Sustainability use of information and communication technologies: A Case study of an asset management company

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KEY WORDS

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Information systems

Sustainability

Green ICT

Green buildings

Environment

Pollution

Renewable

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ABSTRACT

The problem of global warming has triggered a number of environmental initiatives aimed at mitigating climate change, many of which are driven at governmental level - although private organisations have also taken the initiative. The organisation under study - hereafter referred to as "Company-A" - is one such organisation which has taken strides in incorporating environmental initiatives in its business processes. Company-A is a South African based asset management organisation which has seen rapid growth in its business operations and consequently the number of its employees. This growth has necessitated the need for a new office building. At the commencement of this study the organisation was in the process of planning for a new office building to accommodate its growth. The senior management of Company-A recognised the importance of implementing environmentally friendly practices at the new office building, and sought the services of a sustainability consultancy firm to assist in the planning for the new office building.

This study was necessitated by the fact that despite the company's recognition of the importance and need to implement environmentally friendly processes within its business processes, there was a lack of understanding or appreciation of how ICT could be used in an environmentally friendly and sustainable manner in its new office building. With this problem in mind - the researcher - in consultation with the organisations' new office building project manager and research supervisor, formulated a research question which was continuously refined until such a point that it was clear. It was envisaged that a research study to answer the research question: *How can Information and Communication Technologies (ICTs) be used to support environmental sustainability in an organisation?* - would provide insight on how the organisation's top management could deal with the aforementioned problem. The primary purpose of the study was to assist Company-A management in making informed decisions regarding sustainability ICT use, the research can also be used as a foundation in the formulation of the organisation's "green" ICT strategies and policies.

The main research question was divided into smaller sub questions to give structure, clarity and direction in addressing the main research question. These sub questions were in turn used to formulate the research objectives which set the goals and boundaries of this study.

To answer the main research question the researcher reviewed relevant literature on environmental sustainability, sustainability ICT and “green” buildings. The objective was to build the researcher’s knowledge in the research area and the research sub questions, and consequently the main research question determined the literature that was used.

Key points for empirical testing were identified, and a conceptual model was developed as an outcome of the literature review. The conceptual model derived from the literature review was used in formulating interview questions for data collection through semi-structured interviews. Interview participants were selected based on some predefined criteria (purposive sampling). With the consent of the interview participants the researcher recorded the interview proceedings for data analysis. Data gathered from the interviews was analysed to determine evidence of patterns in the data collected, and these were compared to patterns that the author identified in the literature reviewed. As a result of this study, the author discovered that establishing an environmentally friendly and sustainable working environment goes beyond merely acquiring what is perceived to be sustainable or “green” ICT equipment, and requires actually building what is regarded as a “green” building. The author also identified four main concepts of interest: (1) awareness and knowledge, (2) strategy and policy (formulation and implementation), (3) efficient use of existing ICT equipment, and (4) culture. These findings helped the researcher to refine the conceptual model derived from the literature review, and this yielded to the final conceptual model arrived at by the author. Subsequently, the use of this model is recommended in two ways: (1) as the practical recommendation for practitioners at company-A and possibly other similar organisations, and (2) recommendations for further academic research.

The study contributed to the body of knowledge regarding “greening” building and application areas of “Green” ICT to support a green working environment in office buildings. Like many other studies, this study has its shortcomings notably that limited generalisations due to the study findings having been based on data obtained from only a limited number of interviews conducted in this research, the potential lack of independence/objectivity on the part of the researcher given that the researcher was employed by the organisation under study, and potential influence of the researcher on the study results. It is, however, deemed that those shortcomings did not significantly influence validity and relevance of this study.

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DECLARATION

I declare that; *Sustainability use of information and communication technologies: A Case study of an asset management company,* is my own original work and has not been submitted at any other university for any degree or examination, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Mpendulo Hilary Farai Ngwenya Date:…….

Signature:……..

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ABBREVIATIONS AND ACRONYMS

BREEAM	Building Research Establishment's Environmental Assessment Method
C02	Carbon dioxide
CASBEE	Comprehensive Assessment System for Built Environment Efficiency
CSIR	Council for Scientific and Industrial Research (CSIR)
CPU	Central processing unit
CRT	Cathode ray tube
CSR	Corporate social responsibility
DOE	U.S Department of Energy
EPA	United States Environmental Protection Agency
EPEAT	Electronic Product Environmental Assessment Tool
GBCSA	Green building council of South Africa
GHG	Greenhouse gas
GRIHA	Green Rating for Integrated Habitat Assessment
IEEE	Institute of Electrical and Electronics Engineers
IMBOK	Information Management Body of Knowledge
LAN	Large area network
LCD	liquid crystal display
LED	light emitting diode
LEED	Leadership in Energy and Environmental Design
MAS	Multiple agent system
PDA	Personal digital assistant
SBAT	Sustainable Building Assessment Tool
SPiRiT	Sustainable Project Rating Tool
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNEP	United Nations Environment Program
UNFCCC	United Nations Framework Convention on Climate Change
WCED	World Commission on Environment and Development
WSSD	World Summit on Sustainable Development

CHAPTER 1: INTRODUCTION

1.1 Introduction

This chapter delineates the background, problem statement, research questions and objectives, research design and methodology, delineation of the study, and contribution of the study. A chapter conclusion wraps up the discussion in this chapter.

1.2 Background

The problem of global warming has triggered a lot of environmental initiatives, many of which are driven at governmental level. Private companies have also taken the initiative, either in anticipation of future government regulation or as part of social corporate responsibility. This is defined by Publications (2012) as the obligation to the community and the environment an organisation is located in, which involves activities that benefit the community. Whatever the motivation behind the environmental initiatives taken by companies, it is in the interest of companies with a huge global presence such as Company-A, to directly or indirectly pursue environmentally friendly and sustainable business practices and initiatives

Company-A is in the process of planning a new office building, at the harbour of V&A Waterfront, Cape Town, South Africa. Because Company-A recognises the importance of implementing environmentally friendly practices, they have contracted Arup, a green consultancy firm, as their environmental consultants in planning the new office building. However, implementation of “green” information and communication technologies (ICT) remains a gray area, which gave ruse to the topic of this study – sustainability use of ICT at the new Company-A building.

The ICT industry accounts for around 2-3% of the global carbon footprint, and ICT applications have a very large potential to enhance performance across the remaining 97-98%, (Kounatze, 2009). Kounatze’s findings highlight the contribution of ICT in global warming while at the same time unveiling the potential ICT has in the fight to curb global warming.

1.3 Problem Statement

Despite the company's recognition of the need for, and importance of implementing environmentally friendly processes within its business processes, there is still lack of understanding and/or appreciation of how ICT can be used in an environmentally friendly and sustainable manner. In this concrete case, there was a lack of understanding of how ICT can be used to make a new office building more environmentally friendly (sustainable). An improved understanding of ICT's potential in this area can be utilised to drive the organisational sustainability strategy, policies, and their subsequent implementation.

1.4 Research question

In light of the problem at hand, the main research question can be defined as follows:

How can Information and Communication Technologies (ICTs) be used to support environmental sustainability in an organisation?

To effectively answer the above question, it is important to take into consideration the following set of sub-questions.

1. What is sustainability and "green" ICT?
2. What are the requirements for a sustainability information system ("green" IS)?
3. What are the technologies used in "green" information systems?
4. What are the main concerns in implementing a "green" IS?
5. What are the areas of application of ICT in "green" buildings?
6. What are the optimal methods of adopting ICT for a "green" working environment which could be replicated in other similar environments?

1.5 Objectives

1. To define and describe sustainability, and "Green" ICT.
2. To identify the requirements for sustainability/ "green" IS.
3. To explore ICTs used in "green" information systems.
4. To identify main concerns in implementing a "green" IS.
5. To explore areas of application of ICT in "green" buildings.

6. To suggest optimal methods of adopting ICT for a sustainable working environment in the Company-A building in Cape Town that could be replicated in other similar environments.

1.6 Research design and methodology

This research was conducted in the form of a qualitative case study. According to Yin (2009) case study research is "*…an inquiry that investigates a contemporary phenomenon within a real-life context in which multiple sources of evidence are used*". Case study research can either be a single or multiple-case. According to Gerring (2007) the difference between single case and multiple-case study lies in the sample size of the cases used in each type of case study. In a single case study the sample size is N=1 while in a multiple-case study, the sample size is N>1.Since the research focuses on a single organisation (Company-A), a single case study research method was used to address the objectives of this study.

In Green, Camilli, Elmore, Skukauskaite, and Grace (2006), Yin specified six sources of case study research evidence: documents, archival records, interviews, direct observation, participant-observation, and physical artefacts. The study made use of the available literature on environmentally friendly ICT, and the archival records of current IT procedures and policies was reviewed. 12 interviews were conducted between 1 August 2013 and 30 September 2013 with key stake holders including the IT infrastructure manager and the project manager of the new building. This researcher was privileged to be an employee at Company-A during the research period, which allowed the researcher to "*capture data on the perceptions of local actors from within"* (Miles & Huberman, 1994; Leedy, 1997; Yin 2011). The researcher analysed the information that was collected, data analysis began during the interviews with participants. All the interviews were recorded with full consent from the participants, and later transcribed for further analysis. The researcher analysed each transcript line by line and took note of key points that summarised the essence of the interviewee's response. Naturally different interviewees respond differently to the same open ended questions, and this resulted in a lot of conceptually related key points being generated. These related keys points were then grouped under specific themes and conclusions were drawn from these themes.

1.7 Delineation of the study

The study is based on one organisation and one office building in particular. It focuses on environmental issues and how they are affected or may be influenced directly or indirectly by the use of ICT. This inevitably limits the generalisation of this study. Although recommendations on how best the organisation can implement a sustainability information system ("green" IS) are given, research on the feasibility of implementing a "green" IS is beyond the scope of this study.

1.8 Contribution

It is envisaged that this research will have a twofold contribution:

1) It will contribute to the body of knowledge regarding "greening"/making sustainable – the working environment in the new office building that may possibly be replicated in similar environments/context; and
2) It can also be used by Company-A for decision making regarding ICT use in an environmentally friendly and sustainable manner. In line with Company-A's quest to build an environmentally friendly office building, the research can provide a foundation for the formulation of the organisation's "green" ICT strategy and policies.

1.9 Chapter outline

This study is composed of five chapters. Each chapter begins with an introduction which highlights what that chapter seeks to achieve, and ends with a conclusion which rounds off the content discussed in the chapter. The chapters are:

1) **Chapter 1: Introduction to study: T**his chapter sets the foundation on which the study is built. It outlines the background, problem statement, research questions and objectives, research design and methodology, delineation of the study, and contribution of the study. The research design and methodology section outlines how the research was conducted at an abstract level. A more detailed discussion on this is reported in chapter 3.
2) **Chapter 2: Literature review: T**his chapter seeks to build an understanding of the concept of "Green" ICT. The chapter explores literature relating to sustainability, "Green" ICT, smart buildings, various green technologies and "green" information systems. The chapter ends with a brief conclusion highlighting the key points that

were used in the development of a conceptual model which was generated through consulting the literature.

3) **Chapter 3: Research design and methodology:** This chapter seeks to describe, explain, and justify the research design and methods as well as the tools used in the study. It also includes a detailed discussion on the interview process as a data gathering tool, including how it was used in this study, from the formulation of the interview questions, to the selection of interview participants, conducting the actual face to face interviews, recording of data, and the analysis of the data that was gathered in empirically testing the conceptual model proposed in Chapter two. Issues pertaining to ethics, validity, and reliability are also reported in this chapter.
4) **Chapter 4: Presentation of research findings**: This chapter presents and analyses the research findings, and the responses obtained from the interviews are analysed in comparison to the findings obtained from the literature review. It seeks to determine if there is any correlation between the emerging patterns observed in the interview data and literature review. The findings are used in developing a model that could be used in answering the main research question.
5) **Chapter 5: Conclusion and recommendations**: This chapter concludes the study by reflecting back to the research objectives outlined in Chapter one. There is a brief discussion around each research objective, and how it was achieved during the course of the study. The chapter also discusses the author's practical and academic recommendations, as well as the achievements and limitations of this study.

1.10 Chapter conclusion

This chapter has laid out the background and the problem that necessitated undertaking of this research. The main research question was formulated from the problem at hand and what follows from this chapter is an attempt to find an answer to the main research question, leading to a solution to the identified problem. The next chapter explores the literature in search of answers to the main research question.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This chapter is structured according to the research objectives of this study. The chapter explores literature relating to sustainability, "green" ICT, and smart buildings. To build a gradual understanding of the concept of "green" ICT, the chapter begins by articulating the history of sustainability then discusses different types, definitions, and descriptions of sustainability. Focus is placed on how ICT can be used in such a way that it directly or indirectly enhances environmental sustainability. The chapter also explores various "green" technologies and "green" information systems. The chapter ends with a brief conclusion that summarises the discussion by highlighting the key points of the chapter that seek to answer the main research question.

2.2 Definitions and descriptions of sustainability

2.2.1 History of sustainability

The history of sustainability in literature dates back as far as a study in forestry in 1849 (Hilborn, Ludwig, & Walters, 1995) which is the first known reference to it. As a subject and a concept, it has developed and been revised from the 1960s to the present, as is graphically illustrated in the timeline in Figure 1.

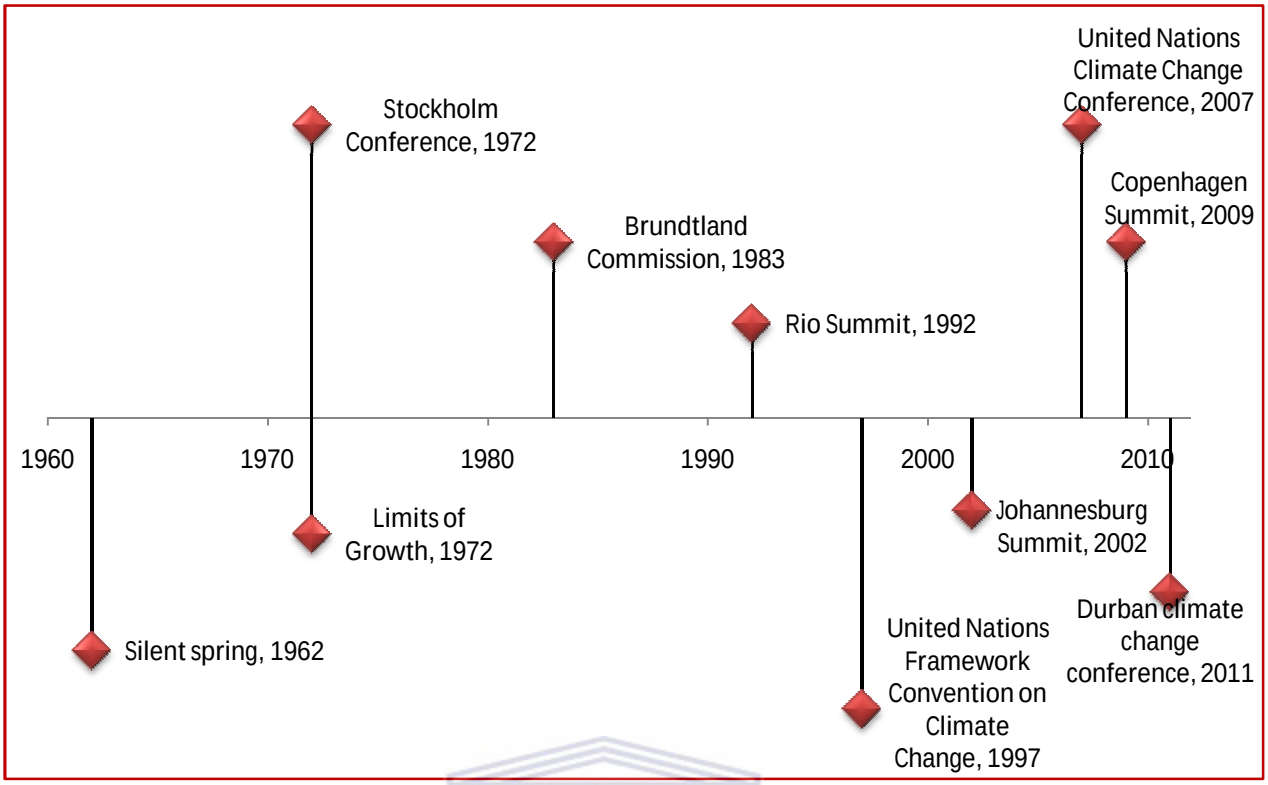

Figure 1: Timeline: The History of sustainability in literature (Source: Author)

Some of these events were either initiated by previous events or as responses to earlier gatherings and conferences. The events named above are discussed below in more detail.

2.2.1.1 Silent spring, 1962

In her book titled *Silent spring*, Carson (1962) states that, *"The most alarming of all man's assaults upon the environment is the contamination of air, earth, rivers, and sea with dangerous and even lethal materials.*" Carson was mainly concerned with the adverse environmental and ecological impact of chemical pesticides such as *dichlorodiphenyltrichloroethane* (DDT) which were used in agriculture. The book itself was in a sense a response to and comment on the the 'Green revolution' which was marked by increased use of technologies such as pesticides, herbicides, and fertilizers to increase agriculrural production (Mulhauser, 2011). *Silent spring* is credited by most as the pioneering contribution to ecological and environmental awareness.

2.2.1.2 Limits of Growth, 1972

Limits of Growth, a widely criticised report published in 1972 used a mathematical model and concluded that "*under the assumption of no major change in the present system, population and industrial growth will certainly stop within the next century, at the latest*" (Turek, 2005).

The report invited criticism from industrialists and politicians who accused it of being too pessimistic. However, Meadows, Randers, and Meadows (2005) pointed out that there are merits to the report in that there are limits to the capacity of the planet to produce material and energy, and to absorb pollutants. According to Meadows *et al*. (2005), there are also limits to "*the rates at which sources can produce these materials and energy without harm to people, the economy, or the earth's processes of regeneration and regulation.*"

In spite of the criticisms levelled at it, *Limits of Growth* sparked debate on critical issues of public policy and raised awareness of future environmental problems that the world would experience if the status quo of population and industrial growth at that time continued.

2.2.1.3 Stockholm Conference, 1972

The concept of sustainable development was born out of the first United Nations (UN) Conference on the Human Environment also known as the Stockholm Conference in 1972 in Stockholm, Sweden. The Conference brought together developed and developing nations to discuss the impacts of increasing global development on the environment (EPA, 2011). While developing countries expressed their need to pursue economic development, both parties agreed on the "*right of all humans to a healthy and productive environment*" (Turek, 2005).

The Stockholm conference set the stage for politics and international bodies to play an active role in managing the global environment. The outcome of the conference was an action plan for national governments on how the natural resources of the earth should be safeguarded. One of the principles in the declaration states that:

> *The natural resources of the earth, including the air, water, land, flora and fauna and especially representative samples of natural ecosystems, must be safeguarded for the benefit of present and future generations through careful planning or management, as appropriate (Sohn, 1973).*

The declaration went further, and highlighted the need to manage the use of non-renewable resources, and to encourage the use of science and technology in contributing to economic and social development in harmony with the environment. The conference also led to the formation of the UN Environment Program (UNEP) based in Nairobi, Kenya, which had a mandate to offer leadership and promote international partnership in caring for the

environment (UNEP, 2008). As part of its mission, the UNEP launched the International Environmental Educational Program in 1975 and the World Conservation Strategy in 1980.

2.2.1.4 Brundtland Commission, 1983

In 1983 the World Commission on Environment and Development (WCED) set up a commission commonly known as the Brundtland Commission, chaired by the then Norwegian Prime minister Gro Harlem Brundtland. The commission was tasked amongst other things with re-assessing environmental and developmental issues around the world, and coming up with proposals on how to promote international cooperation in addressing these issues. The commission aimed to raise the level of understanding of the concept of and need for, sustainable development amongst private, governmental, and non-governmental organisations as well by individuals (EPA, 2011). The commission adopted an open process with hearings and site visits to remote areas all over the world over the course of three years. The commission presented its findings in 1987 in a report titled *Our Common Future,* also known as the *Brundtland report,* which is regarded as a landmark milestone in the history of sustainability (Elkington, 2007).

2.2.1.5 Rio Summit, 1992

The Brundtland report provided the impetus for the UN Conference on Environment and Development (UNCED), also known as the Rio Summit or Earth Summit, held in Rio de Janeiro, Brazil in 1992. The main objective of the conference was to come up with a global consensus on how to strike a balance between the developmental needs of countries, and safeguarding the environment (Turek, 2005). The outcome of this conference was a series of international conventions which heads of states had to sign. The most notable of these was the Agenda for the 21st Century - commonly referred to as *Agenda 21* which sought to encourage governments to invest in environmental and developmental education, as well as planning and taking action to attain sustainability. The Secretary General of UNCED summarized Agenda 21 as, a "*program of action for a sustainable future for the human family and a first step towards ensuring that the world will become a more just, secure and prosperous habitat for all humanity*" (EPA, 2011).

Later in the same year, the Commission on Sustainable Development was set up to monitor the implementation of Agenda 21's directives.

2.2.1.6 United Nations Framework Convention on Climate Change, 1997

The United Nations Framework Convention on Climate Change (UNFCCC) held in Kyoto, Japan in 1997 was marked by the adoption of a legally binding agreement known as the Kyoto Protocol. The Kyoto Protocol sought to tackle greenhouse gas (GHG) emissions by setting a price tag on emissions in ways that reflected national differences in emissions, wealth and capacity (Grubb, 2003). However critics contend that it created a *pay- to-pollute* process whereby wealthy individuals, organisations or countries could use their financial muscle to emit at will (Dhanda & Hartman, 2011) .The Kyoto protocol took effect as from 16 February 2005. It set a target to cut down overall GHG emissions by five percent measured against a benchmark of 1990 GHG emission levels for the period between 2008 and 2012. Penalties calculated per tonne of GHG would then apply after 2012 (Karling, 2001).

2.2.1.7 Johannesburg Summit, 2002

The Johannesburg Summit - officially known as the World Summit on Sustainable Development (WSSD) - was held in Johannesburg, South Africa in 2002, marking the10 year anniversary of the Rio Summit. Its main objective was to assess progress and revive commitment to implementing *Agenda21* declarations and agreements in the face of worldwide poverty and growing population (EPA, 2011). One of the outcomes of this summit was a declaration on sustainable development which sought to "*reaffirm commitment to sustainable development*" and encourage collective effort in working towards it (WSSD, 2002). Also born out of this summit were the Johannesburg Plan of Implementation and the United Nations Millennium Development Goals, detailing action plans and targets in five focus areas: water, energy, health, agriculture and biodiversity.

2.2.1.8 United Nations Climate Change Conference, 2007

The 2007 United Nations Climate Change Conference took place in Bali, Indonesia. The conference aimed to put together defined timelines and steps on negotiations to draft an agreement that would be a successor to the Kyoto Protocol which was set to expire in 2012 (Muller, 2008). This was outlined in the Bali Action Plan which was adopted at the end of the conference. "*The Bali Action Plan envisaged enhanced actions on adaptation, technology development and on the provision financial resources, as well as measures against deforestation*" (Gupta & Roy, 2010). A fund called the Adaptation Fund was created to fund adaptation projects in developing country Parties to Kyoto Protocol who were susceptible to adverse effects of climate change (National Research Council, 2010).

2.2.1.9 Copenhagen Summit, 2009

The Copenhagen Summit formally known as the 2009 United Nations Climate Change Conference and was held in Copenhagen, Denmark. The summit sought to map the way forward after the expiry of Kyoto Protocol in 2012. However, the summit was characterised by disagreements between developed and developing countries, the latter wanted the Kyoto Protocol to continue beyond its life span while developed nations advocated for a new agreement combined with the outcomes from the Kyoto negotiations (Allegretti, Bas, Kenber, Posner, Ryan, & Wu, 2010) . An outcome of this Summit was the Copenhagen Accord, a non-legally binding document drafted by America, Brazil, China, India, and South Africa. The Copenhagen Accord acknowledged the need to limit the increase in global temperature to 2°C but did not compel nations to do so. Some researchers (den Elzen *et al*., 2010, Anderson & Bows, 2008) have dismissed the Accord as highly optimistic, citing the need for immediate mitigation action. The Summit took a decision not to adopt the Copenhagen Accord but it was 'taken note of'.

2.2.1.10 Durban Climate Change Conference 2011

This conference took place in 2011 in Durban, South Africa and the theme was "*Working together, saving tomorrow, today*". The focus was on how to tackle the problems of climate change, and one of the most critical issues was whether or not the *Kyoto Protocol* would be extended beyond its expiry date at the end of 2012. The conference was marred by disagreements between developing and developed nations with developing nations questioning the determination of developed nations to take bold steps in to cutting down GHG emissions (Ogunbanjo, 2011). This was further aggravated by other major players like United States of America, Canada and Russia announcing that they would not extend their participation in the Kyoto Protocol after its expiry.

A decision was taken to launch a fund called the *Green Climate Fund*. This fund was designed to directly and indirectly assist both public and private institutions in developing countries with financial resources for adaptation and mitigation activities in line with climate change strategies (UNFCCC, 2011). Some of the outcomes of the conference included the launch of a new process towards a legally binding framework applicable to all parties to the convention and the *"...establishment of a second commitment period under the Kyoto Protocol ..."* (Aguilar, Appleton, Dafoe, Kosolapova, McColl, & Mead, 2011).

2.2.2 Definitions of sustainability

There are several definitions with diverse interpretations of the concept of sustainability. The literature has shown that most of these definitions are derived from the 1987 Brundtland's definition of sustainable development which defined it as "*... meeting the needs of the present without compromising the ability of future generations to meet their needs.*" Drexhage and Murphy (2010), and Levett (2004) regard this definition as the *classic* definition of sustainability. However, some researchers like Meppem and Bourke (1999), Gosseries (2008), and McKenzie (2004) have criticised this definition for being ambiguous. According to Tol (2009) the definition leaves "*infinite scope for interpretation*". According to Annandale, Morrison-Saunders, and Pope (2004), sustainability is a difficult concept to define like "*love, hope or freedom*", because it is context dependent.

A more detailed definition was given by Hawken (1993) who defined sustainability as"*... an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations.*" This definition brings an economic element into the subject matter and sustainability is here envisaged as the continued extraction of economic benefit from the environment by people without exhausting the capacity of the environment. The triangular relationship between people, environment, and economy is perhaps best described by the *Triple bottom line* framework and the three-ringed sector model of dimensions of sustainability discussed below

2.2.3 Triple bottom line

The Triple bottom line is a framework for measuring corporate economic, social and environmental performance, that is, the degree to which an organisation's activities affect the economy, society and the natural environment. It urges organisations not only to evaluate the impact of their decisions on their profits but also to evaluate the impact of their decisions on the environment and society. The Triple bottom line is also known as the *three Ps*; profit, people and planet. It prescribes three separate accounts based on the *three Ps* that organisations should report on, namely (1) profit account, (2) people account, and (3) planet account (Elkington, 1998). A triangular depiction of the *three Ps* is shown of Figure 2.

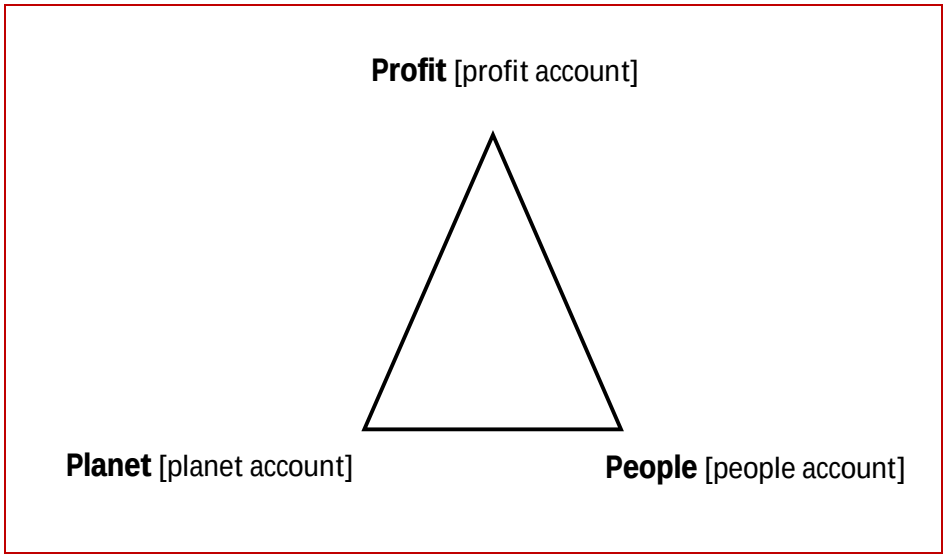

Figure 2: Triple bottom line triangle (Adapted from Elkington, 1998).

