Sustainable Green Information Technology to Reduce the Environmental Impact on Universities

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Abstract

Climate change are the challenges facing environment today. Environmental sustainability is a persistent problem. IT is also growing at a quicker rate in a variety of fields. Due to this, the world is facing an increasing environmental threat which are posing severe challenges to the human race. Tackling these environmental problems and establishing a sustainable environment requires the adoption of appropriate sustainable green IT strategies in all of the South African tertiary institutions. This study addressed this environmental problem by developing a framework for measuring sustainable green IT practices and policies at universities in South Africa. The research methodology entailed an empirical investigation using a qualitative approach using a case study. The data was collected in the form of semi-structured interview using a representative sample of IT, IS and Computer Science academics who use the system and are already acquainted with IT terminologies, across the conventional South Africa universities. A theoretical framework based on the findings was designed that presented five themes. These are (1) the sustainable environmental development; (2) IT resource optimisation for green solution; (3) e-waste disposal management; (3) energy efficiency and carbon footprint reduction; and (5) cost benefit relevance. A total of 30 items relating to the five themes have also been identified. Finally, this paper presented practical guidelines and recommendations for universities in South Africa which are applicable to other educational areas such as schools, institutions and colleges.

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Introduction

In the past, organisations paid little attention to the environmental aspects of the equipment they used and disposed off (UNEP 2010; UNEP 2011). Today, sustainability issues are becoming a consideration in transforming the world's economies (Gholami *et al.* 2013). Understanding the impact (for instance securing cost savings) of implementing a green IT strategy should be essential for improving the effectiveness of education in South Africa.

Green IT's are playing an increasing role in the environment, among government and private and civil society stakeholders (Melville 2010; Watson *et al.* 2008). It has penetrated all areas of socio-economic development. It is enabling the development of new skills, competitiveness and growth, particularly in developing nations. All of this create challenges of climate change. The capacity of green IT to mitigate the harmful effects of climate change impose a responsibility on all stakeholders of the Information Society to promote the use of technology to combat climate change (Murugesan 2008; Murugesan 2010).

As humans depend on the environment and technology offers a future of enriched facilities, they need to keep track of climate change (Organisation for Economic Co-operation and Development – OECD 2011). On the other hand, the use of technology contributes to an increased degree of impact such as pollution, excess energy use and electronic waste that affects the environment negatively (Murugesan 2013; Molla 2009).

A university, as an organisational body, is responsible for sustainable educational materials. It should provide academics with the information they need to understand fundamental environmental issues and to take measures that help safeguard the earth from environmental depletion (Ahmad *et al.* 2013). Wals and Jickling (2002) state that education for sustainable development promotes competencies like critical thinking, imagining future developments and making decisions usingg a collaborative technique. Sustainable green IT can make a contribution to education in achieving a better world through the use of IT by ensuring elimination of damage to the biosphere, and minimizing the environmental impact (Ahmad *et al.* 2013).

Computers, used academics and other staff members are found all over campuses. All of these equipment is a source of energy use and greenhouse gas emissions, and accounted for environmental problems during disposal (O'Connor & Meil 2012). In addition, computers generate heat and often possibly take as much energy to cool down as it takes to run it (Rowe 2011). But even worse, as specified by Mill (2013), electronics account for 10% of the world's energy use; and leaves a surprisingly large footprint.

Problem Statement

Environmental problems are not only problems of technology, yet they encompass a wide area such as industry, biology, ecology, chemistry, geology, sociology, and so on. Though technology has liberated human beings from hunger, deprivation and insecurity, it has also created side effects, because it consumes resources. It is necessary to deal with general problems such as managing of e-waste deployment, generation of greenhouse gas emission, determining the environmental and health impact of IT related products and redesigning alternative solutions that improve efficiency in products and usages.

The overall general problem statements can be decomposed and rephrased as the following sub-problems that can be individually subjected to empirical investigation:

1. Strategies can be implemented in organisations that currently own a large number of IT infrastructures as these pose severe environmental problems, both during its production and disposal.

2. The policy adopted should reduce the generation of greenhouse gas (GHG) emission, the carbon footprint and other related side effects. All of this to minimize the use of excess energy throughout the all the processes associated with the production, including the redesign of alternative solutions.

3. The production of sustainable green IT to reduce energy consumption and carbon footprint and other related side effects of technology and that are bound to be an important issue for several years have not yet been identified and implemented.

4. It is not yet determined how the adoption of green IT practice will affect the cost in implementing rapid technology change that offer energy saving benefits for adopting good for the environment green IT products.

