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An Assessment of Green ICT Effect on Sustainable Environment in Institutions of Higher Learning in Kenya

By

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DECLARATION

This project is my original work and, to the best of my knowledge, this research work has not been submitted for any other award in any University.

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This project report has been submitted in partial fulfillment of the requirements for the Master of Science Degree in Information Technology Management of the University of Nairobi with my approval as the University supervisor.

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DEDICATION

This research project is dedicated to my husband Philip and son Levi for their perseverance during my studies. To my parents Mr. and Mrs. Samoei, and Mrs. Mutuku&Family, my sisters Mrs. Naomy Jonah & Family, Mrs. Emmy Patrick & Family, my brother Samson and his wife Oglah for their unconditional support.

May God bless you, Amen!!

ABSTRACT

There is increasing pressure on institutions of higher learning to adopt more sustainable approaches to ICT use.ICT has made significant impact in institution of higher learning and whether the effects are largely positive or negative it is not evident. The study sought to determine effect that green ICT has had on sustainable environment and how effective green ICT management is in institutions of higher learning in Kenya. There are those users who perceive that green ICT has value and others who hold opposing views. Explanatory research design was used. A survey of 67 institutions of higher learning in Kenya was done using random sampling while specific elements under study were identified using purposive sampling. Quantitative and qualitative approaches were used to explore the depth and breadth of green ICT effect and its management.

The findings showed that green ICT effect is still on the negative side where institutions of higher learning in Kenya do not manage power despite installing energy efficient equipment this direct effect leads to huge power bills and global warming; there is incomplete substitution and lack of realization of optimization of enabling effect of green ICT solution and also systematic effect resulting from green ICT includes induction of other product and re-materialization. Further the study revealed that there was a positive indicator where institutions of higher learning consolidate and reduce printing, dispose equipment based on government disposal laws hence reducing cost of purchasing hardware and toxic materials from e-waste. Challenges related to green ICT management include low awareness, uncertainty in return on investment, constrained collaboration and scarcity of financial resources in institutions of higher learning. The study recommends that institutions of higher learning in Kenya should focus on a framework for implementing green ICT policies.

Key Words: Green ICT, Green ICT Effect, Sustainable Environment, Green ICT Management.

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LIST OF ABREVIATIONS

CO2	-	Carbon dioxide
ICT	-	Information and Communication Technology
IHL	-	Institutions of Higher Learning
KGUN	-	Kenya Green University Network
KEBS	-	Kenya bureau of statistics
NEMA	-	National Environment Management Authority
PPOA	-	Public procurement oversight authority
UNEP	-	United nations environment programme
MoEST	-	Ministry of education science and technology
ITU-T	-	International Telecommunication Union-Telecommunication

CHAPTER ONE
INTRODUCTION

1.1 Background

Today one of the most widespread concerns globally is about green information communication and technology and sustainability. Green ICT is “a pioneering approach of using ICT related to the environment protection and sustainability of ICT in future as well as consists of practices to achieve corporate social responsibility by minimizing carbon footprint, ICT waste and by conserving energy “ (Suryawanshi & Narkhede, 2014).On the other hand (Wabwoba,2013) defines green ICT as “systematic application of ecological-sustainability criteria to the design, production, sourcing, use and disposal of ICT technical infrastructure as well as within the ICT personnel in order to reduce ICT, business process and supply chain related emissions, waste and water use; improving efficiency and generate green economic rent” . Whereas sustainability means “planning and investing in a technology infrastructure that serves the needs of today as well as future while conserving resources and saving money” (Pollack, 2008).Information and communication technology (ICT) is both enabler and a driver of sustainable solution this is via proactive initiatives such as ICT based solution that support sustainable growth.

IISD (2010) found that green ICT positively affect sustainability by “lessening direct effects on the environment of the manufacturing, distribution, operation and discarding of ICTs equipment through enhanced energy and resources efficiency, increased use of renewable energy sources, reduced use of toxic materials and improved recycling and end-of life disposal of ICTs”. It also “increase the enabling effects of ICTs on sustainability by reducing energy consumption and demand of materials through the whole or partial substitution of virtual goods and services for their physical equivalents and through the dematerialization of human activities and interactions; by supporting systemic effects it result in the change of behavior, attitudes and values of individuals as citizens and consumers; economic and social structures; and governance processes”.

ICT is not only an enabler but the contributor of carbon print (Trewin, 2009) states that “ ICT is responsible for 2 % of global emission of carbon dioxide (CO_2)” which is on par with the aviation industry and both are growing rapidly .However its quantification of benefits and cost of ICT in relation to sustainability can be maximized hence reducing its effect to the society by reducing the remaining 98% of carbon emission.Wabwoba (2012) established that green technologies are available in Kenya However, according to (Kevin et al., 2015) very little have been done in terms of

green ICT. Where policies are in place, “only a few of all government programmes and industry association initiatives have measurable targets and indicators to measure whether these targets are being achieved”. This is seen in page 39 of ICT master plan for 2013/14-2017/18 under guiding principles on implementation of master; “Environmental protection and conservation section states that all institutions involved in ICT master plan implementation to adhere to the green ICT concept by environmentally friendly equipments that are cheaper and easy to implement and ensuring there is no e-waste dumping”. This statement is to a large extent vague as very little in terms of policy existing to provide guidelines on green ICT within the Kenyan government.Wabwoba (2014) states that technology is rapidly changing in Kenya and “ lack of its understanding has put a lot of pressure on management and ICT personnel to implement them in trial and error manner” . This has limited the gains meant to be obtained from green ICT despite its technology availability. The mission of Ministry of Education Science and Technology (MoEST) in Kenya is to “ facilitate effective use of ICT to improve access, learning and administration in delivery education programmes and services” . Institutions of higher learning in Kenya have adopted and implemented ICT to support learning, teaching and management as intended but they are not using it efficiently (Tarus et al., 2015) .Whether the effect of ICT on environment is positive or negative it is not clear . Therefore the study aimed at assessing green ICT effect on sustainable environment and further sought to determine the role of green ICT management on the relationship between green ICT effect and sustainable environment in institutions of higher learning (IHL) in Kenya.

1.2 Statement of the Problem

The rising use of Information communication and technology (ICT) in institutions of higher learning, “brings great benefits of managerial efficiencies and improved effectiveness in teaching and research development and on the other hand, it is accompanied by an environmental and economic cost” (James &Hopkins, 2009). Suryawanshi (2014) states that there is increasing pressure on institutions of higher learning to adopt more sustainable approaches to ICT use. “ This pressure comes from government, from regulatory sources and from external stakeholders and the public, who are increasingly aware of the environmental cost” . Wambwoba et al. (2013) argues that ‘ there is great need to apply green ICT to improve chances of realizing both organizational and environmental sustainability in order for Kenyan organizations to contribute towards the realization of the country’s 2030 vision’ . Assessing green ICT effect by auditing, evaluating and doing follow-up study on green ICT management; ‘greenness of green ICT solutions and disseminating the best

practice of green ICT' is an essential undertaking of every government (Kevin et al., 2015) Institutions of higher learning in Kenya (IHL) have been compelled by government to automate their processes. However, a few academic departments have introduced e-learning, institutional mail, use of online library systems and repositories while administrative departments have adopted information system such as finance system, human resource system and student management system. This initiative has focused more on enabling effect of green ICT; consequently, there is minimal focus on direct and systematic effect of green ICT. This indicates that there is lack of holistic approach in implementation of sustainable green ICT in institutions of higher learning. It is out of this fact that this study be carried out to assess green ICT effect on sustainable environment in institutions of higher learning in Kenya.

1.3 Research Objectives

General Objective

This study assessed green ICTs effects on sustainable environment in institutions of higher learning in Kenya.

Specific Objectives

1. To analyze direct effect of green ICTs on sustainable environment in institutions of higher learning in Kenya.
2. To establish enabling effect of green ICTs affects on sustainable environment in institutions of higher learning in Kenya.
3. To investigate systematic effect of green ICTs affects on sustainable environment in institutions of higher learning in Kenya.
4. To determine the role of existing green ICTs management action on the relationship between Green ICT effects and sustainable environment in institutions of higher learning in Kenya.

1.4 Significance of the Study

Findings of the study will be useful in various dimensions. Research that was done by (Gadenne & Kennedy, 2009) indicates that "there are two major categories of benefits: environmental benefits and cost-reduction benefits are associated with green ICTs". And by assessing green ICT effect on sustainable environment in institutions of higher learning in Kenya will help in analyzing and monitoring its CO2 emissions every year which is necessary in order to provide evidence of CO2 emissions reduction. In addition to reducing of institutions carbon footprint there will be reduction

of waste, green ICT will enhance sustainable environment that is seen to have multiple long-term institutional benefits. “These include an improved public image, competitive advantage via innovation, and potential economic benefits through improved efficiencies, longer lasting materials, and less expense on waste disposal and clean-up”. In particular, the study will be useful to ICT managers, ICT professionals, Procurement professionals, Environmental managers, Senior management and staff on the role green ICT plays in advancing economic, environmental and social concerns their respective organization.

1.5 Scope of Study

There are currently seventy (70) Chartered universities in Kenya (CUE, 2015). The study area covered 67 institutions of higher learning in Kenya based on 2016 international website ranking, two (2) regulatory bodies in Kenya. Some of the issues the researcher considered when defining the scope of the study was that institution of higher learning to be visited should have a prior evaluation on carbon emission.

CHAPTER TWO

LITERATURE REVIEW

2.1 Definition of Green ICT

Green ICTs is an " organization's capability to analytically apply environmental sustainability criterion (such as pollution prevention, product stewardship, use of clean technologies) to the design, production, sourcing, use and disposal of the ICT technical infrastructure as well as within the human and decision-making components of the ICT infrastructure"(Molla, 2009).

Anthony et al. (2016) established the following green ICT processes which are used to define green ICT:-*Sourcing* this is the implementation of "sourcing practices such as analysis of the environmental foot print of an ICT hardware, evaluation of the green track record of software application and ICT services providers, integrating green issues" such as recyclable design and packaging in merchant evaluation, and inclusion of social concerns such as the presence of harmful materials in ICT process in Green procurement decisions. While *disposal* or "end of life perspective of green ICT refers to practices in recycling reusing and disposing ICT hardware". *Operation* perspective of green ICT involves enhancing "energy efficiency in powering and cooling enterprise ICT assets and reducing ICT induced CO2 emissions". Services includes "ICT based low carbon business solutions such as video-conferencing, enterprise information system, e-governance, e-commerce, e-learning, cloud service and thin client and web based business services, virtual collaboration and IP telephony" (Anthony et al.,2016)

2.2 Evolution of Green ICTs

Green ICTs evolved in terms of standards and regulation. In 1992 U.S environmental protection agency launched *Energy Star*. "This is a voluntarily labeling program that segregates computers, monitors and other equipment based on their energy efficiency. Its impact was seen when manufacturers introduced sleep mode which places the consumer's electronic equipment on standby when no user activity takes place during the pre-set time". In 2007 "Energy Star Specifications were revised, so as to place stringent requirements to attain energy star ratings". "The new specifications determine efficient use of computing technology through guidelines such as the company's e-waste reduction, regulatory compliance, telecommuting policies, server resource virtualization, energy use cost accounting, thin client solutions, and the like. Existing equipment has to re-qualify to continue using the Energy Star logo" (Kiruthiga & Kumar, 2014).The *1997 Kyoto Protocol* followed whose

mandate is to "reduce carbon emissions. The Kyoto Protocol made computer manufacturers undertake energy audits to calculate the electricity used by the device over its lifetime and determine the quantum of carbon dioxide emissions to take remedial action" (Murugesan&Gangadharan, 2012).