2.2.3.1 Profit account

The profit account measures an organisation's economic capital which can be subdivided into three types; financial, tangible, and intangible capital (for example reputation, skill, processes). Economic capital determines an organisation's potential to generate income (Hediger, 2000). According to Dyllick and Hockerts, (2002) an economically sustainable company is one that produces above average returns to its shareholders while maintaning its liquidty, whilst an organisation ceases to exist when there is no economic capital left.

2.2.3.2 People account

The people account keeps track of an organisation's social capital, an intangible asset that can be expressed as the strength of the relationships and trust between an organisation, its employees, and the community (Woolcock, 1998). According to Dyllick and Hockerts (2002) social capital is a measure of corporate social responsibility (CSR), which is an organisation's obligation to ensure that its policies and operations are compatible with the expectations and values of society (Douglas, Doris, & Johnson, 2004). CSR goes beyond providing acceptable working conditions for employees commonly referred to as human capital, it also assesses the extent to which an organisation is involved in societal development activities such as promoting human rights, democracy, and community improvement activities (Hemingway & Maclagan, 2004). In short CSR aims at positively affecting an organisation's stakeholders (Smith, 2003).

2.2.3.3 Planet account

The planet account measures an organisation's natural capital, a measure of an organisation's ecological footprint. Natural capital can be split into two forms: (1) natural resources and (2) ecosystem services. Any organisation utilises natural resources in its economic processes, be these renewable or non-renewable resources. To preserve natural capital, an organisation should not utilise renewable resources at a faster rate than the ability of the planet to replenish them. By the same token an organisation should not use non-renewable resources at a faster rate than the development of substitutes (Dyllick & Hockerts, 2002). The second form of natural capital, ecosystem services, focuses on ecosystem regeneration. (Ayres, 1989) used the notion of "*industrial metabolism*" which depicts industry as a living organism that uses energy and materials to produce products and services. The industrial organism emits waste to the ecosystem during product/service production, and the industrial system becomes ecologically unsustainable when the rate at which emissions are released to the ecosystem is higher than the rate at which the ecosystem can absorb such emissions through its natural sinks (Ayres, 1996).

2.2.4 Dimensions of sustainability

According to Herremans and Reid (2002) there are three dimensions of sustainability, the economic, social, and environmental dimensions. The economic dimension entails producing economic benefit for the company shareholders. The social dimension considers an organisation's activities in improving human living standards as well as operating within social and cultural expectations of the community. The environmental dimension focuses on the impact of an organisation's operations on the ecosystem and it seeks to measure an organisation's eco-efficiency which is the economic value generated by an organisation in relation to its combined ecological impact (Dyllick & Hockerts, 2002).

The three-ringed sector model below in Figure 3 graphically depicts the three dimensions of sustainability, but it is important to note that the model is over-simplified as it does not show the nature of the connections and interactions between the environment, economy and society (Palme, 2011).

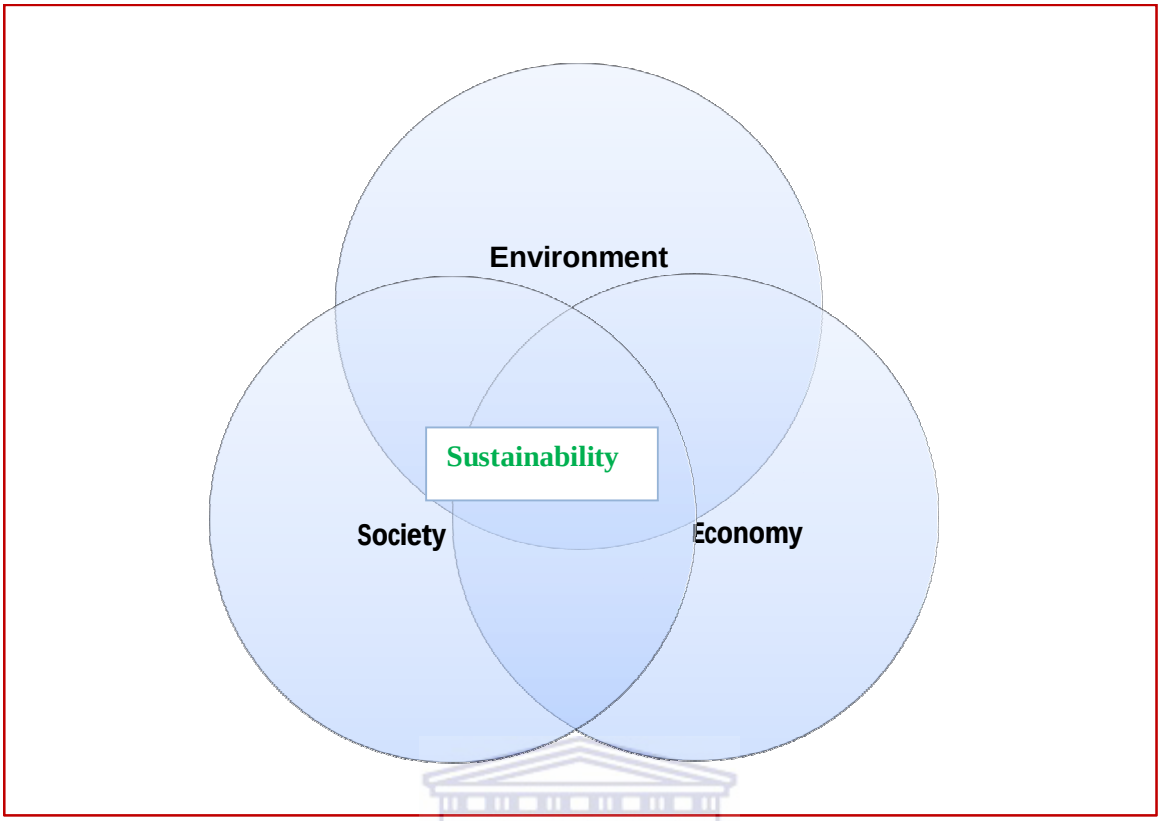

Figure 3: Three dimensions of sustainability (Palme, 2011)

Sustainability lies at the intersection of economic, social, and environmental dimensions and is the pointat which an organisation continues to exist in harmony with the society and environment it operates in (Herremans & Reid, 2002). Organisations need to fully integrate all the three dimensions to achieve optimal sustainability. Economic and social sustainability are beyond the scope of this study, which focuses on how ICT can be used to enhance the third dimension, 'environmental sustainability'. This dimension inevitably includes organisational premises – "green"/sustainable buildings which are directly a part of this study.

2.3 "Green" building

According to the literature, "green" building is not only good for the environment but also for the health of occupants, it also increases comfort thereby resulting in high levels of motivation amongst the occupants which in turn yields high productivity levels be it at a work environment or school environment (Cole, 1999). Tolan (2011) supports the view that "green" building makes financial sense as the long term financial savings outweigh initial construction costs. Questions arising from the literature are: what is "green" building? What does "green" building seek to achieve?

Just like the concept of sustainability Howe and Gerrard (2010) concurred that the definition of what constitutes a "green" building is still evolving. EPA (2010) defines "green" building as "*the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle from site choice to design, construction, operation, maintenance, renovation and deconstruction.*"

According to Howe and Gerrard (2010) "green" building seeks to efficiently use land, energy, water, and minimise the emission of pollutants and greenhouse gases while increasing the use of recycled and renewable resources. The objective is to build healthy, comfortable, and economically sound buildings while minimising the negative impacts on the environment during the entire life span of the structure (Pyke, McMahon, & Dietsche, 2010). "Green" buildings are sometimes referred to as smart, sustainable, intelligent, or high performance buildings. It is important to note that the efficiency/performance of a "green" building is an assesment applied throught out the life cycle of the building from construction to deconstruction.

"Green" buildings are characterised by improved indoor and outdoor air quality, high levels of energy and water efficiency, and much effort directed in minimising the use of external sources of energy (Van Wyk, 2008). Sustainable site and material resource management which involves land conservation practices such as recycling and reuse of materials at the building site, are also important characteristics of "green" building. Material resource management includes maximising the use of renewable and minimising the use of non renewable resources. Gunnell (2009) pointed out at the importance of using locally available resources to minimise transportation there by reducing the carbon footprint on the environment and promoting the local economy by creating jobs for the local society – and the approach pointed out by Gunnell's (2009) satisfy all three dimensions of sustainability.

The sustainability of a smart building is an assessment applied throughout the building's lifecycle, from building design, to construction, maintenance, up to decommission phase.

2.3.1 Sustainable/"green" building design

"Green" building design is a process in building planning that seeks to minimise the potential environmental impacts of a building and also evaluating plans of optimising building performance (Lloyd & Glazebrook, 2005). Joy and Jaya (2011) list among other performance criteria, minimising the use of non-renewable resources, efficient use of eco-friendly materials, and maximising recycling and use of renewable resources.

IEA (2003) specify an integrated design process that begins with drawing up a set of goals that act as a guideline on key decisions from design through to building maintenance. The initial broad goals are broken down into more specific design topics and refined into further specific sub-topics during the design process. An example of the initial goals can be set as:

Goal 1: To build an energy efficient building

Goal 2: To maximise the use of renewable material and energy resources

Goal 3: To maximise the use of locally available materials

Goal 4: To build a healthy and spacious environment

The performance of the end product (constructed building) is measured against these goals, hence their effectiveness is dependent on whether they are clear, measurable, and are understood by all the stakeholders including the design team (Deru & Torcellini, 2004). Evaluation of the design team's success can be enhanced by the use of clear set performance metrics and the use of building management systems (Hitchcock, 2003).

Deru and Torcellini (2004) concluded that building performance is directly related to the design goals, and as such buildings that go through green design process will perform better than conventional buildings where no or vague goals are set at the design stage

A regulation framework or set of standards is important to certify a building to ensure that implemented green designs are recognised. The following section will discuss "green" building standards.

2.3.2 "Green" building standards

"Green" building standards, also referred to as "green" building rating systems, seek to regulate and maintain the integrity of "green" building by encouraging environmentally sound building design and construction practices while promoting the integration of sustainability ICT (Jingwei, Ping, & Xue, 2011; USGBC, 2011). Although they contribute to the understanding of the environmental impacts of buildings, Ding (2008) is of the view that the relationship between building construction and the environment is still unknown.

Different standards use different evaluation criterion in measuring the 'greenness' of a building, and all the different standards have their limitations which, according to Ding (2008), may hinder their effectiveness. A common limitation lies in the assignment of weighting/points awarded for each evaluation criterion. This can be manipulated to improve the overall scores by concentrating effort on the evaluation criteria with the highest possible points, while paying or giving) little or no attention to\o those areas that do not carry a lot of

points. Holmes and Hudson (2002) pointed out that the actual effects of "green" building standards were difficult to ascertain and that the benefits of being rated or certified were not quantifiably measurable due to their nature. Yates (1997) noted that one of the key reasons people sought "green" certification/ accreditation was for public relations and marketing purposes.

There are many “green” building standards and programs internationally, with most of them driven or sponsored at government level, for example Sustainable Project Rating Tool (SPiRiT) – USA, Green Star – Australia, Green Star SA – South Africa, Comprehensive Assessment System for Built Environment Efficiency (CASBEE) – Japan, and Green Rating for Integrated Habitat Assessment (GRIHA) – India, amongst others (Ecolife, 2011). Most of these standards have their roots in two main “green” building standards namely: (1) Leadership in Energy and Environmental Design (LEED), and (2) Building Research Establishment’s Environmental Assessment Method (BREEAM). The followingsections will discuss these two standards, as well as two South African-developed “green” building standards namely, Green Star SA and the Sustainable Building Assessment Tool (SBAT).

2.3.2.1 LEED rating system

The LEED rating system was launched by the U.S Green building council in 2000 (Lockwood, 2006), and it has evolved since its inception from the pilot version LEED 1.0, through to LEED 2.0, LEED 2.2, and to the current LEED 2009 version (Jingwei *et al*., 2011). LEED 2009 provides rating tools for nine categories:

1) New Construction (NC)
2) Existing Buildings: Operations & Maintenance (EB: O&M)
3) Commercial Interiors (CI)
4) Core & Shell (CS)
5) Schools (SCH)
6) Retail
7) Healthcare (HC)
8) Homes
9) Neighbourhood Development (ND)

This study only discusses category 1, since it was the category of interest to Company-A’s planning for the construction of the new office building. The LEED for New Construction (LEED-NC) rating system is designed to assess and grade the performance of large construction projects such as office, high-rise residential and government buildings as well as

manufacturing plants. LEED-NC evaluates a building in seven key performance areas;: (1) sustainable sites, (2) water efficiency, (3) energy and atmosphere, (4) materials and resources, (5) indoor environmental quality, (6) innovation in design, and (7) regional priority (USGBC, 2011). It is important to note that LEED-NC performance areas are referred to as environmental sections in BREEAM.

The LEED-NC rating system uses points to evaluate environmental performance in each of the seven key performance areas. The weighting of the points is not even, the energy and atmosphere performance area weighs the most, while the regional priority performance area carries the least possible points as shown in Table 1.

Table 1: LEED -NC point allocation per performance area (USGBC, 2011)

	Performance area	Maximum Points
	Sustainable Sites	26
	Water Efficiency	10
	Energy & Atmosphere	35
	Materials & Resources	14
	Indoor Environmental Quality	15
	Innovation in Design	6
	Regional Priority	4
TOTAL POINTS		**110**

The percentage weighting per performance area is depicted in Figure 4.

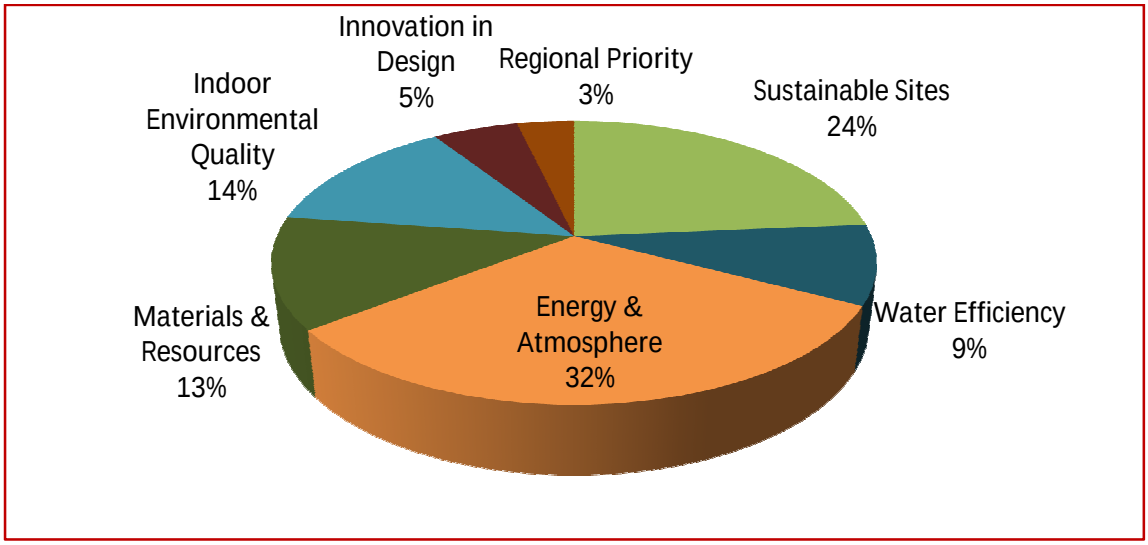

Figure 4: LEED-NC percentage weighting per performance area (Source: Author)

The final rating of a building rating is calculated by summing up the point scores from each performance area. The maximum possible total score for a building is 110 points. LEED has four rating/accreditation awards which are: Certified, Silver, Gold, and Platinum. A Platinum rated building will have the least negative impact on the environment (Lockwood, 2006). The table below shows the total number of points required for each accreditation award.

Table 2: LEED ratings (USGBC, 2011)

LEED rating	Required points
Certified	40-49
Silver	50-59
Gold	60-79
Platinum	80 and above

A building is rated certified, silver, gold or platinum depending on the total points scored. The BREEAM rating system offers a wider range of accreditation awards.

2.3.2.2 BREEAM rating system

According to Larsson (1998) BREEAM remains the most widely used standard, and countries like Australia and Canada have used it to develop their own standards (Ding, 2008). BREEAM was launched by the UK government in the early 1990s, to establish reliable assessment criteria to evaluate the environmental impacts of new and existing buildings. It seeks to distinguish buildings with minimal impact on the environment by setting high

standards exceeding those required by law and regulations, and to raise awareness of the benefits of "green" buildings. It also seeks to promote "*... best environmental practice in building design, operation, management and maintenance*" (Holmes & Hudson, 2002). BREEAM provides rating schemes for new constructions, communities, buildings in-use, refurbishments, and homes. For the purposes of this study only the *BREEAM New Construction* (BREEAM NC) scheme is discussed. The BREEAM-NC scheme provides rating tools for courts, data centres, education, healthcare, industrial, multi-residential, offices, other buildings, prisons, and retail facilities. Among these categories BREEAM-NC for office buildings is of interest to this study.

BREEAM-NC assesses a building's specification, design, construction and use against established benchmarks (Holmes & Hudson, 2002). The assessment is done based on nine environmental sections and these sections carry a specific percentage weighting in the calculation of the overall building rating (BRE-Global, 2012). The nine environmental sections and their corresponding weightings are shown in Table 3 below.

Table 3: BREEAM environmental section weighting (BRE-Global, 2012)

	Environmental section	Weighting
	Land Use & Ecology	10
	Water	6
	Energy	19
	Materials	12.5
	Health & Wellbeing	15
	Management	12
	Pollution	10
	Waste	7.5
	Transport	8
TOTAL POINTS		**100**

A building's environmental impact on each of these environmental sections is assessed and a score is allocated for the actual building performance in each section, bearing in mind the different weightings of these environmental sections. The final building rating is calculated by aggregating the points scored in each environmental section and the total is used to

determine the BREEAM-NC rating. The BREEAM-NC rating benchmarks from the 2011 version of BREEAM are shown in Table 4:

Table 4: BREEAM-NC rating benchmarks (BRE-Global, 2012)

BREEAM rating	Percentage score
Unclassified	0-29
Pass	30-44
Good	45-54
Very good	55-69
Excellent	70-84
Outstanding	85-100

An unclassified BREEAM rating represents a building that does not meet the minimum performance standards on key environmental categories for formal BREEAM certification (BRE-Global, 2012). Unlike LEED and BREEAM, the Green star SA rating system rates buildings in terms of stars.

2.3.2.3 Green Star SA

The Green Star SA rating system was developed by the Green building council of South Africa (GBCSA). It is based on the Australian Green Star rating tool which was developed as a combination of LEED and BREEAM (Fowler & Rauch, 2006). The Green Star SA rating system seeks to establish a common standard to evaluate green buildings and reduce the negative environmental impact associated with development. It aims to promote integrated green-building design, raise awareness of green building benefits, and recognise environmental leadership (GBCSA, 2012). The Green Star SA rating system offers rating tools for four categories which are: (1) offices, (2) retail centres, (3) multi-unit residential, and (4) public and educational buildings.

This study will only discuss Category 1, the Green Star SA rating tool for office buildings. The Green Star SA - Office rating tool is used to assess environmental merits of new office buildings as well as base renovations of existing office facilities. It awards two different certifications for the building design and for the actual building following construction completion. The design certification allows for the marketing of the proposed building and

the “green” strategies it will incorporate. The ‘As built’ certification assesses the extent to which “green” strategies were implemented on the completed office facility.

The rating tool assesses a building or building design on eight environmental impact categories. Similarly to the LEED-NC rating system, the Green Star SA – Office rating tool uses points to evaluate performance of a building in each of these categories. The weighting of the points is not even, the 'energy' category weighs the most while 'land use and ecology' category carries least possible points as shown on shown on Table 5:

Table 5: Green Star SA – Office category weightings (GBCSA, 2012)

	Category	Weighting
	Land Use & Ecology	7
	Water	14
	Energy	25
	Materials	13
	Indoor Environmental Quality	15
	Management	9
	Emissions	8
	Transport	9
TOTAL POINTS		**100**

Green Star SA has three star rating/accreditation awards which are: 4, 5, and 6 star awards. According to GBCSA (2012) a 4 star rated building under Green Star SA ratings signifies ‘best practice’, a 5 star signifies ‘South African excellence’, and a 6 star signifies ‘world leadership’ in minimising negative environmental impact of the building. The final building rating is calculated by summing up the point scores from each environmental impact category and the total is used to determine the Green Star SA rating as shown on Table 6.

Table 6: Green Star SA ratings

Rating	Required points
4 Star	45-59
5 Star	60-74
6 Star	75-100

The *Sustainable Building Assessment Tool (SBAT)* discussed in the following section is another South African-developed building assessment tool.

2.3.2.4 The Sustainable Building Assessment Tool (SBAT)

SBAT is a South African tool developed by the Council for Scientific and Industrial Research (CSIR) to assess the contribution of building performance to sustainable development in the context of a developing country. According to Gibberd (2002) the tool seeks to describe buildings in terms of their impacts on social, economic, and ecological systems as well as their contribution in supporting sustainability in these systems. As a result it uses social, economic and environmental performance indicators to calculate overall building performance. Table 7 shows an example of a building assessment with three assessment areas which are further split into five assessment sub-areas.

Table 7: SBAT building assessment results, adapted from (Gibberd, 2008)

Assessment area	Assessment sub-area	Score
Social	Occupant comfort	3.3
	Inclusive environments	4.1
	Access to facilities	2.0
	Participation and control	2.8
	Education, health and safety local contractors	4.1
Economic	Local economy	3.3
	Efficiency of use	2.5
	Adaptability & flexibility	2.2
	Ongoing costs	3.0
	Capital costs	1.3
Environmental	Water	3.4
	Energy	4.3
	Waste	2.5
	Site	4.1
	Materials and components	4.2
Rating		3.1

Each assessment sub-area carries a maximum score of 5 points. The final building rating is calculated by finding the average of the total score. To allow for an easy graphical representation , SBAT uses a radar diagram to present assessment results as shown in Figure 5.

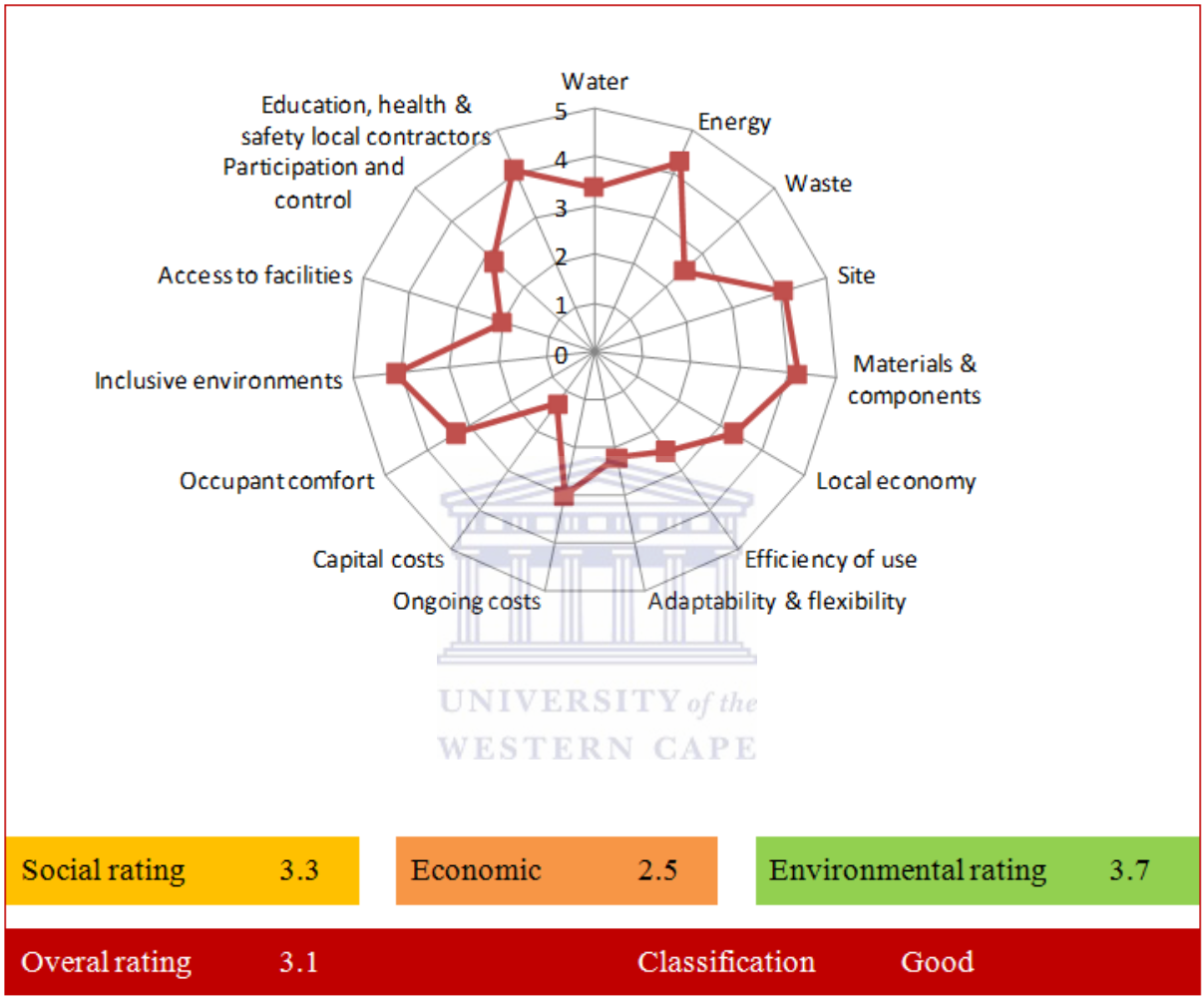

Figure 5: SBAT assessment radar diagram (Adapted from Gibberd, 2008).

Now that building standards have been discussed, one question that lingers is: what is the impact of ICT use on the buildings that these standards are used to rate. The literature shows that innovative use of ICT can greatly improve a building rating and its use is not limited to one assessment area. This study will only focus on its use to improve the environmental aspects of buildings; this type of ICT is referred to as “green” ICT. The following section will discuss “green” ICT in detail.

2.4 **"Green" ICT**

The terms "green", cool, smart and sustainable ICT are often used interchangeably in the literature. For the purpose of consistency this study will use the term "green" ICT to refer to the aforementioned terms. Molla *et al*. (2008) pointed out at the lack of a common understanding of the term "Green" ICT and proposed four attributes of "green" ICT;

1. ICT's contribution in addressing the challenges surrounding IT infrastructure,
2. ICT's contribution to reducing environmental impacts of business IT activities,
3. ICT's support for environmentally sustainable business practices,
4. ICT's role in a low carbon economy

For a complete definition of "green" ICT to be drawn it should encompass all of these four attributes (Pradipta & Young, 2009). "Green" ICT is therefore defined as:

> *... a systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of IT products and services in order to reduce IT, business process and supply chain related emissions, waste and water use, improve energy efficiency and generate tangible and intangible green economic rent. (Molla, Cooper, & Pittayachawan, 2009)*

According to Hart (1997) there are three types of sustainability goals in "green" ICT, which are: pollution prevention, product stewardship, and clean technology.

1) Pollution prevention attempts to minimize the level of emissions, effluents, and electronic waste (e-waste). This can be achieved through the use of virtualisation, thin client technology, and flexible printing capabilities.
2) Product stewardship focuses on both reducing pollution and also minimising the adverse environmental effects associated with the full life cycle of an ICT product through recycling computers and reuse of ICT components. This is also known as the *'cradle-to-cradle'* approach, where the end state of one product is involved in the beginning of another (Watson, 2007).
3) Clean technology refers to the use of technology that creates minimal or no harmful emissions or waste. Paperless interaction 'dematerialisation', video conferencing and collaboration tools are some of the technologies used to reduce an organisation's carbon footprint (Esty & Winston, 2006).

Some researchers have sought to describe and explore the concept of “green ICT” by aligning it to ICT life cycle phases, and have come up with broad categories referred to by Vykoukal, Wolf, and Beck (2009) as the three dimensions of “green” ICT.

2.4.1 Three dimensions of “green” ICT

Vykoukal *et al*. (2009) described “green” ICT as the intersection between three dimensions, namely: (1) "green" design and manufacturing, (2)"green" use, and (3) "green" disposal. The conceptualisation is rooted in the widely accepted view in the literature that the assessment of sustainable ICT should cover the whole ICT product life cycle (Elliot, 2007). Mitrovic (2011) also concurred with this view by pointing out that the use of ICT has become a significant contributor to environmental degradation throughout all its lifecycle phases. Figure 6 depicts the three dimensions of "green" ICT as conceptualised by Vykoukal *et al*. (2009).

