environmental awareness is directly linked to a change in perception (Yannis & Michael, 2013). Thus, when an individual or groups of people become aware of how important it is to protect the environment, at that moment, there is the hope of having new technological innovations. Some of the respondents reported why the use of green adoption could be used as a guide for new technological innovations. Respondent two (2) reported the following:

"Expansion is pushing us to increase our client servers and green data centre technology seems to have what it takes to accommodate pressure from an increase in the number of servers."

Various studies have shown a lack of awareness to be a significant factor affecting the organisational level of adoption of green data centres (Burns & Grove, 1997). According to (Chatterjee, 2002), this low level of awareness in developing countries has been a significant problem affecting green adoption in a considerable area of technological advancements, as a data centre. Respondent six (6) and respondent seven (7) also reported the following, respectively:

"major obstacle will be our lack of green technology awareness."

"The main factor is the lack of awareness of green data centre technology in Nigeria."

4.3.2 Inconsistent supply of electricity

The expansion of industrialization has caused a tremendous increase in the emission of harmful gases to the environment due to increased power utilization. A large number of technological tools such as physical servers, air conditioners, routers, storage area network are found in data centres across the world and industries that operate and manage the use of these technologies.

Therefore, they must play a significant role in adopting green technology (Kuehr & Williams, 2003).

According to respondent five (5), powering an eco-friendly data centre must be considered important to be called a green data centre. So respondent five (5) said:

"*Electrical power source will need to take a lot of adjustments if we want to adopt a green data centre."*

Recent servers are built to be process data faster and consume lesser electrical power. These servers are built to meet and surpass its purpose while it promotes eco-sustainability. The cost of setting up these energy tools can be voluminous (Akuru & Okoro, 2014). Respondent four (4) and respondent six (6) reported respectively:

"We mostly discuss the expenses of managing the power generators, which has been a major challenge in the aspect of our finance."

"Our diesel generator consumes a lot of money to operate."

Olise *et al.* (2014) found that finance plays a crucial role in the adoption of information technology. Respondent three (3) and respondent two (2) stressed the issue faced by a lack of finance in the adoption of green data centre technology.

According to (Tejaswi & Vignesh, 2019), financial limitations to adopting green innovations are influenced by indecision and high risks. Respondent one (1) stated:

"finance team were reluctant because they were not certain about the long term profit that would be made from the greening of our data centre."

A study by Rehfield in 2007 established that eco-sustainable services can be too costly than other services (Rehfeld *et al*., 2007). For instance, respondent two (2) and respondent one (1) stressed on the issue of finance during green adoption:

"When we started to embrace the green environment in our company, we faced lots of financial challenges."

"It is costly to have, and solar panels and other renewable power plants."

But in the long-run, the cost of operation is reduced. Respondent two (2) reported as following:

"We realised how much we could save from the use of alternative electrical power generation that differs from the usual one, which is the use of a diesel generator."

However, the benefit of greening a data centre is not limited to the cost reduction in power energy generation but also have other benefits that encourage an organisation to continue in green data centre operations. Respondent one (1) elaborated how the adoption of green technology has positively influenced the data centre of his organisation by identifying different benefits through:

"generating of eco-friendly electricity that promotes a conducive environment whereby we have less noise and reduced smokes from power plants.

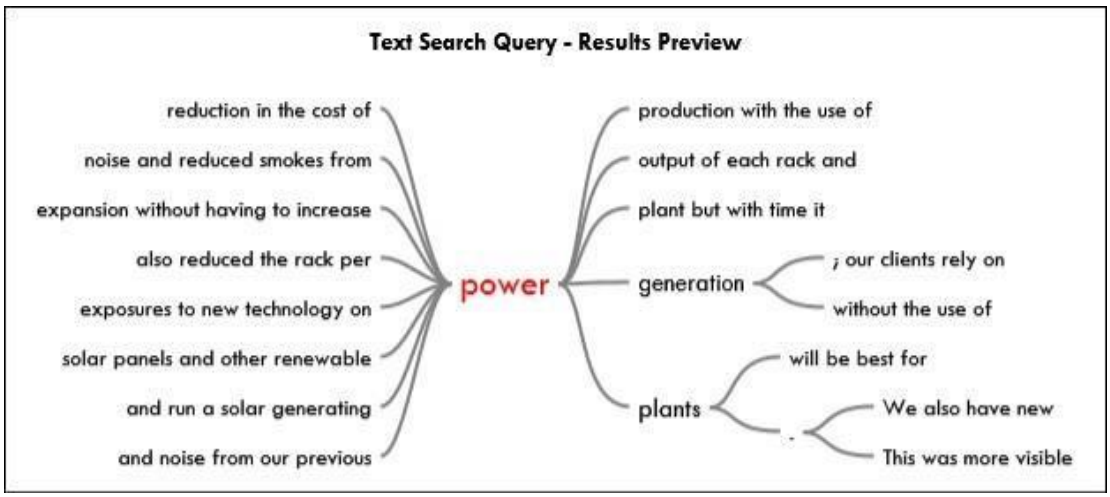

Figure 4-3: Text Query – The effect of Power on green data centre operation

The text search query derived Figure 4-3 shows that the main positive effect gotten from operating a green data centre is mainly on power usage. The entire respondent identified few benefits around power generation through the reduction in the cost of power, change in power-generating sources that are less noisy and emit less smoke. Pawlish *et al.* (2010) states that every data centre depends on a powerful energy source and that energy saving can be calculated based on energy-saving when choosing servers.

A word cloud (Figure 4-4) shows that lack of awareness and the challenges of power (electrical power) supply are the most emphasized and common factors reported by a majority of the respondents (5 out of 7) and they expressed attributes to ***negatively influencing*** the organisation from adopting green data centres. In conclusion, respondents' responses on the factors affecting the adoption of green data centres in Nigeria were impacted by **lack of awareness** and the issues of unreliable power supply in Nigeria. The Nigerian power per capita in has been ranked one of the lowest in Africa (Adebobun-Toplonu & Ogunleye, 2004). Erratic electrical power supply pushes data centres to use diesel power generators that emit harmful gases into the atmosphere as reported that developing countries release more gas emission by a 60% average increase (Shahrul *et al.,* 2013) than developed countries.

Figure 4-4: Word Cloud – Level of adoption

4.4 TECHNOLOGICAL FACTOR

According to Thong (1999), technological factors have a significant influence on the implementation of information systems. Therefore, it is essential to study the relationship and gap between public challenges and technical involvement in how we look at technology influence (Brent, 2015). These brought up more questions that are specifically on the technological factors preventing organisations in Nigeria from adopting green data centres. The cost of technologies and technical difficulties were two subthemes identified within this factor.

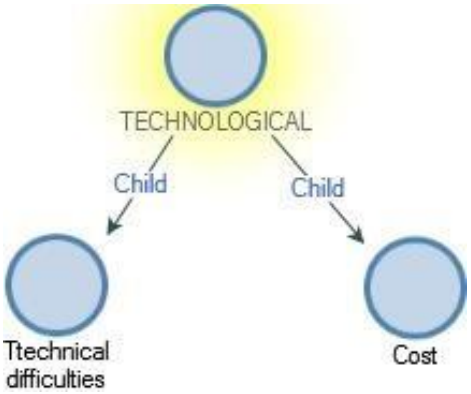

Figure 4-5: TECHNOLOGICAL FACTORS

4.4.1 Technical difficulties

According to Jain, *et al.* (2011), the difficulty of innovation and the practice involved in its implementation, negatively influence its adoption. Respondent seven (7) stated that:

"Yes, there are technological obstacles preventing my current organisation from adopting a green data centre. Majorly is a lack of technical expertise."

Respondent five (5) also said that:

"*our technical difficult will rely on our technical know-how associated with green data centre operation."*

Respondent 1 stated that technical difficulties were a significant factor when his organisation initially tried to adopt green technology and how the innovation was caused by their lack of understanding. Respondent one (1), reported the following:

"I will start by saying the challenges in terms of technicality was the aspect of our lack of exposure to technological tools that make up developing a green data centre. The good use of the solar system was new to our electricians, and they had to expand their knowledge on how to manage and run a solar generating power plant, but with time it got better. Aside from that aspect of technical difficulties, we had no difficulty from other areas of operation in our company."

However, to adjust this type of technicality, Respondent three (3) attest that training of staff on green data centres should be considered essential, before embarking on any other concepts that

promote the adoption of a green data centre. Another respondent indicated that organisations lack of understanding of green data centres is a major barrier that would stop them from adopting green data centre technology. Respondent three (3) stated:

"I believe our low understanding of operating a data centre in a green environment is key. So lack of technical training would be a major barrier."

In addition, respondent seven (7) also reported:

"The lack of technical know-how of facilities that promote green technology."

Hence, for data centres to grow in line with eco-sustainability; it requires a proper understanding of the technology in question because a lack of knowledge affects the ability to understand the technical tools that are needed to make a data centre's technology green. More emphasis was based on the lack of training due to technical difficulty. Respondent three (3) and respondent four (4) both stated similar terms that prove "lack of understanding" of technical tools that promote green data centre operation as the main barrier stopping them from adopting green data centre technology.

Respondent three (3) and respondent four (4) also highlighted training of staff on how to use tools that promotes green data centres to be a vital way of preventing technical difficulties that data centres face during the adoption of greening. Respondent 3 reported:

"*Understanding the technical tools that promote green data centre needs to be made known to the staff that support our data centre, then we can stop the other technical difficulties facing our adoption of a green data centre."*

In addition, respondent four (4) highlights the lack of training as a major factor that will stop the organisation from adopting a green data centre. The respondent reported:

"lack of training on the use of technological tools that support green data centre technology."

Technical training also remains the popular means by which a trained workforce is produced for economic and industrial growth for both developed and developing countries (Isah *et al.*, 2013). Based on the emphases laid by respondents on technical difficulties, lack of training proves to be a primary factor that needs to be solved before embarking on green data centre operation. Respondent two (2) and respondent three (3) reported respectively:

"We had to train most of our staff in a short time because most of the new computer servers came with upgraded applications."

"*need to be trained on the new technology that supports green data centres. If not, it will be our primary difficulty if we want to go into a green data centre."*

4.4.2 Cost

This technology perception is influenced by technological factors affecting the adoption of green data centre technology, and it is described as the rate at which an innovation is perceived to be better (Rogers, 2003). Therefore, the rate in the use of new technology is perceived to be better in enhancing productivity than the formerly utilized technology is referred to as relative advantage (Youwei *et al*., 2008). However, the cost of these technologies can be a significant barrier to adoption. For instance, respondent one (1) stated:

"We then had two options of either to buy more technological tools for expansion and meet the increase in the demand for our services, or we spend more on start greening our data centre."