Taticchi & Albino (2013) found that in 2003 the European Union's adopted of *Restriction of Hazardous Substances* (RoHS). "The RoHS directive restricts the use of lead, mercury, cadmium, hexavalent chromium, polybrominated biphenyls, and polybrominated diphenyl ether in the manufacture of electronic and electrical equipments. The implementation of the RoHS was through the *Waste Electrical and Electronic Equipment Directive* (WEEE) of 2005. This directive set targets for collection, recycling, and recovery of electrical goods, aimed at reducing toxic e-waste. These regulations forced manufacturers to use non-hazardous materials in the production of chipsets, processors, and companion chips". *Electronic Products Environmental Assessment* (EPEAT) was established by the Green electronics Council in 2005. "It is a set of standards based on the IEEE 1680 standard for environmental assessment of personal computer products. These standards aimed at increasing the efficiency and life of the products, and minimizing energy expenditures and maintenance activities throughout the life of the product" (Kiruthiga & Kumar, 2014).

2.3 ICT for Green and Sustainability

"Using green ICT initiatives we solve environmental problems and we ensure the sustainable environmental management with environmental data". Green ICTs is a specific process that focuses on greening of ICT this involves making the ICT sector green and greening by ICT involves using of ICTs to transform socioeconomic sectors (Ernst & Young, 2012). Greening of ICT involves

" Power management solutions are focused on reducing energy consumption of ICT resources and using alternative environment friendly energy sources; Software and deployment optimization solutions concentrate on reducing the number of ICT hardware components and increasing the products' lifespan and material recycling initiatives take care of environmentally friendly utilization of used ICT equipment and establish standards for hardware products' manufacturing".

Global e-sustainability initiative (2010) report defined greening by ICT according SMART 2020 categorization such as the use of " Smart motors technologies to reduce the energy consumed by industrial motors, or support industrial process' automation; smart logistics technologies that enable fuel reduction and energy efficiency through improved route and load planning" ; " smart buildings solutions that maximize energy efficiency in buildings, such as building management systems that

run heating and cooling systems according to occupants' needs" ; " smart grids digital technologies that allow greater visibility of energy use and power flows and dematerialization where substitution of high-carbon products and activities with low-carbon alternatives, such as replacing paper bills with e-billing". This provides numerous opportunities to replace existing processes and technologies with software solutions and e-services. Ahola et al. (2010) argues that green ICTs support "the construction and improvement of natural environment and resources surveillance systems, as a means to protect and restore natural ecosystems". Further climate change management, "ICT-enabled optimization can provide great savings in production through tailored mass production, the utilization of production lines, the optimization of raw material usage, preventive maintenance". "Recycling is seen as a source of raw material and in terms of energy production, the use of renewable energy sources is definitely increasing, mainly due to reasons related to the politics of global warming".

2.4 Green ICTs Management

Green ICT management involves taking actions and making decisions, leading to a sustainable ICT environment (Ambtman, 2011).Several green ICT management actions have been identified by researchers, they include:-

Green ICTs strategy: **-** Stewart et al (2016) established that Green ICT strategies include:-measuring and progress reporting, greening the ICT infrastructure, exploiting ICT to Green government operation and exploiting ICT to green public service. "An effective Green ICT strategy should clearly identify reduction measures in such areas as achieving energy savings, reducing carbon emissions, improving recycling efforts and conserving water".

Green ICT policy:-A policy framework "must be established to ensure green ICT becomes a business-endorsed program of work rather than a discreet ICT project. It must take into account the required roles and responsibilities, skill-sets, commitments, targets, deliverables and methodologies used" (Philipson, 2010).

Green ICTs Standards: **-** (Raju et.al.,2013) established that " **s**tandards amount to internationally agreed technical means of improving energy efficiency, reducing waste and curbing greenhouse gas emissions". Standardization work can be categorized along a wide spectrum: according to the methods used, indicators and statistics used, data-aggregation and modeling approaches, and corporate responsibility and reporting structure, some of which specifically focus on energy

efficiency. There are approximately 30 standardization organizations and initiatives related to green ICT (for example, the ITU, ETSI, Energy Star, and IEEE all have related initiatives). Green ICT standards developed by ITU-T Study Group 5 (Environment and climate change) now include universal charging solutions, best practices capable of halving a data centre's energy consumption, recycling methods for rare-metal components of ICTs, and methodologies to assess ICTs' impacts on the environment and the energy and emissions savings enacted by ICTs in other industry sectors.

Best Practices:-"Practice refers to techniques and behavior – things we do. There are many practices that individuals and organizations can adopt that directly help in the greening of the ICT function. Good examples are turning off PCs when not in use, recycling printer paper and printing less, and using ICT equipment for longer rather than replacing it when it is still useful. The simplest things are often the most effective" (Philipson, 2010).

2.5 Green ICT in Institutions of Higher Learning

Global Overview

There is increasing pressure on institutions of higher learning to implement green ICTs "so as to minimize energy consumption, carbon footprint, ICT waste, to maximize recycling & reuse and to reduce energy cost". United Kingdom (UK) is " one of the first countries to focus on Green ICTs in form of governmental policies and put pressure on institution of higher learning in UK to implement Green ICTs" (Suryawanshi et al., 2013). Chai-Arayalert& Nakata (2011) stated that the "overall evolution of Green ICT practices in IHL displayed a significant increase in concerns on ICT and environmental issues". Institution of higher learning in UK HAVE paid "attention to develop Green ICT practice for printing in term of reduction consumables usage, minimizing ICT waste and the green ICT practice of personal computing". The Dutch institution of higher learning are following " green ICTs practices by building a Green ICT community of more than 300 members which stimulate and help their universities to work on green (ICT) issues, They are also following various green ICT practices like mobile workplace, flexible office/classroom spaces, distance learning/teaching, minimize student commuting" (Hankel et. al. ,2013). Study done by (Thomson et al., 2015) showed that actual level of Green ICT adoption and readiness within institutions of higher learning in South Africa appears to be fairly low. Asabere et al. (2016) argues that some green ICT practices are being done on a very low scale in institutions of higher learning in Ghana. In Kenya

institutions of higher learning have joined Kenyan green university network whose aim is "to incorporate environment, low carbon-climate resilience development strategies and sustainability aspect in their education, training, campus operations and enhanced student engagement" (UNEP, 2016). Institutions of higher learning in Kenya who are in forefront on implementing green technologies include Strathmore University, who have already implemented low-carbon by installing solar panels with the capacity to produce 0.6 megawatts annually. Apart from being climate-friendly, the move has also proven economically viable, with the university selling 0.25 megawatts to Kenya Power Company. Multimedia university of Kenya has not been left behind recently in collaboration with CRBAS, ECLAC, and ITU Nassau, The Bahamas, 16 December 2015 they carried out training on green ICT policies and standards. 2016 global ranking of institutions of higher learning evaluated Carbon footprint and found that only five out of 400 institutions of higher learning ranked from Africa practice environmentally friendly policies to help combat climate change, 67 institutions of higher learning from Kenya were among 400 universities ranked internationally. This literature shows that green ICT adoption and implementation level in institutions of higher learning in developing nation is relatively low as compared to institutions of higher learning institutions in developed nations.

2.6 Green ICT Theoretical Framework

The researcher adopted ICT impacts framework by (Hilty,2008), three other framework had limitation they included Green IT Value Framework was 'developed to identify and measure the value derived from Green ICT impact levels' (Sourcing, Operation, Services and End of life) and value dimension (Economic, Environmental and Ethical) this assess the net benefits and leaving out Green ICT risk (Scott&watson2012), A framework for ICT analysis By Forum for future in close cooperation with EITO Taskforce(2002) was used analyze the impact of ICT on sustainable development the framework classified ICT effect in relation to sustainability and the opportunities related to green ICT implementation also there was a computer program model called Rapid Assessment program(RAP),(BOMHOF et al., 2009) was used to analyze systematic effects of green ICT,RAP is a simulation model meant to " analyze which part through intervention model have positive reinforcing effect or have negative dampening effect, the relation between effects are qualitative therefore it is suitable to use where most experts agree that effect exist, but when how big that effect is unknown or disputed thus this may lead to too many different paths of effects i.e.

the system does not impose guideline on the choice of the system boundary which can only be solved using actual quantification effects".

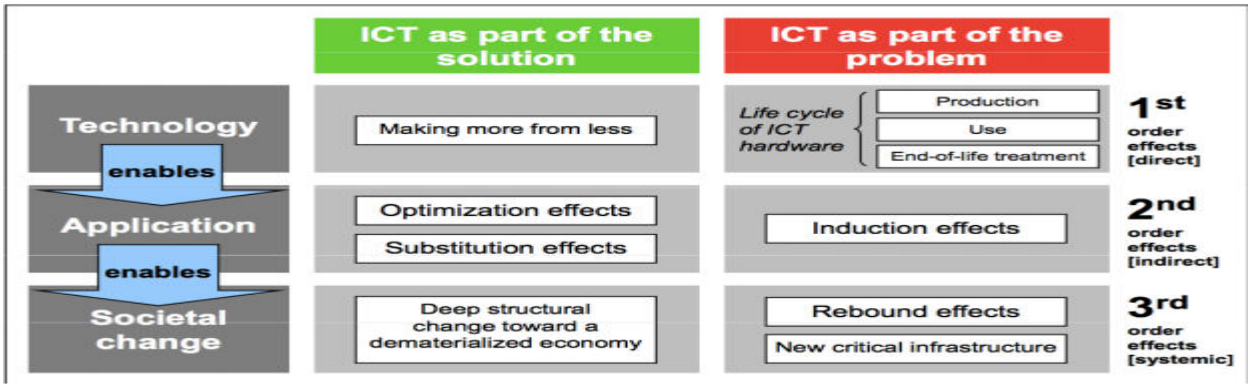

Figure 1: *Framework of ICT impacts: Adapted from (Hilty, 2008).*

There are diverse set of effects of ICT on environment according to ICT impact analysis framework by (Hilty, 2008). The effects can be categorized into three levels as follows:-

Direct Effects: - These are effects as a result of physical existence of ICT equipment in an environmental which involves the "production, use, recycling and disposal of ICT hardware" (Hankel, 2014).