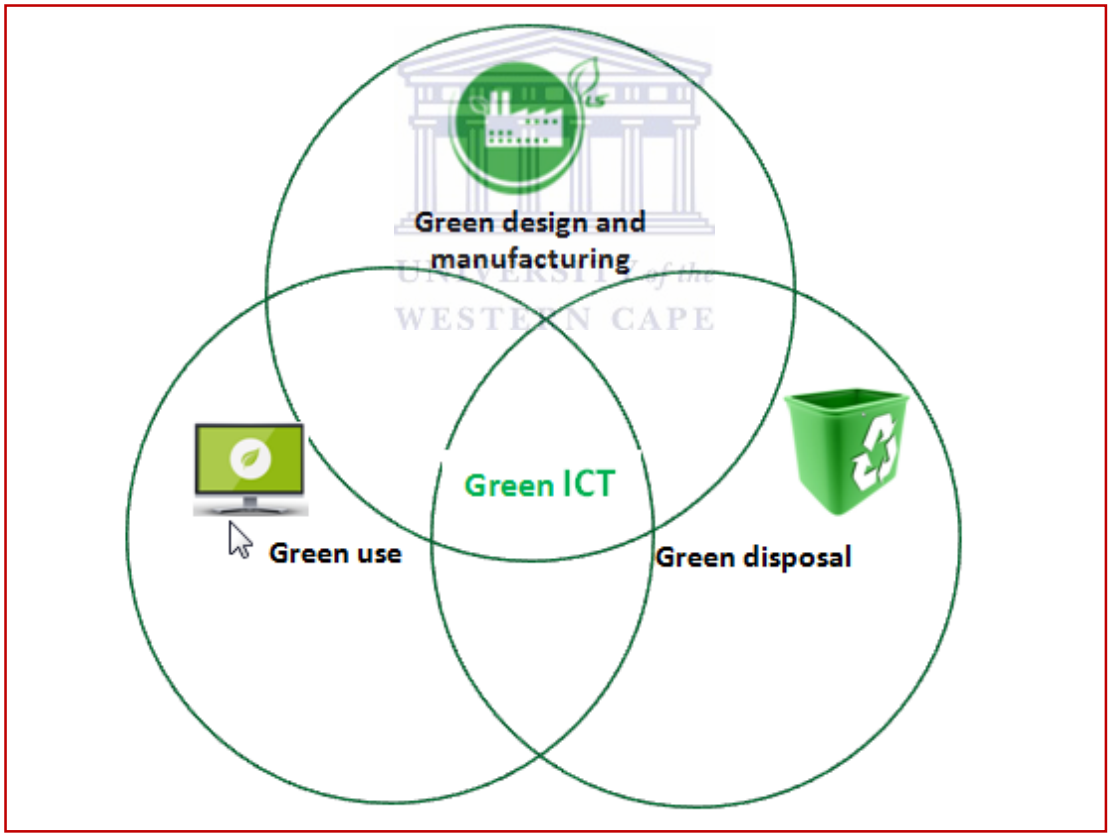

Figure 6: Three dimensions of “green” ICT (Source: Author)

2.4.1.1 “Green” design and manufacturing

“Green” ICT design focuses on designing eco-friendly and energy efficient ICT equipment, through the adoption of new ICTs that are both environmentally friendly and economically

sound (Vykoukal *et al*., 2009). An example of such "green" technology design is the move from Cathode ray tube (CRT) monitors to more eco-friendly and energy efficient liquid crystal display (LCD) and light emitting diode (LED) monitors. These and other "green" technologies such as virtualisation, cloud computing and thin client computing are discussed in detail in section 2.6 (*Technologies used in "green" information systems*). "Green" ICT manufacturing on the other hand focuses on the need for ICT manufacturers to improve their production processes so that they produce eco-friendly and energy efficient ICT equipment from a life cycle point of view (Vykoukal *et al*., 2009).

2.4.1.2 "Green" use

This dimension focuses on the environmental impacts and opportunities brought forth by the use of ICT. Environmental impacts of ICT use can be classified under three categories; first, second and third order effects (Hilty, Arnfalk, Erdmann, Goodman, Lehmann, & Wager, 2006; Erdmann, Hilty, Goodman, & Arnfalk, 2004).

1) First order or primary effects are created by the physical presence of ICTs together with the processes involved (Erdmann *et al*., 2004).
2) Second order or secondary effects are created by continued use of ICTs. They can be classified under three types; substitution, optimisation, and induction effects. The use of personal computers (PCs) as modern typewriters exhibit all three types of second order effects. Through the use of PCs, documents can be sent as soft copies instead of hard copies and read directly from the screen - '*substitution effect*'. Credit to document processing software tools errors can easily be identified and corrected before documents are printed - '*optimisation effect*'. A user can now print a lot of document pages by a series of clicks - '*induction effects*' (Hilty, Seifert, & Treibert, Information systems for sustainable development, 2005).
3) Third order or tertiary effects are an aggregated result of ICT use by a large number of people over a long period of time leading to a change in lifestyle or economic structures, for example telecommuting and the transformation towards electronic commerce (Jason, 2010).

When it comes to "green" ICT use the literature emphasises ICT-related energy consumption and increasing energy efficiency. However the 'green' use dimension also looks at: recycling and reuse of ICT resources, minimising CO2 emissions due to ICT use, reducing paper use through dematerialisation techniques, skilling and motivating ICT users with "green" ICT usage skills, and so forth. This dimension is of significant importance in answering the main

research question of this study and as such it is discussed in further detail in section 2.7 (*"Green" ICT use in smart buildings*).

2.4.1.3 "Green" disposal

Due to the ever shortening life span of ICT hardware as technology innovation and continuous improvements move at a faster pace organisations are faced with a need to continuously replace and dispose of their older ICT equipment - hereafter referred to as electronic waste (e-waste)'. E-waste has been proved to be environmentally unfriendly as most of it ends up in landfills and some of it contains toxic substances such as mercury.

Some researchers like Murugesan (2007) have urged organisations to consider reusing, refurbishing, and recycling old ICT equipment to reduce ICT environmental footprint. The reuse of IT hardware aims at extending the life cycle of IT hardware by prolonging its use i.e. giving it to those who need it, a typical example is the donation of old PCs to schools. Refurbishing refers to the process of upgrading the old hardware by using components from retired equipment to meet the functional needs that would otherwise have been met using new hardware. *"If IT hardware cannot be reused or refurbished it has to be recycled or at least properly disposed of in an environmentally friendly way*" (Vykoukal *et al.*, 2009).

Now that "green" ICT has been defined and its dimensions discussed it is important to determine the reasons why some organisations are implementing "Green" ICT and green business practices. Is it purely on environmental grounds? The following section will explore driving and inhibiting factors that influence organisations to/from implementing "green" ICT.

2.4.2 Drivers and inhibitors of "green" ICT

This section explores the drivers and inhibitors of "green" ICT to find out what are the push or pull factors that influence organisations towards as well as away from implementing "green" ICT. It also looks at the influence of the government on "green" ICT capacity.

2.4.2.1 Drivers

Molla (2008) identified three drivers of "green" ICT as: economical, regulatory and ethical.This section will discus these three drivers.

1) Economic drivers focus on maximising cost savings from the use of ICT. Molla (2008) noted that as global businesses expand, the volume of corporate data also increases thereby raising the demand for larger servers in the data centres implying

increased power usage and real estate costs to cater for a larger data center. According to Rasmussen (2006) energy costs of data centres are estimated to exceed the cost of the ICT hardware. The need to reduce energy and real estate costs might push organisations to implement "green" ICT to establish data center efficiency (Molla, 2008).

2) Regulatory drivers refer to mandatory or voluntary requiredments to comply with certain regulations. "Green" ICT-related regulations and guidelines are fomulated by professional and inter-governmental bodies, for example the Energy Star certification for data centres and the pending carbon tax policy by the South African National Treasury department that will impose a tax on carbon dioxide (C02) emissions (National Treasury, 2010). Mines and Davis (2007) noted that at present compliance with environmental regulations and guidelines is voluntary, and predicted a change in the trend as more organisations set emission targets and join carbon trading schemes (Molla, 2008)
3) Ethical drivers refer to organisations adopting "green" ICT as part of sustainable business practices, in a move to be recognised as socially and environmentally responsible entities. Research has shown that an increasing proportion of investors and customers take an organisation's environmental performance into consideration as a factor in their business decisions (Molla, 2008). Porter & Kramer (2006) and Sen, Bhattacharya, & Korschun (2006) claimed that corporate social responsibility is now being used as an opportunity for competitive branding and to attract new business from investors and customers.

It is important to also look at factors that hinder organisations from adopting and implementing "green" ICT, and the following section discusses some of these factors.

2.4.2.2 Inhibitors

According to a study on the Australian ICT industry, conducted by Molla *et al*. (2010), lack of demand for "green" ICT was cited as the most important factor discouraging large and medium organisations from implementing "green" ICT. Some of the inhibitors included lack of skill and senior management leadership. The same study showed that financial constraints and a lack of clarity of the potential value to businesses in implementing "green" ICT were also significant factors inhibiting "green" ICT capacity in the hardware and software sectors respectively (Molla *et al*., 2010).

The government can significantly influence organisations in terms of their adoption of "green" business practices either directly by enforcing regulations designed to protect the environment, or indirectly through tax exemptions as a reward for taking initiatives towards protecting the environment. The following section discuses South African government's contribution in supporting "green" technology.

2.4.3 South African government support for "green" ICT

According to Fernando and Okuda (2009) government plays a significant role in promoting "green" ICT. In his 2011 national budget speech, the South African minister of finance Pravin Gordhan allocated substantial amounts of money for green economy initiatives. Additional allocations were also made to fund research into energy-efficiency technologies. A total of R2.2 billion was allocated for environmental programmes over the next medium term period (Gordhan, 2011). It is apparent that "green" ICT is at the centre of the South African government strategy towards a green economy as is evidenced by the financial resources made available to stimulate research into "green" technologies. A question that comes forth is: 'What pushes the government to pursue these "green" initiatives?'

Apart from the economic and social benefits at national level, global treaties can be factors behind a government's push towards environmentally friendly policies and regulations. South Africa produces 65 percent of Africa's CO2 emissions, and as an active member of the Kyoto Protocol the National Treasury department has proposed carbon tax in a move to curb CO2 emissions (Devarajan, Go, Robinson, & Thierfelder, 2009).

2.4.4 "Green" ICT standards and labels

There are a number of established "green" ICT standards and labels also known as eco-labels that assess the impact of an ICT product on the environment. Eco-labels provide the purchaser with basic product and process information (Anderson, Backhouse, Curtis, Redding, & Wallom, 2009). Product information refers to the environmental characteristics of an ICT product, for example a product's power consumption during operation. Process information describes the production processes followed during the production phase of an ICT product (Anderson *et al.*, 2009). This section will discuss widely used eco-labels and concludes with an assessment of their impact and effectiveness.

2.4.4.1 Energy Star

The Energy Star program was launched in 1992 by the U.S Environmental Protection Agency (EPA) and the U.S Department of Energy (DOE) as a labelling program that sought to promote energy efficient products and reduce greenhouse gas emissions, and it was initially introduced for computers and monitors (Brown, Webber, & Koomey, 2002).

An ICT product can only qualify for the Energy Star label when its energy use in standby, sleep, and running modes falls within the Energy Star guidelines (Anderson *et al*., 2009). According to Brown *et al*. (2002) utilising Energy Star labelled office equipment can save as much as 30 to 70 percent of power usage.

2.4.4.2 European Eco-label

The European Eco-label (EU Eco-label) is a general label developed by the European Union in 1992 that covers a wide range of products and services, the label has different product groups where products of the same type are assessed for their impact on the environment. Only products with the least negative environmental impact are awarded the EU Eco-label (Anderson *et al*., 2009). The product groups include electronic equipment, household appliances, and paper products. These product groups are revised every three years to keep the assessment criteria up to date with market changes and technical improvements. The electronic equipment group includes products such as personal computers, portable computers and televisions (EU, 2012). The Eco-label for personal computers can only be awarded if the product meets the following criteria:

Table 8: EU Eco-label assessment criteria for personal computers (EU, 2012)

1. *The product consumes less energy during use and standby*
2. *It contains less substances that are dangerous for health and the environment*
3. *The product can be taken back free of charge by the manufacturer after use*
4. *It can be easily dismantled and recycled*
5. *The product durability is increased through up-grades*

The assessment criteria for portable computers is the same as that of personal computers with the exception that it also seeks to ensure that portable computers use less polluting batteries

2.4.4.3 Electronic Product Environmental Assessment Tool (EPEAT)

Launched in 2006, EPEAT is a rating system for electronic products that seeks to encourage consumers to buy eco-friendly electronic products to reward manufacturers who demonstrate environmentally friendly practices and innovation (EPA, 2010).

EPEAT offers a wider set of environmental assessment criteria than the two systems discussed above. It does not focus only on energy efficiency but also covers the whole product lifecycle of ICT hardware such as desktops, laptops and monitors. It evaluates products from the product design phase to the production phase where it considers the impact of the materials used, to the operational phase where it looks at the energy consumption and CO2 emissions, up to the disposal phase where is assesses the recyclability and reusability of the product (Anderson *et al.*, 2009).

EPEAT requires compliance with the IEEE 1680 standard. There are 22 required and 28 optional criteria that products are assessed on. For a product to be awarded an EPEAT rating it must meet all the required criteria. EPEAT has three rates; bronze, silver and gold which are awarded depending on how many of the optional criteria a product meets. Table 9 shows the requirements for each rating.

Table 9: EPEAT ratings (Source: Author)

Rating	Description
Bronze	Complies with all required criteria
Silver	Complies with all required criteria and at least 50% of the optional criteria.
Gold	Complies with all required criteria and at least 75% of the optional criteria.

2.4.4.4 Impact and effectiveness of eco-labels

According to Teisl, Roe, and Hicks (2002) most literature has tried to measure the effectiveness of eco-labels based on the changes in consumer awareness after exposure to label information. Teisl *et al*. (2002) argued that this assessment is misleading as it assumes that consumer awareness and purchasing behaviour have a positive correlation which in reality is not necessarily true. Chase and Smith (1992) echoed the same sentiments andtheir

study revealeld that although most consumers are aware of the different eco-labels in the market, they do not believe or understand all that the labels claim.

According to D'Souza (2004) environmental labelling has created a misconception that consumers can make environmentally friendly decisions when purchasing electronic products. D'Souza argued that, with the ever-increasing number of 'eco-labels' on products, consumers are failing to identify the differences between them. A study by Chase and Smith (1992) showed that as many as 70 percent of consumers who participated in a survey claimed that their purchasing decisions were sometimes influenced by marketing advertisements and product labelling. Marketing strategists/strategies have taken advantage of this, with labels falsely or misleadingly claiming that products are eco-friendly. Although in some small respect, some products may be recyclable, ozone friendly etcetera, very often this is only true of a small proportion or an unimportant aspect of the product, however it successfully misleads consumers seeking to be environmentally mindful in their shopping (West, 1995).
While the idea behind the use of eco-labels remains a noble one, questions may arise questioning the integrity of these labels and whether they are achieving their intended goals, especially as consumers' good intentions can be undermined by the false information supplied by marketing opportunists.

2.5 Requirements for sustainability IS

This section seeks to identify "*ingredients*" for coming up with an integrated eco-friendly information system. It is important to go back to the basics of what an information system is and what its components are before the environmental aspect is considered.

The term information refers to structured data that has value/meaning, and is built to enable communication and knowledge construction (Carvalho, 2000; Glazer, 1991), and the term system is defined as an integrated set of elements interacting together to achieve some common objective (Emery, 1969). An information system is a set of elements that include computer hardware, software, people, procedures and data interacting together to collect, store, and process, transmit, or to display information (Tatnall, Davey, Burgess, Davison, & Wenn, 2002; Kroenke & Dolan, 1987). Alter (2008) expresses it as a work system in which people, machines or both perform work using information technology, and other resources to produce specific products or services for internal or external users.

2.5.1 Linking IS and business: the IMBOK framework

The successful establishment and maintenance of a "green" information system lies in an organisation's ability to uniquely identify and manage the different components of an information system in an environmentally friendly manner. The Information Management Body of Knowledge (IMBOK) is an information management framework that explains the relationship between information technology, information systems and the business processes in a way that enhances effective information management, which is in turn a key to the establishment and maintenance of a "green" information system. It is designed to help organisations generate value from their ICT investments; hence its primary objective is the fulfilment of business strategy (Bytheway, 2011).

The IMBOK as depicted in Figure 7 identifies five knowledge areas of managerial concern:

- Information technology
- Information systems
- Business processes
- Business benefits
- Business strategy

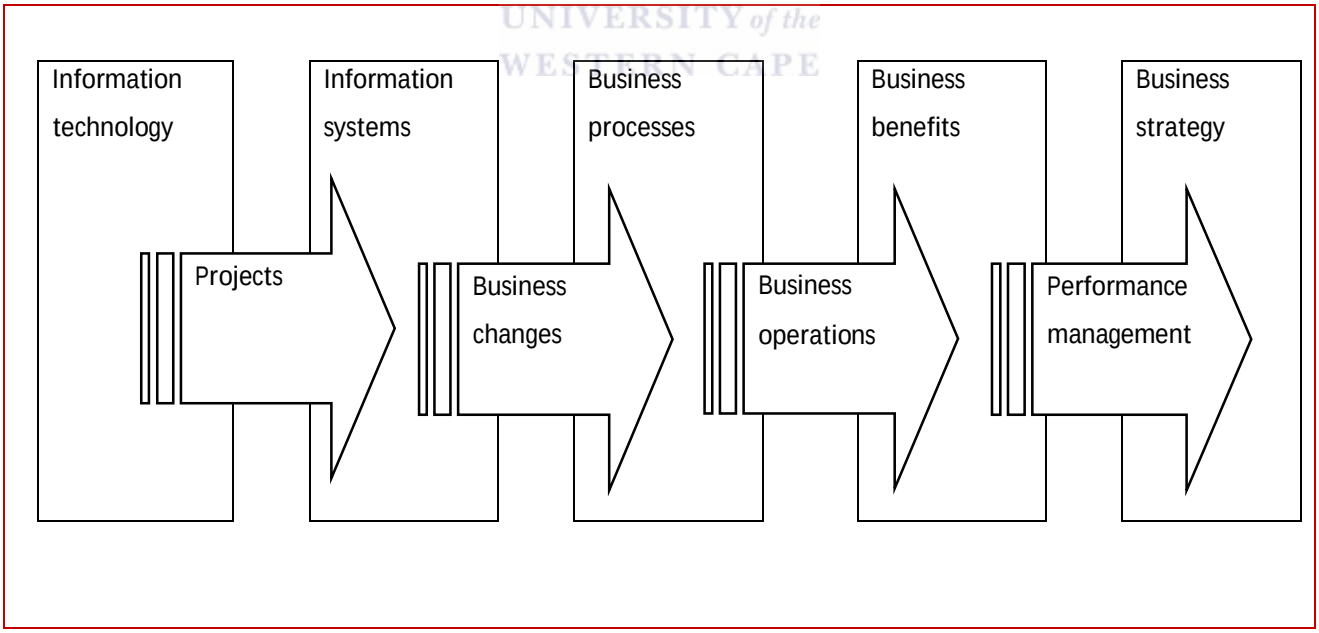

Figure 7: IMBOK Framework (Bytheway, 2004)

2.5.1.1 IMBOK knowledge areas

1) **Information technology:** This knowledge area focuses on the different software and hardware technologies used in an organisation. Management is faced with challenges in keeping up with the fast changing technologies, and this knowledge area seeks to equip management with knowledge of how to make the optimal use of technology at a time when technology is changing at an ever faster rate (Bytheway, 2004).
2) **Information systems:** This knowledge area focuses on integrated system components that include technology, processes, and people. Bytheway (2004) places emphasis on the need to move from cost-ineffective traditional methods of in-house information system development to purchasing ready-made solutions in the form of software packages. However in-house development can be justified when a business has unique requirements or when such development gives an organisation a competitive advantage over its competitors.
3) **Business processes:** A business process is a set of activities structured in a logical order. It is viewed from *"one boundary of a business to the opposite boundary"* (Bytheway, 2004) and its objective is to add value to an organisation (Aguilar-Savén, 2004; Scheer & Nüttgens, 2000). This knowledge area emphasises the need to adopt business process management and focuses on how business processes can be improved by applying Information systems.
4) **Business benefits:** This knowledge area seeks to clarify questions such as: to what extent is the business benefiting from the information systems in place? What are those benefits and how are they being measured? Bytheway (2004) argues that the management of business benefits related to investments in information technology is not well understood and attributes this to lack of understanding of business processes. Management should be in a position to clearly state the required business benefits and anticipate these benefits early in the investment analysis cycle.
5) **Business strategy:** The essence of a business strategy is an integrated set of actions, usually formulated by top management in the pursuit of a competitive advantage (Day, 1984) .This knowledge area tackles issues of strategy formulation and implementation, according to Bytheway (2004) strategy formulation is relatively easy compared with implementing strategy. The literature has shown that business strategy is more effective when technology strategy is linked to it (Adler, 1989; Kantrow, 1980; Althonayan, 2008)

2.5.1.2 IMBOK processes

As shown in Figure 7 the five knowledge areas are linked to each other by a set of processes namely: projects, business changes, business operations, and performance management. Information system *'projects'* are carried out to support business strategy with information technology, *'business changes'* in business processes might be required as a result of adopting a new information systems which will also affect *'business operations'*. *'Performance management'* is required to gauge the extent to which business strategy is achieved (Mitrovic, 2010).

2.5.2 Using IMBOK to establish a "green" information system

While IMBOK equips information system managers with effective information management skills, it does not include the environmental aspect in its knowledge areas as well as in the processes involved. This brings forth the question: how can the IMBOK framework be used as the foundation for an organisation to build and manage a "green" information system on? This section seeks to answer this question by proposing a "green" information system based on the IMBOK knowledge areas and processes as shown on Figure 8.

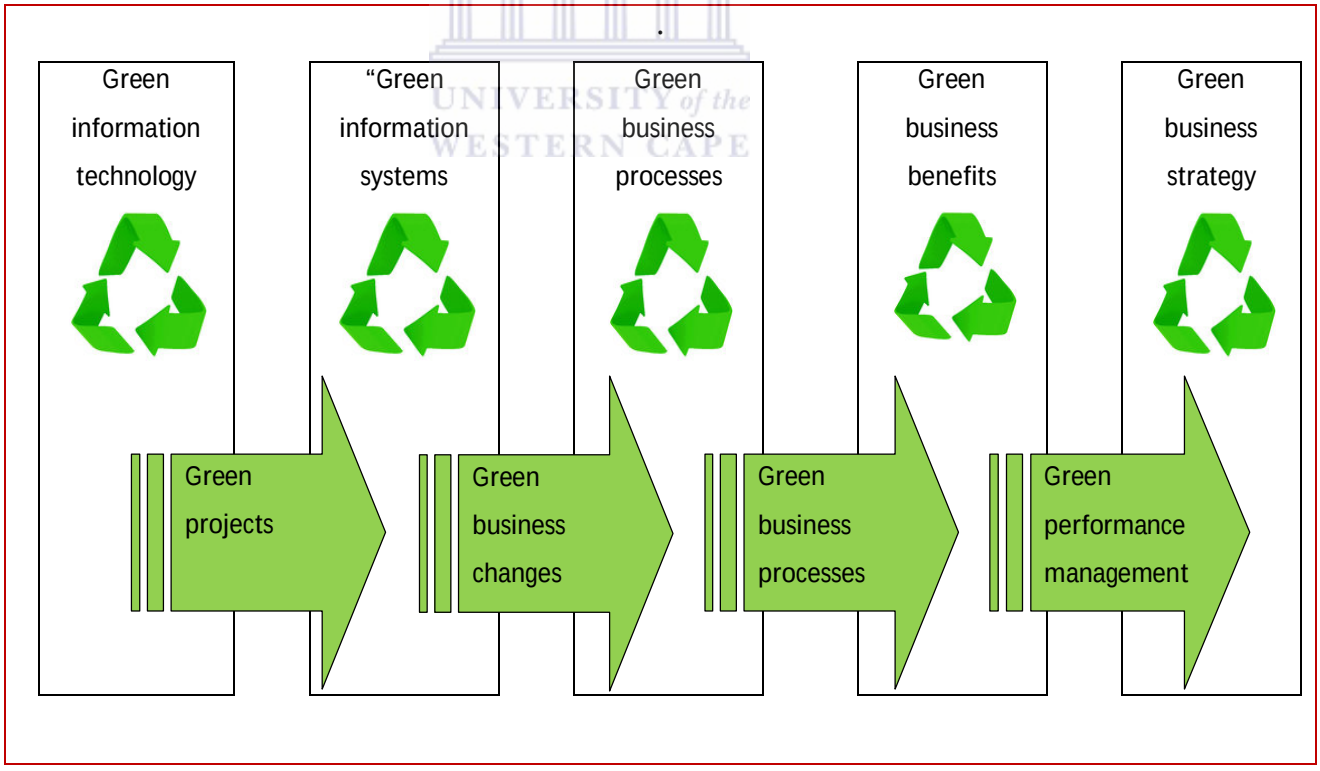

Figure 8: "Green" IS based on the IMBOK Framework (Adapted from Bytheway, 2004)

The modified framework above adds three triangular arrows in each knowledge area, resembling a continuous iteration cycle of "*greening*" processes within each IMBOK knowledge area. This emphasises the point that sustainability is not a once-off process, but rather a continuous process that involves continuous "green" performance measurement and improvement.

2.5.2.1 "Green" IMBOK knowledge areas

"Green" information technology is used in *"green" information systems* which improve business processes into *"green" business processes* that when properly managed yield "*green "business benefits*. "Green" business benefits are usually expressed as performance targets entrenched in *"green" business strategy* (Bytheway, 2004).

2.5.2.2 "Green" IMBOK processes

Change management is essential in authorising and monitoring information system changes, it is essential for the change board to consider the environmental impacts of all tabled changes. For example if there was a change request to replace old printing machines, the change board should consider the environmental issues such as energy consumption of the new printing machines, and an organisation could opt to purchase a few shared printing machines with print-to-email capabilities to minimise energy use and paper printing. Another important environmental aspect to consider would be the disposal of the old printing machines, 'e-waste'. Prior to authoring such a project, management should ensure the use of "green" technology and project methods ("green" projects).

From the above example it is evident that *"green" business changes* brought about through *"green" projects* will also affect business operations in an environmentally friendly manner and give birth to *"green" business processes* as the business operations move from paper based business processes to dematerialisation. *"Green" performance management* is required to gauge the extent to which "green" business strategy is achieved. The following section discusses software and hardware technologies used in "green" information systems

2.6 Technologies used in "green" information systems

This section explores widely used technologies in the field of "green" information system. Most of these technologies emphasise energy efficiency, and to some extent e-waste reduction, as well as dematerialisation. This section focuses more on the environmental impacts, and to a lesser extent it also points out non-environmental shortfalls of technologies.

2.6.1 Virtualisation

Virtualisation is a method of dividing computer hardware into multiple execution environments known as virtual machines, using a software abstraction layer called a *Virtual Machine Manager* between the computer hardware and operating system (Nikitasha, Jyotiprakash, & Subasish, 2011). It uses technologies like hardware partitioning and time sharing to allow a single physical server to provide the same functionality as multiple physical machines (Sridhar, 2009).

Nikitasha *et al*. (2011) identified resource sharing and data isolation as the two main benefits of virtualisation. Since virtualisation is synonymous to centralising a number of physical servers into a single physical hardware unit, it therefore inherits the advantages and disadvantages of a centralised system. Virtualisation reduces the carbon footprint of the server estate by significantly cutting down on power and air conditioning requirements in sharp contrast to multiple physical servers (Agarwal & Nath, 2011). It also reduces real estate costs as it lessens the demand for larger data centres.

Despite the benefits of virtualisation the disadvantages of a single point of failure and security risks associated with it pose a significant hindrance towards virtualisation.