Likewise, respondent seven (7) and respondent three (3) reported the following, respectively:

"Change is inevitable for an organisation but in a case whereby the change will be to bring in new things that gulp lots of money for an exchange of old things that don't look less important. That means top management body must be convinced that the green data centre will benefit the organisation and bring more profit in the long run."

"It seems to be expensive to even try to move into. Although I have read the importance of greening a data centre, our company doesn't seem to buy the idea since our present data centre serves us well."

4.5 ORGANISATIONAL FACTOR

Lack of strategic planning and lack of management support were the two subthemes identified as essential factors affecting green data centre adoption (Figure 4.6).

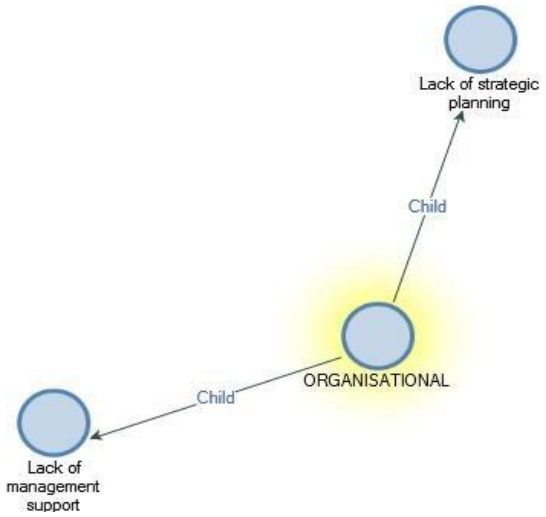

Figure 4-6: ORGANISATIONAL FACTORS

4.5.1 Lack of a strategic plan

For any large organisation to move to green technologies, it needs to be embedded in a strategic plan so all departments and employees on the organisation can go on the path of greening. Three respondents in this study indicated a lack of a strategic plan by their organisation towards environmental sustainability. Respondent four (4) stated that:

"*No strategic plan for environmental sustainability."*

Likewise, respondent six (6) reported:

"We do not have any plan coming from our company for environmental sustainability."

Unlike respondent four (4) and respondent six (6). Respondent one (1) reported on the following:

"Eco-sustainability has become a non-negotiable tool in our services, driven by a plan to promote greening."

4.5.2 Lack of management support

According to Venkatesh *et al.* (2003), organisational innovativeness is an organisation's orientation toward innovation. In most instances, this innovativeness is driven by key decision-makers or top management support. This study found that there is a lack of management support with respondent seven (7) and respondent four (4) stating the following, respectively:

"decision-makers can take a longer time to embrace the idea of green technology, or they can even shove it down if they are not convincing enough."

"decision-makers are a lot slower to ideas that involve discarding our company tools and purchasing a new thing."

Respondents four (4) and respondent seven (7) further explained that a lot of effort goes into trying to convince top management to pursue green computing. Respondent seven (7) stated that:

"financing projects associated with green data will be difficult because it will take a lot of effort to convince the top management body."

Likewise, respondent four (4) also reported the following that:

"We suggested few things like using solar powers as backups, but the cost of putting one in place has made us reluctant to execute the decision because top management staff must all agree before such an important discussion is executed."

Therefore, all the departments of an organisation must strategize towards achieving goals through the allocation of essential resources, operational and tactical planning (Ogbo *et al.*, 2016) whereby all the departments of an organisation supports the idea of greening. (Lacovou *et al*., 1995) make clear that inter-organisational systems influence technology adoption.

4.6 ENVIRONMENTAL FACTOR

Inadequate governmental policies (Figure 4.7) were identified as a key environmental factor affecting green data centre adoption.

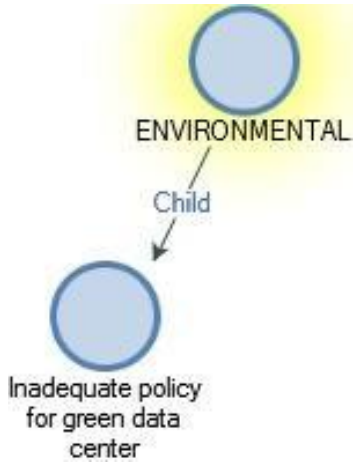

Figure 4-7: ENVIRONMENTAL FACTORS

The data centres examined are located in Nigeria, where the main power supply is controlled by the government, and it is inadequate to meet the power needs of the nation (Oyebanji, 2017), this forces data centres to depend wholly on alternative power sources. Most of these alternative power energy sources are from diesel generators that emit carbon dioxide. This energy-induced gas causes environmental degradation, and which is on the increase (Sambo, 2009). There are various issues such as Global climate policies, societal pressure, Infrastructure location, Government Regulation, and Policy that might have a positive or negative effect on innovation. (Husic *et al.*, 1977; Mansfield, 1968).

Therefore, this section identifies external pressures that affect green data centre adoption in Nigeria on environmental issues that are stopping organisations from adopting green technology. Respondent three (3) highlighted his knowledge on environmental issues caused by his organisation through their use of diesel generators which emit harmful gasses into the environment, yet even with this knowledge of how his organisation's powers data centre is affecting the environment, respondent 3 still insisted that environmental laws are meant for chemical-based organisations only:

"*I know of the environmental law that all houses and companies should abide with, but the one specifically on global warming doesn't seem to affect our organisation even though we are into services that are not chemical-based. Although our generators produce lots of carbon gas into the air truly, we aren't pressurized."*

In addition to the question of how effective is the government regulatory framework on global warming in an organisation's mode of operation. Respondent four (4) affirmed that government regulation is on food and chemical products:

"Government regulatory framework is more on food and chemical company. I don't have an idea of such regulatory over our company since we are an information technology firm."

This perception is challenging in that some industries believe environmental regulations only apply to certain industries and not their own, yet, these regulations are universal and applicable to all.

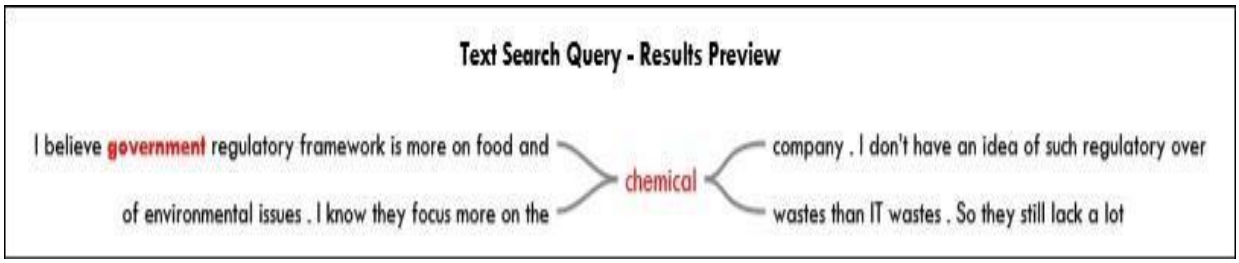

Figure 4-8: Text Query - Effect of government regulatory framework on global warming

According to Figure 4-8 above, government influence, such as legislative pressure is an essential attribute in the practices of sustainability of an organisation. Porter & Van der (1995) were quoted as stating that "organisations engaged in green practices as a way of responding to increasingly stringent and comprehensive environmental regulations". The unavailability of government policy maker's pressure and incentives on the decision-makers of data centres will continue to affect the adoption process of green data centres. Government policymakers need to approach the issue of environmental pollution with different strategic ways to deal with the slow adoption of green technology (Bollinger, 2011) because the government plays an important role to motivate the organisation to adopt green technology in their way of operation (Gadenne *et al.*, 2009). However, respondents seven (7) pointed out a lack of awareness as a problem affecting government regulations. Respondent seven (7) stated that:

"lack of awareness of green technology did not give room for government regulatory framework to take effect because both the government and the organisation I work with lack proper knowledge of what green technology is all about."

Karanasios *et al*. (2010) affirm that influence from other green-aware organisations is significant to the functionality of an eco-friendly data centre. This suggests that adopting green data centre technology can also be influenced by external organisations and is beyond the inter-organisation departments.

Organizations must show commitment to the evolution of technology, especially in the aspect of electronic waste because disposal of waste should not be limited to waste caused by chemical and agricultural products only. More attention should be put into the control of residues from technological tools. This can only be achieved if the external organisations like the government positively influence the data centre mode of operation because technological advancements come with a lot of advantages which sometimes overshadow the negative effect on the environment. So, policies should be put in place for environmental protection of electronic wastes in every country. Respondent one (1) identified government public awareness of green technology to be very low.

"Adverts and sanctions are rarely seen from government policymakers in the area of eco-sustainability."

The government's policies should not just depend on the technology's probability distribution of cost breakthroughs for each technology but also on the environmental impact (Isaksson, 2014) and interventions should be used to speed up the adoption of green technologies (Bollinger, 2011). To easily enhance this adoption of a green data centre, standard global practice or policies must be made available to enable data centre energy efficiency and to allow developing countries to embrace the idea of green Information technology for continued growth (Raje *et al.*, 2015). Respondent (1) reported that government influence on the green data centre is very low because;

"*Government in this part of Africa does not know what is going on with technological waste."*

These technological waste also known as electronic waste equipment such as computers are considered to be harmful when they do not serve any purpose (Asiimwe & Gronlund, 2013). Yet, e-waste is said to be one of the fastest-growing waste streams (Cairns, 2005). Respondent six (6), reported that:

"We tried to find a better way to dispose of unused electrical and electronic equipment, but we didn't execute the plan."

Respondent six (6) stated that electronic devices are meant to be adequately disposed of because some of the discarded electronic gadgets contain highly toxic materials (Liu, 2009). Also, respondent six (6) stated:

"As for data centre, in particular, most of the non-functional servers will have to be disposed of in a better way instead of being left to rust or forced to operate."

Unfortunately, in most developing countries, ICT tools such as computer hardware are challenging to acquire, and the best option has always been the use of outdated products (Asiimwe & Gronlund, 2013). Respondent two (2) reported stated:

"We didn't consider the disposal of devices. I believe this was not one of our options because Nigeria is a country that lacks in the area of recycling, and most electronic items are dumped as refuse."

Veugelers (2012) recognised policy intervention as a powerful tool to introduce when considering clean technologies and some studies also confirmed environment regulation as a contributing factor to the adoption of green innovation (Kousar *et al.,* 2017). Therefore, generating power energy and distributing power energy is significant in the operating costs of data centres (Raje *et al*., 2015). Respondent one (1) reported that:

"efforts are being made through solar power plants but majorly sponsored by individuals. It is costly to have, and solar panels and other renewable power plants will be best for a country like Nigeria. If financial support is made by governments to help domestic homes, this will allow companies to get their electrical sources from the National electric grids, and they will not have to depend on diesel generators that pollute the air."