Enabling effects:- These are " indirect environmental effects of green ICT as a result its influence to change processes which includes production or transport processes, leading to decrease or increase of their ecological effect" .Vickery (2012) found that enabling effect can be categorized into four main ways namely *Optimization* this involves automation using ICT creates effectiveness of processes, products and services thus optimization can fasten processes, reduce cost and environmental impact; *Dematerialization and substitution "*where substantial goods and processes can be replaced by online ones with lower impacts on the environment". Substitution can be incomplete (resistance to ICT change), complete (acceptance to ICT change) and over complete (as a result of additional feature in ICT Products); *Induction effect* ICT products leads to extra use of other products like 'more efficient stimulate demand for high quality paper', this increases deforestation pressure paper-making resources and *Degradation* which occurs when ICT devices are 'embedded in non-ICT products lead to difficulties in managing disposal'**.** This often requires specific recycling procedures that are more complex and potentially increases environmental pollution load.

Systematic effect result from availability of ICT and services it provides that leads to " environmental effects of the medium- or long-term adaptation of behavior (e.g. consumption

patterns) or cost-effective structures" (Hankel,2014).Study by (vickery,2012) established that ICTs and the Internet helps to bridge information gap by ' facilitating monitoring, measuring and reporting information on the environment' **;** ICT applications facilitate dynamic pricing system where consumers can update price of their products based on real-time online information and decide which market to go for so as to sell their products. Electricity consumers can decide to turn off non-critical devices when renewable energy is inadequate and turn them on again when it is in plenty; further study by (Hankel, 2014) showed that ICT *triggers rebound affect* this are all general effects that are a (system) response to introduced change by ICT. In its simplest form it is a behavior change that followed a certain introduction of technology like optimization or a substitution it can have both positive and negative; and also technology has lead to introduction of new *critical infrastructure* that we depend upon in our daily lives. ICT is a general-purpose technology, thus it has becomes part of other infrastructures, such as transport and energy. Interconnectedness of ICT infrastructure in our daily lives lead to two kinds of criticalities: how vulnerable it is i.e. complexity on whether software coding is mastered or not and how easily it can be replaced this is in relation to innovation and future to change.

2.7 Conceptual Framework

A conceptual framework explains either "graphically, or narratively, the main things to be studied, taking into consideration the main factors, constructs or variables, and the presumed relationships among them" (Miles & Huberman, 1994). This study uses Casual relationship where Green ICT effects are considered independent variable which affect sustainable environment which is dependant Variable. Considering the scope of study the researcher will focus on assessing effect of greens ICTs on sustainable environment in institutions of higher learning in Kenya. (Hanne, 2011) recommended that "it would be appropriate to carry out an empirical study to assess Green-ICT actions undertaken by developing countries and their effectiveness". Thus the study introduced green ICT action as a moderator on the conceptualized framework by (Hilty, 2008), So as to study whether its effectiveness influence relationship between green ICT effect and Sustainable environment as shown in the figure 2 below.

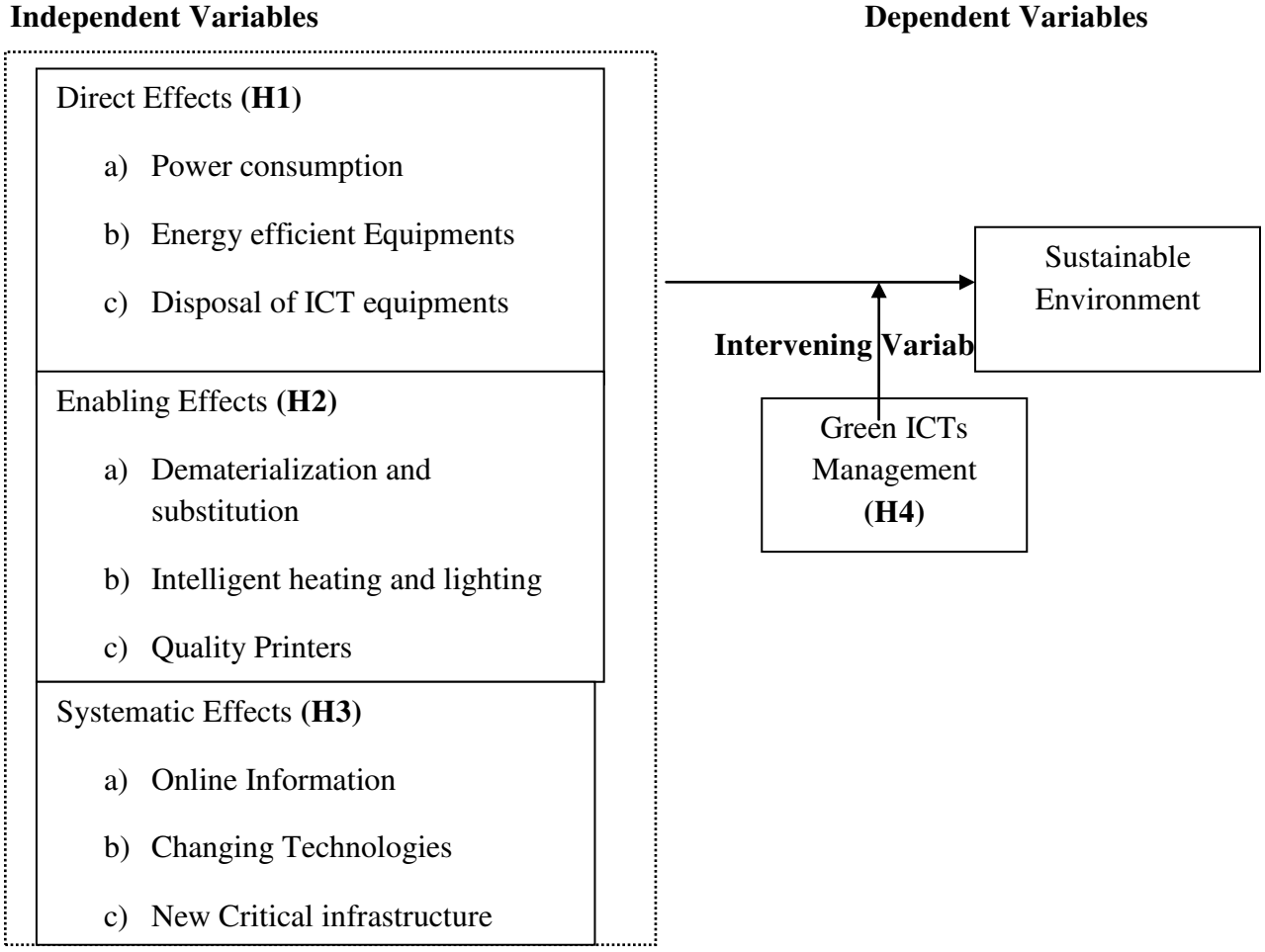

Figure 2: *Conceptual Framework*

2.8 Hypothesis

H_1: Direct effect of green ICTs has a significant role on sustainable development in institutions of higher learning

H_{1a} Power consumption has significant effect on sustainable environment

H_{1b}Energy efficient and certified green ICT have significant effect on sustainable environment

H_{1c} Recycling, reuse and refurbishing of ICT equipment have significant affect on environment

H_2: Enabling effect of green ICTs has a significant role on affects on sustainable environment in institutions of higher learning in Kenya.

H_{2a} Dematerialization and substitution of ICT has significant effect on sustainable environment

H_{2b}Intelligent heating and lighting have significant effect on sustainable environment

H_{2c}Use of quality printers have significant effect on sustainable environment

H_3: Systematic effect of green ICTs has a significant role on affects on sustainable environment in institutions of higher learning in Kenya.

H_{3a} Use of online information has significant effect on environment

H_{3a} Changing technologies have significant effect on environment

H_{3a} New critical infrastructures have significant effect on environment

H_4: Green ICTs management has a significant role on the relationship between green ICT effect and sustainable environment in institutions of higher learning in Kenya.

CHAPTER THREE
RESEARCH METHODOLOGY

3.1 Introduction

This chapter comprises of research philosophy, design, research population, Sampling, data collection instruments, data validity and reliability, logical and ethical issues and data analysis. The research methodology was guided by the research objectives and hypothesis.

3.2 Research Philosophy

Saunders et al. (2009) argue that the research philosophy has "assumptions about how the authors view the world and this view should underpin the research strategy of the work". The research philosophy used in the study is pragmatism, (Creswell, 2003) argues that "pragmatism is not committed to any one system of philosophy and reality". "This applies to mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions when collecting and analyzing data rather than subscribing to only one way (e.g., quantitative or qualitative)". Evaluating Green ICT impacts involve looking into its depth and breadth as illustrated in Green ICT Reachness -Richness matrix (Molla, 2009). The study combined quantitative research for depth and qualitative research for breadth in order to test the hypothesis.

3.3 Research Design

Kumar (2011)argues that "research design is a plan, structure and strategy of investigation so conceived as to obtain answers to research questions or problems; the choice of the most appropriate design depends largely on the objectives of the research and how much we already know about the problem and the research objectives". This study used explanatory research design whose main aim was to identify any causal links between the factors or variables that pertain to the research problem, thus focusing on why questions and hypotheses of the research.

3.4 Research Population

Target number of (IHL) was sixty seven (67) and two (2) Regulators KEBS and NEMA; the departments visited included administrative and academic in IHL's, ICT Standards and E-waste for

NEMA and KEBS respectively. The number of respondents were as follows: - 67 head of ICT, 201 ICT end-users, 1 head of standards,1 head of waste management giving a total of 270 respondents.

3.5 Sampling

Sampling Design

Kothari (2009) established that "a sample design is a definite plan determined before any data are actually collected for obtaining a sample from a given population". The research employed survey where a small sample of population is chosen to represent population. The sample design used mixed method sampling combination of probabilistic and non-probabilistic sampling this is where researcher aims to generate a sample that is representative and also provides meaningful information (Graff, 2014)."Purposive or non-probability sampling is a sampling method that involves purposive or deliberate selection of particular units of the universe for constituting a sample which represents the universe the respondent". Random sampling is "typically used by research in the positivist paradigm, because it ensures the objective reality is being measured accurately"(Davis et.al. 2013).

Sampling Technique

The study adopted clustered sampling where respondents were divided into (clusters) two heterogeneous groups; First group which included Heads of ICT,ICT Standards and waste management where purposive sampling for was used .The second group of respondents where end-users where they were selected using random sampling. Samples derived from purposive sampling and random samplings were used to test a hypothesis for the quantitative phase and to answer research questions in the qualitative phase.

Sample Size

Davis et.al. (2013) states that "sample size is the number of data sources that are selected from the total population".'The size of the sample depends on a number of factors the researchers have to give in statistically information before they can get an answer'. To determine a manageable sample size the researcher applied slovins1960 formula to the sample with a marginal error of 3%.