2.6.2 Cloud computing

Cloud computing is a pay-per-use model for enabling convenient, on-demand network access to a shared pool of configurable and reliable computing resources (e.g., networks, servers, storage, applications, services) that can be rapidly provisioned and released with minimal consumer management effort or service provider interaction. (Mell & Grance, 2009)

Traditionally, organisations used to acquire, configure, and maintain their own ICT hardware. Garg & Buyya (2012) observed that this trend is changing from an ownership-based to a rental-based approach, as organisations are now outsourcing hardware infrastructure services to a third party 'Cloud provider'. Cloud computing allows users remote access to computational infrastructure as and when needed without the client having to worry about infrastructure maintenance (Garg & Buyya, 2012). Zamani, Mobin, and Ahmad (2011) likened cloud computing to a form of the internet and referred to it as "*... a shift in the geography of computation.*"

Figure 9 depicts a simplified example of a cloud computing architecture.

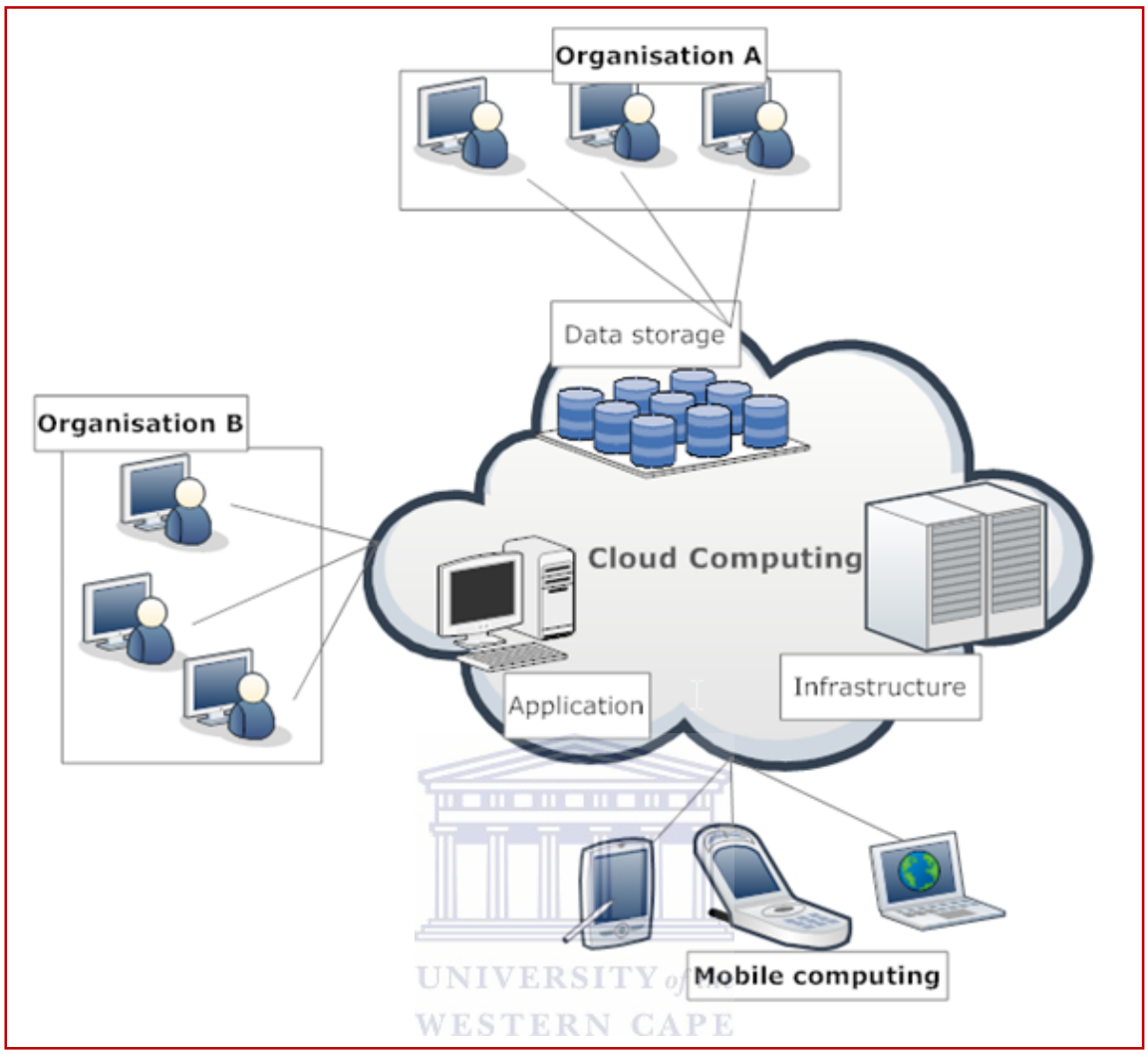

Figure 9: Cloud computing (Adapted from SmartDraw, 2012).

The Environmental benefits of cloud computing lie in the centralisation of ICT resources that are shared by different organisations, thereby allowing for re-use of ICT resources amongst the Cloud users. Recommendations for cloud computing have been centred on its energy efficiency. Instead of having a number of traditionally-energy inefficient data centres owned by different organisations, cloud data centres allow infrastructure sharing, thereby saving energy and reducing CO2 emissions (Garg & Buyya, 2012). Like any centralised system, cloud services are subject to outages, software attacks or loss of data, a risk that repels organisations contemplating using cloud computing (Marston, Li, Bandyopadhyay, Zhang, & Ghalsasi, 2011).

2.6.3 Grid computing

Grid -computing was coined from n analogy with the electrical network (Irving, Taylor, & Hobson, 2004). The idea is to offer computational resources on demand by simply plugging into a Grid just as one plugs into a power Grid for electrical energy. It uses open source software to allow multi-institutional and virtual organisations to share computational resources such as computers, software, and data. Grid users do not need to know where the computing 'power' is being supplied from (Coveney, 2005; Foster, Kesselman, & Tuecke, 2001).

Establishing a grid involves installing middleware software on a set of computers in a network. The middleware performs user authentication, coordinated scheduling of tasks across distributed hardware or software resources, and also keeps track of resource locations (Foster *et al.*, 2001). It is more like the *World Wide Web* but not anyone can access it, it has its registered users and controlled access (Irving *et al*., 2004). Grid computing provides organisations with high computational power, while being energy efficient i.e. without having to build their own data centres (Vykoukal *et al*., 2009). By using re-existing resources on the Grid, the use of Grid technology reduces the amount of hardware that would have otherwise been acquired by each virtual organisation on the Grid to meet its needs. Reduced hardware means less energy consumption, CO2 emissions and e-waste.

2.6.4 Thin client computing

Thin client computing, also referred to as server based computing relies on a central server for processing and data storage. Users connect to the central server over a network using client terminals, here referred to as ‘thin-clients’. Thin clients act as input and output terminals with no processing capabilities. Figure 10 depicts a simplified thin-client computing architecture.

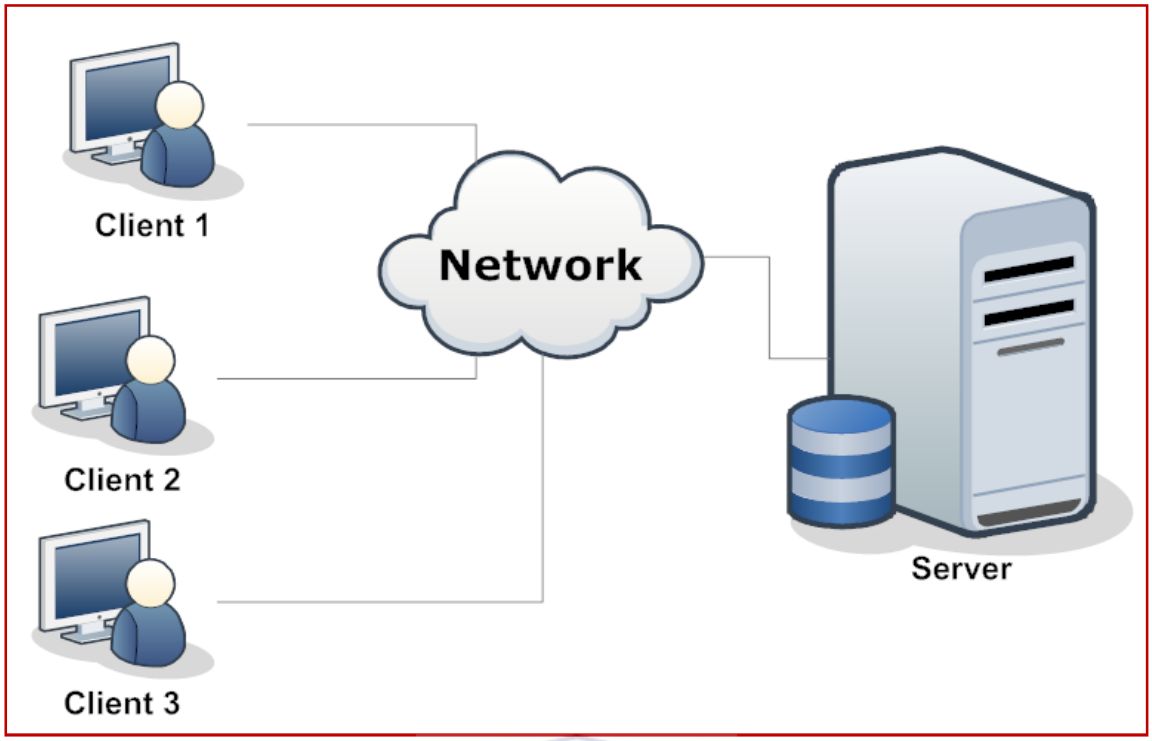

Figure 10: Thin client computing architecture (Source: Author)

Since thin-clients are display and capturing terminals (input/output terminals) with no central processing units (CPU), they tend to use less power compared to traditional desktop computers. According to Agarwal and Nath (2011) thin-clients use about 12% of the energy used by a normal workstation, resulting in reduction of energy costs. Due to the reduced amount of ICT hardware, thin client computing reduces e-waste disposal material because of the absence of CPUs on thin clients.

2.6.5 Environmentally friendly monitors

CRT monitors have been observed to be environmentally unfriendly to the environment compared with other types of monitors, such as LCD monitors. In a study by Socolof, Overly, and Geibig (2005) comparing the ecological impacts of CRT and LCD monitors, CRT monitors scored low points in the following environmental categories: resource use, energy consumption, ozone depletion, e-waste space use, and human health toxicity (Kiatkittipong, Wongsuchoto, Meevasana, & Pavasant, 2008). LCD monitors consume as much as 80 pecent less energy compared to CRT monitors (Chilamkurti, Zeadally, & Mentiplay, 2009).

Until more recently, LCD monitors were a hit in the marketplace their low power consumption and because they are so lightweight. However, modern technology has seen the introduction of LED monitors which have a longer lifespan, offer better color and picture

quality while using less energy compared to LCD monitors. Additionally LED monitors do not use mercury, a toxic chemical used in LCD and CRT monitors (Florin & Mastorakis, 2010).

2.6.6 "Green" network devices

"Green" networking looks at all aspects of the network such as *"...personal computers, peripherals, switches, routers, and communication media*" (Chilamkurti *et al*., 2009). It seeks to improve energy efficiency and reduce any negative environmental impacts of network components throughout their life cycle. According to Kakemizu and Chugo (2009), an increase in network traffic volumes also increases network power consumption and organisations are increasingly making use of techniques such as 'sleep control' to reduce network power consumption. Sleep control saves energy by setting a network device to sleep-mode when it is not in use. While sleep control is an innovative energy saving technique Kakemizu and Chugo (2009) cautioned that sleep control capabilities are more effective when applied to large area networks (LANs), or home networks with a large number of devices, "*low network traffic volumes handled by individual networks, and low device operating ratios*". The type of network traffic also has a significant impact on the network power consumption, for example an increase in video traffic requires the use of packet buffers, which in turn requires high power consumption. Some of the power efficient switching and routing technologies include eco-switching and eco-routing.

- Eco-switching is a switching method that reduces power consumption by reducing the need for memory usage through "*eliminating packet buffering and routing*." (Kakemizu & Chugo, 2009). Switching based on pseudo time slots rather than referencing routing tables reduces the need for both buffer and routing table memory.
- Eco-routing seeks to save energy by aggregating paths, then setting as many routers as possible to sleep mode when network traffic volumes are low.

The use of fibre optics and wireless technologies can significantly reduce the amount of energy used in the transmission of data, however there are some limitations hindering the use of these types of technologies, such as: (1) high costs associated with manufacturing and laying-out of fibre optic cables, (2) loss of power over distance associated with wireless networks, and (3) vulnerability of wireless networks to interference.

The protocols used in data transmission also affect network efficiency:

"*Network efficiency can be enhanced by the design of protocols used. Reducing the number of bits associated with a transmission and minimising network load will optimise communication efficiency. Where fewer bits are transmitted, less processing operation will be required at nodes, fewer finite power resources consumed during transmission and less carbon emitted...*" (Peoples, Parr, McClean, & Morrow, 2012).

Networks are the basis upon which travel substitution technologies are built, the next section discuses some of these technologies.

2.6.7 Travel substitution technologies

Travel substitution technologies can substitute the need for face-to-face business meetings that require travelling, thereby reducing travel costs and carbon footprints associated with travel. Technologies such as video and teleconferencing were originally designed to facilitate communication without having eco-efficiency particularly in mind. However, they have since shown that they can significantly reduce global business travel (Toffel & Horvath, 2004). Skouby and Windekilde (2010) envisaged that video and teleconferencing could be substituted for between 5 and 20% of global business trips. Travel substitution technologies also include tele-presence technologies, collaboration tools, internet-based webinars and so forth. Mingay (2007) pointed out at the need to change employee attitudes towards travel by increasing employee sensitivity to eco-efficiency and sustainability, and encouraging the use of travel substitution technologies.

2.7 "Green" ICT use in smart buildings

Now that smart/"green" buildings, their attributes, and "green" building standards have been discussed , this section will seek to explore the use of sustainable ICT in smart buildings. IT innovation is at the core of the existence of smart buildings - the fact that IT innovation is listed as an independent performance area in most "green" building standards gives credence to this notion. The use of "green" building management systems has greatly improved the performance of smart buildings. The following section gives a brief discussion of "green" building management systems, also known as building automation systems.

2.7.1 "Green" building management systems

Heating, cooling, ventilation, and lighting systems, as well as electronic appliances, are necessary in maintaining occupant comfort and functionality - however they are the primary consumers of energy (Klein, Kavulya, Jazizadeh, Kwak, Becerik-Gerber, & Varakantham,

2011). “Green” building management systems seek to minimise building energy consumption while still offering occupant comfort. They use a network of sensors, controls and activators to monitor and record a building's internal and external environmental data in real-time. This data is then used to provide intelligence in order to automatically maintain a specific environmental state (Keane & Kelliher, 2001).They use techniques like occupancy-based lighting and demand-control ventilation to regulate energy use (Worthington, 2009).

Klein *et al*. (2011) noted that building management systems usually operate according to a fixed set of rules and schedules, which are designed to ensure satisfactory air conditioning and luminance at all times regardless of whether parts of the building are occupied or not. Tailoring building management systems to be more flexible and adaptive in controlling air conditioning and room lighting according to actual occupancy loads can offer great opportunities to reduce building energy consumption (Nicol & Humphreys, 2009). An agent based building management system is an example of a flexible and adaptive control system.

2.7.1.1 Agent based building control system

Agent based building control systems are driven by a network of interacting intelligent agents. Intelligent agents are entities that can perceive environmental changes using some kind of a sensor and then apply some rule(s) to take an action (Treado & Delgoshaei, 2010). They can either be “*... physical or virtual entities that intelligently interact in an environment*” (Klein *et al*., 2011).

Agents can be classified under five basic categories which are simple reflex, model based reflex, goal based, utility based, and learning agents. Simple reflex agents operate using simple *'If-Else'* rules to respond to a condition, model based reflex agents keep an internal model of the environment (or part of it), and they then use the model to select an action. Goal based agents keep information on predefined desirable environmental states *'goal states'*, and the agents respond to environmental changes by choosing an action with the aim of attaining a desirable state. Utility based agents are able to differentiate among possible states using some utility function or metric to select goal states, and learning agents are more sophisticated agents in that they can build and accumulate knowledge which makes them able to operate in an unknown environment (Treado & Delgoshaei, 2010). Figure 11 depicts a basic structure of an agent.

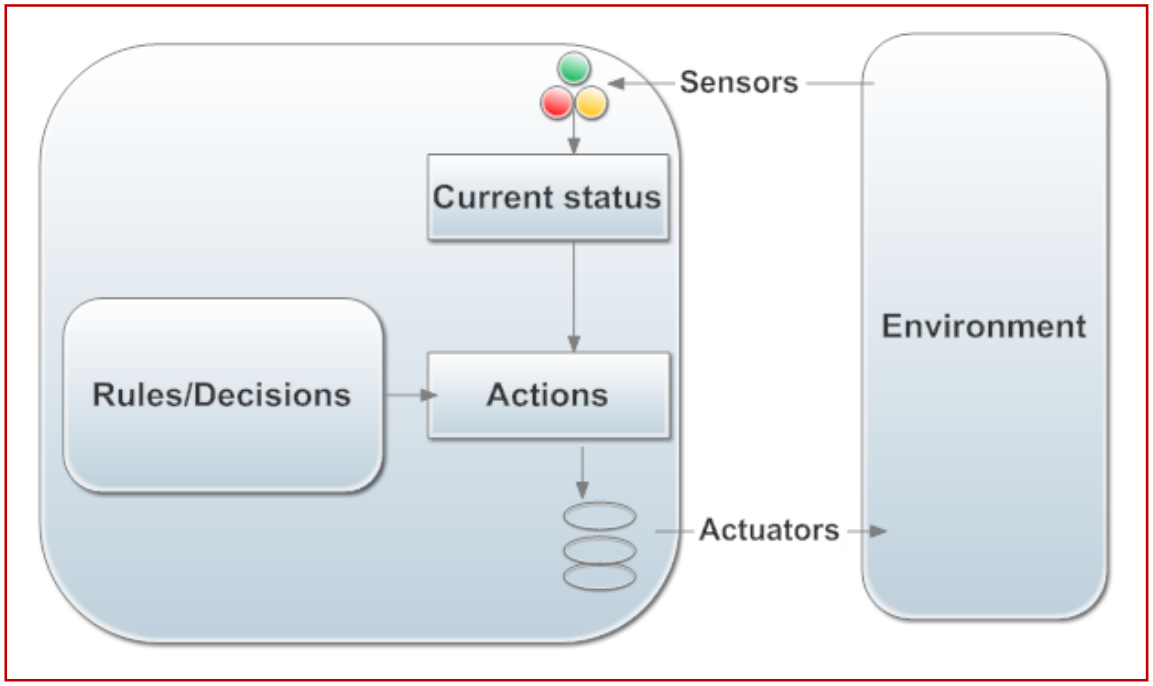

Figure 11: Intelligent agent structure (Adapted from Treado & Delgoshaei, 2010).

When certain events such as a sudden increase in room temperature occur, system agents will pick up these changes using sensors (e.g. electronic thermometers) and execute some appropriate rule(s) that will in turn trigger actuators (e.g. air conditioners) to some take re-adjustment action(s) with the aim of regulating the environmental conditions to some preferred state (Boman, Davidsson, Skarmeas, Clark, & Gustavsson, 1998).

2.7.1.2 The multiple agent system (MAS)

The MAS proposed by Davidsson and Boman (2005) is one of the many agent based systems in the literature and among some already in use, this section will describe the architecture and functionality of the MAS with the objective of illustrating how ICT can be used in an environmentally friendly manner in "green" buildings.

The MAS is a Bluetooth-based system which uses a collection of software agents that monitor and control environmental parameters in an office building. It seeks to increase occupant satisfaction while reducing energy consumption (Davidsson & Boman, 2005). It uses three types of agents; personal comfort, room, and environmental parameter agents.

i. Personal comfort agents are located in mobile devices like personal digital assistants (PDAs) and they contain individuals' personal preferences such as room temperature. Each agent here represents a person, and it communicates with other agents using Bluetooth.

ii. Room agents are localised agents in the sense that they control specific rooms or areas in the building, using individual preferences drawn from personal comfort agents. They seek to minimise energy consumption in the rooms or areas that they control.

iii. Environmental parameter (EP) agents monitor and control specific environmental parameters within a particular room. They seek to achieve and maintain a certain environmental state in a specific room using sensors for monitoring and then sending commands to relevant actuators to initiate corrective action(s) if necessary (Davidsson & Boman, 2005).

The MAS continually polls room agents that detect the location of PDAs in the building (the assumption here is that every person carries their PDAs with them at all times. When a person moves from one room to another, the *room agent* of the new location sends an information request to the *personal comfort agent* that stores the personal preferences of the individual. The *personal comfort agent* then passes the requested information back to the *room agent,* which will then execute some rule(s) using these preferences to decide on what the new environmental state should be. After calculating the new desired environmental state, the *room agent* passes this information on to the relevant *EP agents* that will try to achieve and maintain the calculated environmental state (Davidsson & Boman, 2005).

The agents are programmed with some general working rules which can be modified by the system administrator - some examples of MAS general working rules are depicted in Table 10.

Table 10: MAS general working rules, adapted from Davidsson & Boman (2005)

Rule	Description
1	Room agents must maintain some default environmental conditions in all empty rooms.
2	If a person is in her office, environmental conditions are adjusted to her personal preferences; else the room agents will maintain some default environmental conditions as per rule 1.
3	If another person other than the one who normally works in that office enters, the environmental conditions in that office do not change. The exception is that the lights will go on if the room was empty.
4	In meeting rooms, the temperature is adjusted to the mean value of all the meeting participants' temperature preferences, and the light intensity is adjusted to the highest preference value.
5	For other common rooms, like corridors and canteens, rule 1 applies whether there are people in the room or not. When a person enters a common room the lights will be turned on if the room was empty.

The MAS allows for human intervention by making it possible to manually override agents' decisions through "... *physical interaction with the electrical equipment*" (Davidsson & Boman, 2005), for example a room agent can decide to switch on the lights in a meeting room as per rule 4 but if the meeting participants need to dim the lights to use a projector, they should be able to switch off the lights through an electric switch.

ICT devices consume a significant proportion of energy used in a building, and the following section discusses methods and ideas in the literature that relate to reducing the amount of energy consumed by ICT devices.

2.7.2 Reducing ICT-related energy consumption

A great deal of attention is directed towards reducing energy consumption and increasing energy efficiency in smart buildings, and it is increasingly evident that ICT plays an integral part in attaining energy efficiency in smart buildings, however the growing energy consumption rate of ICT has been a cause for concern for environmentalists. Coroama and

Hilty (2009) noted that ICTs' demand for energy is growing at a faster rate than the total energy demand, and much of this demand is attributable to data centres.

2.7.2.1 Energy efficient data centres

Data centres' energy consumption is significantly higher than that of ordinary commercial office space (Sun & Lee, 2006). Using Eskom's 2012/13 revised standard average price increase, a typical rack of servers drawing 20 kilowatts of power at 60.66 cents per kWh would cost an organisation more than 100 thousand rand per year (NERSA, 2012; Greenberg, Mills, Tschudi, Rumsey, & Myatt, 2006). The cost will escalate depending on the number of racks in the data centre.

According to Greenberg *et al*. (2006), the effective supply of cool air and waste heat collection hereafter referred to as air management, has a direct impact on energy efficiency. There are many design and operational practices used in data centre air management such as proper arrangement of racks of computers, reducing obstructions to suitable airflow, and raised flooring. Figure 12 depicts a typical hot aisle-cold aisle arrangement "*where racks of computers are stacked with the cold inlet sides facing each other and similarly the hot discharge sides facing each.*"

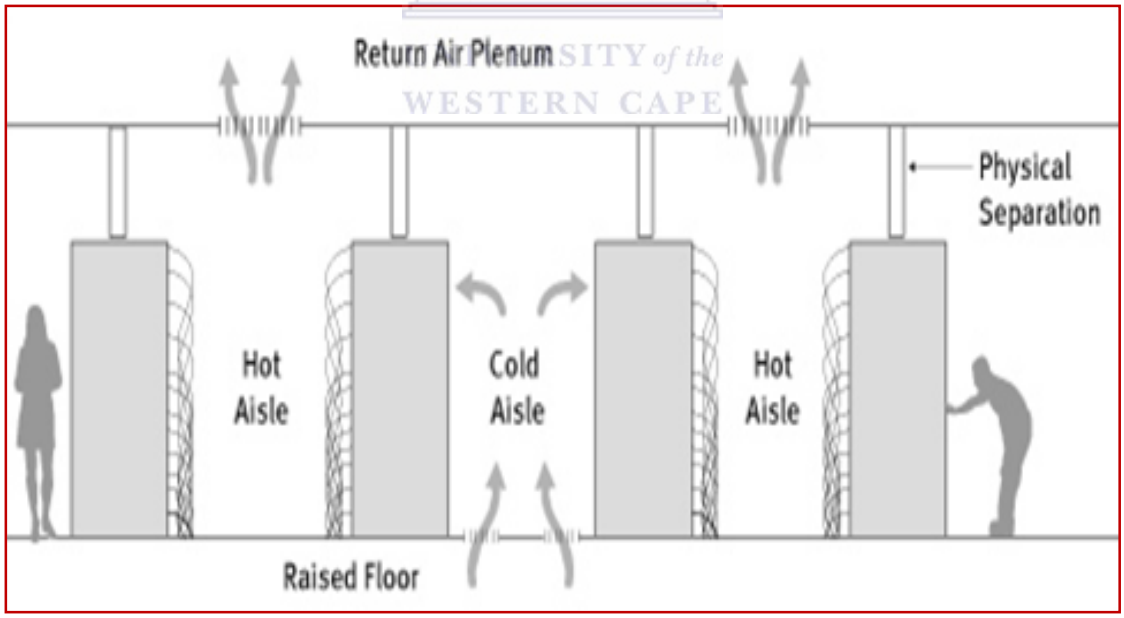

Figure 12: Typical hot aisle-cold aisle arrangement (Greenberg et al., 2006)

The idea of raised floors has been around since the early years of data centre design, and according to IBM (2011) the major effects of raised floors are:

- Improved operational efficiency and flexibility in hardware arrangement.

- Increased space between the two floors which can be used to supply cooling air to the equipment area.
- Increased flexibility for future layout change with minimum reconstruction cost.
- Secured interconnecting and power cables.
- Minimised tripping hazards.

Reflecting back on Figure 12, a physical barrier is required to separate the hot aisle from the cold aisle to avoid hot air in the hot aisle, due to waste heat, mixing with cold air in the cold aisle. Cold air is then supplied to the cold aisle and waste heat extracted from the hot aisle. Since cold air is denser than warm or hot air, it will eventually settle close to the surface below warm or hot air hence cold air can be supplied from above or through perforated tiles below but collection of hot air should be done from above. Equipment that requires more cooling should be placed closer to the ground (GDCA, 2010). The hot exhaust air from the hot aisles is extracted and cooled by modular computer room air conditioning units (CRAC) located within or close to the data centre (Sharma, Bash, & Patel, 2002). These CRAC units are basically industrial air-conditioning units that employ different methods of cooling (Fakhim, Behnia, Armfield, & Srinarayan, 2011). Liquid cooling is a widely used cooling method in data centres mainly because of its higher heat transfer coefficient compared to air-cooling (Mohapatra, 2006).

The concept of liquid cooling in data centres began in 1964 when IBM introduced first water cooled products which used chilled water pumped directly to the ICT hardware. There it was used to cool inter-board heat exchangers across multiple stacks of boards populated with cards (Schmidt, 2005). Figure 13 depicts a schematic view of a liquid cooled data centre

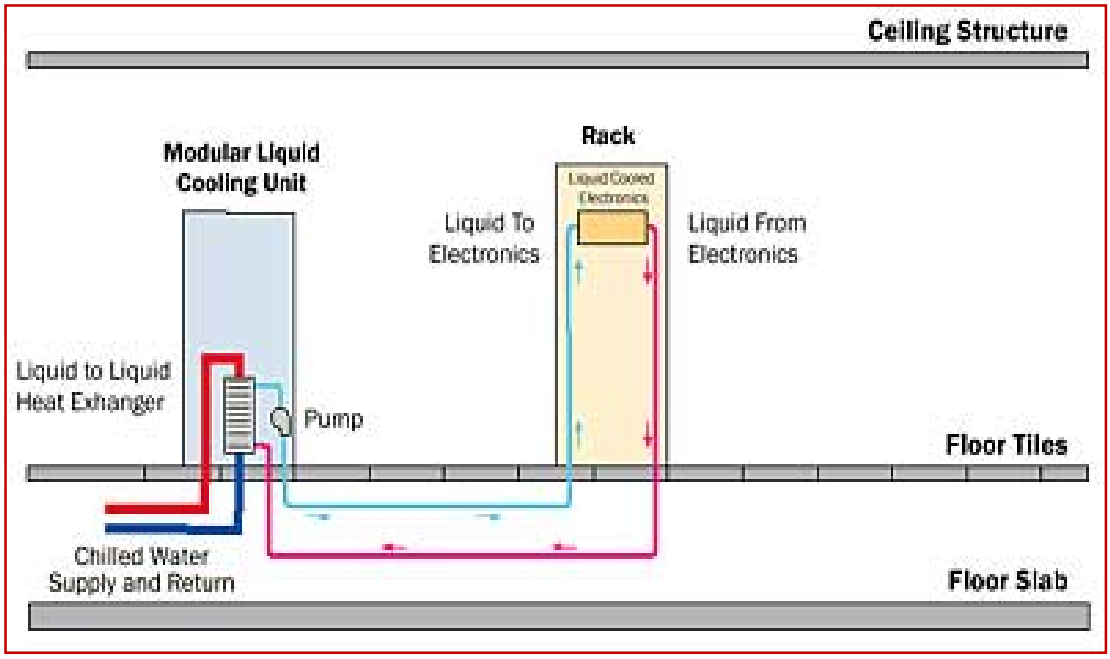

Figure 13: Data centre liquid cooling (Schmidt, 2005)

The modular liquid cooling unit also contains a buffer between the building chilled water and the secondary water loop that supplies conditioned water to the racks (Schmidt, 2005).