Figure 4-9: Text query - Influence on renewable energy in Nigeria

Figure 4-9 shows that the respondent was able to express concern on the low level of governmental influence on renewable power in Nigeria and this has been a significant issue in the powering of data centres across the developing country. The use of solar energy in Africa is preferable because of the concentration of the Sun towards the Africa continent, but the cost of buying and installing solar energy without government financial assistance is more expensive in developing countries than developed countries (Shahsavari & Akbari, 2018).

4.7 Summary

This chapter revealed the results obtained via interviews from all the respondents. The TOE framework was used as a guide to determine the factors affecting the adoption of green data centres in Nigeria. Factors such as lack of awareness, technical difficulties, the problem of electricity, issues of finance, and governmental regulatory policy were identified. The next chapter presents the conclusion and recommendations section of the study.

CHAPTER FIVE: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

The previous chapter presented and discussed the results of the research study by investigating the factors that influence green data centre adoption. The study used a purposive sampling technique and TOE framework to assist the identification of these factors. Data was collected from seven participants in seven different organisations, and analysed, using NVivo software. This chapter will provide a summary and recommendations based on the findings that were aligned with the research questions. Nonetheless, this chapter also highlights limitations to the research and recommendations for future work that can arise from this study.

5.2 Summary of Finding

Figure 5.1 illustrates the factors the affect green data centre adoption in Nigeria.

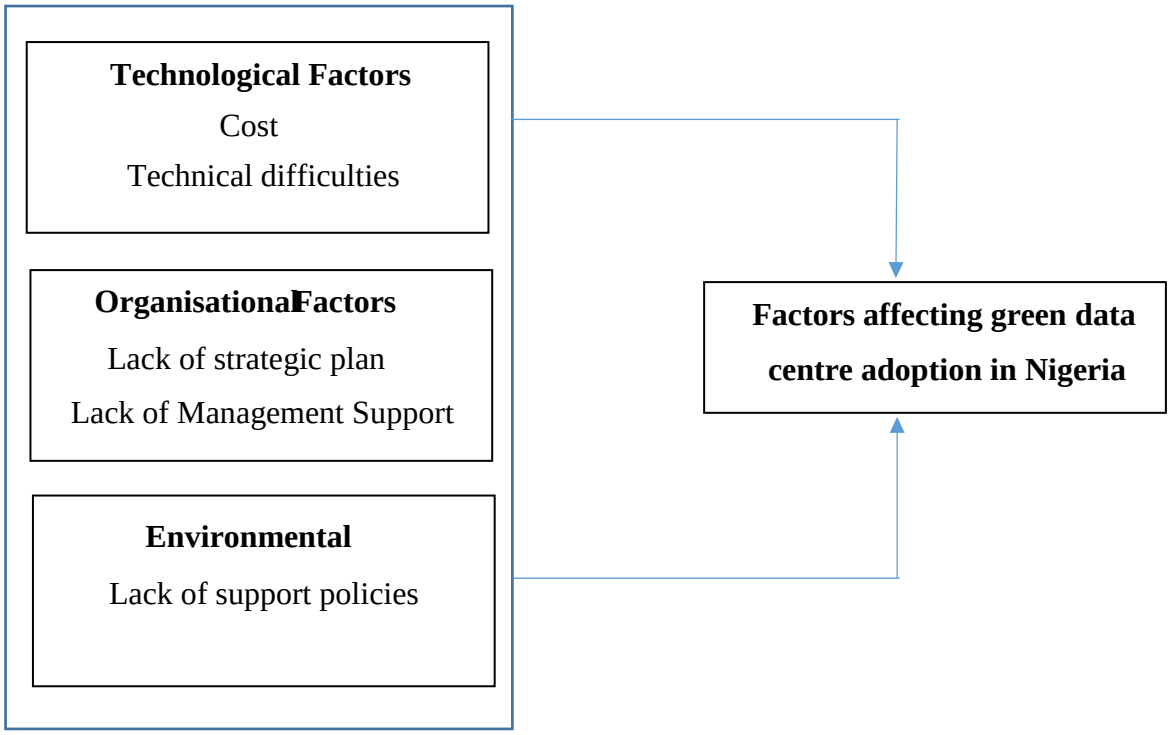

Figure 5-1: Factors affecting data centre adoption in Nigeria

The following is a summary of the findings for each of the research questions, based on the TOE framework.

5.2.1 What technological factors affected the adoption of a green data centres in Nigeria?

The thematic analysis performed identified the cost of adoption and technical difficulties as technological factors affecting the adoption of green data centres in Nigeria. These technical challenges are caused by the unavailability of knowledge and skills to plan, implement, and monitor green technologies.

5.2.2 What organisational factors affected the adoption of a green data centres in Nigeria?

Lack of a strategic plan for green computing and lack of top management support was the predominant theme for organisational factors. Respondents perceived that the strategic plan for green data centre adoption would be difficult to achieve when the departments of an organisation do not share a common goal. If there were a strategic plan, the vision and targeted goal will be shared throughout the organisation. Besides, getting approval and funding for the green data centre project will be much easier. Therefore, the IT department of an organisation should educate top management on the benefits of green data centre adoption.

5.2.3 What environmental factors influenced the organisational adoption of green data centres in Nigeria?

A lack of governmental policies is the leading environmental factor affecting the adoption of green data centres in Nigeria. Respondents believe that there are no policies in place by the government to encourage the adoption of green data centres in Nigeria. Respondents also alluded that these policies should penalize organisations that do not follow green practices and incentivize organisations that are implementing green computing in their organisations.

5.3 Recommendations:

The following recommendations aligned to the research questions are discussed below:

5.3.1 What is the level of green data centres adoption in Nigeria?

The descriptive analysis of this research study has identified low adoption of green data centre technology in Nigeria. However, all the respondents are IT experts, and their contribution has

an impact on their data centre development. Five out of seven respondents were unable to identify adequate knowledge of green technology. Awareness is the foundation of any technology that benefits a well-functioning system. Regrettably, this research revealed low awareness of green IT in Nigeria, and how it negatively affects the adoption of green data centre technology. Hence, environmental awareness must be increased to allow for organisational development. The level of green awareness in Nigeria can improve by initiating educational programs on eco-sustainability, knowledge sharing between ICT experts and environmental practitioners. For this reason, According to Hanne (2011), it is essential to discuss the importance of green information technology in developing countries. However, to establish this importance, different measures must be implemented to solve the problem of green adoption in Nigeria.

Lin (2014) identified that lack of awareness and the lack of managerial support is a determinant affecting the adoption of innovation in supply chain management. These factors can be solved by encouraging people to contribute to the adoption process. According to Molla (2008), promoting environmental sustainability practices or measuring IT preparedness for good productivity, need an increasing level of awareness of green data centre technology. This practice of increasing awareness serves as a motivation, which gives the organisation a solution to global warming, through energy-efficient equipment, improved airflow management systems, and virtualization technology (Vykoukal *et al*., 2009).

5.3.2 What technological factors impact data centres adoption in Nigeria?

The result recognised technical difficulty as a key technological factor affecting the adoption of a green data centre in Nigeria, which is caused by the lack of specialized training. The research findings also explain how a green data centre is different from traditional data centres because a green data centre focuses on the provision of ICT solutions through an eco-friendly method. Technology experts must promote the environment by improving their technical know-how on renewable energy development, cloud computing, virtualization, energy-efficient servers and cooling systems. Therefore, technical training on how to operate a green data centre must be encouraged by organisations anticipating green data centre adoption. Besides, a green data centre can be achieved by increasing the technical skills required for green adoption by training of staff through educational programs (Aoyi *et al*., 2016). A research study conducted by Johnson *et al.* in 2010 (on what topic and location) revealed that "educational programs can encourage technology adoption" (Johnson *et al.*, 2010, p. 28).

The cost of transition from the traditional data centre to green technologies is also a barrier. However, virtualisation helps to reduce this cost of transition (Swathi & Srikanth 2014; Krishna & Eswar 2013) by reducing the number of physical servers, which will minimise the cooling of a data centre. Moreover, the energy from waste heat in a data centre can be recovered and utilized (Garimella *et al*., 2013) through renewable techniques that will convert the heat energy back to electrical power. The use of this technology advancement of a renewable energy option is essential to reduce the running cost of data centres.

5.3.3 What organisational factors impact data centres adoption?

This research result further looked at the organisational influence on the adoption of a green data centre in Nigeria. From the results, it shows that one of the main organisational factors affecting the adoption of green data centres in Nigeria is a lack of strategic planning. This is an organisational factor affecting the adoption of green data centres in Nigeria. The implementation of green adoption by top management can be rewarded by incentives which will ultimately promote eco-sustainability in an organisation. Tenhunen (2011) states that Stakeholder's environmental mindfulness is an incentive that drives a business organisation to go green. Norhashimi & Selamat (2015) identified initiatives that could aid data centre managers to embrace green data centre operation with incentives such as departmental awards ~~and amongst others~~. Therefore, organisations have the responsibility to protect the environment and establish more environmental programs (Yusoff & Nejati, 2019), through a proper strategic plan.

It is advisable and equally obligatory for IT experts to convince top management staff about the benefits of green data centre technology because top management staff are decision-makers of an organisation. The top management staff of an organisation will not embrace green adoption when IT professionals of the same organisation fail to convince them. Thus, top management support is essential to promote internal collaboration within the organisation. Decision-makers of an organisation need to have an awareness of the benefits of adopting green data centre technology by introducing necessary strategies that encourage eco-sustainability.

5.3.4 What environmental factors influence organisational adoption of green data centres in Nigeria?

Research findings show that the unavailability of government environmental policies negatively affects the adoption of green data centre technology in Nigeria. Industries in Nigeria depend solely on an alternative source of electricity, such as diesel generators because of the erratic power supply from the national electricity grids. This issue of power supply affects the government from implementing and executing environmental policy on data centres.

The expansion of carbon footprint has a detrimental effect on the environment (Forrest *et al*., 2008; Fuchs, 2008). For that reason, it is vital to encourage functions such as the introduction of renewable energy to solve the problem of unstable power supply (Guster *et al*., 2009; Niyato *et al*., 2009). The lack of government support to subsidize the cost of renewable energy sources affects the adoption of a green data centre in Nigeria. Hence, governmental policies must be encouraged in green data centre adoption through various incentives. The government should also improve the level of awareness of green data centres by supporting organisations through programs that educate IT experts on environment sustainability. Shi *et al*. (2013) stated that environmental awareness program should be introduced in every organisation and government practice.