Literature Review

Green Information Technology (IT) started as early as 1992, when the Environmental Protection Agency (EPA) created Energy Star, This was a voluntary labelling programme aimed at supporting organisations and individuals to save money and protect climate change through superior energy efficiency (Weems 2010). Green IT was initiated as a plan to ensure smart decisions that protect investments and safeguard the health and security of societies, economies and infrastructure from the impacts of severe weather affecting climate change (Gholami *et al.* 2013). EPA is continuously promoting a number of factors that contribute to cleaner technology by proposing carbon pollution standards for power stations. Also, by formulating guidelines by which the business sectors can possibly reduce greenhouse gases and become global market leaders in addressing the challenge of climate change (Herrmann *et al.* 2012).

The term Green IT is interchangeably known as sustainable Information Communication and Technology (ICT) or ICT for sustainability, environmental technology (envirotech), Environmental Management Information System (EMIS), green technology (green tech), as well as clean technology (clean tech) (Gholami *et al.* 2013; Molla, *et al.* 2009; Murugesan 2010; Porter & Kramer 2006). Sustainable green IT covers a range of subjects: energy savings or conservation, energy efficiency and renewable energy that generate electric power from sources of primary energy, the reduction of a carbon footprint and coal consumption, actively dealing with environmentally sustainable infrastructure design and e-waste disposal (Gholami *et al.* 2013; Molla *et al.* 2009; Murugesan 2010). Ultimately, Green IT deals with subjects that can potentially cause dangerous climate change. Its main issue is to realize and encourage ways of reducing pollution, implementing higher efficiency and alternative power generation systems, discovering alternative data servers, and manufacturing computers that are recyclable. Also, the use of less hazardous materials to use in products that the technological revolution will bring the world (Murugesan 2013).

The term 'sustainable' usually include a complete openness to green IT. The word is derived from the Latin word 'sustinere' or 'tenere', which means 'to hold on' or 'to maintain or capable of being maintained' (Dictionary.com n.d), to keep up, especially without interruption, diminution, flagging or to prolong (*Webster's New International Dictionary* 1986). But sustainability in relation to green IT is more meaningful than just 'to keep' or 'to maintain' or live a life on this planet. Sustainable green IT refers to the environmentally sustainable computing or sustainable IT, evolving product-delivery mechanisms, manufacturing, operating methods, such as waste management practices (materials recycling, waste exchange), better utilisation of IT software and hardware that conserve energy and natural resources, minimise environmental load of human activities, and protect the natural environment (Molla 2009).

Sustainable green IT encompasses the adoption of IT application patterns for green optimisation, as well as green maturity models for virtualisation and practices in an efficient environmentally responsible way (Murugesan 2013). It entails planning and investing in a technology infrastructure that serves the needs of today as well as the future generation while conserving resources and saving money. Molla *et al.* (2011), in agreement with Lamb (2009) define sustainable green IT as the way and practice of using computing resources efficiently, and of treating the environment with responsibility.

Though the terms 'green' and 'sustainable' are regularly used interchangeably, there are quite a few differences between them. Molla (2008) portrayed a distinction between 'green' versus 'sustainable' technology. According to him, 'green' generally means environmentally friendly and energy efficient, whereas 'sustainable' reflects planning and investing in a technology infrastructure that will serve all the needs in helping to save money on wasted resources, for instance, energy and paper. In general, sustainable products and activities are subject to a standard of performance of 'future' factors.

Sustainability encompasses a comprehensive term regarding the implications of products and services used over a longer period of time, considering social and financial impacts. Jenkin *et al.* (2011) highlight environmental sustainability as the development that encounters the need and aspirations of the present without compromising the ability of future generations to meet their own requirements. To Molla (2009), green is the

starting point to a sustainable journey, while sustainable is a journey of improving technology rather than aiming at a destination. Murugesan (2013) pointed out that sustainable IT is a broader research area spanning across the spectrum of Computer Science and engineering, electrical engineering, buildings, products and supply chains as well as other engineering disciplines that affect the environment. In general, Murugesan (2013) argues that sustainable products and activities are subject to a higher standard of performance because of 'future' factors in a wider spectrum.

South Africa intended to identify the subjects which need to be addressed when a White Paper was formulated (Lin & Ho 2011). This paper reported on initiating a broad framework for a general approach to environmental management in all areas of Government. Some of the aspects were improved pollution and waste control, focusing on people and their participation in environmental decision making, developing an improved system of governance and achieving sustainable development. The authors specified that there are many capacities which the government needs to address. For instance, the Paper does not present detailed policy proposals for issues involved in achieving effective and ethical environmental management and a sustainable use of natural resources. It rather proposes a framework of principles, processes, structures and mechanisms to integrate environmental governance and enable the development of policy, strategy and action to address specific issues and sectors.