Energy consumption of ICT devices can also be reduced indirectly by influencing the use of these devices, which may entail changing the norms of ICT use by the system users; this is discussed in brief in the following section.

2.7.3 Energy saving through behavioural change

In addition to implementing sustainability ICT, people need to be skilled with "green" practices so as to change their habits and behaviour towards saving energy. Building occupants and the overall IS should share a common interest in the environment and such an interest can be cultivated in the minds of the occupants through campaigns and information workshops with the aim of arousing emotion, which in turn may motivate change (Henryson, Håkansson, & Pyrko, 2000). Building occupants can assist in reducing energy consumption by changing from two monitors to using one monitor, avoiding use of external devices such as usb-cup-warmers, switching off their PCs when they leave, as well as adopting other non-ICT related energy efficient habits such as using the stairs instead of elevators.

Sharing ICT equipment such as printing machines has a double positive effect firstly, in that less energy is consumed compared to the energy that would have been consumed if IS users had individual printing machines attached to their PCs, and secondly it discourages needless

printing thus minimising toner and paper usage. Ideally users should be discouraged from paper printing and urged to make use of softcopies and electronic communication (e-communication), and if printing is necessary double-sided printing on recycled or recyclable paper should be encouraged. Some of these habitual and behavioural changes may not always be feasible under different scenarios. It is important to stress that employee behaviour and ICT usage skills is beyond the scope of this study.

2.8 Applicability of the literature review findings to this study

In order to answer the main research question on how ICT can be used to support a sustainable building this chapter explored the literature around three key phrases within the research question namely: (1) environmental sustainability, (2) sustainable building, and (3) ICT to support environmental sustainability. A set of key points for empirical testing are derived from each key phrase.

Figure 14 depicts the logic used to extract the three key phrases from the main research question.

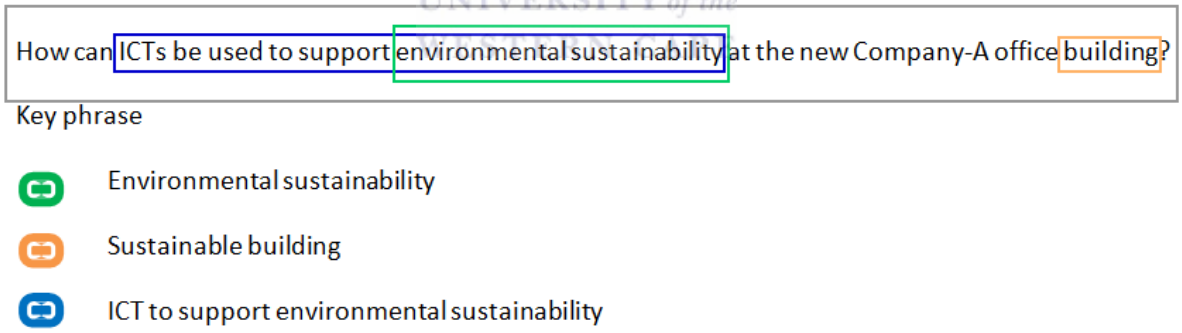

Figure 14: Key research phrases (Source: Author)

2.8.1 Environmental sustainability

This key phrase was explored from the history of sustainability dating back to early 1960s from the early environmental movements down the time line highlighting major events or milestones to the present day understanding of sustainability. Sustainability has been pursued at international level with the main focus on protecting the environment, while there is consensus on the need for continuous economic growth, and international gatherings and

resultant treaties have sought to ensure that governments pursue economic growth not at the expense of the environment hence giving rise to the term 'sustainable development'.

It is important to note that there is no hard-and-fast definition of sustainability in the literature. The concept of sustainability continues to evolve with time. Palme (2011) described sustainability by dividing it into three "*dimensions*", namely economic, social and environmental sustainability. The environmental sustainability dimension was the major focus of this study.

One of the key points for empirical testing on the key phrase, 'sustainable environment' was: **Meaning of environmental sustainability**.

Referring back to the main research question the next key phrase was sustainable building

2.8.2 Sustainable building

There are various terms in the literature that are used to refer to sustainable building, for example "green", intelligent and efficient building among others. The *sustainable building* key phrase was discussed in detail in section 2.3 (*"Green" building*). This section sought to describe what "green" building is and what its characteristics are.

The process of "green" building is more concerned about the efficient use of environmental resources in the construction and maintenance of buildings during their time of use while managing efficient building waste disposal to the environment. Buildings that are characterised by efficient resource and waste disposal management are referred to as sustainable, "green", smart, intelligent or efficient buildings. There are various "green" building standards used to rate and regulate "green" building by encouraging environmentally friendly building design and construction practices.

Key points for empirical testing obtained from the key phrase, sustainable building are:

- Efficient use of environmental resources
- Efficient waste disposal to the environment
- Environmentally friendly building design and construction practices

2.8.3 ICT to support environmental sustainability

The third key phrase of the research question relates to the environmentally friendly use of ICT, commonly referred to "green", cool, smart, or sustainability ICT. There are various definitions of "green" ICT but what stands out the most from these various definitions is that

they seek to describe “green” ICT based on its contribution towards reducing negative environmental impacts of business IT activities, and how ICT can support for environmentally sustainable business practices. According toVykoukal *et al*. (2009), literature has limited sustainability ICT to its use only, and therefore emphasised the importance of assessing the environmental impacts of ICT throughout its overall life cycle. Vykoukal *et al*. (2009) suggested a three dimensional view of sustainability ICT made up of three dimensions namely; *“green” design and manufacturing*, *“green” use*, and *“green” disposal*. Since Company-A has limited influence on the “green” design and manufacturing of ICT hardware the researcher focused on the *‘“green” use’* dimension and to some extent on the *‘“green” disposal’* dimension.

In order to effectively describe “green” ICT use, the chapter sought to put into context the system in which ICT is used in, i.e. “green” IS. Section 2.5 (*Requirements for sustainability IS*) sought to identify a framework for coming up with an integrated eco-friendly IS, and the researcher used the IMBOK framework to explain the relationship between ICT, IS, business processes, business benefits, and business strategy. For a “green” IS to be established it is in the interests of the implementing organisation to ensure continuous “green” performance measurement and improvement processes within each IMBOK knowledge area.

The chapter also explored several technologies used in “green” information systems such as virtualisation, cloud, grid and thin client computing, as well as eco-friendly monitors, “green” network devices, and travel substitution technologies. Most of these technologies focused on energy efficiency, e-waste reduction, dematerialisation, and reducing carbon footprints.

The final part of the chapter explored the literature on sustainability ICT use in smart buildings with a focus on how ICT can be used to improve performance/ efficiency of such buildings. The researcher explored agent based building control systems as an example to illustrate some uses of sustainability ICT in smart buildings. Smart buildings are characterised by their efficient use of power, and although “green” ICT use significantly helps to reduce overall power consumption in smart buildings, the power consumption of ICT devices - most notably data centres - continues to grow at a faster rate than that of ordinary business power consumption (Coroama & Hilty, 2009). This has given rise to research on approaches or models to setting up power-efficient data centres such as hot aisle-cold aisle arrangements, and the use of liquid cooling, amongst others.

Key points for empirical testing from this key phrase are:

- Environmentally friendly use of ICT.
- ICT contribution towards reducing the negative environmental impacts of business activities.
- ICT support for environmentally sustainable business practices.
- Environmental impacts of ICT throughout its overall life cycle.
- Framework for coming up with an integrated eco-friendly IS.
- Technologies used in “green” information systems.
- Use of “green” ICT in smart buildings
- Reducing overall power consumption in smart buildings
- Approaches or models for setting up energy efficient data centres

2.8.4 Conceptual model

The phrase conceptual model and conceptual framework are often used interchangeably in the literature, and according to Miles and Huberman (1994) a conceptual model is a graphical or narrative explanation of key points, factors, or variables and how these variables are inter-related as perceived by the researcher. Figure 15 depicts a conceptual model derived from the key points for empirical testing. The diagram portrays the relationship of different knowledge areas as subcomponents of broader knowledge areas.

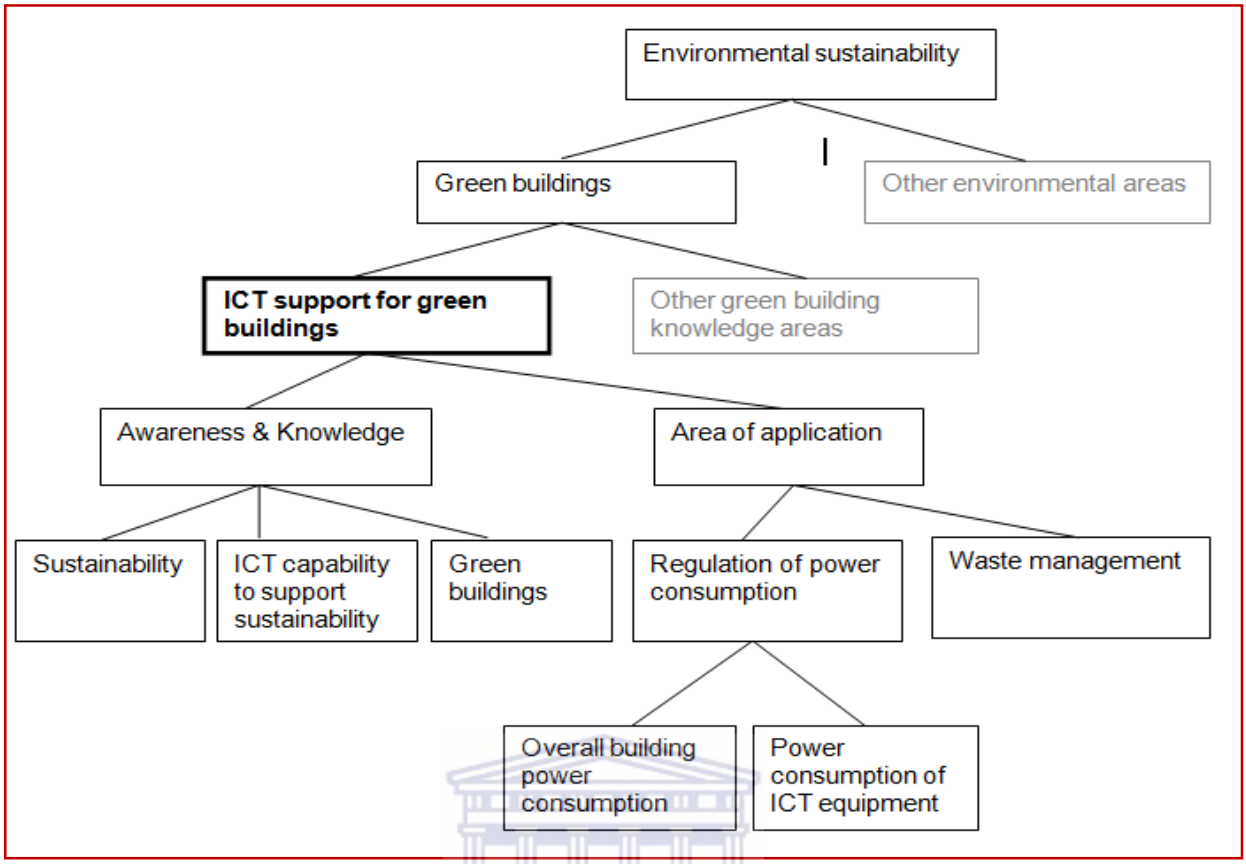

Figure 15: Conceptual model (Source: Author)

Literature has shown that the concept of sustainability is very broad with three dimensions, however only environmental sustainability is within the scope of this study. "Green" buildings seek to conform to environmental guidelines that aim at to be environmentally sustainable, and as a result **"green" buildings** are a subcomponent of **environmental sustainability**. There are various knowledge areas within the "green" buildings component such as the use of renewable materials and energy but **ICT support for "green" buildings** was the topic of this study hence other "green" building knowledge areas were not covered.

To address the main research question the study focussed a lot on the following subcomponents under **ICT support for "green" buildings:**

a) **Awareness:** this subcomponent is concerned with the level of appreciation/awareness of sustainability, ICT capability to support sustainability, and smart buildings.

b) **Area of application:** this subcomponent covers two application areas of "green" ICT support for smart buildings, namely; regulation of power consumption, and waste management.

- **Regulation of power consumption:** this subcomponent seeks to find out the methods and techniques that can be used to reduce the power consumption of the building overall, and that of ICT equipment.
- **Waste management:** this subcomponent looks at how ICT can support environmental sustainability in a smart building through reducing waste disposal to the environment. It covered areas such as e-waste disposal and CO2 emissions.

2.9 Chapter conclusion

This chapter has explored "green" ICT from the history of sustainability and the literature has shown that the concept of sustainability continues to evolve. The existence of numerous different definitions of sustainability has led some researchers to conclude that it is context dependent. The literature has also shown that sustainability ICT owes its existence to the world focus on environmental sustainability which has resulted in researchers seeking ways in which ICT can contribute to support a "green" environment. Technological advancements have led to the development of more environmentally friendly ICT, and while this has been viewed as a positive advancement it has also resulted in an increase of e-waste, raising concerns about the impact of e-waste on the environment. The chapter also explored the use of sustainability ICT in smart buildings, and it showed that there is need to consider the whole life cycle of ICT to ensure "green" ICT manufacturing, use, and disposal instead of limiting the concept of sustainability ICT to minimising energy consumption. The following chapter outlines the process followed in conducting this study, and it also provides a description of the research strategy and methods used, as well as the reasons that they were suitable.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 Introduction

The purpose of this study is to explain the concept of the '"green"'/sustainability use of ICT and how it can be used to support a sustainable environment at Company-A's new office building. This chapter seeks to describe, explain, and justify the research design and methods as well as the tools used in this study to empirically test the conceptual model proposed in Chapter 2. It will also discuss issues pertaining to ethics, validity and reliability. The chapter will conclude with a brief discussion on the limitations and adaptability of the study.

3.2 Research design

According to Babbie and Mouton (2001) a research design is a plan or blueprint to obtain answers to research questions. *"It is a logical model of proof that allows the researcher to draw inferences concerning causal relations among the variables under investigation,"* (Nachmias & Nachmias, 1976). It also guides the researcher in identifying relevant data to collect, and analysing the results (Yin, 2009). Figure 16 depicts the research design followed in conducting this study, the rectangular blocks represent activities and the solid arrows represent the sequence in which the activities were carried out. The dotted arrows show a backward reference to the **main research question** block to ensure that each activity is conducted with the objective of addressing the main research question.

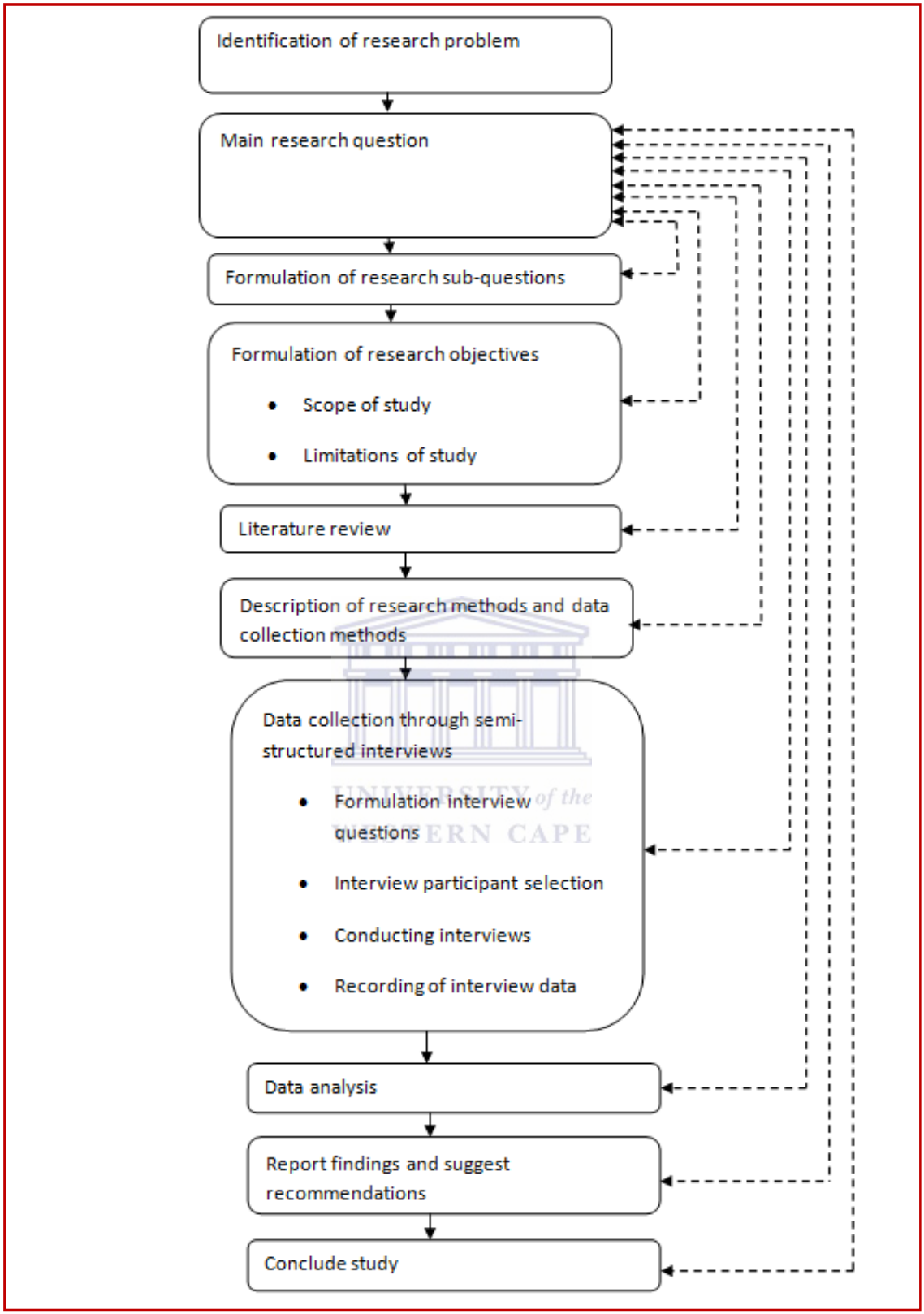

Figure 16: Research design (Source: Author)

1) **Identification of research problem:** the first activity involved identifying a problem area within the organisation that could warrant research aimed at revealing, solving, or building knowledge around it. Amongst the various projects that Company-A was

involved was involved in various projects, and most of the employees were very interested in the construction of the new office building. However it was the invitation by the organisation's chief executive officer to all interested employees to get involved to try to contribute towards the construction of an environmentally friendly building that led the researcher to seek a way to contribute toward that goal. The role of ICT in supporting a "green" building was identified as a problem area that needed to be understood.

2) **Main research question:** after consultations with the new office building project manager and research supervisor the main research question was formulated and refined until such a point when it was clear. It was envisaged that a research study to answer the formulated research question would be relevant and of significant contribution to the organisation.
3) **Formulation of research sub questions:** the main research question was divided into smaller sub-questions to give structure and clarity and direction in addressing the main research question. The dotted arrows on Figure 16 represent a continuous backward movement to the main research question. During the course of the entire study the researcher would refer back to the main question to ensure that the study focussed on addressing the main question (the reason for its undertaking).
4) **Formulation of research objectives:** the formulation of research objectives involved setting the goals that this study sought to achieve, and how it would be offer a meaningful and relevant contribution not only to Company-A but also to other organisations in different settings. This activity also included setting of study boundaries, in other words what the study would and would not cover. Given the fact that no study can be perfect, the researcher identified the limitations of the study in abstract terms.
5) **Literature review activity:** during this activity the researcher reviewed literature on environmental sustainability, sustainability ICT and smart buildings. The objective was to build the researcher's knowledge in the research area, and the main research question determined what literature was used. The researcher structured the literature review chapter using the research sub-questions to ensure that the literature review phase focused on answering the research questions, and so as to avoid being lost in the literature.

6) **Description of research methods and data collection methods:** in this activity the researcher provided a detailed description of the research methods and data collection methods used during the course of the research. The researcher gave a brief discussion on the various methods used in conducting research, and then gave reasons on every choice of method, technique or tool used. The reasons given by the author all refer back to the main research question to ensure that suitable methods were used in addressing the research question.
7) **Data collection through semi-structured interviews:** this activity began by formulating the interview questions and selecting the interview participants, the participants were selected based on some predefined criteria as discussed in section 3.5.2 (*Interview participant selection*). The actual interviews also involved recording data from the responses of the interviewees.
8) **Data analysis activity:** during this activity the researcher analysed the data collected in an attempt to determine evidence of patterns in the data collected from different interviewees as well as comparing it to what patterns the literature held with regards to sustainability ICT.
9) **Report findings and suggested recommendations activity**: this activity involved documenting and explaining any patterns identified in the data analysis activity. The researcher also suggested some recommendations based on the knowledge gained in the literature review activity.
10) **Conclude study activity:** this involved summarising the study findings and concluding the study.

3.3 Research methodology

A research methodology, also referred to as a research strategy, is "*... a system of methods used in a particular area of study or activity*" (Oxford University Press, 2011). It is the science and philosophy behind all research (Adams, Khan, Raeside, & Whit, 2007). There are two types of research strategies, namely quantitative and qualitative. A study can use any of the two strategies or a combination of both, and according to Johnson and Harris (2002) the environment being studied and the nature of the research problem and objectives determine the choice of a strategy to use. The two strategies are discussed in the following sections.

3.3.1 Quantitative research

Quantitative research uses experimental methods such as statistical and other quantification procedures to test hypothetical generalisations (Hoepfl, 1997). According to Denzin and Lincoln (2003) quantitative researchers focus mainly on measuring and analysing causal relationships between variables, for example in studies that seek to gauge reactions of many people using a limited number of questions, thus allowing comparison and statistical aggregation of the data with the objective of giving a broad findings from which generalisations can be drawn (Labuschagn, 2003).

3.3.2 Qualitative research

Qualitative research is a diverse set of interpretive practices with a wide subject-disciplinary range, and it makes use of these interpretive practices to get a better understanding of the subject matter at hand (Seale, Gobo, Gubrium, & Silverman, 2004; Denzin & Lincoln, 2003). According to Ploeg (1999) the purpose of qualitative research is to describe, explore, and explain phenomena being studied in its natural setting. Table 11 shows the five main types of qualitative research as identified by Neill (2006).

Table 11: Types of qualitative research source: (Neill, 2006)

Qualitative research type	Description
Case study	Attempts to shed light on a phenomenon through an in-depth study of a case. A case can be a person, an event, a group, or an institution.
Grounded theory	Theory is developed inductively from a corpus of data acquired by a participant-observer.
Phenomenology	Describes the structures of experience as they present themselves to consciousness, without recourse to theory, deduction, or assumptions from other disciplines.
Ethnography	Focuses on the sociology of meaning through close field observation of socio-cultural phenomena. Typically, the ethnographer focuses on a community.
Historical	Systematic collection and objective evaluation of data related to past occurrences in order to test hypotheses concerning causes, effects, or trends of these events.

Unlike in quantitative research where there is already some level of knowledge about the existing variables and their relationships, there is little knowledge of such variables and their relationships in qualitative research (Johnson & Harris, 2002). According to Strauss and Corbin (1990) qualitative research is useful in studies that seek to understand any phenomenon where there is little understanding of it. Analysis of the data is usually conducted over a small sample, as opposed to the larger samples used in quantitative approaches where the use of small samples would limit how possible it is to draw generalisations from the results (Cormack, 1991). A drawback of qualitative research is its vulnerability to the influence of the researcher on the results of the study.

3.4 Choice of the research strategy

This section articulates the choice and the reasoning behind the choice of the research strategy used in this study.

3.4.1 Justification of the research strategy used

This study was conducted in the form of a qualitative case study. This research strategy was chosen due to the nature of the main research question. Case studies are applicable in studies that seek to address a descriptive or explanatory research question (Yin, 2011). Yin (2009) added that a case study strategy is more suitable when:

a) The research question poses a '*how*' or '*why*' question.
b) The researcher has minimal influence on events.
c) The study focuses on a phenomenon within a natural setting.

The main research question of this study poses a '*how*' question, secondly this researcher had minimal influence on the use of ICT at Company-A, and thirdly, this study focuses on "green" ICT within a real life context. According to Darke, Shanks, and Broadbent (1998) case study reserch can be used in investigating IS developement, implementation, and use within an organisation.

3.4.2 Case study methodology

It is essential to first clarify what a '*case*' in case study research is, in order to understand what a case study is. According to Yin (2011) a '*case'* is a bounded entity such as a person, organisation, event, or any social phenomenon. It represents the topic of the study.

There are various definitions of '*a case study'* from authors such as Yin, (1981; 2009; 2011), Gerring (2007), and Nachmias & Nachmias, (1976), but for the purposes of this study the following working definition was chosen:

"*A case study is an in-depth study which explores issues, present and past, as they affect one or more units (organisation, group, department or person)*" (Adams *et al*., 2007).

A case study attempts to examine a particular phenomenon in its real-life context especially when there are no clearly defined boundaries between phenomenon and context (Yin, 1981).There are two types of case study design: 1) single-case study, and 2) multiple-case study (Yin,1984, 2004). According to Gerring (2007) the difference between single and multiple-case study is in the number of cases under study in each type of case study, a single-case study is based on one case while a multiple-case study is based on more than one case.

1. **Single-case** study is appropriate if the study represents a critical, extreme, or unique case. Single cases allow for an in-depth investigation and generation of a deep understanding of a phenomenon (Darke *et al*., 1998) however they have been criticised as the results cannot always be widely generalised.
2. **Multiple-case** studies allow cross-case analysis and the study of a specific phenomenon in different settings, they can also be used to replicate and test a previously developed theory (Darke *et al*., 1998). Multiple-case case studies, unlike single case studies, often do increase possibilities for generalisations to be drawn from the results.

The objective of this study was to generate a deep understanding of a single case - the 'use of "green" ICT at a specific building' and as such a single-case study design was adopted. The following section discusses the methods used in collecting case study evidence.

3.5 Data collection methods

This section describes the methods used in gathering data while carrying out this research. Data can be collected from primary or secondary sources. Data obtained through data collection methods such as observation and interviews during the course of a research is considered to be primary data, whereas data from other sources such as books, journals and online material which may have been developed for other purposes is considers to be secondary data (Ghauri & Grønhaug, 2005). Data collection methods used for collecting primary and secondary data in qualitative case study research include: (a) analysing written

documents and material, (b) observation, and (c) interviewing (Green *et al.*, 2006; SAGE, 2006). This study adopted:

1) Analysis written documents and material related to "green" ICT from the commencement of the study in March 2011 right till the conclusion stages of the study in May 2013.
2) Interview method in gathering primary data, because of the background of this study *i.e.* little understanding of "green" ICT at Company-A meant that there was insufficient source of observational data hence it was not used.

3.5.1 Interview method

A qualitative interview is a data collection method that can be employed as a primary source of data or in conjunction with other data collection methods (Hoepfl, 1997). Its purpose is *"…to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena*" (Kvale, 1983).It can be conducted in the form of a face-to-face interview, telephone interview, as well as interviews over the internet (Opdenakker, 2006). Based on the level of structuring, interviews can be classified under three categories: 1) structured interviews, 2) semi-structured interviews, and 3) unstructured interviews (Fontana & Frey, 1994; Zhang & Wildemuth, 2009a).