5.4 Limitation of this Study

There is no research study without limitations. Therefore, this research study has a few limitations that need to be addressed. One of the main limitations is the level of access granted to the researcher to collect data. Ten respondents accepted to be interviewed, but seven responded due to the limited time meant for the completion of the research study, and the interview was carried out on the seven respondents. Over twelve months, the researcher tried to get more respondents but was not successful in getting more respondents for the research study.

This study was also limited to data centres in Nigeria which is a developing country with a large population. Thus, future studies should investigate whether these factors also affect other developing countries.

5.5 Future Research Recommendations

In addition to the future studies highlighted under limitations, the following can also be considered:

1. Future research on initiatives that could encourage decision-makers of an organisation to embrace the adoption of a green data centre.

2. Future research to demonstrate if the Green IT readiness used in developed countries is transferable and applicable to developing countries underlying the difference in climatic conditions, culture, government policies, and resources.

3. A quantitative study that expands on the current factors that will enable a generalised result.

5.6 Summary

In conclusion, this study determined the factors affecting the adoption of green data centres in Nigeria. Significant factors such as awareness, technical difficulty, top management support, power generation and government policy, were the main factors that affected the adoption of green data centres in Nigeria. These factors were derived after coding of the data collected from seven respondents by means of a semi-structured interview. These factors must be taken into consideration in addressing the increase of green data centre adoption. As such, this will involve the efforts of both the organisations and the government.

References

Abedsaeidi, J., & Amiraliakbari, S. (2015). Research Methods in Medical Sciences and Health.

Adebobun-Toplonu, S., & Ogunleye, J. (2004). Recent Developments on Green Growth in Nigeria. *Organisation for Economic Corporation and Development*, 1-19.

Ahmad, M. I. (2015). Unified theory of acceptance and use of technology (UTAUT). *LinkedIn Pulse*, 179-211.

Ahmed, A. I. (2018). Understanding the factors affecting the adoption of green computing in the Gulf Universities. Riyadh, Kingdom of Saudi Arabia: (IJACSA) International Journal of Advanced Computer Science and Applications, 9(3), 304-311.

Ainin, S., Naqshbandi, M. M., & Dezdar, S. (2016). Impact of adoption of Green IT practices on organizational performance. *Quality & Quantity*, *50*(5), 1929-1948.

Akuru, U. B., & Okoro, O. I. (2014). Renewable energy investment in Nigeria: A review of the Renewable Energy Master Plan. *Journal of Energy in Southern Africa*, *25*(3), 62-67.

Altheide, D., & Johnson, J. M. (1998). Criteria for assessing interpretative validity in qualitative research. *Collecting and interpreting qualitative materials* (pp. 283 - 312). Thousand Oaks. USA.

Amol, C. A., Vikram, D. S., Seema, H. P., & Gopakumaran, T. T. (2015). Cloud Computing – A Market Perspective and Research Directions. *International Journal of Information Technology and Computer Science*, 10(1), 42-53.

Anderson, S. F. (2010). Improving data center efficiency. *Energy Engineering*, *107*(5), 42-63.

Anixter (2012). Data Centre Infrastructure Resource Guide. *Anxiter Data Cente College, Illinois, USA.*

Aoyi, O., Seodigeng, T., Modiba, E., Otieno, B., Mabuza, J., & Masedisho, B. (2016). PROJECT No SSP/GREEN ECONOMY RESEARCH/2012//201516.

Argon-Correa, J. A., Matias, R., & Senise-Barrio, M. E. (2004). Managerial Discretion and Corporate commitment to the Natural Environment. Journal of Business. Vol. 57.

Arif, S., & Murat, A. (2015). *Security and Optimization Challenges of Green Data Centres.* Cyprus: Girne American University (pp 492-500).

ASSAf. (2014). The State of Green Technologies in South Africa. *Academy of Science of South Africa* (ASSAf), Pretoria, South Africa.

Awoyemi, J. O., & Awoyemi, B. O. (2017). The Role of Information Technology in Nigerian Economy. *International Journal of Scientific Research in Science and Technology*, 3(6), 20-28.

Bachour, N. (2012). Green IT Project Management: Optimizing the Value of Green IT Projects within Organizations. Retrieved from: https://www.igiglobal.com/book/sustainable-icts-management-systemsgreen/62631 [12 June 2019].

Bader, A. (2013). A COMPARATIVE – Contrastive Integration between Green Cloud and Dynamic Data Centre Power Management (DDCPM). *European Scientific Journal*, 9(12), 332-340.

Baker, J., Dwivedi, Y. K., Wade, M. R., & Schneberger, S. L. (2012). The technology-organization environment framework in information systems theory. *Integrated Series in Information Systems, 28*, 231 - 245.

Balodis, R., & Opmane, I. (2012). History of data centre development. In *Reflections on the History of Computing* (pp. 180-203). Springer, Berlin, Heidelberg.

Baumol, W. J., & Oates, W. E. (1998). The Theory of Environmental Policy. UK: Cambridge University Press.

Belvis, E. (2007). Sustainable interaction design: Invention and Disposal, Renewal and Reuse. *In proceedings to the SIGCHI, 503-512.* doi:https://doi.org/10.1145/1240624.1240705.

Benbasat, I., & Barki, H. (2007). Quo Vadis, Technology Acceptance Model? *Journal of the Association for Information Systems*, 8, 212-218.

Benson, T., Anand, A., Akella, A., & Zhang, M. (2010). Understanding data center traffic characteristics. *ACM SIGCOMM Computer Communication Review*, *40*(1), 92-99.

Bollinger, B. K. (2011). Green technology adoption in response to environmental policies. USA: ProQuest Dissertations Publishing.

Borg, W. R., & Gall, M. D. (1989). Educational research*; An introduction, 6th ed. White Plains.* New York, USA.

Botha, N., & Atkins, K. (2005). *An assessment of five different theoretical frameworks to study the uptake of innovations* (No. 1163-2016-93108).

Bramfitt, M., & Coles, H. (2011). Modular/Container Data Centers Procurement Guide: *Optimizing for Energy Efficiency and Quick Deployment.* Retrieved from

https://www.missioncriticalmagazine.com/ext/resources/MC/Home/Files/PDFs/WP_Bramfitt.pdf. [02 February 2018].

Brannick, T., & Roche, W. K. (1997). Strategies, Techniques and Sources. *Business Research Methods* (pp. 1-296). Oak Tree Press.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. Qualitative Research in Psychology, 3(2), 77-101. https://doi.org/10.1191/1478088706qp063oa

Brent, A. C. (2015). A system approach to Managing Technology. In *The Transition to a green economy.* Stellenbosch University, South Africa.

Brink, H. I. (1993). Validity and Reliability in Qualitative Research. *Paper delivered at SA Society of Nurse Researcher's Workshop*, 16(2), 35-38.

Burns, N., & Grove, S. K. (1997). The Practice of nursing research. *Conduct, Critique and Utilization.* Philadelphia, USA.

Buzzelli, D. T. (1991). Time to structure an environmental policy strategy. *Journal Business Strategy* (pp. 17 - 20). New York, USA.

Cairns, F. (2005). Sustainable travel towns. In Papers of the Lanford Latin Seminar.

Campbell, S., & Jeronimo, M. (2006). *Applied Virtualization Technology: Usage Models for IT Professionals and Software Developers*. Intel Press.

Campbell-Kelly, M., & Aspray, W. (2004). Computer: A History of the Information Machine (Boulder, CO.

Carr, V. H. (1999). Technology adoption and diffusion. *The Learning Centre for Interactive Technology.*

Casey, T., & Wilson-Evered, E. (2012). Predicting uptake of technology innovations in online family dispute resolution services. *An application and extension of the UTAUT* (pp. 2034 - 2045). Article in Computers in Human Behavior 28(6) DOI: 10.1016/j.chb.2012.05.022.

Chatterjee, K. (2002). Education, training and public awareness on climate change. *A paper presented by Development Alternatives to the United Nations Framework Convention on Climate Change.* Retrieved from http://www.devalt.org/newsletter/sep03/of_1.htm.

Chau, P. Y., & Tam, K. Y. (1997). Factors affecting the adoption of open systems. In *an exploratory study* (pp. 1 - 24). MIS Quarterly, Vol. 21.

Chen, Y. S. (2008). The driver of green innovation and green image. In *green core competence* (pp. 531 - 543). Journal of Business Ethics, 81(3).

Chinwuko, E. C., Mgbemena, C. O., Aguh, P. S., & Ebhota, W. S. (2011). Electricity Generation and Distribution in Nigeria. In *Technical Issues and solutions* (pp. 7934-7941). Nigeria: International Journal of Engineering, Science and Technology of Nigeria.

Christopher, E. S. (2014). Qualitative data analysis (QDA). In *Qualitative data analysis (QDA)* (p. 16). University of the Western Cape, South Africa. Retrieved from file:///C:/Users/uer/Downloads/Qualitative%20data%20analysis.pdf. [18 November 2017].

Cole, D. (2012). Data center infrastructure management. *Data Center Knowledge*.

Collins, P. D., Hage, J., & Hull, F. M. (1988). Organizational and technological predictors of change in automaticity. *Academy of Management Journal*, *31*(3), 512-543.

Commscope Inc. (2014). How data centers are using lighting with intelligent sensors to reduce energy consumption and improve operations. *In Lighting and the efficient data center*. White Paper.

Compeau, D., Higgins, C. A., & Huff, S. (1999). Social cognitive theory and individual reactions to computing technology: A longitudinal study. MIS quarterly, 145-158.Creswell, J. W. (2009). Research Design*: qualitative, quantitative and mixed approaches. In Thousand Oaks*, Sage (p. 269). SAGE Publications, Inc. 3rd Edition.

Daim, T., Justice, J., Krampits, M., Letts, M., Subramanian, G., & Thirumalai, M. (2009). Data center metrics. *Management of Environmental Quality: An International Journal*.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. MIS quarterly, 319-340.

De Zoysa, M., & Wijayanayake, J. (2013). The influential factors of green IT adoption in data centres of Sri Lankan banks. *Journal of Emerging Trends in Computing and Information Sciences*, *4*(12), 908-915.

Ding, F., Kinch, B. D., Tonison, L., Mao, L., & Ohya, S. (2012). Green energy development and technology transfer in China and India. *Journal of International development and cooperation*, *19*(2), 13-24.

Dipaola, A. (2017). Saudis Kick Off $50 Billion Renewable Energy Plan to Cut Oil Use. *Bloomberg*,(2017, Feb 20).