The formula is as follows:-

$n=N/1+Ne^2$ Where

n is the sample size

N is the population size

E is the margin error

1 is the constant value

n=270/1+270(0.03)^2= 217 (Manageable sample size for carrying out the study)

Table 3.1: *Distribution of sample size*

	Target Population	Institution	Total
1	Head of ICT	Institution of Higher learning	14
2	Head of Standards	KEBS	1
3	Head of Waste Management	NEMA	1
4	ICT end-users	Institution of Higher learning	201
Total Target Population			217

Source: Research 2016

3.6 Data Collection

The researcher used mixed method research strategies such as interviews and questionnaires the blending of strategies is to yield the data for quantitative and qualitative research. Research strategies definitions according to (Kothari, 2009)

(a) **Personal interview:** The interview method used in this study was open-ended interview questions to yield narrative data from regulatory boards in Kenya (KEBS and NEMA). Close ended questions with pre-established response where issued randomly to fourteen(14) respondents in institutions of higher learning this was to give an insight of green ICT Management which was part of section two (II) of research questionnaire.

(b) **Questionnaires:** The study used close-ended questions on 5-Point likert scale for pre-established and predetermined response and open-ended questions for items that require narrative were used. Questionnaires were online and self administered to the respondents (end-users) with a request to return after completing the same. Before applying this method, a pilot study for testing the questionnaire was conducted this revealed the weaknesses of the questionnaire.

Data Collection Issues to be considered

The researcher having set goals on how to collect data and already decided on staff to gather data from in each university target population. The study took into consideration other data gathering issues which include:-

i. **Logical and ethical issues**

Creswell et al. (2011) described the 'gate keepers' as "an individual in the organization supportive of proposed research who will essentially open up the organization" .Approval for this study was sought from deputy director school of computing and informatics. Authority to visit institutions of higher learning was sought from administrators in charge of research of their respective institutions. Assurance was given to the respondents on issues touching on integrity of the study including, confidentiality, privacy and any other research ethical issues. The respondents were not required to indicate their names in the questionnaire which is stored safely after the exercise. The data collected in the study was used for academic purposes only.

ii. Triangulation Design

Triangulation design " is used when a researcher wants to directly compare and contrast quantitative statistical results with qualitative findings or to validate or expand quantitative results with qualitative data" (Creswell et.al, 2003). 'The intent in using this design was to bring together the differing strengths and non-overlapping weaknesses of quantitative methods (large sample size, trends, generalization) with those of qualitative methods (small N, details, in depth)' (Checho, 2007). For increased data reliability and validity, the researcher collected data from multiple sources like data collection with the help of interviews and document review from heads of ICT and Regulatory Boards in Kenya such as KEBS and NEMA.

iii. Validity and Reliability of Data Gathered

Graff (2014) argues that the " quality of data collected by researchers conducting mixed methods studies is determined to an extent by the standards of quality established for the qualitative and quantitative phase of research, valid and credible qualitative and quantitative data will contribute to high quality data in mixed method study". Data in qualitative research is based on credibility and dependability while data in quantitative research is based on validity and reliability. To determine reliability in quantitative phase of mixed methods study test-retest reliability was done. Validity of qualitative phase of a mixed method was determined using trustworthiness (Lincon & Guba, 1986).

a. Validity of the instruments

It is the extent in which the instrument measures what it is supposed to measure (Mugenda & Mugenda, 2003). In this case validity was aimed at gauging whether the subject matter was clear and relevant in generating data. Therefore instruments of data collection ensured that each of the items in the instruments addressed specific contents of a particular concept of the study. Moreover,

the instruments were given to twenty (20) respondents 10 heads of ICT and 10 end-users that assessed the validity of instruments.

b. Reliability of the instruments

Orodho (2009) established that reliability is the " degree to which a measuring procedure gives similar results of a number of repeated trials". This tested whether the instruments where reliable enough to collect data. Prior to visiting the sampled institutions of higher learning for data collection, the researcher pre- tested the questionnaire using ten (10) institutions of higher learning in Kenya with in Nairobi County which were not part of study group. The purpose of the pilot study was to enable the researcher improve on the validity and reliability of the data collecting instruments and to familiarize with their administration. Pre testing provided a check on the feasibility of the proposed procedure for coding data and showed up flaws and ambiguities in the instruments of data collection. It also yielded suggestions for improvement of data collecting tools. The test-retest technique of measuring reliability was used in this case and it included administering the questionnaires to twenty pilot members selected twice with a time lapse of one week. A Cronbach's alpha test was calculated to further test the reliability. If a coefficient close to one (1) was seen, then it indicates that the factor that was tested were valid and consistent in measuring the variables or the concepts. Using George and Mallory's (2003) rule of thumb that state any results above 0.7 is acceptable was used for the assessment of the results as shown in table 3.2 below.

Table 3.2: *Reliability Statistics*

Variables	**Cronbach's Alpha**	**N of Items**
Direct Effect	.723	4
Enabling Effect	.818	4
Systematic Effect	.714	4
Sustainable environment	.761	6

Source field data 2016

3.7 Data Analysis

Campbell (2008) defines regression as "a statistical technique to determine the linear relationship between two or more variables; regression is primarily used for prediction and causal inference". Normally, 'a regression analysis is used for one (or more) of three purposes: prediction of the target variable (forecasting), modeling the relationship between x and y and testing of hypotheses'. Thus

the researcher used multiple regressions to evaluate the effect of independent variables on dependent variable. "Multiple regression is a technique that allows additional factors to enter the analysis separately so that the effect of each can be estimated. It is valuable for quantifying the impact of various simultaneous influences upon a single dependent variable" Sykes,(1993). Further, because of omitted variables bias with simple regression, multiple regressions are often essential even when the researcher is only interested in the effects of one of the independent variables. In "its simplest form, regression shows the relationship between one independent variable (X) and a dependent variable (Y), as in the formula" (1) below:-

$$y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \varepsilon \ldots\ldots\ldots\ldots\ldots\ldots \text{(1)}$$

MacKinnon (2008) defines moderator as " a variable that change the sign or strength of the effect of an independent variable on dependent variable". As shown in formula (2) below:-

$$y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_m M \ldots\ldots\ldots\ldots \text{(2)}$$

y Green ICT effect on Sustainable environment

β_0 Is the constant

X_1 Direct Effect

X_2 Enabling Effect

X_3 Systematic Effects

M Green ICT Management

β_1 β_3 Are the coefficient regression or change induced in y by change in x

ε error term

The researcher used SPSS software for applying relevant tests to these factors to measure relationships between descriptive and inferential statistics were qualitative data was use to explore quantitative data. The researcher entered all the data of this research study in SPSS software version 21.00 for doing data analysis of each element of factors.

CHAPTER FOUR

DATA ANALYSIS, RESULTS AND DISCUSSION

4.1 Introduction

This chapter presents data analysis, results and the discussion of the study. The analysis was based on the data collected by use of questionnaires which were administered and interviews carried out as scheduled. The information presented below is based on the objectives of the research.

4.2 Analysis of Response Rate

The research response rate is as shown in Table 4.1below.

Table 4.1: *Analysis of response rate*

Category/variable	**Frequency**	**Percentages**
Responded questionnaires	165	76.0%
Non responded questionnaires	36	16.6%
Interviews	16	7.4%
Total	**217**	**100**

Source: Field data 2016

4.3 Demographic Information

Table 4.2 shows respondents demographic below. Majority of them (43.0%) were from Private universities followed closely by (37.6%) of respondents from public universities wheres (14.5%) were from colleges and only (4.8%) where from TVET institutions. From the findings it shows that most computers 48.5% had been in use for a period of (0-3yrs) followed by 31.5% of computers with a period of (3-5yrs) and only 20% had lasted over 6 years . This clearly proves that as the duration of work experience increases the lifespan of computer decrease.

Table 4.2: *Demographic Information*

Variable		Classification	Freq	Percent
i	Duration of work in the institution	1-5years	75	45.5%
		5-10years	48	29.1%
		10-15years	29	17.7.9%
		Over 15years	13	7.9%
ii	Level of education	College	24	35.8%
		Undergraduate	59	35.2%
		Masters	58	41.8%
		Doctorate	24	14.2%
iii	Respondent according to Category of the institution?	Public University(19)	62	37.6%
		Private University(25)	71	43.0%
		TVET(3)	8	4.8%
		College(8)	24	14.5%
iv	Duration of institutional computer use	0-3years	80	48.5%
		3-5years	52	31.5%
		Over 5 years	33	20.0%

Source: Field Data 2016

Cross tabulation of demographic data

From the finding the level of awareness is not affected by level of education as shown in table 4.3 below:-

Table 4.3: *Level of Education versus Awareness*

	Level of Green ICT Awareness			
Level of Education	**Fully Aware**	**Partially Aware**	**Not Aware**	Total
College	6	13	5	24
Undergraduate	32	21	6	59
Postgraduate	29	27	2	58
Doctorate	8	16	0	24
Total	75	77	13	165

Source: Field data 2016

From the findings one public university and private university have fully implemented green ICT and majority have partilly implemented while Minority have not implemented green ICT as shown in table 4.4 below:-

Table 4.4: *Category of Institution versus Implementation*

	Green ICT Implement				
Category of Institution	**Fully Implementation**	**Partially Implementation**	**Not Implementation**	**Do Not Know**	**Total**
Public University	1	49	6	7	62
Private University	1	60	1	9	71
TVET	0	4	0	4	8
College	0	19	0	5	24
Total	11	122	7	25	165

Source: Field data 2016

From the finding it indicate current use have been lasted in a period of 82 computers (0-3), 48 computers(3-6), 33 computers (>5).From the relation of working years and years of computer use its clear that computer use in institutions of higher in kenya do not go beyond six years of use as shown in table 4.5 below.

Table 4.5: *working Experience versus Duration of computer use*

Work Duration	**Duration of Computer Use**			**Total**
	0-3	3-5	>5	
1-5	57	18	0	75
5-10	17	20	11	48
10-15	10	12	7	29
over 15	0	8	5	13
Total	82	48	33	165

Source: Field data 2016

4.4 Green ICT and Management

4.4.1 Level of Awareness and Implementation

There respondents were asked to indicate there level of awareness of green ICT and the level of implementation of green ICT in there respective institutions of higher learning as shown in table 4.6 below:-

Table 4.6 : *Level of Awareness and Implementation*

	Fully	Partially	Not at All	Do Not Know
	Freq (%)	Freq (%)	Freq (%)	Freq (%)
Awarenes level	75(45.5%)	77(46.7%)	13(7.9%)	-
Implementation level	11(6.7%)	122(73.9%)	7(4.2%)	25(15.2%)

Source: Field Data 2016

From the results from table 4.6 above 45.5% of the respondent where fully aware of green ICT followed by 54.50% who were partially aware.While Majority 92.7% of the institutions have partialy implemented green ICT,Only 3.6% have fully implemented and 3.6% have not implemented at all.This denotes that awareness level is moderate and above while implementation level is still moderate.