It was vital for the researcher to have a clear understanding of the level of awareness held by Company-A employees about and around the concept of sustainability ICT, and a semi-structured interview method was best suited to achieve this feat. The intention was to capture detailed information from the employees in their own expressions, views, and experiences while keeping some level of direction by sticking to the research topic. The researcher used an interview guide which is a document containing a list of questions covering specific topics, and this document was used to lead the interviewer in asking the questions and setting the order in which the questions were asked. The interviewer did not necessarily follow the exact order in which the questions were outlined on the guide and on some instances asked questions that were not in the guide to clarify some points arising from the responses of the interviewees during the interview process. All the questions in the guide were asked using similar wording in each interview.

3.5.2 Construction of interview questions

To ensure that final interview questions capture relevant data for the study, Bryman and Bell (2007) suggested that a researcher should begin the formulation of interview questions by revisiting the research topic and the research questions that the study seeks to address. The questions for the interviews were formulated using a 9-step guide depicted in Figure 17.

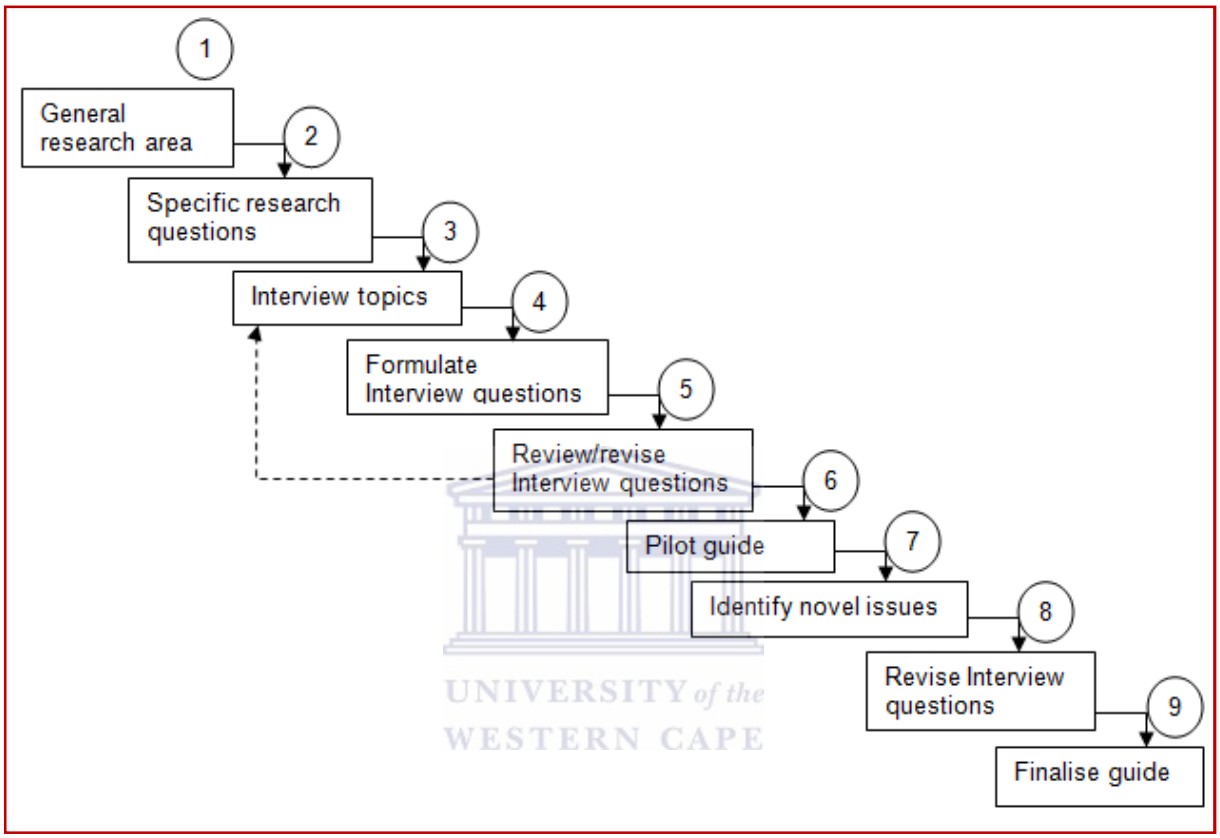

Figure 17: Formulating interview questions (Bryman & Bell, 2007)

1. General research area knowledge was of paramount importance in coming up with a suitable interview guide, and the researcher reviewed various literature on environmental sustainability and "green" ICT. Before the commencement of this study the researcher had a number of meetings with senior management involved in the construction of the new Company-A office building to gain some knowledge and background leading to this research.
2. After identifying the need for a research study 'research problem', a research question was formulated. The main research question was divided into smaller specific sub-questions such that an answer to all these sub-questions would consequently answer the main research question. Objectives of the study were then formulated based on the sub-questions.

3. The study objectives were turned into literature review headings to ensure that the literature review was focussed on answering the research sub-questions from which the research objectives were derived. Interview topics were then identified from the literature review.
4. Questions for the interviews were derived from the literature review key points, section 2.8.4 (C*onceptual model*). The subcomponents of **ICT support for "green" buildings** were converted into open-ended questions.
5. To ensure that the formulated interview questions were not ambiguous and would yield quality answers for this study, the researcher consulted an experienced qualitative study researcher to go through the questions, and amendments were made where necessary. This review process involved referring back to the research questions.
6. A pilot interview guide was then developed using the interview questions formulated on step 4 and 5. The questions were arranged in such a manner that the first questions were more abstract and generalised around the research area, and later questions were more specific.
7. The researcher identified one colleague at Company-A with some level of interest in "green" ICT and arranged a pilot interview session. The objective was to evaluate the effectiveness of the pilot guide and to identify issues that needed to be addressed.
8. After the pilot interview, the questions were re-visited again and revised in preparation for the formulation of the final guide.
9. This step marked the completion of the whole process of formulating the interview questions and the output was a finalised interview guide, which can be found in Appendix III (*Interview guide*).

3.5.3 Interview participant selection

This section will discuss the factors considered in determining the number of interview participants 'sample size' and the sampling method used in selecting interview participants in preparation for the interviews. There are various sampling techniques used in qualitative research, and this section will highlight some of these methods.

3.5.3.1 Sample size considerations

It is important to highlight that unlike quantitative studies, qualitative studies do not seek to place emphasis on being able to generalise the findings, hence the smaller sample sizes

usually seen in these studies are not necessarily problematic (Onwuegbuzie & Leech, 2007). Onwuegbuzie and Leech (2007) add that a sample size should not be too small to achieve data saturation nor too large to hinder deep analysis of cases. Creswell (1998) recommend a sample size of between 20 and 30 participants for grounded theory, between 3 and 5 for case study research, and up to 10 for phenomenological research. According to Guest *et al*. (2006) a sample size of 12 is sufficient if the objective of the study is to describe a phenomenon among relatively homogeneous group.

The researcher took into consideration the advice from experienced qualitative researchers and from the literature in determining a suitable sample size for this study. A sample size of 12 was deemed sufficient to allow gathering of quality information. A sample size of 12 was large enough to maximise range by enabling the selection of participants with different kinds of experiences, and at the same time it was small enough to allow the researcher to get a deeper understanding of each of the participant's knowledge and perception of "green" ICT.

3.5.3.2 Qualitative sampling methods

It is imperative to define the term **sample** as used in qualitative interview methods before discussing sampling methods. "*A sample is a group of people who have been selected to act as representatives of a population as a whole*" (Offredy & Vickers, 2010). There several sampling methods whose applicability is dependent on the scope of the study, the time available for data collection, and the type of research strategy used for the study (Mertus, 2012). Weiss (1994) identified probability, convenience , and purposive sampling as the three sampling methods used in for studies that adopt interviewing as a data collection tool.

This study adopted purposive sampling method in selecting interview participants. Purposive sampling involves selecting interview participants based on some specific purpose, for example selecting only those that may offer the most suitable or relevant data to answer the main research question (Marshall, 1996; Teddlie & Yu, 2007). It seeks to maximise range by selecting participants with different kinds of experiences who can offer different points of view (Mertus, 2012), however its weakness is that it relies on the researcher's judgment on the participant's reliability and competency, and therefore lacks the benefits of randomisation in minimising bias (Tongco, 2007).

To maximise range, interview participants were selected using the following criteria:

- Participants with influence on the organisation's new office building (Company-A senior management)
- Participants with high knowledge of the organisation's ICT system (IT management)
- Participants with influence on the organisation's business processes (business management)

The author selected 3 senior managers, 4 business managers, and 5 IT managers. All the selected participants were located at either one of the two Company-A offices (Portswood and Granger bay offices, V&A Waterfront, Cape Town). Due to the close proximity of the selected participants, the researcher opted to conduct face-to-face interviews rather than telephone interviews. The sample size of 12 allowed the researcher to conduct a one-on-one interview with each participant rather than group interviews. This decision was taken to eliminate bias from collected data using group interviews which can occur when the views of influential individuals in a group dominate their views and contributions from other group members. The order in which the participants were scheduled to be interviewed was simply based on who was available first. Some of the scheduled interviews had to be postponed due to the unavailability of the participant.

3.6 Conducting interviews

Yin (2009) listed a couple of basic interviewing skills that a researcher should posses whilst gathering case study evidence: a case study researcher should be able to ask good interview questions, be a good listener, be flexible and adaptive, and be unbiased while keeping a firm grasp of the subject at hand. The author researched deeply and consulted a seasoned qualitative researcher in an effort to equip himself with the above skills on how to prepare, conduct, and collect quality data from interviews. A detailed account on how the interviews were conducted is given in the following sections starting with the invitation of participants to the interviews.

3.6.1 Participant interview invitations

Initial emails were sent to each selected participant on the 1st of August 2012 requesting their participation in the interviews for which at this time a date had not been set. The initial email included a brief abstract of this study and a short motivation behind the research. Follow-up calls were made to the individuals to confirm their receipt of the initial email and to find out

if they had any questions. A few individuals had questions about the relevance of the study but these questions were answered to their satisfaction. All the selected participants were happy to be involved, and some suggested additional subjects for interview whom they thought would be able to contribute usefully to the study if invited to participate, however only individuals the researcher judged to have valuable information for this study were invited.

A second and more formal email was sent to the participants on the 6th of August 2012 detailing the interview process and the expected interview times. The email also included a brief description of the structure of the interview questions and focus areas, with the intention of preparing the participants in terms of knowing what to expect, and avoiding taking them by surprise on the day of the interview. The final part of the second email was an invitation to the interview, and the participants were asked to suggest times at which it would be convenient for them to be interviewed. With the preferred times from the participants, the researcher booked meeting rooms for the interviews at the two Company-A offices depending on which office a participant was located in. Although each interview was scheduled for 30 minutes, however the researcher booked the venues for 45 minutes to allow for flexibility in the event that the interview started late or ran beyond the scheduled time.

3.6.2 Actual interviews

Prior to starting each interview with each participant the researcher gave an overview of the study and sought to ensure that the interviewees were relaxed, and that they free to give their views on the subject at hand. Participants were informed that notes would be taken during the interview and they were asked not to be distracted by the process. The researcher used field notes and audio recording to take down notes. The recording device was positioned at close proximity to the interviewer and the interviewee so as to capture the conversation. The researcher only captured some key points on the field notes and left the rest to the audio recorders so as to allow the researcher to engage and maintain eye contact with the interviewee.

Although the prepared questions were used, the researcher was flexible enough to allow participants to express themselves beyond the questions asked. This brought out some unexpected but important information. Careful attention was taken to avoid losing track of the subject under study due to the unexpected information. Constant reference back to the

objectives of this research helped the researcher to stay focused. After the interviews at the end of October 2013 the researcher transcribed the audio recordings of each interview, and prepared for data analysis.

3.7 **Data analysis**

Qualitative data analysis is the process of identifying themes as they are suggested by the data, and an effort is made to provide support for the themes that emerge. This involves the organisation of qualitative data in an attempt to discover patterns, themes, forms and qualities in the gathered data (Johnson & Christensen, 2000; Labuschagn, 2003). According to Hartley (1994) qualitative data analysis occurs at the same time as data collection, while Suter (2012) emphasised the point that qualitative data analysis is more flexible and less prescribed than the statistical analysis methods used in quantitative research. It is an iterative process that follows an inductive approach in that conceptual categories and descriptive themes are extracted directly from the collected data without imposing explicit theories in testing a hypothesis, as evident in the kind of deductive analysis commonly used in quantitative research. In this study, data analysis began during the interviews with participants, when the researcher noted down key points as expressed by the interviewees. All the interviews were recorded with full consent from the participants ,and later transcribed for further analysis. Extraction of themes from the interview transcripts was done through a process called coding.

3.7.1 Coding

Coding is used to organise data in a way that enhances further analysis and interpretation (Catterall & Maclaran, 1997). The researcher analysed each transcript line by line and took note of key points that summarised the essence of the interviewee's response. Naturally different interviewees respond differently to the same open ended questions, and this resulted in a lot of conceptually related key points being generated. These related keys points were then grouped under specific themes or codes. Each code is labelled by a descriptive phrase that gives a general description encompassing the key points that fall under it. As the list of codes grew, the researcher identified relationships/patterns amongst other codes and aggregated closely related codes into bigger and more general categories, and related categories were in-turn sorted under specific umbrella concepts. This process continued until saturation point, which is the point whereby further coding begins to only confirm the categories, themes, and conclusions already reached (Suter, 2012). The concepts derived

from gathered data were then compared with the literature review-generated concepts to identify any patterns in what is referred to as pattern matching.

3.7.2 Pattern matching

Pattern matching is a technique for aligning data analysis findings to theoretical propositions. It involves linking theoretical patterns from the literature review with observed or operational patterns (Trochim, 2000). Visual tools such as diagrams, charts, and maps are often used to conceptualise the observed patterns and the relationship(s) between them. In this study the author made use of diagrams to visually potray a conceptual model derived from the data analysis findings. Pattern matching was then carried out to compare the literature review conceptual model (Figure 15) with the conceptual model derived from analysis of gathered data. Findings from the pattern matching process were used to draw conclusions and to update the final model shown in Figure 22.The following section discusses measures taken to increase the validity and reliability of the study results.

3.8 Validity and reliability of results

The term validity in research refers to the quality of the study; valid research is "*plausible, credible, trustworthy, and, therefore, defensible*" (Johnson & Christensen, 2000). Reliability on the other hand is the extent to which a measuring process can yield consistent results when repeatedly applied to a phenomenon that does not change. According to Suter (2012) validity and reliability entail the degree to which the study can be trusted in so far as (1) the findings 'make sense' given the processes followed and tools used, (2) the findings are supported by sound reasoning and solid evidence, (3) the whole research process is transparent for the reader to follow through. To ensure trusworthiness of the study findings the researcher followed an valuative criteria suggested by Lincoln and Guba (1985) that includes four criteria:

- Credibility
- Transferability
- Dependability
- Conformability

In this study credibility was established through member checking and peer debriefing. Member checking was done during data collection, during the interviews the researcher probed further into a question in order to verify that the interviewee's views were correctly

interpreted. At the end of each interview the researcher discussed the interview questions with the interviewee. After transcribing all the interview sessions the researcher sent a sample of six transcripts to the respective participants to provide feedback as well as verify if the first round of coding on their interview transcript captured the key points of their views. As part of peer debriefing, consultations with a seasoned researcher were done to confirm interpretations and the development of coding categories (Zhang & Wildemuth, 2009b). To enable the transferability of the study, the author extensively described the research process, as emphasised by Foster (2004). Practitioners and researchers can therefore use the described research process to assess the extent to which the findings of this study have applicablity in other settings. To address dependability and confirmability, the researcher recordeded decisions taken, processes followed, tools used, and the infereence of study results to ensure consistency of findings and maximise transparancy so as to minimise researcher bias.

3.9 **Ethical considerations**

According to Neuman (2000) it is the researcher's obligation to be ethical, even in cases where the research subjects are unaware or unconcerned about ethics. The researcher identified four distinct areas of ethical consideration:

1) **Participation in this study**: Participation in this study was completely voluntary and participants had the right to withdraw at any time without any consequences. Participants had an option to refuse to answer any questions during the interviews without affecting their participation. Refer to the consent form in **Appendix I**.
2) **Recording of interview proceedings:** Prior to starting each interview with each participant the researcher verified their consent to their participation and also requested permission from each participant to record the interview proceedings, the researcher explained to the satisfaction of each interviewee why the recording was necessary and what it would be used for, and all the participants consented to the use of an audio recorder.
3) **Confidentiality of information from participants:** Participants were assured that any information they gave in connection with this study would remain confidential and will be disclosed only with their permission. Confidentiality was maintained by means of referring to participants as Interviewee 1, 2, 3, etcetera. The information participants gave will not be used to reflect negatively on them in any way.

4) **Organisation's confidentiality policy:** The organisation under study employs a strict confidentiality policy with regards to the organisation's information and it was the intention of this researcher to conduct thorough, non biased research without violating the organisation's confidentiality policy. Consultations with the Project manager for the new office building were done on a regular basis to ensure compliance with the policy.

3.10 **Methodological critique**

Critics of the qualitative methodology refer to it as a soft science because of its "*unscientific work*" compared to quantitative methodology (Denzin & Lincoln, 2003). This study adopted a single case study design which has several inherent shortfalls, amongst them are its limitations in the generalisability of the sudy results, as unlike multiple case study it dopes not allow for cross-case analysis.The study only used the interview method as the source of case study evidence and as a result this reduced the strength of its realibility which according to Yin (2004) is strengthened by triangulating lines of evidence. The researcher was involved in the selection of interview participants, data collection, analysis, and presentation of results of data, which may have resulted in the researcher consciously or subconsciously influencing the study results. The number of interviewees selected might be considered to be too small or it could be argued that it was selected because it was the most convenient number for the researcher. Given that the researcher was involved in formulating the interview questions it is possible that during the interviews the researcher consciously or subconsciously influenced the interviewees to respond in a certain manner. Pre-understanding and perceptions on the part of the researcher may also have resulted in some aspects being highlighted and others being omitted during data analysis and presentation of results.

3.11 **Chapter conclusion**

This chapter has discussed the research strategy, design, data collection tools, and data analysis strategies used in this study. The chapter also discussed how the research was conducted to ensure quality of the study through addressing trustworthiness evaluative criterions. In conclusion to this chapter the researcher highlighted some of the steps taken to ensure ethics were upheld through the course of this research, the author further acknowledged some of the shortfalls and critique areas of the study. The next chapter will discuss the study findings.

CHAPTER 4: RESEARCH FINDINGS

4.1 Introduction

This chapter presents and analyses the research findings, and the responses obtained from the interviews are analysed in comparison to the findings obtained from the literature review. The chapter is structured according to the patterns of evidence that emerged from the interviewee transcripts during data analysis. It seeks to determine if there is any correlation between the emerging patterns observed in the interview data and literature review, and the findings are used in developing a model that could be used in answering the research questions.

4.2 Emerging patterns

During data analyses of interview transcripts the following patterns were observed:

- Awareness and knowledge of environmental sustainability
- Strategy and policy formulation and implementation
- Efficient use of existing ICT equipment
- Culture, attitudes and behaviour towards "green" practices

These patterns are discussed in detail below. Direct comments from interviewees are presented in italics.

4.2.1 Awareness and knowledge of environmental sustainability

Most of the interviewees acknowledged a lack of sufficient knowledge about environmental sustainability, with what little knowledge they had on the subject mostly obtained from secondary sources, such as association with acquaintances with an interest in environmentally friendly practices, and from the media. Below are responses from some of the interviewees about their knowledge of environmental sustainability.

"*I'm only aware as much as I read about it, I cannot say I consciously go out there and find out about environmental sustainability… on a score of 1 to 10 I would probably score 3*" (Interviewee 6).

"*My understanding of environmental sustainability is very much formed by popular media and a lot of it formed by things like carbon footprint and trying to zero it out by putting*

something back in to the tune of what you have removed from the environment" (Interviewee 7).

Although the interviewees could not give a precise definition of the term 'environmental sustainability', most of them were aware of some components and attributes of environmental sustainability such as: a) efficient use of environmental resources with the future in mind, b) careful waste disposal, and c) waste reduction methods among others. This lack of solid knowledge gives credence to the view by Annandale *et al.* (2004) that there is no precise definition of sustainability, it is broad, vague and context dependent.

In answering the research sub-question on what is sustainability, the literature distinguished between environmental, economic, and social sustainability however there were various definitions of this term, while a common pattern in literature with regards to these definitions was a general reference to Brundtland's (1987) definition of sustainable development. This pattern observed in the literature conforms to the pattern observed in the interview responses although not on a similar scale. All the interviewees could single out some components of environmental sustainability referenced from Brundtland's definition whereas the definitions in the literature sought to add to or rewrite Brundtland's definition in a different context.

There were a few responses from interviewees who were relatively more knowledgeable with regards to environmental sustainability for example Interviewee 11 defined environmental sustainability as:

"…how our actions today and also as businesses ensure that our environmental planet remains viable for future generations and therefore how we use the limited resources available is quite important and also that any effects of processing we do like manufacturing doesn't damage the environment further, whether it's in the form of emissions."

The above response had a striking similarity to Hawken (1993) who defined sustainability as: "*... an economic state where the demands placed upon the environment by people and commerce can be met without reducing the capacity of the environment to provide for future generations.*" This positive pattern showed that not all interviewees were clueless on the matter, and at the same time it raised the possibility that the secondary sources of information from which most of the respondents got their knowledge could have provided a good starting point in raising awareness on environmental sustainability amongst Company-A employees.

However, the reliance on the secondary sources in an awareness-raising campaign is not sufficient for achieving environmental sustainability within an organisation. This research shows that an organised approach to increasing sustainability-related awareness and knowledge is necessary and will be beneficial. As the analysis of the conducted interviews suggested, one of ways to do so is to formulate and implement appropriate sustainability strategies and policies.

4.2.2 Strategy and policy formulation and implementation

There was a general accord among the interviewees on the organisation's policies with regards to environmental sustainability, although some interviewees questioned the appropriateness of some of the organisation's policies and suggested that there was need to revisit them to verify if they are still relevant, and update those that were not formulated with the environment in mind.

The interviewees shared a common view on the need to educate and raise awareness amongst Company-A employees on the importance of "green" practices, and ultimately develop a "green" working environment in the organisation. However the interviewees differed on the strategy that they thought would best achieve these required. Interviewee 9 was of the view that top management should drive "green" initiatives at a strategic level down the managerial hierarchy, *"...the implementation process will be a challenge it has to be driven from top management pushing it down to their employees or subordinates, if you don't have top management buy-in you not going to go anywhere*" (Interviewee 9). These views are in agreement with Philipson (2010) who pointed out that in business, positive attitudes towards sustainability ICT are most effective if they come from the top, and management buy-in is essential for any "green" ICT program to succeed.

However Company-A's senior management were of a different view as noted from Interviewee 11's comments stating that anyone, regardless of their managerial level within the organisation, who was passionate and felt strongly about environmental issues could take the lead and drive "green" programmes. Interviewee 5 concurred with Interviewee 11's view that environmental issues were not only an issue for top management, but a problem that requires the involvement of everyone in the organisation, and anyone can champion environmental initiatives. There appeared to be a lack of leadership and a formal

sustainability strategy, as no particular individual or section of the organisation was willing to take responsibility for "green" programmes and formulate sustainability strategies.

The creation of a new sustainability management portfolio to act as the face of the organisation in issues pertaining to environmental sustainability showed a tacit acceptance by the senior management that there was need to have a unit within the organisation dedicated to formulating sustainability strategies and policies. The lack of clarity on the scope of this portfolio relates back to section 4.2.1 (*Awareness and knowledge of environmental sustainability*), which suggests that two courses of action are urgently needed:

- Championing sustainability issues within the organisation. According to the interviews conducted and Philipson (2010), this must be driven by top management in order to secure buy-in by employees.
- Organising a company-wide awareness campaign (supported by the champion/s), and also organising seminars or courses that will increase employee capacity regarding a sustainable approach to business.

Another conclusion coming from the analysis of the interviews was that an effective sustainability strategy must be followed up with effective and implementable supporting policies. In addition, the interviews pointed out a certain confusion regarding the current understanding of 'policies' among Company-A employees with regard to the use of ICT equipment. This suggests that the current policies require revision from a sustainability perspective as described in section 4.2.3 (*Efficient use of existing ICT equipment*). In this regard, the interviewees felt strongly that two types of sustainability policies should be formulated and implemented: (1) purchasing policy, and (2) policy regarding relationships with external business partners.

4.2.2.1 ICT equipment procurement policy

There was general discontent among the interviewees on the procurement policy of ICT equipment – if such a policy exists. Interviewee 7 questioned the ratio of personal computers to people, and further claimed that Company-A had a lot of personal computers compared to the number of its employees. Interviewee 6 used the term "uncontrolled" to refer to the purchasing of equipment, and a lack of communication amongst different departments which resulted in duplicate equipment that could have been shared within the organisation.

Interviewee 3 concurred with Interviewee 6 and emphasised the need to extend the life span of some of the ICT equipment to reduce purchasing new equipment, stating: "*The lifespan of certain things especially phones and PCs (the things we donate) can still be used for a little while longer... I think that it's easy for Company-A to say buy a new computer or buy something else that is new.*"

Interviewees also questioned the quality of some of the ICT equipment that they were provided with by the IT infrastructure department. The interviewees pointed out that some of the equipment was of poor quality with some even stating that equipment was already e-waste at the point of procurement. The interviewees reasoned that this contributed to the build up of unused ICT equipment, and consequently the build up of e-waste. According to Philipson (2010) "*procurement is arguably the most important aspect of "green" ICT in terms of making an overall impact on sustainability.*" An organisation should take into consideration: a) the nature of the ICT equipment and b) the nature of the suppliers of that equipment (Philipson, 2010). An organisation should take steps to ensure that the nature of the ICT equipment it purchases complies with environmental standards such as Energy Star and EPEAT as discussed in section 2.4.4 (*"Green" ICT standards and labels*). The nature of the suppliers of ICT equipment is discussed in the following sub-section.

4.2.2.2 Relationship with external business partners

There was a general agreement among the interviewees about the importance of and the need to extend the organisation's "green" policies to its relationship with its business partners. Interviewee 9 gave an example of partnering with an accredited e-waste disposal company that has "green" initiatives of their own to dispose Company-A's waste equipment in a "green" manner. Similarly, this was observed in the literature, as Philipson (2010) pointed out that an organisation should take into consideration the suppliers' own "green" strategies, and there is a growing trend in organisations taking a keen interest and formulating policies to assess their ICT suppliers' environmental performance.

The analysis of the conducted interviews also showed a dominant pattern signifying the need to ensure that existing ICT equipment is used efficiently.

4.2.3 Efficient use of existing ICT equipment

There was a general feeling amongst the interviewees that the usage patterns of existing ICT in the organisation were inefficient and environmentally unfriendly... Some of the issues raised were closely linked to the current understanding of 'polices' among Company-A employees with regards to use of ICT equipment. This lack of a clear organisational policy on "green" use of ICT equipment has led to some questions being raised by some interviewees who are better informed about the existing ICT infrastructure. For example, in reference to the main research question posed on how ICT can be used in an environmentally friendly manner, Interviewee 1 questioned the current policies in place:

"If I look at our policies here – why must our computers remain on during the night? But they [ICT infrastructure team] *say they need to patch or apply security updates… So you have to look at policies that would address those things – it's easy for us to say how ICT can play a bigger role in sustaining environment*" (Interviewee 1).

The background to Interviewee 1's opinion was that the organisation had software tools that could be used to turn PCs on and off whenever there was a need to apply security updates. Other interviewees from the business who were less knowledgeable about ICT were of the view that the limitations of the current ICT system itself were one of the causes of environmentally unfriendly ICT use. For example some business users resorted to printing their important emails and filing them in their desks, as a way to avoid exceeding their allocated email storage space. Each employee has a fixed mailbox size and any request to increase this limit is subject to management authorisation, and needs to be based on a strong motivation, which is generally perceived to be a deterrent. Indeed, this prompted Interviewee 3 to point out that *"… if you are frustrated by the system, you will resort to your old ways*". ICT management, however had an opposite take on the issue, and defended the policy of limiting the mailbox size of individuals by arguing that:

"*We try to keep the most mission critical systems on the fastest disk – on the fastest storage so email is something we use every day and that we keep on the fastest storage, if you got a lot of documents and there is lots of big documents don't store it on your email but rather store it on the Filesrve* [File storage location] *because that is where you are supposed to keep it, and there it's like those files that you maybe access a lot less and there – we buy slightly slower disks but it's a lot cheaper so try and move your stuff there and keep your mail for what is quite useful not for storing documents…If we say people use email for storage then*

that will mean we would have to buy a lot more storage and more data centre storage space, lot more power, lot more cooling…" (Interviewee 5)

Although Interviewee 5 had a technical justification for the existing policy which incorporated environmental awareness, there appears to be a rebound effect at the business user's end. According to Hilty (2008), the rebound effect refers to a rise in environmentally-unfriendly trends such as growing paper consumption as a result of a transition to or development of more efficient technologies. While the infrastructure team sought to avoid acquiring more email storage at the data centre which would have a knock-on effect on power consumption, there was a counterproductive trend developing on the business side marked by an increase in email paper printing and filling by business users. "*Because of this* [rebound] *effect, technological measures alone do not cause a reduction in the use of natural resources…*" (Hilty, 2008).