Dwivedi, Y. K., Papazafeiropoulo, A., Brown, D. H., & Kaewkitipong, L. (2009). Relative size and complexity: *e-business use in small and medium sized tourism enterprises in Thailand. Journal of Enterprise Information Management*.

EATEL, B. (2017). Data centre infrastructure management (DCIM).*Everything You Need to Know About Colocation* (p. 3). European Association of Technology Enhanced Learning. Retrieved from https://www.eatelbusiness.com/documents/27553/179932/ebook-colocation.pdf/a61125a9-00f2-3676-85bb-e4ee309e79f2. [16 October 2020.

Ebrahimi, K., Jones, G. F., & Fleischer, A. S. (2014). A review of data center cooling technology, operating conditions and the corresponding low-grade waste heat recovery opportunities. *Renewable and Sustainable Energy Reviews*, *31*, 622-638.

Eisenhart, M. (1991). Conceptual frameworks for research circa 1991: Ideas from a cultural anthropologist; implications for mathematics education rese.

Esty, D. C., & Charnovitz, S. (2013). Environmental sustainability and competitiveness: Policy imperative and corporate opportunity. *Harvard Business School: Boston, MA, USA*, *10*.

Etukudor, C., Abdulkareem, A., & Ayo, O. (2015). The daunting challenges of the Nigerian electricity supply industry. *Journal of Energy Technologies and Policy*, *5*(9), 25-32.

Etzion, D. (2007). Research on organizations and the natural environment, 1992-present: A review. *Journal of Management*, *33*(4), 637-664.

Fain, J. A. (2020). *Reading, understanding, and applying nursing research*. FA Davis.

Fay, M. (2012), Inclusive Green Growth: *The Pathway to Sustainable Development*. Washington, DC: World Bank Publications

Fishbein, M., & Ajzen, I. (1977). Belief, attitude, intention, and behavior: An introduction to theory and research.

Flick, U., Von Kardorff, E., & Steinke, I. (2004). What is qualitative research? An introduction to the field. *A companion to qualitative research*, 3-11.

Florida, R., & Davison, D. (2001). Gaining from green management: environmental management systems inside and outside the factory. *California management review*, *43*(3), 64-84.

Florida, R., Atlas, M., & Cline, M. (2001). What makes companies green? Organizational and geographic factors in the adoption of environmental practices. *Economic Geography*, *77*(3), 209-224.

Forrest, W., Kaplan, J. M., & Kindler, N. (2008). Data centers: How to cut carbon emissions and costs. *McKinsey on business technology*, *14*(6), 4-13.

Froehle, C. M., Roth, A. V., Chase, R. B., & Voss, C. A. (2000). Antecedents of new service development effectiveness: an exploratory examination of strategic operations choices. *Journal of Service Research*, *3*(1), 3-17.

Fuchs, C. (2008). The implications of new information and communication technologies for sustainability. *Environment, Development and Sustainability*, *10*(3), 291-309.

Gallagher, G., & Namek, R. (2008). *Implementing Green Initiatives in the Data Centre Environment.* USA. Retrieved from https://silo.tips/download/implementing-green-initiatives-in-the-data-center-environment. [16 October 2020].

Garimella, S. V., Persoons, T., Weibel, J., & Yeh, L. T. (2013). Technological drivers in data centers and telecom systems: Multiscale thermal, electrical, and energy management. *Applied energy*, *107*, 66-80.

Gartner. (2008). Sustainable IT, A Gartner Briefing.

Gatignon, H. (1991). Innovative decision process. *Handbook of consumer behavior*.

Gholami, R., Watson, R. T., Hasan, H., Molla, A., & Bjorn-Andersen, N. (2016). Information systems solutions for environmental sustainability: How can we do more?. *Journal of the Association for Information Systems*, 17(8), 2.

Gilbert, N., & Stoneman, P. (Eds.). (2015). *Researching social life*. Sage.

Glaser, B. G., & Strauss, A. L. (1967). The discovery of grounded theory: strategies for qualitative research [pdf]. *Zugriff unter http://www. sxf. uevora. pt/wp-content/uploads/2013/03/Glaser_1967. pdf*.

Goundar, S. (2012). Cloud Computing: Understanding the Technology before Getting "Clouded". In *Recent Progress in Data Engineering and Internet Technology* (pp. 217-222). Springer, Berlin, Heidelberg.

Gowri, K. (2005). Desktop tools for sustainable design. *ASHRAE journal*, *47*(1), 42.

Guest, G., Namey, E., & McKenna, K. (2017). How many focus groups are enough? Building an evidence base for nonprobability sample sizes. *Field methods*, *29*(1), 3-22.

Guster, D., Hemminger, C., & Krzenski, S. (2009). Using virtualization to reduce data center infrastructure and promote green computing. *International Journal of Business Research*, *9*(6), 133-139.

Harrell, M. C., & Bradley, M. A. (2009). *Data collection methods. Semi-structured interviews and focus groups*. Rand National Defense Research Inst santa monica CA.

Harris, C. (2006). Electricity marks. *pricing, structures and economics.* USA: pp. 542. John Wiley and Sons publisher.

Hart, S. L. (1997). Beyond greening: strategies for a sustainable world. *Harvard business review*, *75*(1), 66-77.

Herat, S. (2007). Sustainable management of electronic waste (e-waste). *Clean–Soil, Air, Water*, *35*(4), 305-310.

Hilty, L., Aebischer, B., Andersson, G., & Lohmann, W. (2013). ICT4S–ICT for Sustainability: Proceedings of the First International Conference on Information and Communication Technologies for Sustainability.

Holmner, Å., Rocklöv, J., Ng, N., & Nilsson, M. (2012). Climate change and eHealth: a promising strategy for health sector mitigation and adaptation. *Global health action*, *5*(1), 18428.

Hoover, R. S., & Koerber, A. L. (2009). Using NVivo to answer the challenges of qualitative research in professional communication: Benefits and best practices tutorial. *IEEE transactions on Professional Communication*, *54*(1), 68-82.

Hopper, A., & Rice, A. (2008). Computing for the future of the planet. *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, *366*(1881), 3685-3697.

Houghton, C., Murphy, K., Meehan, B., Thomas, J., Brooker, D., & Casey, D. (2017). From screening to synthesis: using nvivo to enhance transparency in qualitative evidence synthesis. *Journal of clinical nursing*, 26(5-6), 873-881.

Hu, P. J. H., Hu, H. F., Wei, C. P., & Hsu, P. F. (2016). Examining firms' green information technology practices: A hierarchical view of key drivers and their effects. *Journal of Management Information Systems*, *33*(4), 1149-1179.

Husic, F., Rapoport, J., Romeo, A., Villani, E., & Wagner, S. (1977). The Production and Application of New Industrial Technology. *WW Norton & Company, Inc., New York. Maudos, J., Pastor, JM and Serrano, L.(1999). Total factor productivity measurement and human capital in OECD countries. Economics Letters*, *63*, 39-44.

Hwang, B. N., Huang, C. Y., & Wu, C. H. (2016). A TOE approach to establish a green supply chain adoption decision model in the semiconductor industry. *Sustainability*, *8*(2), 168.

Iacovou, C. L., Benbasat, I., & Dexter, A. S. (1995). Electronic data interchange and small organizations: Adoption and impact of technology. *MIS quarterly*, 465-485.

IBM, C. (2007). Optimising IT; The green data centre. *More than social responsibility.* New York, USA: IBM Global Services.

IEA. (2011). Green Growth and Developing Countries. Consultant Draft.

Index, E. P. (2016). Global metrics for the environment. *Yale University. Information available online at: http://epi. yale. edu/sites/default/files/2016EPI_Full_Report_opt. pdf*..

Info-Tech Research Group. (2008). North America underperforms in green IT attitudes and actions. *Retrieved May*, *11*, 2013.

Isah Usman, D., Celement, C. K., & Raihan, M. A. A. (2013). Study of the Problems for Development of Technical and Vocational Education in Katsina State, Nigeria.

Isaksson, K. (2014). *Logistics Service Providers Going Green: A Framework for Developing Green Service Offerings* (Doctoral dissertation, Linköping University Electronic Press).

Janpitak, N., & Sathitwiriyawong, C. (2011). Data center physical security ontology for automated evaluation. In *Proceedings of the International Conference on Security and Management (SAM)* (p. 1). The Steering Committee of The World Congress in Computer Science, Computer Engineering and Applied Computing (WorldComp).

Jeyaraj, A., Rottman, J. W., & Lacity, M. C. (2006). A review of the predictors, linkages, and biases in IT innovation adoption research. *Journal of information technology*, *21*(1), 1-23.

Jin, Y., Wen, Y., Chen, Q., & Zhu, Z. (2013). An empirical investigation of the impact of server virtualization on energy efficiency for green data center. *The Computer Journal*, *56*(8), 977-990.

Johnson, R. J., Doye, D. G., Lalman, D. L., Peel, D. S., Raper, K., & Chung, C. (2010). Factors affecting adoption of recommended management practices in stocker cattle production.

Jones, A. R., & Mingay, S. (2008). Executive Summary: Going Green: The CIO's Role in Enterprisewide Environmental Sustainability. *Gartner Exp Premier, Accessed June*, *10*, 2008.

Jugder, N. (2016). The thematic analysis of interview data: An approach used to examine the influence of the market on curricular provision in Mongolian higher education institutions. *Hillary Place Papers, 3rd edition, University of Leeds*.

Juthathip Damkeungtrakul; Krittin Kulsri; Ramita Rodgrasae; Songpop Chavongluend; Jittaboon Wanichwatphibun; and Pisit Chanvarasuth (2013). Organizational adoption of green IT in Thailand. In *Proceedings of the 4th International Conference on Engineering, Project, and Production Management (EPPM 2013)* [CD-ROM], 23-25 October 2013, Bangkok, Thailand, pp. 292-303.

Kadhim, M. A. K. (2018). *Holistic Study of Thermal Management in Direct Liquid Cooled Data Centres: from the Chip to the Environment* (Doctoral dissertation, University of Leeds).

Kanmdar, M. R. (2008). Literature Review: Green Computing Implementation Procedures for Energy Efficiency.

Kansal, N. J., & Chana, I. (2012). Cloud load balancing techniques: A step towards green computing. *IJCSI International Journal of Computer Science Issues*, *9*(1), 238-246.

Kant, K. (2009). Data center evolution: A tutorial on state of the art, issues, and challenges. *Computer Networks*, *53*(17), 2939-2965.

Karanasios, S., Cooper, V., Deng, H., Molla, A., & Pittayachawan, S. (2010). Antecedents to greening data centres: A conceptual framework and exploratory case study.