4.4.2 Awareness of Green ICT Management Actions

There respondents were asked to indicate there level of awareness of green ICT management action(policies,standards,strategies and Best Practices) in there respective institutions of higher learning as shown in table 4.7 below:-

Table 4.7: *Awareness of Green ICT Management Actions*

	Yes	No	Do Not Know
Green ICT Management Action Awareness	140	15	10

Source: Field data 2016

4.4.3 Existing Green ICT Management Action

There respondents were asked to indicate green ICT management action that exist in there respective institutions of higher learning as shown in table 4.8 below:-

Table 4.8: *Existing Green ICT Management Action*

	Existing Management Actions	**Frequency**	**N**
1	Polices	140	165
2	Standards	84	165
3	Strategies	67	165
4	Best Practices	92	165

Source: Field Data 2016

4.4.4 Effective use of Existing Green ICT Management Actions

From the findings it showed that respondent agreed that they are encouraged to use online services (mean=1.57, Std dev=1.09), and disagreed on power management (mean=3.52, std dev=1.31) and uncertain in regards green procurement management (mean=3.16, Std dev=1.56), e-waste management (mean=3.30, Std dev=1.55), and printing management (mean=3.42, Std dev=1.30) as shown in table 4.9 below.

Table 4.9: *Existing green ICT Management Actions*

Use of existing green ICT Management Actions	Mean	Std. Deviation	N
ICT equipments are procured based on green procurement policies and standards	3.16	1.56	165
Printing is managed in our institution	3.42	1.30	165
Power is managed in our institution	3.52	1.31	165
E-waste is managed in our institution	3.30	1.55	165
We are encouraged to use online service	1.57	1.09	165

Source: Field Data 2016

4.4.5 Green ICT Management status

Coding of the interview was done where some of the themes highlighted the similarities of information provided by the interviewees while others emphasized the difference.Quotes from the interview are discussed below:-

a) Procurement of ICT equipments

Interviewees stated that some time due to low budget allocation “ICT equipment is purchased on price and/or performance”, so long as it meets the end user requirement. While other from both public university and private university stated that they “encourage procurement of ICT equipment which meets green standards (e.g. Energy Star, EPEAT, and WEEE) but they do not influence purchase decisions”.

b) General Lifetime of ICT equipment

In regards to general lifetime of ICT equipment one common theme stated that, As soon as the user request for change of equipment. ICT technician will be required to ascertain that the equipment is not meeting user requirement or as a result of major faulty and inducing latest software’s (obsolete). While a few stated that general life time of ICT equipment is fixed period 3 years

c) Disposal of ICT Equipments

One predominant theme in the procurement process of the public Universities is that they are bound by law to procure based on the Public Procurement and Disposal Act. Majority of interviewees from

public universities explains, Kenyan gazette regulations (2015) .While other interviewees from private university said that they dispose obsolete ICT by donating part of them to other user department and sell the rest to disposal agents through our procurement committee formed in the institution.

d) End User-Computing

Concerning power management all agreed that they "do not manage power consumption of ICT equipment" .Despite some institution having guidelines for users to turn on power save features on their equipment they do not enforce them. Majority of interviewees from both public and private universities conquered that they have "guidelines (e.g. duplex printing etc.) for staff to minimize printing and we centralize and control printing requests".

e) **Enterprises & Data Centre**

Some interviewees stated that they "encourage features such as virtualization/rack servers". Others said "ICT equipment are kept at minimum temperature possible" and they have "guidelines to minimize cooling requirements" and others said that they have several physical servers.

f) ICT as a Low Carbon Enabler

One common theme stated "that lights are on in offices throughout the workday" while a few others stated that "lights are switched off as soon as they are not required in offices".

g) Managing travelling in institution

When asked if staff were allowed to work from home interviewee mostly said they work remotely .In public universities since the staffs are reimbursed their travelling costs (public or private means) this made staff prefers travelling to meetings other than working remotely.

h) Using ICT to reduce the impact of your institution on the Environment

Also the interviewees were asked how the use ICT to reduce the impact in institutional environment majority said that they use ICT to improve our performance mostly. Similarly other interviewees stated that they provide all opportunities for their customers/suppliers to interact electronically with us using ICT.

Further more the interviewee from KEBS ICT Standards office explains that:-

Kenya uses world trade organization standards in regards to Information communication and technology for sustainability .Kenya is still under observatory stage in regards to "standardization related to the intersection of resource efficiency and ICT which supports environmentally and economically viable development, application, operation and management aspects" (Standard,

2008).To what extent to KEBS ICT standards measures correspond to global trends in medium and long term perspective. According to Standard (2008) there is a JTC committee which has been formed and currently collaborating with " ISO TC 207, ISO TC 242, ISO TC 257;IEC TC 100, IEC TC 108, IEC TC 111, SMB SG 4, IEC/PC 118, IEC TC 57/WG 21, IEC TC 9 and SMB SG 3;ITU-T SG 5; and Subcommittees/Working Groups under:-ISO/IEC JTC 1/SC 39/WG 1,:-Resource Efficient Data Centre's and ISO/IEC JTC 1/SC 39/WG 2:-Green ICT".

The second interviewee from NEMA stated that we work hand in hand with kenya berau of standards (KEBS),public procurement oversight authority(PPOA) and approved disposal agents interms of disposing obsolete ICT equipment in order to make our environment sustainable and thus you can view our relevant policy document in the NEMA website.

According to guidelines for e-waste management in Kenya (2010) "Electronic waste or E-waste describes discarded electrical or electronic devices or appliances that have ceased to be of any value to their owners. The e-waste guidelines provide a framework for identification, collection, sorting, recycling and disposing of electrical and electronic waste (e-waste). The guidelines also provide the basis for developing legal instruments to enhance enforcement. The purpose of these guidelines is to assist the government, private sector, learning institutions among others to manage e-waste in a manner that enhances environmental conservation".

4.4.6 Green ICT Management Implementation

Findings from interview indicated that some institutions of higher learning have a well established purchasing policy for green ICT which describes a standard configuration for new desktop equipment. While policy on procurement of ICT equipment which meets green standards (e.g. Energy Star, EPEAT, and WEEE) have not been fully implemented; An interviewee from one regulatory body stated that the policies cannot be fully enforced since WEEE standards are not yet met in Kenya considering it's still a developing country.

Some policies on disposal were based on public procurement oversight authority (PPOA) disposal policy and national environment management authority (NEMA) guidelines as discussed in interview analysis above, in the case where there is conflict of act, NEMA act prevail if the disposal affect the environment. NEMA act is be used to determine if the equipment can be further used or not as a result of consumption and generation of more energy leading to global warming. Disposal policies have been fully implemented though institutional polices on e-waste are in there initial stage of implementation (drafts).

Most of the institutions have no power management policies yet but some institutions have guidelines on power management i.e. switch off lights when living office.ICT policies capture the existing ICT applications which have been fully implemented and partially implemented based on e-government requirement. Thus it's more of compliance than use thus leads to partial use. Printing policies have been implemented by at least half of the institutions we interviewed.

Interviewees stated that the roll out of any policy often meets some level of user resistance or low engagement that challenges effective implementation .End users sometimes fail to use policies because they lack motivation; they feel discriminated when they are told to implement policy that have been formulated.

Measuring Sustainability

When the KGUN member was asked on how the measures sustainability of their green ICT Projects:-they said we measure sustainability through the use of COBIT5 Balanced Scorecard by focusing on Financial, Customer, Learning and growth dimensions as show in table 4.10 below.

Table 4.10: *Measuring Sustainability*

	BSC Dimensions	**Description**
1	**Financial Measure**	Environmental fines and penalties
		Energy cost
		Disposal Cost
		Capital investment in green ICT initiatives
		Recycling Revenues
		Cost Savings
2	**Customer Measures**	Electricity consumed
		Parties conforming to green Standards
		Purchase conforming to green regulation
		Equipment recycled and reuse
		Equipment sold for refurbishing
		Heat generated from Equipment refurbished, Equipment bought
3	**Learning and Growth**	Employees switching off equipment when not in use
		Number of employees aware of green ICT initiatives

Source: Field Data 2016

4.5 Descriptive Analysis

This is analysis of data that helps describe, show or summarize data in a meaningful way. Simply stated, they refer to means, ranges, and numbers of valid cases of one variable. In this case, all

independent and dependent variables are illustrated below. The overall objective of the study was to assess green ICT effect on sustainable environment in institutions of higher learning in Kenya.

In this section the researcher used the following ranges for analysis interpretation (1-2.4 **Agree**, 2.5-3.4 **Uncertain** and 3.5-5 **Disagree**).

4.5.1 Direct Effects of Green ICT

From the analysis of direct effects the findings showed that majority were uncertain with switching off the computer when leaving office (mean=2.62, std dev=1.50), and agreed that institution uses centralized ICT system (mean=2.04, std dev=1.05), reuse and recycle of equipments (mean=1.93, std dev 0.92) and installs energy saving ICT equipment (mean=1.99, std dev=1.06) as shown in table 4.11 below.

Table 4.11: *Direct Effects of Green ICT*

Statement	Mean	Std. Deviation	N
I switch off my computer when leaving office	2.62	1.50	165
The Institution uses centralized ICT Systems E.g. Printers	2.04	1.05	165
The institution reuse , recycle and dispose equipment	1.93	.92	165
We install energy saving ICT equipment	1.99	1.06	165

Source: Field Data 2016

4.5.2 Enabling Effect of Green ICT

From the analysis of enabling effects the findings showed that respondent agreed that they read online materials (mean=2.24, Std dev=0.91), the institution experience problem relating to low quality Paper while using printers (mean=2.10, std dev=0.73), institution allows employees to work remotely (2.44, std dev=1.03) and uncertain in regards control of office temperature by building control system (mean=2.92, std dev=1.16) as shown in the table 4.12 below.

Table 4.12: *Enabling Effect of Green ICT*

Statement	Mean	Std. Deviation	N
I read online materials	2.24	0.91	165
While using printers we do a time experience problem relating to low quality Paper	2.10	0.73	165
The institution allows employees to work remotely	2.44	1.03	165
Temperatures in the offices of the institution are controlled by a building control system	2.92	1.16	165

Source: Field Data 2016

4.5.3 Systematic Effect of Green ICT

From the analysis of direct effects the findings showed that the respondents were uncertain of institution using online information to report on institutional activities and progress (mean=3.18,std deviation=1.32) ,Upgrading of software's induce hardware obsolesce(mean=1.57,std deviation=1.09) and institutions providing of laptops for heads of department(mean=3.65,std dev=1.09) while it was uncertain if the institution recruited employees using online system(mean=3.81,std dev=1.14) as show on the table 4.13 below.

Table 4.13: *Systematic Effect of Green ICT*

Statement	Mean	Std. Deviation	N
The institution uses online information to monitor and learn about the institutional activities and progress.	3.18	1.32	165
Upgrading of software's induces hardware obsolesce	1.57	1.09	165
The institution provide laptops for heads of department	3.65	1.06	165
The institution can easily recruit employees using online system	3.81	1.14	165

Source: Field Data 2016

4.5.4 Sustainable Environment

Objective 1, 2 and3 was to analyze how direct, enabling and systematic effect affect sustainable environment. From the finding it indicates that the respondents agreed that teleworking and Teleconferencing affects the environment by reducing air pollution from motor vehicles.(Mean= 1.57,std dev=1.09),and disagreed on Operating ICT equipment in standby mode causes consumption of energy (Mean=3.48,std dev 1.35) , More efficient printers stimulate demand for high quality paper (Mean=3.52,std dev=1.31), though it was uncertain that green ICT Managed

control system affects the environment (Mean=3.30,std dev=1.55) , Implementation of green ICT leads to new critical infrastructure (Mean=3.42,std dev=1.30) and disposal of ICT equipment affect the environment. (Mean=3.16, std dev1.56), as shown in the table 4.14 below.