McCabe (2009) affirms that the adoption of sustainable green IT is based on the strategy of mini, medium and large size progressive market companies. He illustrates that increased profitability, reduced operating costs and improved brand reputation together with growing consumer demand for sustainable products and government policies are gearing the acceptance of sustainable business practices in every industry. Businesses are increasingly dependent on technology such as personal computers, notebooks, palmtops, tablets, iPod, iPad, iPhone and smart phones on a daily basis, connected to servers running 24 hours per day.

Research Objectives

The primary objective of this research was to create a framework for measuring sustainable green IT in the universities of South Africa that may also be applicable to other areas such as schools, colleges and private education

institutions. Having given special consideration to the primary objective, we realise that the objectives of the study give rise to the following:

i. To implement practices of electronic waste management reducing, reusing and recycling electronic waste, so as to benefit education and to reduce the pressure on non-renewable resources as well as to help reduce waste, space and pollution.

ii. To enable the role of eco-sustainability in reducing the pollution of a carbon footprint and energy consumption, in order to assist South African universities to measure their green IT readiness.

iii. To establish a holistic approach to the use of green IT products, applications, services and practices.

iv. To determine what green business practices examine the impact of the start-up cost in implementing rapid technology change that offers energy-saving benefits for adopting green IT practices.

Research Methodology

The research design for this study was highlighted as exploratory and interpretive case study that was analysed largely through qualitative methods. The pilot study was also used as a measure of testing the validity and reliability of the research instruments.

This study accomplished its objectives by establishing philosophical concepts (ontology, epistemology and methodology) underpinning the study; validating the research approach indicated to the research problem, research objective, and the subsequent research methods. The qualitative research method was chosen to gather data using interviews rather than a quantitative method. The researchers used direct observations, document reviews, group discussion, and interviews to gather data from diverse sources. This was done in line with the principle of multiple sources of evidences.

Findings were gathered from five randomly selected conventional universities namely University of North-West (UNW), University of KwaZulu-Natal (UKZN), University of Pretoria (UP), University of the Witwatersrand (Wits) and University of Cape Town (UCT). All five of these higher educational institutions allowed four respondents; the study was thus

done with 20 participants,allowing the researchers triangulation. This sample could be regarded as representative of the varied population and professional experience. Besides, it should be noted that interviewees were not discriminatory or differentiating according to gender, proficiency and area.

Results and Discussion

The data-gathering process was aimed at students and academic lecturers in the field of Information Technology and Computer Science. A sample size of 20 participants across five universities of South Africa with in-depth knowledge and experience of green IT were purposely used for the focus group interviews. Although it was not the purpose of this study, it is worthwhile explaining the input of focus group respondents.

Equivalent to a framework developed from literature review and closely similar to the one developed using the grounded data, the focus group did not indicate a change of the core parts of the framework. Therefore, a proposed theoretical framework for measuring sustainable green IT practices emerged. This was verified from the non-empirical framework developed during the literature study, combined with the input obtained from the focus group. These measures of sustainable green IT practices are theoretical by nature and contribute to the body of knowledge. The final empirical framework developed from qualitative data was obtained using case study research. The advantage of having a framework based on case study research is that it provides wide-ranging insight into the phenomena being considered. However, their generalizability and applicability is restricted.

Thematic Evidence

Core categories that emerged from the data were environmental sustainability, IT resource optimisation for green solution, e-waste disposal management, energy efficiency and carbon footprint reduction and the cost benefit relevance as independent variables. Thematic evidence explained the content and correspondence analysis helped to summarise the findings, following a grounded theory method. The content analysis provided basic descriptive statistics and a quantitative input using the correspondence analysis. Data were gathered from five randomly selected conventional universities namely UNW, UKZN, UP, Wits and UCT. All five of these higher educational institutions

offered four interviewees; the study was thus done with 20 interviewees. This could be regarded as a weak point as data might not be saturated during interviewees.

Environmental Sustainability

Environmental sustainability is the core element that emerged from the data. It has become a concern for organisations in recent times.