Kay, S., & Nagesha, V. (2016). The Demographic Profile of African Countries. *United Nations Economic Commission for Africa.* 77. Retrieved from https://www.uneca.org/sites/default/files/PublicationFiles/demographic_profile_rev_april_25.pdf. [25 April 2017].

Kendall, D. G. (1953). Stochastic processes occurring in the theory of queues and their analysis by the method of the imbedded Markov chain. *The Annals of Mathematical Statistics*, 338-354.

Kennedy-Darling, J., Hoyt, N., Murao, K., & Ross, A. (2008). The energy crisis of Nigeria: an overview and implications for the future. *The University of Chicago, Chicago*, 2008775-784.

Kerlinger, F. N. (1966). Foundations of behavioral research. San Diego, CA, USA: *Foundations of behavioral research*.

Ketter, W. & Koolen, D. (2017). *How the current electricity market design may keep fossil fuel alive*. Retrieved from RSM (Rotterdam School of Management) Discovery: https://discovery.rsm.nl/articles/290-how-the-current-electricity-market-design-may-keep-fossil-fuel-alive/ [7 July 2017].

Koomey, J. (2011). Growth in data center electricity use 2005 to 2010. *A report by Analytical Press, completed at the request of The New York Times*, *9*(2011), 161.

Kousar, S., Sabri, P. S. U., Zafar, M., & Akhtar, A. (2017). Technological factors and adoption of green innovation: Moderating role of government intervention: a case of SMEs in Pakistan. *Pakistan Journal of Commerce and Social Sciences (PJCSS)*, *11*(3), 833-861.

Kuehr, R., & Williams, E. (Eds.). (2003). *Computers and the Environment: Understanding and Managing their Impacts: Understanding and Managing Their Impacts* (Vol. 14). Springer Science & Business Media.

Kuhlman, T., & Farrington, J. (2010). What is sustainability?. *Sustainability*, *2*(11), 3436-3448.

Kurnia, S., & Johnston, R. B. (2000). The need for a processual view of inter-organizational systems adoption. *The Journal of Strategic Information Systems*, *9*(4), 295-319.

Kvale, S. (1996). *InterViews: an introduction to qualitive research interviewing*. Sage.

Bhardwaj, M., & Neelam, N. (2015). The advantages and disadvantages of green technology. *Journal of Basic and Applied Engineering Research*, *2*(22), 1957-1960.

Lavrakas, P. J. (2008). *Encyclopedia of survey research methods*. Sage Publications.

Legrand, W., Sloan, P., & Chen, J. S. (2016). *Sustainability in the hospitality industry: Principles of sustainable operations*. Routledge.

Leininger, M. (1991). Culture care diversity and universality theory. *Nursing*.

Lin, C. Y., & Ho, Y. H. (2011). Determinants of green practice adoption for logistics companies in China. *Journal of business ethics*, *98*(1), 67-83.

Lincoln, Y. S., & Guba, E. G. (1986). But is it rigorous? Trustworthiness and authenticity in naturalistic evaluation. *New directions for program evaluation*, *1986*(30), 73-84.

LoBiondo-Wood, G., & Haber, J. (2014). *Nursing research-e-book: methods and critical appraisal for evidence-based practice*. Elsevier Health Sciences.

Lohse, S. (2014). Incentivizing the Adoption of Green Technology on a Global Scale. *Global Challenges Brief. WIPO, Geneva*.

Lovitts*, B. E. (2005). Being a good course-taker is not enough: a theoretical perspective on the transition to independent research. *Studies in higher education*, *30*(2), 137-154.

Low, C., Chen, Y., & Wu, M. (2011). Understanding the determinants of cloud computing adoption. *Industrial management & data systems*.

Lucchese, R. (2019). Cooling Control Strategies in Data Centers for Energy Efficiency and Heat Recovery. *Luleå University of Technology: Luleå, Sweden*.

Lykou, G., Mentzelioti, D., & Gritzalis, D. (2017). A new methodology toward effectively assessing data center sustainability. *Computers & Security*, *76*, 327-340.

MacDonald, S., & Headlam, N. (2008). *Research Methods Handbook: Introductory guide to research methods for social research*. Centre for Local Economic Strategies.

MacMillan Education Limited. (2020). The American English Definition of Framework. Spring Nature Publisher. Online: Retrieved from *https://www.macmillandictionary.com/dictionary/american/framework*. [20 July 2020]

Mahesh, B. (2016). Data Security and security controls in cloud computing. *International Journal of Advances in Electronics and Computer Science*, 11-13.

Mansfield, E. (1968). Industrial research and technological innovation; an econometric analysis.

Mata-Toledo, R., & Gupta, P. (2010). Green data center: how green can we perform. *Journal of Technology Research, Academic and Business Research Institute*, *2*(1), 1-8.

Mathieson, K. (1991). Predicting user intentions: comparing the technology acceptance model with the theory of planned behavior. *Information systems research*, *2*(3), 173-191.

Meade, N., & Islam, T. (2006). Modelling and forecasting the diffusion of innovation–A 25-year review. *International Journal of forecasting*, *22*(3), 519-545.

Mikalsen, A. B. (2009). TISIP Hardware components with focus on servers. Norway: Sor-Trondelag University.

Miniwatts Marketing Group. (2018). *World Internet Users, Population Statistics, Social Media Stats and Internet Market Research Data, for over 246 individual countries and world regions*. Retrieved from Internet world stats: https://www.internetworldstats.com/stats.htm. [17 July 2018].

Mishra, D., Akman, I., & Mishra, A. (2014). Theory of reasoned action application for green information technology acceptance. *Computers in human behavior*, *36*, 29-40.

Molla, A. (2009). The reach and richness of green it: a principal component analysis.

Molla, A. (2009). The reach and the reachness of green IT: A principle component analysis. Australia: 20th Australasian Conference on Information systems.

Molla, A. (2009, December). The reach and richness of green IT. In *20th Australasian Conference on Information Systems* (pp. 2-4).

Molla, A., Cooper, V. A., & Pittayachawan, S. (2009). IT and eco-sustainability: Developing and validating a green IT readiness model. *ICIS 2009 proceedings*, 141.

Monroe, M. (2016). How to Reuse Waste Heat from Data Centres Intelligently. *Data center knowledge*.

Moore, G. C., & Benbasat, I. (1991). Development of an instrument to measure the perceptions of adopting an information technology innovation. *Information systems research*, *2*(3), 192-222.

Morse, J. M. (1999). Myth# 93: Reliability and validity are not relevant to qualitative inquiry.

Mueller, S. (2017). Green technology and its effect on the modern world.

Murugesan, S. (2008). Harnessing green IT: Principles and practices. *IT professional*, *10*(1), 24-33.

Nath, V., Kumar, R., Agrawal, R., Gautam, A., & Sharma, V. (2014). Impediments to adoption of green products: An ISM analysis. *Journal of Promotion Management*, *20*(5), 501-520.

Nathuji, R., & Schwan, K. (2007). Virtualpower: coordinated power management in virtualized enterprise systems. *ACM SIGOPS operating systems review*, *41*(6), 265-278.

Nganji, J. T., & Brayshaw, M. (2010). Is Green IT an Antidote to E-Waste Problems?. *Innovation in Teaching and Learning in Information and Computer Sciences*, *9*(2), 1-9.

Ngene, C. U., & Aviara, N. A. (2014). Implication of Poor Energy Supply on the Sustainability of ICT Infrastructure in Nigeria. ARPN Journal of Science and Technology, 4(5), 305-317.

Nishitani, K. (2009). An empirical study of the initial adoption of ISO 14001 in Japanese manufacturing firms. *Ecological Economics*, *68*(3), 669-679.

Niyato, D., Chaisiri, S., & Sung, L. B. (2009, May). Optimal power management for server farm to support green computing. In *2009 9th IEEE/ACM International Symposium on Cluster Computing and the Grid* (pp. 84-91). IEEE.

Nor, N. B. M., & Selamat, M. H. B. Green Data Center Frameworks and Guidelines.Nutley, S., Davis, H., & Walter, I. (2002). Conceptual Synthesis, 1. In *learning from the diffusion of innovation.*

Odumeru, J. A. (2013). Going cashless: Adoption of mobile banking in Nigeria. *Nigerian Chapter of Arabian Journal of Business and Management Review*, *62*(1085), 1-9.

Ogbo, A. I., Eneh, N. C., Agbaeze, E. K., Chukwu, B. I., & Isijola, D. O. (2017). Strategies for achieving sustainable economy in Nigeria taking into consideration the acceptable stakeholders. *African Journal of Business Management*, *11*(19), 582-589.

Oliveira, T., & Martins, M. F. (2010). Understanding e-business adoption across industries in European countries. *Industrial Management & Data Systems*.

Oluwatolani, O., Joshua, A., & Philip, A. (2011). The Impact of Information Technology in Nigeria's Banking Industry. *arXiv preprint arXiv:1108.1153*.

Omamo, J. O. (2012). *Factors affecting adoption of green technology by firms in Kenya* (Doctoral dissertation, University of Nairobi, Kenya).

Osanloo, A., & Grant, C. (2016). Understanding, selecting, and integrating a theoretical framework in dissertation research: Creating the blueprint for your "house". *Administrative issues journal: connecting education, practice, and research*, *4*(2), 7

Oyebanji, I. J. (2017). Green growth and environmental sustainability in Nigeria.

Papadopoulos, C., & Wurm, A. (2012). Trends, Pressures and Factors that affect Data Center Management taking Environmental Sustainability into Account.

Parminter, T. G., & Wilson, J. A. (2003). Systemic interventions into biodiversity management based upon the theory of reasoned action. In *Proceedings of the 1st Australian Farming Systems Association Conference* (p. 199).

Patton, M. Q. (2002). Qualitative research and evaluation methods. Thousand Oaks. *Cal.: Sage Publications*.

Pawlish, M. J., & Varde, A. S. (2010). A decision support system for green data centers. In *Proceedings of the 3rd workshop on Ph. D. students in information and knowledge management* (pp. 47-56).

Pelley, S., Meisner, D., Wenisch, T. F., & VanGilder, J. W. (2009, June). Understanding and abstracting total data center power. In *Workshop on energy-efficient design* (Vol. 11, pp. 1-6).

Pelley, S., Meisner, D., Wenisch, T. F., & VanGilder, J. W. (2009, June). Understanding and abstracting total data center power. In *Workshop on energy-efficient design* (Vol. 11, pp. 1-6).

Polit, D. F., & Beck, C. T. (2004). *Nursing research: Principles and methods*. Lippincott Williams & Wilkins.

Porter, M., & Van der Linde, C. (1995). Green and competitive: ending the stalemate. *The Dynamics of the eco-efficient economy: environmental regulation and competitive advantage*, *33*.