Table 4.14: *Sustainable Environment*

Statement	Mean	Std. Deviation	N
Operating ICT equipment in standby mode causes consumption of energy	3.48	1.35	165
Disposal of ICT equipment affect the environment	3.16	1.56	165
Implementation of green ICT Leads to new critical infrastructure	3.42	1.30	165
More efficient printers stimulate demand for high quality paper	3.52	1.31	165
Green ICT managed control system affects the environment	3.30	1.55	165
Teleworking and Teleconferencing affects the environment by reducing air pollution from motor vehicles	1.57	1.09	165

Source: Field Data 2016

4.6 Path Analysis

4.6.1 Correlation analysis

The findings from correlation test showed that, one variable showed a negative relationship and two showed positive relationship as indicated in the matrix table below. The direct effect showed negative significant relationship on sustainable environment, (Pearson's r=0. -.302, p<0.000 and Systematic effect positive significant relationship (Pearson's r=0.806, p<0.000), While enabling and enabling effect showed positive insignificant relationship, enabling effect, (Pearson's r=0.129, p<0.100) as shown in table matrix 4.15 below.

Table 4.15: *Correlation Analysis*

Correlations					
		Direct Effect	Enabling Effect	Systematic Effect	Sustainable Environment
Direct Effect	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	165			
Enabling Effect	Pearson Correlation	-.016	1		
	Sig. (2-tailed)	.838			
	N	165	165		
Systematic Effect	Pearson Correlation	-.211**	.110	1	
	Sig. (2-tailed)	.006	.159		
	N	165	165	165	
Sustainable Environment	Pearson Correlation	-.302**	.129	.806**	1
	Sig. (2-tailed)	.000	.100	.000	
	N	165	165	165	165
**. Correlation is significant at the 0.01 level (2-tailed).					

Source: Field Data 2016

4.6.2 Regression Analysis

Model Summary

From the model summary table, R^2 is a statistical term saying how good one term is at predicting another. If R^2 is 1.0 then given the value of one term, you can perfectly predict the value of another term. If R^2 is 0.0, then knowing one term does not help to know the other term at all. More generally, a higher value of R-Square means that you can better predict one term from another. According to King'oriah (2004), the correlation coefficient r, below merely talks of relationship between variables, but coefficient of determination (r^2) derived from regression analysis, explains how much of the variation within the dependent variable (sustainable environment) is caused by the variation of each of the independent variables, in exact percentage. In this case, all the independent variables accounts for 67.0% of sustainable environment in institutions of higher learning in Kenya as shown in part one of model summary below; while green ICT management accounts to 32.2% on the relationship between independent variables (green ICT effect) and dependent variable (Sustainable development) in institutions of higher learning in Kenya as shown in part two table 4.16 below.

Table 4.16: *Model Summary*

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.818[a]	.670	.663	.59996	.670	108.724	3	161	.000
2	.996[b]	.991	.991	.09663	.322	6046.797	1	160	.000

a. Predictors: (Constant), Systematic Effect, Enabling Effect, Direct Effect

b. Predictors: (Constant), Systematic Effect, Enabling Effect, Direct Effect, GICT Management

Source: Field Data 2016

Analysis of Variance

ANOVA table shows results of analysis of variance, sum of squares, degree of freedom (df), mean square, regression and residual values obtained from regression analysis. From table below, the mean square is 39.14. The F static which is regression mean square divided by the residual mean was 108.724. Degree of freedom df, was 3.00. Statistically, the overall relationship was very significant with significant value, P value = 0.000, (P < 0.05) while with the introduction of mediating variable GICT Management the mean square is 43.466. The F static which is regression mean square divided by the residual mean was 4655.295. Degree of freedom df, was 4.00. Statistically, the overall relationship was very significant with significant value, P value = 0.000, (P < 0.05) as shown in table 4.17 below.

Table 4.17: *ANOVA*

ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	117.406	3	39.135	108.724	.000[b]
	Residual	57.952	161	.360		
	Total	175.359	164			
2	Regression	173.865	4	43.466	4655.295	.000[c]
	Residual	1.494	160	.009		
	Total	175.359	164			

a. Dependent Variable: Sustainable Environment

b. Predictors: (Constant), Systematic Effect, Enabling Effect, Direct Effect

c. Predictors: (Constant), Systematic Effect, Enabling Effect, Direct Effect, GICT Management

Source: Field Data 2016

4.6.3 Regression Coefficients

From the coefficient table below, the first variable (constant) represents the constant, also referred to as the Y intercept, the height of the regression line when it crosses the Y axis. In other words,

this is the predicted value of sustainable environment in institutions of higher learning all other variables are 0. The beta values (B) are the values for the regression equation for predicting the dependent variable from the independent variable. In this case, interpretation of beta coefficients means that holding all other independent variables constant. In part one of the table every unit change on direct effects affects sustainable environment by -.138, while enabling effects shall influence sustainable environment by 0.041, and finally systematic effects affects sustainable environment by 0.777. Therefore, direct effect is a negative predictor of sustainable environment while enabling and systematic effect are positive predictors of sustainable environment. However two variables proved to be significant, direct effect (P=0.003) and systematic effect (P=0.000) while enabling effect is not significant at all (P=0.367) .In part 2 of the table Green ICT Management leads to every unit change on direct effects affects sustainable environment by 0.012 while enabling effects shall influence sustainable environment by 0.007, and finally systematic effects affects sustainable environment by 0.053. Therefore, direct effect, systematic effect and enabling effect are positive predictors of sustainable environment, however one variables proved to be very significant systematic effect (P=0.000) while direct effect (P=0.136) and enabling effect (P=0.365) while is not significant at all shown table 4.18 below.

Table 4.18: *Regression Coefficients*

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	.635	.265		2.397	.018
	Direct Effect	-.165	.056	-.138	-2.971	.003
	Enabling Effect	.060	.067	.041	.905	.367
	Systematic Effect	.760	.046	.772	16.565	.000
2	(Constant)	-.138	.044		-3.160	.002
	Direct Effect	.014	.009	.012	1.500	.136
	Enabling Effect	.010	.011	.007	.909	.365
	Systematic Effect	.052	.012	.053	4.429	.000
	GICT Management	.996	.013	.956	77.761	.000

Source: Field Data 2016

$$y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \ldots\ldots\ldots\ldots (1)$$

$$y = 0.635 + -0.165\ X_1 + 0\ .060\ X_2 + 0.0760\ X_3$$

$$y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_m M \ldots\ldots\ldots\ldots (2)$$

$$\mathbf{y}=-0.138+0.014\mathbf{X_1}+0.010\ \mathbf{X_2}+0.052\ \mathbf{X_3}+0.996\mathbf{M}$$

4.7 Hypotheses Testing

Hypothesis testing is the formal procedures used by statisticians to accept or reject statistical hypotheses. After the analysis, hypothesis stated in earlier chapter of this report was tested. The findings showed that two of the stated alternate hypotheses were accepted; while the one was rejected. Specifically, it was found that direct effect and systematic effect of green ICT have significant effect on sustainable environment with (P=0.003<0.05) and (P=0.000<0.05) respectively .while, enabling effect proved to have no significant effect on sustainable environment in institutions of higher learning with P-values (P=0.367>0.05.Green ICT management have significant role between green ICT effect and sustainable environment as shown in table 4.19 below.

Table 4.19: *Hypotheses Testing*

Hypothesis	**Coefficient P-Values**	**Conclusion**
H_1: Direct effect of green ICTs has a significant role on sustainable environment in institutions of higher learning	P=0.003<0.05	**Accept H_1**
H_2: Enabling effect of green ICTs has a significant role on sustainable environment in institutions of higher learning in Kenya.	P=0.367>0.05	**Reject H_2**
H_3: Systematic effect of green ICTs has a significant role on affects on sustainable environment in institutions of higher learning in Kenya.	P=0.000<0.05	**Accept H_3**
H_4: Green ICTs management has a significant role on the relationship between green ICT effect and sustainable environment in institutions of higher learning in Kenya.	P=0.000<0.05	**Accept H_4**

Source: Field Data 2016

4.8 Discussion of the Findings

This study reported on the positive and negative effect of green ICT on sustainable environment in accordance to (Hilty, 2008) ICT Impact analysis framework. The research findings indicated that power is not managed; as a result of not switching off lights, computers and laptops when they are not using them. According to research done by (Vickery,2012) using hilty framework power consumption affects the environment this is in agreement with research done by (Singh, 2014) whereby improper management of power leads to huge power bills and a great increase in the

amount of greenhouse gasses in the atmosphere due to carbon emissions thus contributing to global warming. Using Kenyans emission factors (kgCO2/kWh) 0.332297783 (ecometrica, 2011). Finding from one institution indicated that average carbon emission from ICT Components is as shown in table 4.20 below.

Table 4.20: *Average power consumption per ICT component.*

	ICT Component	**Average Power Consumption(Watts)** Jouma&Kandry(2012)	**Components in No** Source: Author 2016	**Total consumption in kWh**
1	Laptop	22	500	11000
2	System unit /Monitor	150	800	120000
4	Router	6	10	60
		12	20	240
5	Printers	100	120	12000
6	Scanner	3.5	30	105
7	Speakers	7	50	350
8	Thin Client solutions	90	100	9000
	Total Consumption			**152755**
	Emission Factor			**0.332297783**
	Total CO2 Emission			**50760.14784** kgCO2/kWh

Source: Jouma & Kandry(2012) and *Field Data 2016*

Further the findings indicated that they install energy saving ICT equipment this is part of strategy of utilizing power this lead to a twenty percent 20% reduction in the power consumption of equipment whilst doubling the computing resource available.

From the interview we carried out techno trash from obsolete electronic or electrical device are disposed based on procurement bidding process. Where some donate them and sell the rest to recycling institutions and others reuse and recycle. (Masele et al., 2013) states that disposal of ICT equipment through tendering procedures might be out of good will; especially for ICT, it consequently has serious negative environmental effects a set of computer contributes to 108kg of waste (EITO,2002). This is because, in those auctions, anyone (from internal or external) can buy the used ICT product for his/her own intended use. As a result, some users end up taking just small parts of the bought product and the rest is thrown away in very unfriendly manners. Yet with this

procedure, it is difficult to monitor the end of life use (disposing off) of the purchased item. The framework denotes that disposal of equipment affects the environment which is in agreement with the research carried out by (Vickery, 2012), and according to quantitative findings of the research end-user were uncertain on whether disposal of equipment affect the environment while the findings. This is an indicator that there is awareness gap on disposal of ICT equipment.