Table 1: Environmental Sustainability

1 Theme	Main objective	Findings
Sustainable environmental development	Measure sustainable green IT practice in universities in South Africa to reduce the environmental impact	➢ Promote and encourage environmental awareness and education. ➢ Educate the new generation about the real danger of climate change and global warming. ➢ Allow students and academic staff members to engage in diversity of environmental fields. ➢ Enforce environmental policy and acts. ➢ Introduce a core subject about environmental sustainability ➢ Manage environment with responsibility and care. ➢ Protect the environment on which all individuals depend to save energy and precious resource and reduce carbon emissions. ➢ Assess the environmental impact on air quality, water usage and toxicity to human life.

The issue of protecting the environment has turned out to be the focus of the efforts various organisations are making to adhere to an increased degree of

environmental responsibility. It has also drawn the attention to scholars, governments and non-governmental agencies, causing them to make efforts towards tackling the problems facing the global environment.

IT Resource Optimisation for Green Solution

IT resource optimisation for eco-efficiency, involves using Green IT capability to enable the implementation of an organisation towards creating a sustainable environment. Sustainable green IT optimisation demands products to be manufactured from recyclable materials, efficient, flexible and fanciful in ensuring effective business.

Table 2: IT Resource Optimisation for Green Solution

2 Theme	Main objective	Findings
Sustainable green IT practices	Provide improvement on the acquisition, utilization and effectiveness of usage of technology in universities and critically evaluate the approach of creating a dynamic learning experience and develop a green IT	➢ Promote and encourage sustainable green IT awareness and education. ➢ Inspire students and academic staff members to do practical metrics on computer equipment use. ➢ Implement green manufacturing to ensure the packaging process of electronic devices I in order to have little or no negative impact on the environment. ➢ Develop green design with increased efficiency and durability of products to reduce product effects through innovation and resource substitution. ➢ Practice energy-efficiency data centres and cooling configuration to eliminate considerable amount of leaks. ➢ Apply efficient server usage of different virtualisations dedicated to specific tasks.

	model to establish a holistic approach to the use of green IT products, applications, services and practices.	➢ Improve the algorithms of software programmes to minimise the process needed to retrieve searching information. ➢ Assess the effectiveness and efficiencies of the application software and social media websites to save time and electricity. ➢ Strengthen printer output management to cut back operational footprints And do conversion to digital documents. ➢ Adoption of virtual classrooms. ➢ Implement BYOD's (Bring Your Own Device) strategy.

E-waste Disposal Management

Environmental sustainability helps to establish functional relationship between knowledge, awareness and action in individuals and organisations. Becoming environmentally responsible may assist individuals to adopt proper e-waste disposal management. The focus of this is the capability of universities' own internal environmental impact. The focused codes that support this: the issue of recyclability, acquisition of product quality, compatibility, obsolescence and purchasing of eco-labelled products.

Table 3: E-waste Disposal Management

3 Theme	Main objective	Findings
E-waste dispo-sal manage-ment	Implement practices of reducing, reusing and recycling electronic waste management, so as to	➢ Manage e-waste disposal through recycling programs such as: Recycle, re-use and reduce. ➢ Know the volume of discarded e-products and identify the source of e-waste. ➢ Identify toxic materials of e-waste to reduce risk potentialities. ➢ Analyse products from cradle to grave phases.

	benefit education, the local community and the country at large and to reduce the pressure on non-renewable resources as well as help reduce waste, space and pollution.	➢ Assess the proper acquisition of products for the sake of depletion and degradation. ➢ Reclaim the resale values (residual value). ➢ Identify product longevity for the sake of obsolescence through strengthening or producing quality products ➢ Identify types of e-waste ➢ Arrange for safe collection centres, and take-back recycling programs to reduce landfills. ➢ Provide techno trashes (e-waste deployment centres). ➢ Identify safe means of transportation.

Energy Efficiency and Carbon Footprint Reduction

Energy efficiency and conservation, particularly involves three elements: saving energy, improving the use of energy and the reduction of carbon footprints. Rising energy consumption and electricity bills, rising concern over greenhouse gas and hazardous e-waste and the major funds needed to expand the current activity into environmental sustainability transformation are depended on sustainable green IT operations and practices.

Table 4: Energy Efficiency and Carbon Footprint Reduction

4 Theme	Main objective	Findings
Energy efficiency and	Enable role of eco-sustainability in reducing pollution of carbon footprint and energy consumption, in order to	➢ Explore alternative energy sources for energy efficiency (saving) and energy reduction (consumption).

carbon footprint reduction	assist South African universities to conceptualise and measure their green IT readiness as well as to control and redesign low-carbon economy and clean energy activities.	➢ Investigate energy-saving practices (power management, altering lighting systems, safe mode and so on) ➢ Replace energy-intensive computer equipment and peripherals with less energy-intensive devices ➢ Invest in eco-labelled product certification, especially with respect to energy efficiency (energy star). ➢ Apply the reduction of carbon footprint techniques.