Prasad Majumder, B., Sengupta, A., & Bhaduri, P. (2016). Fault Detection Engine in Intelligent Predictive Analytics Platform for DCIM. *arXiv*, arXiv-1610.

Proehaska, J., DiClemente, C., & Norcorss, J. (1992). In search of how people change: applications to addictive behaviours. *American Psychologist*, *47*, 1102-1114.

Pruhs, K. (2019). Green computing algorithmics. In *Computing and Software Science* (pp. 161-183). Springer, Cham.

PwC. (2015). Lagos: City of opportunities. *An Investor's Guide* (pp. 1-80). Lagos, Nigeria: PricewaterhouseCoopers.

Rais, M. Z. (2014). Design of green data center. *International Journal of Research in Engineering and Technology*, *3*(5), 373-377.

Raje, S., Maan, H., Ganguly, S., Singh, T., Jayaram, N., Ghatikar, G., ... & Sartor, D. (2015, July). Data Center Energy Efficiency Standards in India. In *Proceedings of the 2015 ACM Sixth International Conference on Future Energy Systems* (pp. 233-240).

Rao, P., & Holt, D. (2005). Do green supply chains lead to competitiveness and economic performance?. *International journal of operations & production management*.

Ritchie, J., & Spencer, L. (1994). Qualitative data analysis for applied policy research. In, Bryman A, Burgess RG, eds. Analyzing Qualitative Data. *Abindgon: Routledge*, 173-94.

Ritchie, J., Lewis, J., Nicholls, C. M., & Ormston, R. (Eds.). (2013). *Qualitative research practice: A guide for social science students and researchers*. sage.

Rogers, E. M. (1983). Diflitsion of innovations. *New York: Free*.

Rogers, E. M. (1995). Lessons for guidelines from the diffusion of innovations. *The Joint Commission journal on quality improvement*, *21*(7), 324-328.

Rogers, E. M. (2003). Diffusion of innovations. Free Press. *New York, 551*.

Salahudin, S. N., Abdullah, M. M., & Newaz, N. A. (2013). Emissions: sources, policies and development in Malaysia. *International Journal of Education and Research, 1*(7), 1-12.

Sambo, A. S. (2009). Strategic developments in renewable energy in Nigeria. *International Association for Energy Economics*, *16*(3), 15-19.

Sayeed, L., & Gill, S. (2010). An exploratory study on organisational adjustments due to Green IT. *International Journal of Management and Enterprise Development*, *9*(3), 233-250.

Schiederig, T., Tietze, F., & Herstatt, C. (2012). Green innovation in technology and innovation management–an exploratory literature review. *R&d Management*, *42*(2), 180-192.

Schroeder, C. H. (2009). Global Warming and the problem of policy innovation: Lessons from the early environmental movement. *Envtl. L.*, *39*, 285.

Seale, C. (1999). Quality in qualitative research. *Qualitative inquiry*, *5*(4), 465-478.

Sekaran, U., & Bougie, R. (2016). *Research methods for business: A skill building approach*. John Wiley & Sons.

Shahsavari, A., & Akbari, M. (2018). Potential of solar energy in developing countries for reducing energy-related emissions. *Renewable and Sustainable Energy Reviews*, 90, 275-291.

Sharma, P., Pegus II, P., Irwin, D., Shenoy, P., Goodhue, J., & Culbert, J. (2017). Design and operational analysis of a green data center. *IEEE Internet Computing*, *21*(4), 16-24.

Sharma, R., & Mishra, R. (2014). A review of evolution of theories and models of technology adoption. *Indore Management Journal*, *6*(2), 17-29.

Shi, Q., Zuo, J., Huang, R., Huang, J., & Pullen, S. (2013). Identifying the critical factors for green construction–an empirical study in China. *Habitat international*, *40*, 1-8.

Silva, L. (2007). Post-positivist review of technology acceptance model. *Journal of the Association for Information Systems*, *8*(4).

Singapore, G. (2014). Green Data Centre Program (GDCP). Request for Proposal (RFP). *Research Proposals in Increasing Energy Efficiency of Data Centres in Singapore*: Retrieved from http://research.ntu.edu.sg/Documents/GDC%20Research%20RFP%20Document.pdf. [18 August 2017].

Sophonthummapharn, K. (2009). The adoption of techno-relationship innovations: A framework for electronic customer relationship management. *Marketing Intelligence & Planning*, *27*(3), 380-412.

Spafford, G. (2009). *Greening the Data Center: Opportunities for Improving Data Center Energy Efficiency*. IT Governance Ltd.

Srivastava, A., & Thomson, S. B. (2009). Framework analysis: a qualitative methodology for applied policy research.

Stenbacka, C. (2001). Qualitative research requires quality concepts of its own. *Management decision*.

Tatchell-Evans, M. R. (2017). *Energy Efficient Operation of Data Centres–Technical, Computational and Political Challenges* (Doctoral dissertation, University of Leeds).

Taylor, S., & Todd, P. (1995). Assessing IT usage: The role of prior experience. *MIS quarterly*, 561-570.

Tenhunen, S. (2011). Culture, conflict, and translocal communication: Mobile technology and politics in rural West Bengal, India. *Ethnos*, *76*(3), 398-420.

Teo, T. S., Lin, S., & Lai, K. H. (2009). Adopters and non-adopters of e-procurement in Singapore: An empirical study. *Omega*, *37*(5), 972-987.

Terry, A. (2012). Evaluating the Green Revolution after a decade: a Swaziland case study. *International Journal of Agricultural Sustainability*, *10*(2), 135-149.

Thiesse, F., Staake, T., Schmitt, P., & Fleisch, E. (2011). The rise of the "next-generation bar code": *an international RFID adoption study*. *Supply Chain Management: An International Journal*.

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: toward a conceptual model of utilization. *MIS quarterly*, 125-143.

Thong, J. Y. (1999). An integrated model of information systems adoption in small businesses. *Journal of management information systems*, *15*(4), 187-214.

Thorsteinson, P., & Ganesh, G. G. A. (2004). *NET security and cryptography*. Prentice Hall Professional.

TIA-942, (2005) Data Center Standards Overview. *Compliant Data Center Showing Key Functional Area*. White Paper [pp. 4]: Retrieved from https://www.accu-tech.com/hs-fs/hub/54495/file-15894024-pdf/docs/102264ae.pdf. [20 April 2017].

Tornatzky, L. G., & Klein, K. J. (1982). Innovation characteristics and innovation adoption-implementation: A meta-analysis of findings. *IEEE Transactions on engineering management*, (1), 28-45.

Tornatzky, L. G., Fleischer, M., & Chakrabarti, A. K. (1990). *Processes of technological innovation*. Lexington books.

Tushman, M. L., & Anderson, P. (1986). Technological discontinuities and organizational environments. *Administrative science quarterly*, 439-465.

Tozer, R., & Salim, M. (2010, June). Data center air management metrics-practical approach. In *2010 12th IEEE Intersociety Conference on Thermal and Thermomechanical Phenomena in Electronic Systems* (pp. 1-8). IEEE..

Uddin, M., & Rahman, A. A. (2010). Pre-Requisites for Implementing Energy Efficient & Cost Effective Data Centers Using Virtualization. *Journal of Computing 2 (11)*, 95-101.

Velte, T., Velte, A., & Elsenpeter, R. C. (2008). Green IT: Reduce Your Information System's Environmental Impact While Adding to the Bottom Line McGraw-Hill Companies.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425-478.

Vykoukal, J., Wolf, M., & Beck, R. (2009). Does green IT matter? Analysis of the relationship between green IT and grid technology from a resource-based view perspective. *PACIS 2009 proceedings*, 51.

Wahyuni, D. (2012). The research design maze: Understanding paradigms, cases, methods and methodologies. Journal of applied management accounting research, 10(1), 69-80.

Wang, Y., Wang, X., & Zhang, Y. (2011, October). Leveraging thermal storage to cut the electricity bill for datacenter cooling. In *Proceedings of the 4th Workshop on Power-Aware Computing and Systems* (pp. 1-5).

Webber, L., & Wallace, M. (2009). *Green tech: how to plan and implement sustainable IT solutions*. AMACOM Div American Mgmt Assn.

Webster, N. (1983). *Webster's ninth new collegiate dictionary*. Merriam-Webster.

Wen, K. W., & Chen, Y. (2010). E-business value creation in Small and Medium Enterprises: a US study using the TOE framework. *International Journal of Electronic Business*, *8*(1), 80-100.

Weng, M. H., & Lin, C. Y. (2011). Determinants of green innovation adoption for small and medium-size enterprises (SMES). *African journal of business management*, *5*(22), 9154-9163.

Woherem, E. E. (1991). Information technology and Africa: an appraisal of the present situation and future potential. *Project appraisal*, *6*(1), 33-45.

Woods, M. (2011). Interviewing for research and analysing qualitative data: An overview. *Massey University*, 67-80.

Wyk, B. V. (2012). Research design and methods: Part 1. *Post graduate enrolment and throughput, University of Western Cape: South Africa*.

Yusoff, Y. M., & Nejati, M. (2019). A conceptual model of green hrm adoption towards sustainability in hospitality industry. In *Corporate Social Responsibility: Concepts, Methodologies, Tools, and Applications* (pp. 400-421). IGI Global.

Zamawe, F. C. (2015). The implication of using NVivo software in qualitative data analysis: Evidence-based reflections. *Malawi Medical Journal*, *27*(1), 13-15.

Zhang, C., & Dhaliwal, J. (2009). An investigation of resource-based and institutional theoretic factors in technology adoption for operations and supply chain management. *International Journal of Production Economics*, *120*(1), 252-269.

Zhu, K., Kraemer, K., & Xu, S. (2003). Electronic business adoption by European firms: a cross-country assessment of the facilitators and inhibitors. *European journal of information systems*, *12*(4), 251-268.

Zhu, Y., Li, Y., Wang, W., & Chen, J. (2010). What leads to post-implementation success of ERP? An empirical study of the Chinese retail industry. *International Journal of Information Management*, *30*(3), 265-276.

APPENDICES

Appendix A: Letter of Informed Consent

UNIVERSITY OF KWAZULU-NATAL

SCHOOL OF MANAGEMENT, IT & GOVERNANCE

MCom (*Research Work*) Research Project

Request for permission to undertake research study Research conducted by:

Mr. OJEDIRAN .A. Oluwatosin

Student Number: **216076372**

CELL: +27735736522

9 October, 2017.

FACTORS AFFECTING THE ADOPTION OF GREEN DATA CENTRE IN NIGERIA.

Dear Respondent,

You are invited to participate in an academic research study conducted by a Masters' student from the department of Information Systems and Technology at University of KwaZulu-Natal, South Africa.