According to (Vickery,2012) report green ICT helps the institutions in reducing environment deterioration by providing a number of valuable benefits such as optimization where intelligent lighting systems can be used in buildings and urban environments to save energy; dematerialization and substitution where employees were able to use online materials thus replacing physical material, this lower effect on the environment also experts far away from each other can work together and it reduces the environmental effect caused by traveling this agrees with the findings where respondents read online material and are allowed to work remotely. Carbon emission from one institution of higher learning is as shown in table 4.21 below.

CO2 emission = Activity data (kg / litres per Km / etc) * Emission factor (CO2 per unit).

Table 4.21: *CO_2e (CO_2 equivalent) Emission Calculation on Campus*

	ICT Component	**Activity Data Jan-August 2016**	**Carbon Emission Factor**	**Carbon Emission CO_2E KG**
1	Total Electricity consumption	5,851,666 kWts 0.332297783 (kgCO2/kWh)	0.332297783	1944495.6
2	Total fuel consumption for institutional cars	93567.16 litres Diesel: 1litre = 2.68kg CO2	2.68kg CO2	250759.99
3	Total fuel consumption for staff owned cars	28 litresx400 No Diesel: 1litre = 2.68kg CO2	2.68kg CO2	30016
4	Fuel Consumed by Motorbike in campus	28 litres x(40 No) Petrol: 1 litre = 2.31kg CO2	2.31kg CO2	2587.2
	Total			**2,227,858.79**

Source: Field data 2016

From the findings in the table 4.12 above carbon emission of 2,227,858.79 CO_2E KG from one institution is a lot hence enabling effect of green ICT should be fully utilized so as to reduce carbon emission. Average carbon dioxide emission resulting from power consumption of ICT Component from the same institution in a period of 1280 hours*(**50760.14784** kgCO2/kWh) is **2,707,207.88** kgCO2/kWh. Comparing carbon emission for the two carbon emission from ICT components is much higher by 479, 349.1 kgCO2/kWh, this was due to assumption made was that computers are

used for eight (8) hours per day for 160 days. Consumption of electricity would vary when students are on session and off session.

Further the finding disagreed with the use of green ICT to monitor and learn about the institutional activities and progress and the institution do not provide laptops for heads of department the finding showed that majority of heads of department uses their personal laptops tablets for their convenience hence reducing hardware in the institutions. According to (Hilty, 2008) upgrading of software's induces hardware obsolesce which is in agreement with the findings

4.8.1 Rejected Hypothesis

Hankel (2014) critiqued ICT impact analysis framework by (Hilty, 2008) in that it may not include all effects ICT might have, but it captures the mostly mentioned and important ones. Hankel further argues that hilty's framework has conceptual overlap between effects though it gives a starting point for further analysis. Generally ICT can have an effect on the quality, cost, material resources and time of an action; Also ICT can influence the decisions making when collecting and analyzing data. Moreover this effect are not restricted to the goods itself, but also applies to replaced goods, other goods in the context or action space, how long a good is used and the system in its entirety. Other patterns are more centered on the user with main questions like what happens with the extra time and money one has if ICT has made something more efficient. The researcher carried out an interview further to explore on the rejected hypothesis (Enabling effect) according to (Hilty,2008) framework and used (Hankel,2014) framework, which mostly focused on enabling effects so as to compare the results of qualitative data with quantitative data.

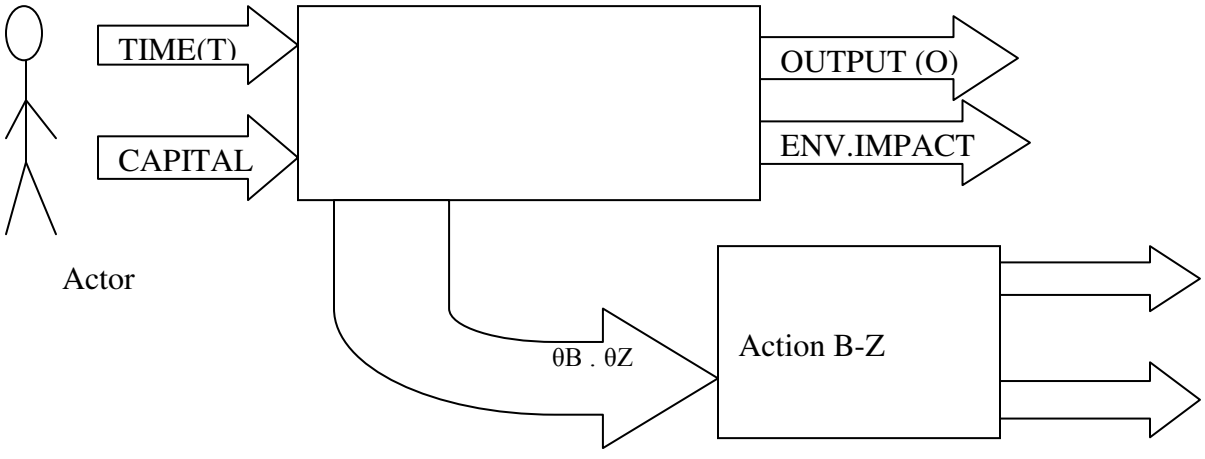

Figure 3: *Enabling Effect framework adapted from Hankel (2014)*

Translating all these aspects to a conceptual framework starts with an action that an individual or an organization (actor) carries out to achieve a certain output. The general form is described in figure 3 above. To carry out action A which results in a desired output O and has an environmental impact I, n goods are required (Gi .. Gn).

An actor needs to spend some time T and capital C to be able to execute an action A. when A is executed; it stimulates extra actions B-Z with a definite threshold θ. This forms the baseline to which one can compare effects of change by ICT. Output of an action is somewhat complex: it has several unlike properties that can all be changed. Based on assumption to achieve desired output between two actions the difference between the two outputs is simple enough to value it and make a decision.

The aim of green ICT is to change the action (A) in such a way that the environmental impact (I) is reduced. A* is the new action, an actor can choose between A and A*.To establish whether action A* is preferred more than action A depends on the differences in inputs and outputs. Expressed in the formula 1 stated below:-

$$wT(AT - A^*T) + wC(AC - A^*C) + wO(A^*O - AO) + wI(AI - A^*I) > 0 \quad (1)$$

Each actor can weigh all factors (time, cost, output and environmental impact) with weights w according to their own preferences. The alternative factors for time, cost and impact should be lower as one would want to reduce those, while the reverse is true for the output where one would want better quality. The concept behind this framework is that ICT can affect all these factors. In fact, it does not matter whether the change was intentionally green or not.

4.8.1.1 Critical Issues

Incomplete substitution of ICT solutions :- This is where people can work remotely but still lack adequate resources to work remotely ;like traveling for meeting because there are no teleconferencing equipment or due to lack of enforcement of policies in regards to use of ICT application. Also the need of tangible evidence (hard copy) according to ISO procedures in institution of higher leads to printing hardcopies; researcher lacked motivation to upload journals and papers in the local websites, some institution are unable to subscribe to online journals and books since they find it expensive hence they purchase print and produce copies; some secured sites mostly prompt printing than saving online copy and low bandwidths that can allow download which exits certain limits. Hankels framework states that substitution effects are more targeted towards changing goods G used in an action. Non-ICT goods are replaced by ICT goods that may or may

not deliver the same output O. Whether an actor accepts this alternative action A* depends on the balance between change in quality and functionality and the achieved reduction in time, cost and environmental impact: as shown in the formula 2 below:-

$wT(AT - A^*T) + wC(AC - A^*C) + wI(AI - A^*I) > wO(AO - A^*O)$ (2)

Induction and re-materialization:-In regards to printing respondents stated that quality printing papers are imported and hence recycled papers leads to low quality papers which lead to frequent paper jams. In e-learning one can study at comfort zone where a student's finds that he/she cant access research journals that relates to their area of study they will still have to travel to various institutional libraries to accessed subscribed journals .This might have social beneficial effect, transport implication are problematic. Induction and rematerialization effects in (Hankels, 2014) framework equal an increase in other actions (B-Z) caused by a functional change in action A*. In other words, the difference between A*O - AO had some impact that lowered the thresholds θB .. θZ to a point that these other actions are carried out more often compared to using action A.

Lack of realizing benefits of optimization: - From research finding there is uncertainty on use of intelligent lighting systems in institutional buildings. This is as a result of lack of clear policy framework on power management where institutions are only concerned when power expenses exceed the expected budget not bothering on global warming effects. Hankel framework states that in optimization effects, optimizing an action more or less means doing something more efficient and in the context of this framework it means keeping the output the same while reducing time, cost or environmental impact. Goods are not changed but for example the usage is made more efficient or their longevity is extended. In formula 1 this means that A*O -AO equals to zero, but (a combination of) the other factors, for example AT - A* T, should be greater than zero to make an actor choose A*. Note that if time or costs are reduced in A* but the increase of impact because on average the extra time and capital will be reinvested in some non-zero impact activity. So for an optimization effect to be environmental friendly (and to avoid some rebound effects), the following should hold, where Iavg is the average impact per unit of time or capital in general:

$AI - A^*I > Iavg(A^*T - AT) + Iavg(A^*C - AC)$ (3)

In regards to the rejected hypothesis the research agrees with the study done by (Ernest &Young,2012) in that enabling effect of green ICT Solution are 'vastly different and a single evaluation methodology cannot be applicable'. Thus the researcher recommends that enabling

effects assessed using hitly framework can be further explored using hankels framework for analyzing enabling effects.

4.8.2 Policy Implementation Barriers Analysis

From the findings it showed five barriers to policy implementation which agrees with the research done by (Spratt, 2009).

Conflicting/intersecting policies/Other Act:-National policies include broad and general language and are not always supported by operational or local policies and guidelines. Public procurement and Asset Disposal act (2015) Section 5: "The act shall prevail in case of any inconsistency between this act and any other legislation or government notices or circulars, in matter relating to procurement and asset disposal expect in cases where procurement of professional services is governed by an Act of parliament applicable for such services". In terms of disposal of hazardous material NEMA Act precedes PPOA act.

Low motivation and commitment: - Motivation and commitment can facilitate the policy implementation process .Personnel in institutional of higher learning in Kenya lacked motivation as a result of different priorities, a lack of incentives, and limited resources this is in tandem with survey done by (Suryawanshi& Narkhede , 2015) " revealed that lack of motivation and rational for adopting green polices among the implementers in institutions in India is a challenge".

Implementation at multiple levels:-The roll out of any policy often meets some level of community resistance or low engagement that challenges effective implementation. Finding showed that cascading policies from government level to institutions level lead to some resistance.

Discrimination:-These issues contribute significantly to the success/failure of policy implementation .Findings denote that majority of the gender formulating policy were men and female where less represented.

Policy formulation versus implementation:-Most of the institutions of higher learning have policies formulated as a government requirement and have not been implemented as a result of lack of resources to implement. Some policies have not been implemented effectively due to lack of clear link between the actual use and integration of greening with ICT in key policy.