Socio-economic Relevance

The fifth regulating concept is called cost analysis benefit. The data alludes that environmental sustainability is managed and controlled by measuring its economic value. Sustainability cannot be managed without optimising performance in the supply chain green procurement, and this has an effect on any environmental transformation. This will ensure that the manufacturing process of electronic devices will have no negative effect on the environment.

Table 5: Socio-economic Relevance

5 Theme	Primary sources	Secondary sources
Cost benefit relevance	Determine what green business practices entail and examine the impact of the start-up cost in implementing rapid technology change that offers considerably under-powered (energy-	➢ Reduce the cost of unnecessary resources. ➢ Promote quality service. ➢ Have an eco-labelled identity. ➢ Optimise market performance and competitiveness in supply chain.

	saving) benefits for adopting green IT products, applications, services, policies and practices.	➢ Marketing and communications teams to sell product sustainability.

Proposed Framework

A framework is a comprehensible system of interrelated objectives and fundamentals that recommends the nature and function of sustainable green IT practice. Understanding a framework also should enable interested parties to realise the content of information provided by sustainable green IT practices. A theoretical framework based on the findings depicts five themes as shown in Figure 1, namely (1) the sustainable environmental development; (2) IT resource optimisation for green solution; (3) e-waste disposal management; (3) energy efficiency and carbon footprint reduction; and (5) cost benefit relevance. The performance and practice of each technology option is evaluated using these broad categories.

- **The Users of the Framework**

The intended users of the framework are students, academic staff as well as employees who respectively learn, teach and work in the universities of South Africa. They are all responsible for sustainable green IT practice for the sake of the environmental changes in the ecosystem that negatively impact human life. Besides, they all drive the environmental sustainability processes and projects, and have an influence in the budgets. Furthermore, this management has an understanding of the environmental sustainability data, processes, analyses, reporting, foot printing, and risk management; including associated opportunities and challenges. According to the Isaac Newton, 'Each and every action on this Earth has an equal and opposite reaction'. In the same sense, each and every human being is influenced by this reality.

- **The Unique Problems Addressed**

1. Human health impacts,
2. Natural environment impacts,
3. Socio-cultural impacts,

4. Global impacts
5. Resource sustainability.

- **The Preconditions to the Framework**

The framework should be used in higher education institutions in general in universities of South Africa, where they provide knowledge to society keeping the in-depth understanding of environmental impacts in mind. There are no restrictions to the use of framework in terms of levels of education or maturity. Notably, the framework may require adaptations in order to be applicable in other education institutions.

- **How should the Framework be Used?**

The framework is for use by students and academics as a tool for facilitating understanding and effective action relating to green IT practices. The framework allows students and academics to focus attention and allocate resources to the optimisation of greenIT, both within cross-departmental faculties and throughout other university activities. The framework achieves its aims by exposing key green IT practices concepts.

- **The Intended Outcomes of the Framework**

The intended outcome of the framework is a positive effect on the organisation's environmental sustainability transformation within the educational organisation and throughout the economy. Another outcome of the framework's use is an awareness of where to focus green IT resources to optimally affect the aforementioned organisational environmental sustainability transformations.

Conclusion and Recommendations

This research outlines a framework for measuring sustainable green IT practices from an Information Systems and Technology perspective within South African tertiary institutions. Former research revealed how green IT have improved organisations in numerous ways. Nevertheless, former research do not highlight the sustainable green IT practices in South African universities. Revisiting the environmental policies and creating a sustainable environment for South Africa's dynamic energy and human health impacts are worthy goals.

The framework is supposedly helping in investigating the acquisition, utilisation and effectiveness of operational carbon footprints and technological breakthroughs that will lead to a cleaner educational environment. In order to help universities of South Africa to adopt environmentally responsible practices, an in-depth qualitative research was undertaken through interviews to gather data. The findings clarify the necessity of ecological sustainability to measure the performance of green IT implementation in universities. The result of the study exposed the role of the universities to reduce their environmental impact focusing on bottom-line issues such as economic values, environmental issues, and social benefits. Some practical guidelines are provided to assist in greening the university. The research makes an original contribution to the body of knowledge in creating a framework for measuring green IT practices, addressing the issue of energy efficiency, reducing of carbon footprint, adopting clean technology and managing the disposal of e-waste such as computers and IT-related devices in universities throughout South Africa.

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