The purpose of the study is to investigate the factors affecting the adoption of green data centre in Nigeria. The final outcome of the study should lead to the development of guidelines that enables data centres in developing countries, especially in Africa, to adopt and implement greening into their data centre system.

Please note the following:

- This study involves an anonymous survey. Your name will not appear on the questionnaire and the answers you give will be treated as strictly confidential. You cannot be identified in person based on the answers you give.

- Your participation in this study is very important to us. You may, however, choose not to participate and you may also stop participating at any time without any negative consequences.

- There are no "right" or "wrong" responses; your answers will reflect your own perceptions, knowledge and or experience of retention determinants.

- Please answer the questions in the attached questionnaire as completely and honestly as possible. This should not take more than 15 minutes of your time.

The result of the study will be used for academic purposes only and may be published in an academic journal. We will provide you with a summary of our findings on request.

- Please contact my supervisor, if you have any questions or comments regarding the study**.**

Please complete the following as confirmation of your willingness to participate in this research project:

I, …… have adequately discussed the study with the researcher, understand that I may withdraw from it without giving reasons, and also voluntarily agree to participate by completing the relevant questionnaire / or being interviewed.

Thank you

Yours sincerely,

Investigator's signature……. Date …….

Appendix B: Ethical Clearance Letter

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

7 March 2018

Mr Oluwatosin Ojediran 216076372
School of Management, IT AND Governance
Westville Campus

Dear Mr Ojediran

Protocol reference number: HSS/0068/018M
Project title: Factors affecting the Adoption of Green Data Center in a Development Country

Full Approval – Expedited Application

In response to your application received on 31 January 2018, the Humanities & Social Sciences Research Ethics Committee has considered the abovementioned application and the protocol has been granted **FULL APPROVAL.**

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment /modification prior to its implementation. In case you have further queries, please quote the above reference number.

PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

The ethical clearance certificate is only valid for a period of 3 years from the date of issue. Thereafter Recertification must be applied for on an annual basis.

I take this opportunity of wishing you everything of the best with your study.

[redacted]

.....

Professor Shenuka Singh (Chair)
Humanities & Social Sciences Research Ethics Committee

/pm

cc Supervisor: Mr Ashley Marimuthu
cc Academic Leader Research: Professor B McArthur
cc. School Administrator: Ms Angela Pearce

Humanities & Social Sciences Research Ethics Committee
Professor Shenuka Singh (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 3587/8350/4557 **Facsimile:** +27 (0) 31 260 4609 **Email:** ximbap@ukzn.ac.za / snymanm@ukzn.ac.za / mohunp@ukzn.ac.za
Website: www.ukzn.ac.za

Appendix C: Interview Protocol

Interview Protocol

According to Stacy and Paige (2012), an interview protocol goes beyond a list of interview questions; it also expands to the procedural level of conducting interviews and often encompasses the script of what the interviewer is expected to say before an interview, the script for what is expected to be said by the interviewer when concluding the interview, cues to help the interviewer collect informed consent, and cues or prompts to guide or remind the interviewer on the kind of data/information he or she is required to collect from the interviewee.

The interview protocol employed in this study is as seen below;

Interview Protocol Title:

Date:

Time:

Location:

Interviewer:

Interviewee(s):

Introductory Speech:

I would like to welcome you and thank you for your participation today. My name is Oluwatosin Ojediran

Akinyele and I am a master's student at the University of KwaZulu-Natal Westville Durban and conducting this research in partial fulfilment of the requirements for a Master's degree in Information Systems and Technology.

The interview would be for about 30 minutes

The questions would enable me gain the required insight and understanding of the various types of data centre, the data centres that adopted greening and those that greening of their data centre. The information acquired during the interview would shed more light on the current state of green technology in your organisation and how to proffer ways to reduce the factors that affects the adoption of green data centre.

I would also want to seek your permission to record this interview using a mobile phone, so that the information conveyed by you would be adequately documented. Your participation in this project is voluntary.

You may refuse to participate or withdraw from the project at any time with no negative consequence. There will be no monetary gain from participating in this interview. Confidentiality and anonymity of records identifying you as a participant will be maintained by the School of Management, IT & Governance UKZN.

Appendix D: Semi-structured interview guide

Research Topic: FACTORS AFFECTING THE ADOPTION OF GREEN DATA CENTRES IN NIGERIA

MCom (Research Work)

Discipline of Information Systems & Technology

School of Management, Information Technology & Governance

University of KwaZulu-Natal (Westville Campus)

Researcher: Oluwatosin Ojediran (0735736522)

Supervisor: Mr M Marimuthu (084 512 4570)

INTRODUCTION

My name is Oluwatosin OJEDIRAN Akinyele with student number (216076372) from the Discipline of Information Systems and Technology, in the School of Management, IT and Governance at the University of KwaZulu-Natal Westville campus Durban South Africa.

I would like to ask you some questions that are related to the factors affecting developing countries (mostly in Africa) in the area of green data centres. The construction of green energy-efficient data centres is not just a choice that enterprises themselves must make because threats from the use of chemical materials like packages made with nylon, plastics, etc are not just the only threat to the ecosystem but threats from technological wastes from lack of energy management also pose bigger threat too.

The aim of this Study are:

- To identify the adoption of green data centre in Nigeria.
- To identify technological factors affecting the adoption of green data centre in Nigeria.
- To identify the organisational factors affecting the adoption of green data centre in Nigeria
- To identify the environmental factors affecting the adoption of green data centre in Nigeria.

Through your contribution I hope to understand the factors affecting the adoption of green data centres in Nigeria. The information would also help to effectively investigate the process taken by IT organisations that are into Data centre operations in Nigeria.

The result of the survey are intended to provide valuable and informed measures for tackling the factors that influence low adoption of green data centre in Nigeria. The study would also be of great help to Africa IT experts in the field of information, communication and technology by providing measures that would support in the area of eco-sustainability in the globe.

The following key words would be frequently used during the interview:

Data centre: Data centre remains the facility that contains various assets, from servers, storage and network devices, power and cooling units. Data centre infrastructures are basically facilities in a data centre that can be viewed in physical or virtually.

Green Data Centre: Green data centre is a technique by which, the operation and management of tools/resources in the data centre without harming our ecosystem. This study aims to investigate the factors influencing low adoption of Green data centre among organisations in Nigeria. An understanding of the factors is essential for IT personnel to best implement green practices and for researchers to best understand the issues that need to be addressed.

The Interview schedule questions are as follows:

PART A **Background Section:**

1. Can you briefly explain the main business your company does?

   [Researchers comments]

   [Reflective notes from the researcher]

2. What department do you belong in your company?

   [Researchers comments]

   [Reflective notes from the researcher]

3. What is your gender?

   [Researchers comments]

[Reflective notes from the researcher]

4. How long have you been in this company?

[Researchers comments]

[Reflective notes from the researcher]

5. What position you hold within the company?

[Researchers comments]

[Reflective notes from the researcher]

PART B **Adoption of Green Data Centre:**

6. Is there an awareness of green technology in your company?

[Researchers comments]

[Reflective notes from the researcher]

7. What are the hindrances affecting green adoption in the data centre of your organisation?

[Researchers comments]

[Reflective notes from the researcher]

8. How aware are you of green data centres adoption in Nigeria?

[Researchers comments]

[Reflective notes from the researcher]

9. Have there been any instances of unsuccessful adoption and what were the main causes of these in your company? *[Researchers comments]*

[Reflective notes from the researcher]

10. What ways do you think adoption of green data centre could help the organisation if introduced in the operating of your data centre?

[Researchers comments]

[Reflective notes from the researcher]

Technology Factors

11. What are the hindrances that stop green technology adoption in your organisation?

    [Researchers comments]

    [Reflective notes from the researcher]

12. In terms of the way you do business, how often do you face issues due to low adoption of green technology into your data centre? Especially in the area of Technology waste.

    [Researchers comments]

    [Reflective notes from the researcher]

13. Can you describe the technical difficulties you think you might face in the adoption of green data centre?

    [Researchers comments]

    [Reflective notes from the researcher]

14. Are there any technical barriers that are preventing your organisation from adoption green data centres?

    [Researchers comments]

    [Reflective notes from the researcher]

Organisational Factors

15. In a Year from now, do you see your organisation's involvement with green technology?

    [Researchers comments]

    [Reflective notes from the researcher]

16. Were there instance where adoption of green data centre has been inducted in your organisational policy? *[Researchers comments]*

[Reflective notes from the researcher]

17. How effective does your organisation take eco-sustainability as a priority on environmental sustainability?

[Researchers comments]

[Reflective notes from the researcher]

18. Are there any organisational factors that are preventing your organisation from adoption green data centres especially pressures from other departments like the finance?

[Researchers comments]

[Reflective notes from the researcher]

Environmental Factors

19. From your own point of view. Do you think government policy and influence has affected green data centre in Nigeria?

[Researchers comments]

[Reflective notes from the researcher]

20. What has been the effect of government regulatory frame work in the area of global warming on your organisation mode of operations in your company?

[Researchers comments]

[Reflective notes from the researcher]

21. What are your thoughts on the distribution of renewable energy generation policy in Nigeria?

[Researchers comments]

[Reflective notes from the researcher]

22. Are you aware and informed of any Market regulatory challenge by other data centres seeking green energy adoption in Nigeria?

[Researchers comments]

[Reflective notes from the researcher]

23. Are there strategic plans for environmental sustainability specifically address by IT specialist in your organisation? *[Researchers comments]*

[Reflective notes from the researcher]

24. Are you aware of any of your competitors' adopting green data centres and its impact on your organisation?

[Researchers comments]

[Reflective notes from the researcher]

25. Are there any environmental barriers that are preventing your organisation from adoption green data centres?

[Researchers comments]

[Reflective notes from the researcher]

26. In summary. Can you mention factors that negatively Influence the adoption and implementation of green data centre in a Nigeria?

[Researchers comments]

[Reflective notes from the researcher]

Thank you for participating in the interview. At the end of this research, a copy of the research study would be sent to your organisation on request as a sign of appreciation for volunteering to take part in the study.

Appendix F: Proofreader and Editor Report

PROOFREADING CONFIRMATION

Re: Oluwatosin Akinyele Ojediran

Topic: **FACTORS AFFECTING THE ADOPTION OF GREEN DATA CENTRE IN NIGERIA**

This document confirms that the manuscript listed above has been proofread for appropriate English language usage, grammar, punctuation and spelling for clarity, in my capacity as an academic proposal and research developer.

Dr Nokhuthula Mavela (MTech.Hom DUT)

Mideh Group

midehgroup@gmail.com

+27312202974