CHAPTER FIVE
CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter gives a summary of the research findings, the conclusions made thereof and the recommendations that the researcher provided on assessing the green ICT effect on sustainable environment.

5.2 Summary of Findings

This section provides in brief the summary of the findings reported in the preceding chapter based on the objectives of the study.

Evaluating research objectives

Objective 1: To analyze direct effect of green ICTs on sustainable environment in institutions of higher learning in Kenya

From the findings the direct effects such as power consumption and proper disposal of ICT equipments are negatively affecting sustainable environment while using centralized system to reduce on hardware is a positive indicator cutting down cost for purchasing and disposing hardware.

Objective 2: To establish enabling effect of green ICTs on sustainable environment in institutions of higher learning in Kenya

The effect is still negative since there is incomplete substitution and realization of benefits of optimization of ICT solutions

Objective 3: To investigate systematic effect of green ICTs affects sustainable environment in institutions of higher learning in Kenya

From the finding the effects are negative where there is uncertainty of using online information; lack of long-term policy on software updates many ICT equipments are disposed as soon as it does not meet software requirements. Meanwhile the institutions are somehow slow in adopting advanced technologies as a result of insufficient finances to procure latest equipments.

Objective 4: To determine the role of existing green ICTs management actions on the relationship between green ICT effects and sustainable environment in institutions of higher learning in Kenya

It was significant that green ICT management affected systematic effect of green ICT. From the three objectives above it clearly indicate that there was agreement, uncertainty and disagreement in some areas this relates to how effective are the existing green ICT management actions, thus affecting the relationship between green ICT effects and sustainable environment.

Based on the above objectives hypothesis was tested where it indicated direct effect (P=0.003<0.05) and systematic effect (P=0.000<0.05) were significant and enabling effect (P=0.367>0.05) which is insignificant while introducing the green ICT management (P=0.000<0.05) this proves that its existence and implementation is of great significant in systematic effects.

5.3 Limitations of the Study

While conducting this research, other institution opted fully not to respond in regards to fear of top management. Secondary data, which included policy drafts, may have been incomplete and long overdue. Many institutions of higher learning in Kenya have not clearly defined green ICT where the researcher had to visit two regulatory bodies NEMA and KEBS for further clarifications.

5.4 Conclusion

From analysis done using generic framework direct and systematic effect of green ICT are significantly affect sustainable environment and enabling effect was insignificant. Enabling effect was subjected it to the second methodology using qualitative data its effect on environment also remains negative as those of direct and systematic effect; this is as a result of obstacles such as low awareness, lack of motivation and commitment, discrimination, implementation at multiple level; Policy formulation and implementation. IHL is not in forefront of integrating greening with ICT in policy areas, a positive general ICT Policy has resulted in a particular use of greening with ICT solutions.

Meanwhile the procurement and environmental department have integrated greening with ICT in accordance to KEBS standards, NEMA guidelines and PPOA policies. The IHL have green ICT topics integrated in several course curricula's but currently there are no specific courses for green ICT.KGUN are investing in greener campuses, where they encourage use of solar panels as alternative source of power also the use of green building, though they are still far behind sector in developed nations like USA and UK they are ambitious that in the coming future they will achieve the main goals in KGUN.

5.5 Recommendation

To minimize negative and to maximize positive green ICT effect on sustainable environment there is importance to review frameworks of existing strategies, polices, standards and best practices. Since this was an indicator that green ICT management action have great significance on relationship between green ICT effect and sustainable environment

Findings showed that there is partial awareness on green ICT. Therefore institution should champion green ICT education to employees on regular basis and green ICT leadership program with well defined rules and management system, performing analysis of green ICT effect on environment. There is no existence of building control system to control temperature, thus institution can use ICT to develop smarter technologies which can adjust themselves to reduce their impact on environmental.

The IHL should provide a variety of platforms to meet teleconferencing requirements in certain rooms. Teleconferencing facilities are an essential component of any strategy to reduce the amount of travel in IHL; Also the IHL should have mature remote application service (RAS) that enables users in remote locations to access applications as if they were on a common desktop machine, and hence perform many of their work functions and thus reduce carbon emissions resulting from travelling by members of staff.

Further for effective policy implementation the green ICT policy must be " coherent, justifiable, legitimate and integrated". Policy communication can be written in law and regulation, enforcement and measurement on effectiveness of policies such procurement policies will reduce purchasing ICT equipments based on price and or performance basis only, power management policies to cub on improper utilization of power thus reducing on huge electricity bills and e-waste management policies where institution should send obsolete equipments to recycling institution where they should ensure they are recycled well.Encourage best practices where institution translates its green ICT concerns and policies to action, employee should motivated to use green ICT application to minimize travelling i.e. institutions should look at performance indicators rather that physical presence of employee, global warming certificate award on employees that switching off lights when not in use, and following appropriate procurement procedures and finally green ICT Standards such as Energy star, EPEAT and WEEE should be adopted though currently Kenya is still under observatory countries

5.6 Suggestion for Further Research

Institutions of higher learning in Kenya have implemented green ICTs to some degree, some have adopted a planned policy, and others are implementing it partially as their ICT systems advances. Further research can be conducted to establish green ICT maturity levels, benchmarking of green ICT and auditing of green ICT management in institutions of higher learning in Kenya. Finally a comparative research can be done on effects of green ICT in institutions of higher learning in

Kenya. This will give a comprehensive recommendation and conclusion on green ICT management actions framework that need to be adopted to ensure all institutions of higher learning maximizes the benefit green ICT.

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APPENDIX 1:QUESTIONNAIRE

Irine Chepkoech

University of Nairobi

P.O. Box 30197-00100

Nairobi

Dear Respondent,

RE: REQUEST TO FILL THE ATTACHED QUESTIONNAIRE

I am a Master student of Nairobi University, School of computing and informatics. I am currently doing my research work and would like to request your assistance in filling the attached questionnaire. The questionnaire has been designed to gather information on **"An Assessment of green ICT effect on sustainable environment in institutions of higher learning in Kenya".**

The information you will present will be entirely for academic and learning purposes and will be treated with utmost confidentiality.

Thank you.

Yours faithfully,

Irine Chepkoech
irinechepkoech@students.uonbi.ac.ke

SECTION I: DEMOGRAPHIC INFORMATION.

1. **Please tick where appropriate**

Name of the institution (Optional)…….Department…….			
a	Gender	Male	
		Female	
B	How long have you been working for the university? **(Single selection)**	1-5years	
		5-10years	
		10-15years	
		Over 15years	
C	Highest Level of education? **(Single selection)**	O-level	
		College	
		Undergraduate	
		Postgraduate	
		Doctorate	
D	Category of the institution? **(Single selection)**	Public University	
		Private University	
		TVET	
		College	
		Doctorate	
E	How many years have you been using your current institutional computer? **(Single selection)**	0-3years	
		3-6years	
		Over 5 years	

SECTION II: GREEN ICT AND MANAGEMENT

2. **Green ICT** is the study and practice of sourcing, using, and disposing of computers, servers, and associated subsystems such as monitors, printers, storage devices, and networking and communications systems efficiently and effectively with minimal or no impact on the environment.

1. What is your level of awareness in Green ICTs? **(Single Selection)**
Fully Aware Partially [ ] Aware Not aware at all [ ]
2. What is the level of Green ICT implementation in your institution? **(Single Selection)**
Fully Implemented [ ] Partially Implemented [ ]
Not Implemented at all [ ] Do Not Know [ ]
3. Are you aware if there exist any green ICT Policies, Standards, Strategies and best practices in your institutions?
Yes [ ] No [ ] Don't Know [ ]
If yes which of the management action exist? (Multiple selection)
Policies [ ] Standards [ ] Strategies [ ] Best Practices [ ]

4. Indicate do what extent you agree with the following statement ticking at the appropriate box. Strongly Agree (SA), 2. Agree (A), 3.Uncertain (UN), 4.Disagree (D), 5.Strongly Disagree (SD)

Statements	SA	A	UN	D	SD
ICT equipments are procured based on green procurement policies and standards					
Printing is managed in our institution					
Power is managed in our institution					
E-waste is managed in our institution					
We are encouraged to use online service					

SECTION III: <u>GREEN ICT EFFECTS</u>

Indicate do what extent you agree with the following statement ticking at the appropriate box. Strongly Agree (SA), 2. Agree (A), 3.Uncertain (UN), 4.Disagree (D), 5.Strongly Disagree (SD)

1. Direct Effect of green ICT

	Statements	SA	A	UN	D	SD
a	I Switch of computer when leaving office					
b	The Institution uses centralized ICT Systems e.g printers					
c	We reuse and recycle ICT equipments					
d	We install energy saving equipments					

2. Enabling Effects of Green ICT

	Statements	SA	A	UN	D	SD
A	I read online materials					
b	While using printers we do a time experience problem relating to low quality Paper					
c	The institution allows employees to work remotely					
d	Temperatures in the offices of the institution are controlled by a building control system					

3. Systematic Effect of green ICT

	Statements	SA	A	UN	D	SD
a	The institution uses online information to monitor and learn about the institutional activities and progress					
b	Upgrading of software's induce hardware obsolesce					
c	The institution provide laptops for heads of department					
d	The institution can easily recruit employees using online system					

SECTION IV: SUSTAINABLE ENVIRONMENT

Green ICT implementations have either positive or negative effects on environment. Rate the following questions using the rating criteria below.

1. Strongly Agree (SA), 2. Agree (A), 3.Uncertain (UN), 4.Disagree (D), 5.Strongly Disagree (SD)

	Statements	**SA**	**A**	**UN**	**D**	**SD**
a	I am aware of global warming					
b	Operating ICT equipment in standby mode causes consumption of energy.					
c	Disposal of ICT equipment affect the environment.					
d	Teleporting and Teleconferencing affects the environment by reducing air pollution from motor vehicles.					
e	High quality printers stimulate demand for high quality paper, increasing pressure on forest and paper making					
f	Green ICT Managed control system affects the environment					
g	Implementation of green ICT Leads to new critical infrastructure					

In your own opinion, what other effects do green ICTs pose to the environment?

…End…

Thank you for taking your time to complete this Questionnaire

APPENDIX 2:INTERVIEW SCHEDULE

Interview Questions for heads of ICT in institutions of higher Learning

1. How is procurement of ICT Equipment done in your Institution?
2. What is the general lifetime of ICT equipment at your Workplace?
3. How do you dispose of your ICT equipment?
4. How is power consumption of ICT equipment managed in your institution?
5. How is printing managed in your institution?
6. How is cooling of ICT Equipment managed in your Institution?
7. How are servers managed in your institution?
8. How is lighting managed in your institution?
9. How is travelling managed in your institution?
10. How is ICT used to reduce the impact of your institution on the Environment?
11. Are you issued with office laptop?
12. Do you have any policy document ?

Interview Questions for KEBS and NEMA

1. Do you have standards and policies for green ICT?
2. What do the e-waste management policy states?