Despite the fact that Company-A was already in possession of relatively efficient technologies it became evident that there was a gap in the understanding of the organisation's ICT infrastructure between the business system users and the ICT infrastructure team. Four possible reasons for this trend are:

1) Business users were not completely aware of the existing ICT infrastructure in the organisation and consequently how to efficiently use it.
2) Business users were aware of the existing ICT infrastructure but did not know how to use it in the ways envisaged by the ICT infrastructure team.
3) Business users were aware of the existing ICT infrastructure but it was not easy or convenient to use it as expected by the ICT infrastructure team.
4) The existing ICT infrastructure did not meet the business users' requirements for their daily jobs.

Scenario 1 indicates a need for education campaign by the IT Infrastructure team to educate ICT system users about parts of the system that they have access to and use. Scenario 2 and 3 indicate a need to teach system users how to use the system in basic layman's terms. A possible cause of the different understanding of the ICT system between business system users and IT personnel is the assumption by the latter that business users know and

understand the system, and how to use it and are therefore able to use the system efficiently. Interviewee 6 pointed out that:

"*IT systems can be so complicated to use sometimes, and IT support personnel attitudes can make it difficult for people to request assistance on how to use the system, what the IT support personnel views as basic common knowledge may not be necessarily the fact to us.*" Interviewee 5 concurred with this view, and stated that making the system easier enough to use would help reduce some of the environmentally unfriendly practices. According to Malhotra and Galletta (2004) the system itself and its use only has a slight personal influence on most system users. Instead, users' motivations and commitment determine how the way in which they use the system. Even the best-designed and most easy-to-use information systems will not used if they are not perceived to be useful in achieving user's objectives. Users with higher motivation and commitment towards a "green" working environment will make greater effort to master even complex systems, whereas users who do not share these goals tend to abuse, misuse or ignore the system. Malhotra and Galletta (2004) added that "*systems may not be used if the users are not motivated to do what the system enables them to do. Also, systems that make it more difficult to do what the users are really motivated to do tend to fall out of use*").

Understanding and enhancing users' commitment and motivation to environmental sustainable practices, and designing systems that support this objective, is vital when implementing information systems designed to improve an organisation's "green" performance, and to eliminate the possibility of scenario 4. The next section will discuss a pattern that emerged from the interviews on people attitudes and habits with regards to use of ICT.

4.2.4 Culture, attitudes and behaviour towards "green" practices

There was a general view among Interviewees that for "green" practices to take root within the organisation there is as need to address different employee attitudes shift from the present practices to more environmentally friendly practices. For example Interviewee 3 pointed out that one of the reasons that printing machines are not set to double-sided printing by default to reduce paper usage is because of resistance from some business users.

"*Unfortunately when you want people to develop behaviour, you have to get them on your side first, and people don't like surprises, so even though what we are trying to achieve is*

really important and is expected of us, you can't just go and change people's printing settings because you will have a really mad bunch of people." (Interviewee 3)

Interviewee 5 supported this view by concluding that people do not accept change well, instead they view it as an inconvenience. Ahola, Ahlqvist, Ermes, Myllyoja, and Savola (2010) pointed out that immaturity in both employee attitudes and business models which are an outcome of organisational strategy and policies (section 4.2.2 *Strategy and policy formulation and implementation*) will limit "green" use of an organisation's ICT infrastructure. There is need to address the immaturity in employee attitudes before they could expect to change their practices, although attitudes could improve, such improvements would not necessarily translate into improvements in "green" practices because *"…actual practises are slower to change. From this perspective, ICT could fasten the transition from "thinking to action..."* (Ahola *et al*., 2010).

Besides ICT system constraints, interviewees identified two main areas that they felt contributed to poor attitudes and motivation towards environmentally friendly practices, these being:

- Significance of employee impact on the environment.
- Lack of matrices to reveal the benefits and progress of "green" practices.

4.2.4.1 Significance of impact on the environment

Most of the interviewees were of the opinion that one of the reasons attributed to poor attitudes towards "green" practices was that employees were not aware of the environmental impact of their actions. Another pattern was that respondents felt that the environmental problems are a global issue, and their personal actions or impact on the environment was of little significance, and hence not important. A common perception was that there are more environmentally damaging organisations such as mining companies that ought to improve their business processes to reduce their negative impact on the environment. Some interviewees argued that at global level African countries and other developing countries were the least environmental damaging countries compared to developed countries, and that these are the countries have a greater obligation to address environmental issues than organisations in developing countries. Interviewee 10 pointed out that rich countries such as China have become the biggest environmental polluters, and maybe when developing nations

get to that stage, environmental issues will be of more relevance. On that basis interviewees did not consider Company-A to have a significant impact on the environment.

4.2.4.2 Lack of matrices to reveal the benefits and progress of "green" practices

Another general view contributing to poor attitudes was the lack of clarity and awareness of the benefits of adopting "green" practices. Interviewee 9 pointed out that awareness goes hand in hand with measurability, that targets should be set for a given time frame, for example to reduce waste over a specific period of time, and an awareness drive should then communicate these targets to the employees and they should be kept updated on how they are performing. Interviewee 7 pointed out the need to have precise measuring matrices to track the "green" performance of the organisation at any given time, and to use that information to make well-informed decisions on where to apply effort and resources. Interviewee 7 added that the lack of such matrices raises questions about the importance of "green" practices, thus contributing to poor attitudes amongst employees. To enhance positive attitudes towards "green" practices, interviewees were of the view that there needed to be some benefits that touched them individually at a personal level, so that they developed a personal attachment to the goals that "green" practices seek to achieve. For example, Interviewee 9 was of the opinion that:

"*If you want a group of people to do something the best way to go about it is to understand the inherent positive that is going to come out of it. So if I ask you to pick up that keyboard and move it to the corner of the room, what's in it for you? Why would you do that? ...If I told you that picking that up and putting it in the corner ...it's going to benefit you from a health perspective, its maybe going to save the company some money somehow, then it's like really a personal thing.*"

It was apparent that if employees don't understand the benefits, and lack personal attachment to the goals that "green" practices seek to achieve, they would resist and perceive such practices to be an inconvenience. Referring to "green" practices Interviewee 6 pointed out that "*It's a lot of work, for example separating different types of waste into different recycle bins.*" Interviewee 9 was of the same view, pointing out that: "*It's not easy and convenient, for example if I have to walk two rooms to find a recycle bin for the type of waste I need to dispose I will probably not do it.*" Philipson (2010) describes such lines of thinking as negative attitudes. Attitude is an intangible thing that describes how people perceive

environmental practices rather than how they act, and a desire to change stimulates a commitment to change which in turn changes the behaviour (Philipson, 2010).

4.3 Comparison of research findings to literature

The study findings were generally in agreement with current literature however the researcher discovered that current literature does not explain the influence of culture in achieving sustainability through the use of "green" ICT. Table 12 shows a comparison of the study findings to literature.

Table 12: Comparison of research findings to literature. (Source: Author)

Research findings	Supports existing literature	Contrasts existing literature	New finding
Lake of sufficient awareness and knowledge of environmental sustainability.	✓	x	x
Lack of clarity on the organisation's sustainability strategies and policies	✓	x	x
Efficient use of existing ICT equipment	✓	x	x
Culture, attitudes and behaviour towards "green" practices	x	x	✓

The following section discusses the researcher's interpretation of the findings developed from the data analysis.

4.4 Conceptualisation of findings

This section presents the researcher's conceptualisation of the findings derived from the data gathered from the interviews, and its correspondence to the literature review. The researcher identified four main concepts namely:

- Awareness and knowledge
- Strategy & policy: Formulation & implementation
- Efficient use of existing ICT equipment
- Culture

These main concepts are characterised by their sub-concepts which in-turn have their own properties/sub-sub concepts. From the researcher's point of view, the answer to the research main question lies in the understanding and implementation of these concepts. It is important for the author to point out that not all of the sub-concepts and their properties are discussed in this section, only those that were considered to be relevant in conveying the researcher's conceptualisation.

4.4.1 Awareness and Knowledge main concept

Figure 18 shows a pictorial representation of the '**Awareness and Knowledge'** main concept.

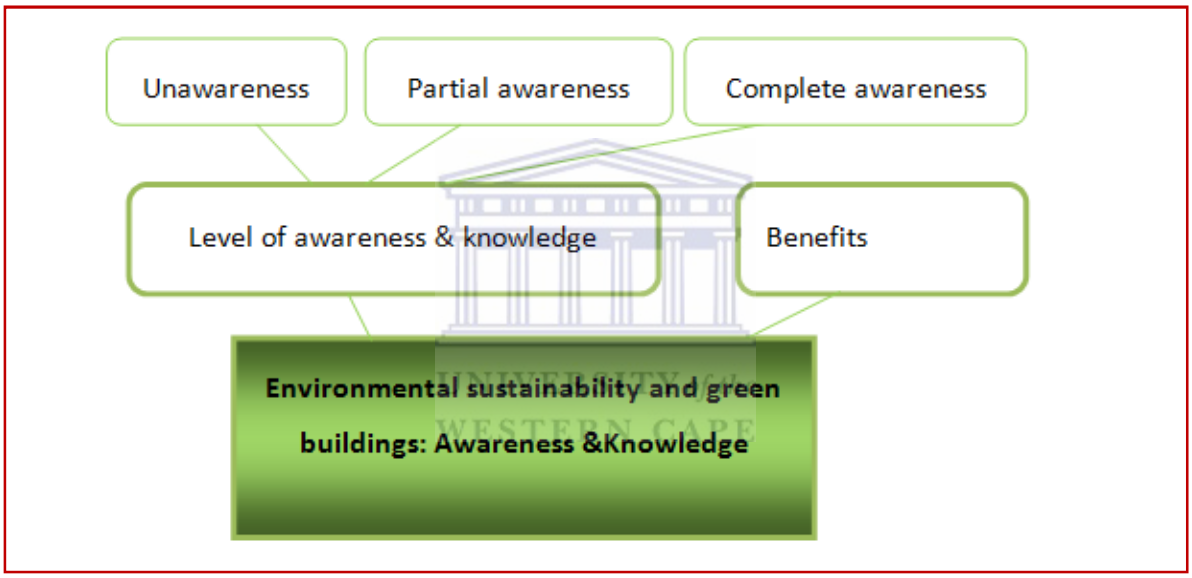

Figure 18: Awareness and Knowledge main concept (Source: Author)

Empirical analysis of data from the interviews showed that there is a component of awareness and knowledge that plays an important role in establishing and maintaining a "green" environment. The awareness and knowledge main concept relates to the level of awareness and knowledge of the following areas: (1) "green" buildings, (2) environmental sustainability and its importance 'benefits', (3) the strategies and policies in place to attain these benefits, (4) the IS designed to support a "green" environment. The researcher identified three levels of awareness which are unawareness, partial awareness, and complete awareness. Complete awareness in this study refers to highest possible level of awareness sufficient enough to attain optimal benefits. Further research is recommended to verify the link between awareness, knowledge and benefits – please also see section 5.3.2 (*Academic*

recommendations). It is envisaged that awareness and knowledge about environmental sustainability are a prerequisite for the formulation and implementation of effective "green" strategy and policy.

4.4.2 Strategy & Policy: Formulation & Implementation main concept

Figure 19 shows a pictorial representation of the '**Strategy and Policy: Formulation and implementation'** main concept.

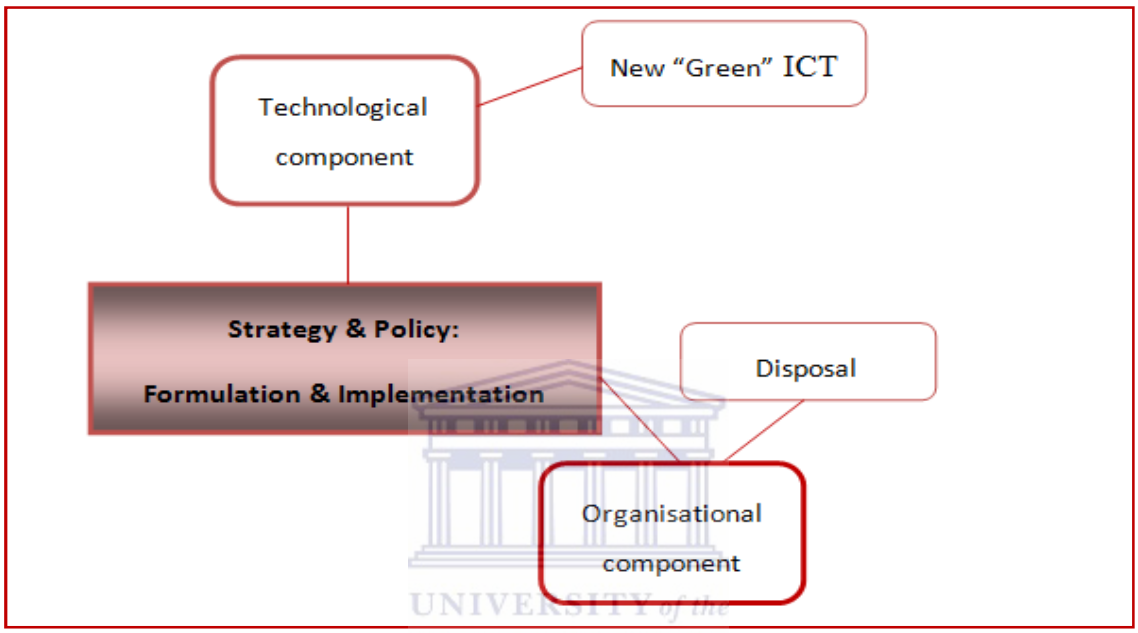

Figure 19: Strategy & Policy: Formulation & Implementation (Source: Author)

This main concept focuses on the ability of an organisation to formulate and implement strategies and policies that will achieve "green" purchasing, use and, disposal of ICT equipment. It is characterised by two sub-components, and these are *organisational* and *technological*.

4.4.2.1 Organisational sub-component

This sub-component focuses on the managerial "green" strategies and policies that govern the relationship between Company-A and its business partners, see section 4.2.2.2 (*Relationship with external business partners*). It also focuses on formulating internal policies that seek to achieve predefined sustainability goals, and also to influence the values of employees to be unison with those of the organisation as far as environmental sustainability is concerned, hence the link between the *Organisational component* and *Values* sub-concept of the '**Culture'** main concept.

4.4.2.2 Technological sub-component

This subcomponent entails the strategies or policies that govern the purchase of new ICT equipment discussed in section 4.2.2.1 (*ICT equipment procurement policy*), and the use of existing ICT equipment, hence this subcomponent is directly linked to the '**Efficient use of existing ICT equipment'** main concept

4.4.3 Efficient use of existing ICT equipment main concept

Figure 20 shows a pictorial representation of the '**Efficient use of existing ICT equipment'** main concept.

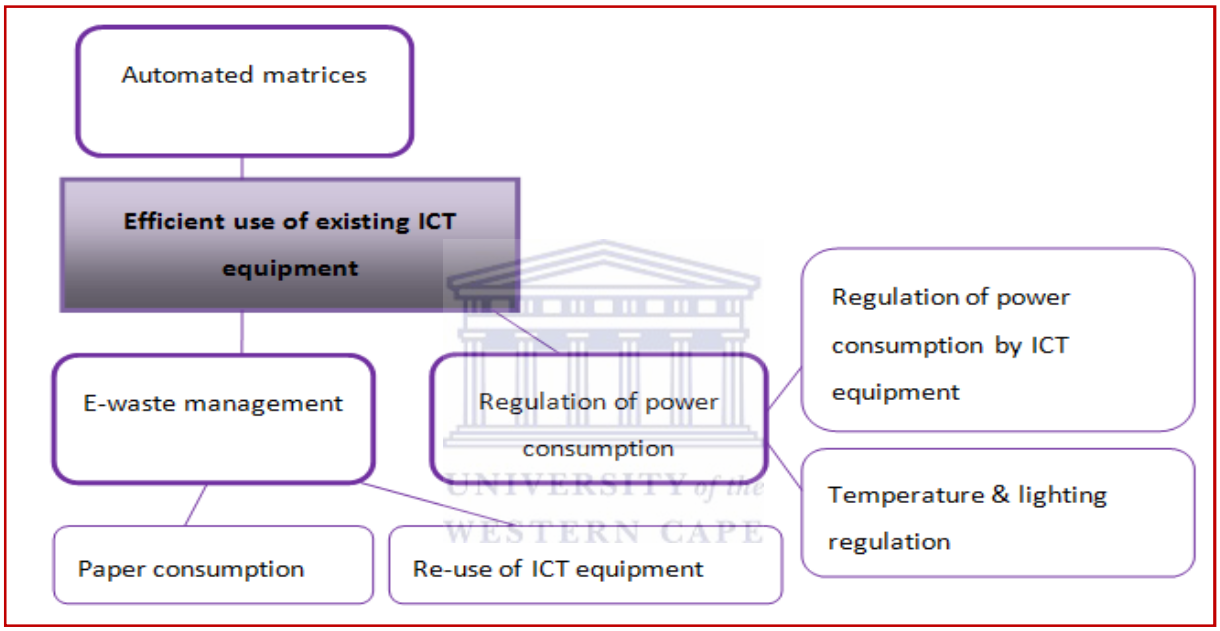

Figure 20: Efficient use of existing ICT equipment (Source: Author)

This main concept pertains to how well the ICT users use the available ICT equipment, and it is directly linked to the '**Awareness and Knowledge main'** concept in that the manner in which the employees use the existing ICT is also dependent on the level of awareness and knowledge of environmental sustainability, the ICT system itself, and how the ICT system supports environmental sustainability. It is also linked to the '**Culture'** main concept on the basis that users' attitudes, motivation, commitment and consequently behaviour - which are all partly a result of **'Awareness and Knowledge'** main concept - play a significant role in determining the efficiency of use of existing equipment.

4.4.3.1 E-waste management

The *e-waste management* sub-concept refers to the use of the existing ICT system to minimise the amount of e-waste that Company-A disposes to the environment. Examples of the properties of this sub-concept include minimisation of paper consumption and re-use of ICT equipment.

As pointed out by the interviewees, the rate of 'unnecessary' paper consumption was an area of concern that requires addressing. They pointed out the possibilities of employing different measures such as enforcing double-sided printing, reducing the number of printing devices, and upgrading the current ICT system to facilitate dematerialisation so as to move away from traditional hard-copy-business practices. However, resistance from other system users is inevitable regardless of how well the current ICT infrastructure is restructured, and is this can be traced back to employee levels of awareness, knowledge, attitude, motivation and commitment to the goals of environmental sustainability.

The re-use of ICT equipment pertains to extending the life span of ICT equipment beyond when it is scheduled to be disposed of, and this could be done through upgrading the equipment or moving it to other sections of the organisation that do not necessarily require new ICT equipment with better processing functionality. Donating working yet organisationally obsolete equipment to other organisations such as schools and orphanages is also an example of re-use of ICT equipment, However it would be naive to ignore the ramifications of donating environmentally unfriendly ICT equipment to other organisations but this is beyond the scope of this study.

4.4.3.2 Regulation of power consumption

Literature and the data gathered from the interviews showed that efficient use of ICT can play a significant role in the regulation of power consumption within the organisation. This sub-concept has two properties, a) Regulation of power consumption by ICT equipment, b) and temperature & lighting regulation. The literature shows that most of the power consumption attributed to ICT equipment is actually consumed by the data centre, and some methods and techniques such as efficient data centre designs and liquid cooling which were discussed in section 2.7.2 (*Reducing ICT-related energy consumption)*, have been employed to reduce data centre power consumption. There various energy saving technologies that can be employed such as virtualisation, cloud computing, grid computing, and thin client computing

which were discussed in section 2.6 (*Technologies used in "green" information systems).* Interviewees also pointed out at the use of ICT sensors to automate the building lighting and air-conditioning.

4.4.3.3 Automated matrices

This sub-concept refers to the use of precise measuring tools embedded within the ICT system to give detailed feedback to the ICT system users on their progress in achieving and maintaining a "green" working environment, and it feeds back to the '**Awareness and Knowledge'** main concept, from which management can also gauge the effectiveness of "green" strategies/polices and therefore make more informed decisions on the way forward. Interviewees also cited the lack of clear matrices as one of the factors that discourage employees from adopting "green" practices.

4.4.4 Culture main concept

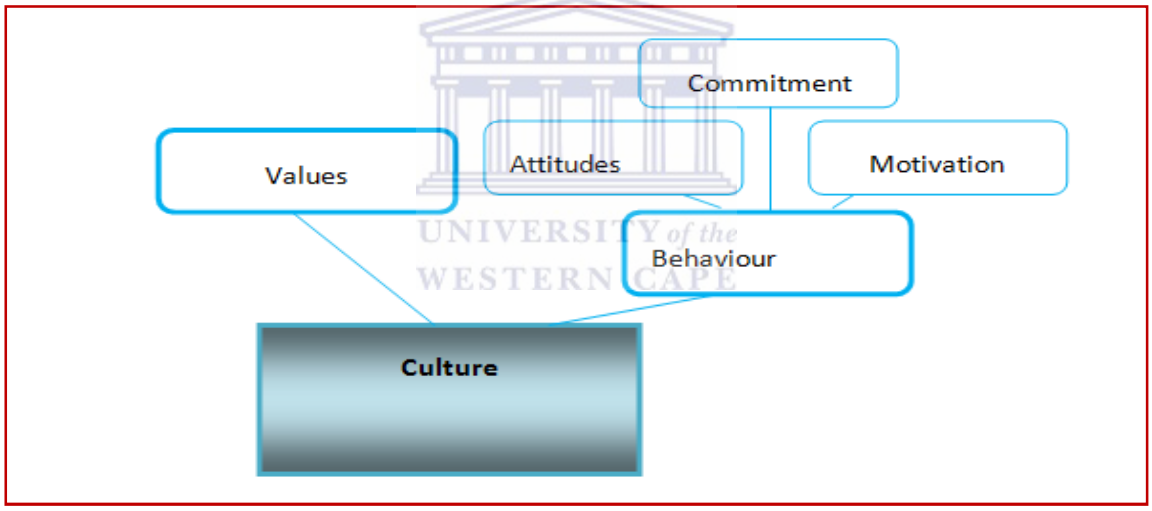

Figure 21: Culture main concept (Source: Author)

Figure 21 shows a pictorial representation of the '**Culture'** main concept. Culture in this context refers to the social aspect of developing environmentally friendly values and behaviour amongst employees. Values are a combination of the individual values of employees and organisational values that an organisation seeks to be identified with hence the relationship between the '**Culture'** main concept and the '**Strategy & Policy: Formulation & Implementation'** main concept is linked by the *Values* sub-concept since it is a product of organisation's strategy. While an organisation has no control over the individual values of its employees, it can influence them by specifying its own position or

values with regards to environmental sustainability, and how it expects its employees to adopt them. At the very least, the organisation can make it a policy to employ only those candidates that are more closely aligned with the organisation's values with regards to environmental sustainability.

The level of awareness and knowledge about environmental sustainability and its importance/ benefits affects the general behaviour of employees with regards to adopting environmental practices and this is the link between the '**Culture'** main concept and the '**Awareness and Knowledge'** main concept. The behaviour sub-concept has three properties which are: a) attitude, b) commitment and c) motivation.

4.5 Chapter conclusion

To answer the main research question on how ICT can be used to support a sustainable environment, the researcher suggests a model that addresses the four main concepts discussed in section **4.3.1**, **4.3.2**, **4.3.3**, and **4.3.4**. This model is shown in Figure 22 which depicts a graphical representation of main concepts and their sub-concepts together with how they are inter-related and Table 12 is a tabular representation of Figure 22.

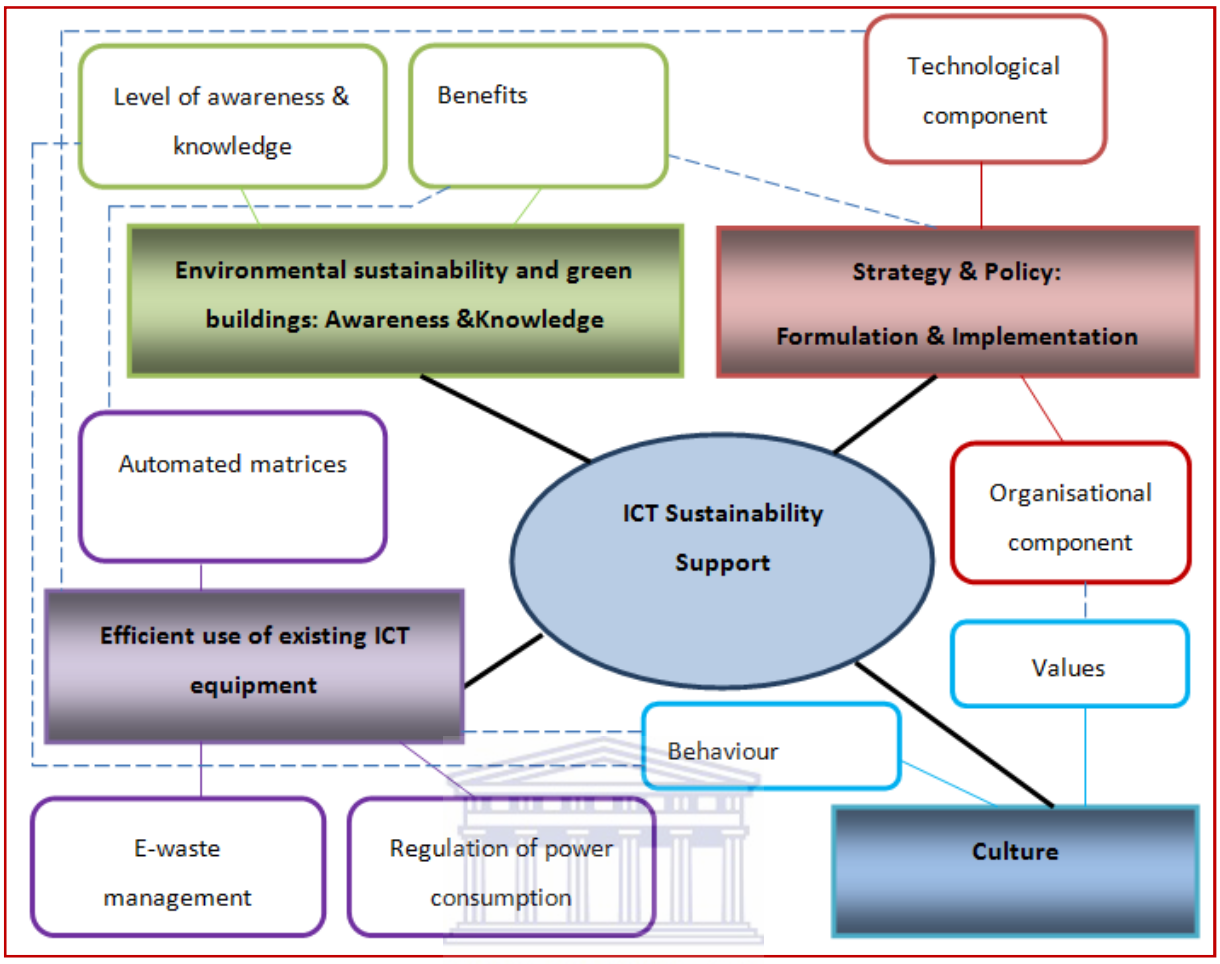

Figure 22: Conceptual model for ICT sustainability support (Source: Author)

Table 13: Conceptual model for ICT sustainability support: A tabular representation.

(Source: Author)

Main concepts	Sub-concept
Environmental sustainability and "green" buildings: Awareness & Knowledge	Level of awareness & knowledge
	Benefits
Strategy & Policy: Formulation & Implementation	Technological component
	Organisational component
Culture	Behaviour
	Values
Efficient use of existing ICT equipment	Automated matrices
	Regulation of power consumption
	E-waste management

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

At the commencement of this study Company-A was in the process of planning a new office building to accommodate its growth in business operations, and consequently the number of its employees. Senior management recognised the importance of implementing environmentally friendly practices at the new office building however there was a lack of understanding or appreciation of how sustainability ICT could be used to support an environmentally friendly and sustainable environment in the new office building. The purpose of this study was to address the main research question: *"How can ICTs be used to support environmental sustainability at the new Company-A office building?"* This chapter will reflect back to the research objectives and sections at which each research objective was achieved. It will also discuss the limitations of this study and suggest recommendations for further research.

5.2 Accomplishment of research objectives

The research objectives highlighted at the commencement of this study are:

1. To define and describe sustainability, and "green" ICT.
2. To identify the requirements for sustainability/"green" IS.
3. To explore ICTs used in "green" information systems.
4. To identify main concerns in implementing a "green" IS.
5. To explore areas of application of ICT in "green" buildings.
6. To suggest optimal methods of adopting ICT for a sustainable working environment in the Company-A building in Cape Town that could be replicated in other similar environments.

5.2.1 Define and describe sustainability, and "green" ICT

The accomplishment of the first objective was reported in Chapter 2 section 2.2 **(***Definitions and descriptions of sustainability*), it was achieved through a review of relevant literature. This chapter gave a brief history of sustainability and how the definition of the concept of sustainability has evolved over the years to include economic, social, and environmental aspects. A working definition of "green" ICT was given in section 2.4 **(***"Green" ICT*) as:

... a systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of IT products and services in order to reduce IT, business process and supply chain related emissions, waste and water use, improve energy efficiency and generate tangible and intangible "green" economic rent. (Molla et al., 2009).

The section also discussed the four main attributes of "green" ICT, its three dimensions, and its sustainability goals. This literature review has helped this author to identify theoretical and conceptual requirements for a sustainability/ "green" IS.

5.2.2 Identifying the requirements for a sustainability/ "green" IS

The researcher identified the requirements for consideration when an organisation seeks to implement a "green" IS during literature review and from the analysis of interview data. Section 2.5 (*Requirements for sustainability IS*) used the IMBOK framework to portray the relationship between ICT, IS, business processes, business benefits, and business strategy. For a "green" IS to be established it is important to ensure continuous "green" performance measurement and improvement processes within each IMBOK knowledge area. Section 4.3 **(***Conceptualisation of findings*), identified four main areas necessary to establish an environmentally friendly IS, namely:

- Awareness and knowledge
- Strategy & policy: Formulation & implementation
- Efficient use of existing ICT equipment
- Culture

The requirements for a "green" IS include: (1) raising awareness and knowledge levels of environmentally friendly practices among building occupants, (2) formulating and implementing strategies and policies that support sustainability, (3) ensuring efficient use of existing ICT equipment, and (4) cultivating a positive culture, attitude, behaviour and enthusiasm among building occupants towards environmentally friendly practices.

5.2.3 Explore ICTs used in "green" information systems

A number of green technologies used in "green" information systems were discussed during literature review in section 2.6 (*Technologies used in "green" information systems*) namely:

- Virtualisation
- Cloud computing
- Grid computing
- Thin client computing
- Environmentally friendly monitors
- "Green" network devices
- Travel substitution technologies

The section explored power efficient technologies, technologies that emit less CO2, and technologies that are less harmful to the environment after disposal, for example LCD monitors have been observed to be more eco-friendly in their disposal life-cycle-phase compared to CRT monitors. Literature also revealed that "green" ICT standards/ eco-labels discussed in section 2.4.4 (*"Green" ICT standards and labels*), are commonly used as a benchmark when acquiring ICT equipment for "green" information systems. Now that technologies and eco-labels used in information systems have been discussed, the next objective was to ascertain the main concerns which underlie the implementation of sustainability information systems.

5.2.4 Identifying main concerns in implementing a "green" IS

This objective was accomplished through a combination of the literature review and the analysis of the data gathered from the interviews. Section 2.4.2 **(***Drivers and inhibitors of "green" ICT*), explored some of the obstacles that hinder organisations from implementing sustainability ICT, while section 4.2 **(***Emerging patterns*), revealed the following patterns which can be viewed as barriers to implementing a "green" IS:

- Insufficient knowledge about environmental sustainability
- Lack of "green" strategy and policy formulation and implementation
- Inefficient use of existing ICT equipment
- Lack of matrices to reveal the benefits and progress of "green" practices
- Culture, attitudes and behaviour towards "green" practices

5.2.5 Explore areas of application of ICT in “green” buildings

This objective was discussed in the literature review section of this study. Section 2.7 (*“Green” ICT use in smart buildings*) discussed the application areas of sustainability ICT in smart buildings for example “green” building management systems. "Green" building management systems seek to regulate energy consumption while still offering occupant comfort. They make use of technologies that monitor and record a building's internal and external environmental data in real-time, so as to automatically maintain a specific environmental state. Agent based control systems are examples of "green" building management systems.

The literature revealed that while ICT plays an integral part in attaining energy efficiency in smart buildings, its growing energy consumption rate has been a cause for concern for environmentalists. As a result there has been a marked increase in research towards finding energy efficient ICT solutions especially in data centres. In addition to implementing sustainability ICT in smart buildings, the literature also revealed that building occupants need to be aware of and skilled in “green” practices so as to effectively make use of the “green” IS at their disposal. Building occupants and the overall IS should share a common interest in the environment, for example building occupants can assist in reducing paper printing while at the same time, the available IS should encourage use of soft copy rather than hard copy material – also known as 'dematerialisation'.

5.2.6 Suggest optimal methods of adopting ICT for a sustainable working environment in the Company-A building in Cape Town that could be replicated in other similar environments.

To accomplish this objective the researcher outlined a number of recommendations towards the end of this study in section 5.3.1 (*Practical recommendations*). Some of the suggestions discussed by the researcher came from (1) a review of literature. (2) the data gathered from the interviews in which participants pointed out possible areas of improvement to help the organisation attain a “green” working environment, (3) analysis of gathered data.

The analysis of the collected data has helped this author to refine the literature review derived conceptual model depicted in Figure 15. This yielded to the final conceptual model shown in Figure 22 and Table 12. Subsequently, the use of this model is recommended in two ways:

(1) as the practical recommendation for practitioners in Company-A and possibly other similar organisations and buildings, and (2) recommendations for further academic research.

5.3 **Recommendations**

This section outlines the recommendations that the researcher obtained through the study of the literature and an analysis of the data gathered from the interviews. The recommendations are grouped into practical and academic recommendations.

5.3.1 Practical recommendations

- The researcher recommends the adoption of the model depicted in Figure 22 (*Conceptual model for ICT sustainability support*), as, if properly implemented, this model will address the main obstacles to implementing a "green" IS. The researcher also recommends that this model be tested under different settings to increase the possibility of drawing generalisations from of this study.
- The organisation already has an established employee training system that takes employees through training workshops on different subject areas, and this training system may be extended to include environmental awareness courses that would enhance the capacity of employees in terms of a sustainable business approach. The orientation programme for new employees could also be used to highlight the organisation's position on environmental matters, and what is expected of all the employees in pursuit of a "green" working environment.
- The organisation is advised to consider revising its current policies to assess whether they are not outdated, and to ensure that they do not directly or indirectly frustrate efforts to achieve an environmentally friendly working environment.
- The organisation is also advised to seek ways to raise awareness and knowledge about environmental sustainability amongst its employees, and top management should champion sustainability issues within the organisation in order to secure buy-in from employees.
- As observed during the interviews, the organisation's IS users were not fully aware of the capacity of the organisation's ICT infrastructure available to them or how to efficiently use it. The organisation's IT infrastructure departments should consider conducting training workshops for all different business departments so as to bridge

the gap in understanding the organisation's ICT infrastructure between the business users and the IT infrastructure.

- Centralised purchasing of ICT equipment would significantly reduce the acquisition of redundant equipment which often remains underutilised or unused while encouraging sharing of ICT equipment. Furthermore, the purchasing policy should enforce or emphasise acquiring equipment that meets specific "green" ICT standards, refer to section 2.4.4 (*"Green" ICT standards and labels*).

5.3.2 Academic recommendations

- The researcher did not cover the feasibility of implementing "green" ICT technology at Company-A as it was beyond the scope of this study. Future research can build upon this study and undertake to study the practicability of implementing some of the "green" technologies discussed in this study.
- The author also recommends further research on one of the patterns, *'Awareness and knowledge of environmental issues'* that emerged out of the empirical analysis of the gathered data. Further research would help address questions such as:
    a) To what extent is awareness and knowledge linked?
    b) How can awareness of sustainability issues be transformed to knowledge?
    c) Does knowledge of sustainability issues amongst employees directly translate into environmentally responsible business practices?

5.4 Contribution of the research

This research has explored and articulated the concept of sustainability from its history to the present day concept of "green" ICT. It also identified areas that might be of significant importance to Company-A's pursuit of a "green" working environment at its new office building, and the researcher recommended further research to explore these areas. It is envisaged that the study contributed to the body of knowledge regarding "greening" building and the application areas of "green" ICT to support a "green" working environment in the new office building. The study can possibly be replicated in similar environments.

5.5 Limitations of study

Although the study findings showed that there was a need for the organisation to formulate implementable strategies /policies, the study did not present a framework suggesting how this

could be done. It might not be possible to draw generalisations from study findings based on the data obtained from the limited number of interviews conducted in this research, and this could be a limitation. More interviews could have altered the patterns that emerged, or revealed other areas of concern or issues that were overlooked by this study. This study was based on one unique organisation and therefore the findings cannot be guaranteed to be true for other organisations, more so those that are not in the financial services sector and are in a different geographical and economic setting than Company-A. Given that the researcher was employed by the organisation under study, there is a risk that the researcher could have lacked some degree of independency in carrying out the study, and there is a possibility of the researcher having influenced the study results. However, the above limitations did not significantly impact the validity and relevance of this study.

5.6 **Concluding remarks**

The study revealed that the route towards achieving an environmentally friendly IS does not only lie in acquiring what is perceived to be sustainable or "green" ICT equipment and building what is regarded as a "green" building but also involves training the people that work in the building and use the IT equipment. In other words, it is important to establish official regulations, standards or policies for the utilisation of the ICT equipment and the building. Implementation of the proposed model is envisaged to assist in establishing environmentally friendly and sustainability use of ICT at the organisation's new office building. It is now up to the practitioners and academics to scrutinise, critic or amend this model in order to make it more beneficial for organisations that strive to use ICT to support environmental sustainability at their premises, and contribute to efforts aimed at ensuring that future generations inherit a "green" environment.

For such noble efforts, that determine the destiny of the earth's environment, to yield the intended results, not one organisation but all the citizens of this world will need to contribute. In the words of the Nobel laureate Barack Obama: *"...our destiny will not be written for us, but by us; by all those men and women who are not content to settle for the world as it is; who have courage to remake the world as it should be."* (Civettini, 2011).

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APPENDIX I

INFORMATION SHEET

The organisation is in the process of planning for the new office building and management would like this new building not only to be comfortable for all the employees but to also ensure that it will provide an environmentally friendly working environment. I am therefore conducting a research on how information and communication technology (ICT) can be used to support environmental sustainability at the new premises.

You are hereby invited in your capacity as an employee of the organisation to participate in this research, for my data gathering I would like to schedule a 30 minutes face-to-face interview meeting with you, the purpose of the interview is basically to cover two main areas: (1) awareness, and (2) application areas of environmentally friendly ICT "green ICT":

1) **Awareness**: This area seeks to determine the level of awareness / appreciation among employees on issues pertaining to environmental issues, sustainability, environmentally friendly buildings, and "green" ICT.

2) **Application areas of "green" ICT**: This area seeks to get the input from interview participants on what they think are the areas where ICT can play a role in supporting an environmentally friendly working environment at the new office building

The interview is basically a discussion guided by open ended questions.

Your participation will be greatly appreciated.

For any additional information please contact:

Researcher:	Supervisor:
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APPENDIX II

CONSENT TO PARTICIPATE IN RESEARCH

STUDY TITLE: Sustainability use of information and communication technologies: A Case Study of an asset management company.

You are hereby requested to participate in a research study conducted by Mr. Mpendulo H.F Ngwenya from the Institutional I.T department, Company-A. This research study is partially conducted towards the completion of the researcher's M.Comm (Information Management) thesis at the University of the Western Cape. You were selected as a possible participant in this study because you are an employee at Company-A.

1. PURPOSE OF THE STUDY

The aim of the study is to investigate how ICT could be used to support environmental sustainability at the new Company-A office building.

2. PROCEDURES

If you volunteer to take part in this study, you will be asked to participate in a face to face interview with Mr. Ngwenya, the purpose of the interview is to get input from interview participants on their understanding of "Green" ICT and application areas where ICT can play a role in supporting an environmentally friendly working environment at the new Company-A office building. The interview will take place at any of the available Company-A meeting rooms either at the Portswood or Granger Bay office building depending on the your place of work and time suitable to you.

3. POTENTIAL RISKS AND DISCOMFORTS

No potential risks are envisaged at this stage. However, if something might come up, it will be dealt with in a sensible and sensitive manner.

4. POTENTIAL BENEFITS TO SUBJECTS AND/OR TO SOCIETY

Potential benefits could be that Company-A employees would be stimulated to think about think about the effects of environmentally unfriendly behaviour and the benefits of adopting "green" practices as they go about with their jobs and hopefully they will adopt these "green"

practices as part of their lives and influence those around them even outside work. Company-A would benefit directly from the results and recommendations that will be made in that these recommendations will assist senior management in making more informed decisions in formulating strategies and policies to ensure an environmentally friendly working environment at the new office building and the study could be tailored for other organisations in the financial services sector that are similar to Company-A.

5**. PAYMENT FOR PARTICIPATION**

No payments to the participants will be made.

6. CONFIDENTIALITY

Any information that is obtained in connection with this study and that can be identified with you will remain confidential and will be disclosed only with your permission or as required by law. Confidentiality will be maintained by means of referring to participants as Interviewee 1, 2, 3, etc, and by means of themes and categories that will be identified and used in the analysis and discussions of the findings and the outcomes of the research. Any information given by participants will be handled in the strictest confidence, and that the information participants give will not be used to reflect negatively on them in any way.

7. PARTICIPATION AND WITHDRAWAL

Participation in this study is completely voluntary and you may withdraw at any time without any consequences. Participants may refuse to answer any questions they don't want to answer during the interviews and this would not affect their participation.

8. IDENTIFICATION OF INVESTIGATORS

If you have any questions or concerns about the research, please feel free to contact me telephonically on 079-077-1221 or e-mail: mpenyongolo@gmail.com

9. RIGHTS OF RESEARCH SUBJECTS

You may withdraw your consent at any time and discontinue participation without penalty. You are not waiving any legal claims, rights or remedies because of your participation in this research study. If you have questions regarding your rights as a research subject, contact Dr Zoran Mitrovic, Programme Coordinator: Masters in Information Systems Management, room 4.38, Level 4, EMS building, UWC, or telephonically, (021) 959- 2162; or via e-mail at zmitrovic@uwc.ac.za

SIGNATURE OF RESEARCH SUBJECT OR LEGAL REPRESENTATIVE

The information above was described to *me, the participant* by Mr Mpendulo H.F Ngwenya in *English* and *I am the participant* in command of this language. 1 was given the opportunity to ask questions and these questions were answered to *my* satisfaction. *I hereby consent voluntarily to participate in this study.* I have been given a copy of this form.

_____ _____

Name of Subject/Participant **Date**

_____ _____

Name of Legal Representative (if applicable) **Date**

SIGNATURE OF INVESTIGATOR

I declare that I explained the information given in this document to _____ [*name of the participant]*.He/she was encouraged and given ample time to ask me any questions. This conversation was conducted in *English* and *no translator was used.*

_____ _____

Signature of Investigator **Date**

APPENDIX III

INTERVIEW GUIDE

1. INTRODUCTION

Greetings, and brief background and purpose of the study

2. QUESTIONS

Awareness

- What do you know about environmental sustainability?
- What do you know about environmentally friendly buildings also known as smart or "green" buildings?
- What are "Green" ICT application domains in "green" buildings?

Areas of applicability

i. Regulation of power consumption

- How can we regulate overall power consumption at the new office building?
- How can we regulate power consumed by ICT equipment?

ii. Waste management

- In your own words what do you think are the waste materials buildings dispose to the environment and what are effects on the environment?
- How can ICT be used to reduce the waste materials just mentioned?

iii. Hindrances in adopting "Green" ICT

- What hinders or discourages people from adopting green practices

APPENDIX IV

SAMPLE INTERVIEW TRANSCRIPT

INTERVIEWEE 3

My first question is about awareness of sustainability? What can you tell me as much as you know about environmental sustainability in your own words?

My own interpretation is based on making sure that the way that we do things whether it's at work or at home is with the knowledge that your are trying to leave a legacy behind for those who are still to come. So you take as little from the environment to sustain yourself as possible. And for me it can be anything from the car you drive to the types of food you eat, whether you take public transport to work, whether you print double side in terms of the way you work with your paper in the office, and whether you recycle simple things and educate your children. And I have become more aware of how I choose to apply myself, not only in the work environment, but my personal expectation is to become a role model in what my job expects me to do. So I won't go a purchase from a shop that I know gets its stuff manufactured in a Chinese sweat shop and then gets sent over. And I know that the carbon footprint for something like that is huge, and yet I managed to pay very little for it , which means that someone somewhere is not rightfully being rewarded for their effort that went into the creation. So does that sit right with me?? So sustainability can then obviously be translated into a value system as well.

So it's more of a morality thing?

Well it is a morality thing, I think it needs to be that first so that it becomes a part of your value structure and so that everything else that you touch should speak of that legacy and you don't have to tell people what it is you are aiming to achieve. So it worked for me, my understanding of this role is that it's a pioneering role where the company says this is what we like to do, it's a nice to do thing, it's not expected of us and we trust you to find those initiative, to create them, to align yourself with likeminded people doing the same thing, or that might have become leaders in their fields. To educate yourself so that you can come back

and educate the staff, so what I'm working on and what we have already put in place is things like the recycling drive that we do. That's secure. Within 2 months, I have managed to put some things in place that the company was battling to get rid of. E.g. we have managed to get rid of tin. The Tetra Packs that you your get juice out of, no were in South Africa did they have the equipment to process them. We have now managed to align ourselves with Tetra Packs itself, they have now imported a machine from Germany, [and] everything managed to get processed, so I managed to get rid of our e-waste. You would know about our old telephones and stuff, we had 2 garages full of those, they have been processed. The bottom line for me is that my job is to get the company and my colleagues ready so that when we move in to our grade 5 buildings, our behaviour would have changed so much that we are comfortable with going in there without experiencing shock. We go to tread very lightly in that building. So the way of operating and the way we do things in the office is going to change and hopefully that change will be instilled so that staff can take it home and emulate that there and that will help make our footprints smaller.

How can we use IT to support this environment? You spoke about areas of environmental sustainability, where can IT play a role to help?

The one aspect that I mentioned is the printing, if I look at the paper consumption, I mean I'm busy with the studying were I look at how much paper we purchase and how much do we process then recycle. So I'm trying to weigh those net weights up. To isolate the areas which a company using the most paper and is it justified? Are people just printing things for a piece of mind? Are they not buying into the whole electronic media? So on that level; IT can help people to trust the service more. We used to have backups of everything; nowadays it's not needed anymore. And I think that with our problem is with metro filing and sticking stuff into a warehouse without ever knowing if you can retrieve it when you needed it. If IT can help us in duplicating things in an electronic way, the battle is half way won. On the other hand, I think IT can help me by communicating the messages that I want people to hear without me having to print it and stick it them somewhere. So for me, I want to use the internet as a tool to tell people stuff about the environment or how we at Alain Grail really make certain changes or differences by how we work cleverly. So whether it's got to do with how we document things or how we back things up or what our turnaround time is in terms of getting something from the point of deliver to being processed and how quickly that happens. A simple example would be, pay slips, [and] we can use the option to not get them printed out. The backdrop of the pay slip itself can actually have subliminal message so that you cannot

duplicate it. On the extra space on the pay check, one can insert a little water saving message or you could have a cartoon character that interacts with people on the internet. This character is not in your face or indoctrinating in any manner, but it does the job. I would need IT to help me with and I think that's in amazing opportunity to get any message to the staff. And I don't think that this is a job for one person.

Everyone has to buy into the idea. [Probe]

And that is probably the biggest challenge because at the moment iv just managed to get a company called Ecology to put together a series of talks they will run over lunch times to educate staff. We will have different aspects of the company to talk about. I think that there is a lot of potential in the IT environment to save money. At the end of the day, a lot of the things that we threw away were things that were still working with the e-waste initiative. The lifespan of certain things especially phones and PCs (the things we donate) can still be used for a little while longer. I do think that we waste a lot of money. I think that it's easy [Company A] to say buy a new computer or buy something else that is new. I understand that our productivity is important but I do think that sometimes we can push a bit with what we have.

From my other interviews, they complained about the way we print at this company.

I think there just needs to be a default setting that automatically prints both sides, if you choose to and for good reason to print one side, then you will have to physically go and look for that option. That's a very simple thing that can help. Unfortunately when you want people to develop behaviour, you have to get them on your side first, and people don't like surprise, so even though what we are trying to achieve is really important and is expected of us, you can't just go and change people's printing settings because you will have a really mad bunch of people. Maybe if you ask for support and give them some statistics, e.g., we figured that if we all print double documents for a week, this is how much money we will save. Unfortunately we are a kind of environment that needs proof first.

Someone also touched on that by saying "people just don't know the value of sustaining their environment; they need to be informed about the benefits so that they can be aware of the reasons they shouldn't print". Can you give me idea of environmentally friendly buildings, or "green" buildings, what it means to you?

When you ask a business owner what is their biggest expense, I think it's their overhead. Sometimes you think its staff salaries, but I think that it's maintaining the building. A good "green" building doesn't just address the structure; it also addresses the environment within

that building as well. Everything from the air that you breathe, to the kinds of noise you hear and feel of the building are considered as well. Most companies would love to be able to do that, but it costs money. We are lucky that Alan Gray covers all of this. I did a course on sustainability auditing, we sat in a room like this and studied the amount of natural light there was in the room and how much unnatural light there was as well, so we also took into account the other insulating factors which play a role in the safety of a building. We looked at everything from the fittings to the exit doors. There are a whole host of things that have to be taken into consideration before the designing of a grade 5 rated building. E.g. one might have a sensor that switches the lights on the moment someone walks into the room. I know that the waterfront buildings are great but they are not necessarily sustainability compliant, but their style has changed, e.g. when one walks into their bathrooms, the water system is automatic and the lights automatically switch on when someone enters. A lot more companies now are trying to operate this way because they are now expected to, because their customers want to align themselves with like companies who are concerned about what we do to this planet, not only for our children, but for us to be able to survive.

This completes the questions on awareness; we have covered it in detail, it seems like you have a good understanding of sustainability, have you been researching on this?

I did a presentation for the new starters on Wednesday, it was daunting but exciting to start with people I know. The internet will be the best medium for me to drive all this. I could have random did you know questions or random pop ups that will help you, so without you knowing, you will be indoctrinated with information that will help you fit in. Things we have done; there is new bins were we dispose of coffee grind or what's left when it comes out of the machine. This coffee grind gets collected once a week and gets thrown into a bigger bin. This coffee is then sent to a centre for abused woman and children in Athlone and they use it in their gardens: simple initiatives but they are so affective. A company called Green Genie is going to supply me with 3 units were I can throw away all the organic waste from the kitchen. The waterfront is very "sticky" about where to put up these. Cooked food that is not organic, e.g. chicken, is considered as wet waste and wet waste is very difficult to process because there a lot of chemical and water used. With the units which Green Genie provided, one just needs to add wood pallets to the food waste, turn the unit on once a day. In 2 weeks that waste would have turned into proper compost.

And the smell?

There is no smell because it is insulated and closed in. It turns into a coffee like mixture

which you can bag and the idea is to give the proceeds to charitable organizations or for staff to utilize for their own gardens. I'm also planning a roof garden for the new building, 2 architects and the guy from New York are helping me workout the layer. This will allow us to grow our own vegetables, isn't that lovely?

With regards to the regulation of power consumption, how can we reduce overall power consumption in our new office?

I think we need to have timers on a lot of things, when I first got here I noticed we had a hydro boil; I was quite adverse to them and didn't know how they fully operated. I found out that they heat the water up to a certain temperature, and then they switch off. But when the temperature drops to a certain level, it switches on again then the water gets heated again. It's not like a kettle which you must switch on when you want the water on, but once it's off you will have to start over again. We need to have water saving shower heads in our office showers. I think that in the new building we will definitely have more sensors on the taps. There should be a rule that is no building should keep their lights on all the time. Even at times when there is no one in the office, some buildings will still be lit. If I come in to do some work on the weekend, I should have a desk lamp to use as my light because I don't need all lights in the office to be on. Simple things like switching the air conditioner on when there is no one else in the room will help significantly.

And obviously IT helps us with many things like energy reduction and sensor activation, but on its own, it also draws energy which creates a hit back effect, so how can we also reduce power consumption from the equipment?

In some offices, each person has their own printer; I feel that if we could all just print to one printer, a lot of energy would be saved. I'm my old position, the printer that was next to my computer was valued at R60 000, which I don't that was justified price for a printer. I think you need to re-evaluate a person's job, analyze their basic needs to get their work done, then provided them with those instead. I feel that the phones we have been provided are pretty useless compare to the last ones because whether I'm in the parking lot, garage or the lift, I will not be able to make a call because the reception is just so bad.

So sometimes it's the kind of equipment we buy?

Totally, I think sometime we need to be more strict about these things because we end up buying things that we do not need. The demand of a person and need of something need to be inline before making a purchase.

We've got a lot of people, including us who have double monitors, whilst someone can

work as well on one.

I agree, Stephan has a lot of monitor, but his role in the company is instrumental so they become essentials for his role. I'm starting to find more and more people with 2 monitors on their desks.

So the underlining word is we have to make sure that people really need equipment that they have or it's unnecessary?

I think it's another opportunity to say to people that when you want to live more sustainably and you are able to do your job with less equipment, that's a way of helping and living more sustainably. Some people have a desktop computer, an ipad and laptop and I feel that the IT department is also responsible for alerting workers on when is too much. I know people who have all three and those things are going to change, if you want to set an example on how you can work cleverly and take less to do so, you have got lead by example and live that way.

Back to the issue on waste management and the recycling...

I think we have done extremely well I've managed to find someone who takes in glass bottles when no one else wanted to take them in. Nampak also took in tins that we had backed up for over a year and a half. Nampak then supplies SA Metal, who then processes the recycled goods into other initiatives. All of the things we have in place to get rid of our waste are reliable and sustainable. Even with our procurement and the people we bring on board to deliver services have to go through a stringent process on the processes they go through to make their product. We have become far more selective on the way we choose who we want to align ourselves with. By expecting suppliers to become more compliant with regards to living more "green", it would make our footprint even smaller. Within a short time, we have managed to achieve a lot. A company called Carbon Calculator is helping us calculate out carbon emission. There will be a transport survey that will go out to employees to find out how the commute to work, the distance they travel and how much fuel they spent. From these different variables, Carbon Calculator is able to tell us our stats and we can work on improving them from there. I mean it's cheaper to have a video conferencing room so that people don't have to travel so far to other offices for meetings, then that type of facility would have to be installed.

Will we be able to use ICT to reduce things like carbon emission by using ICT to print out progress reports showing the staff if we are making progress or if we are lagging behind?

Yes I think so, when you want someone to buy into something, a key thing would be to tell

them about things that you already do right. People don't want to hear the bad things and end feeling like they bought something they actually didn't have an interest in. I Think Michael would agree, the ideal world would be to have a paperless society and I think it should be the slogan which the IT department should try to follow as well because they are in the appropriate position to achieve something like this. Sometime we print things out of habit and if IT could educated us on how to save paper, it would make a big difference. Celia, Bossof and I started a forum called PA forum before I left that room, the main reason was that we are like minded professionals in the same room, doing the same kind of job just in 15 different ways. There will always be someone with a better way of doing something and the forum is a good platform to share these ideas. We meet once a month, if anyone has a problem, we try to find a solution for it. When there is a problem, we can call somebody from the IT department who to help us resolve some of these problems. For instance, Janice won't have to print the function sheet, which consists of 2 pages if she could view everything. I think for each role there are things that are critical to do you jobs, but if you are frustrated by the system, you will resort to your old ways. All the people on the floor are equally important to deliver the same opportunity to transform their minds, habits and behaviour.

I was really able to get some rich information here.