

**ADDIS ABABA UNIVERSITY  
COLLEGE OF NATURAL SCIENCES  
SCHOOL OF INFORMATION SCIENCE**

**Assessing Green Computing Readiness in  
Government Organizations in Addis Ababa**

By

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## DECLARATION

I, the undersigned, hereby declare that this thesis titled “**Assessing Green Computing Readiness in Government Organizations in Addis Ababa**” is my original work carried out under the supervision of Dr. Elisabeth Ayalew. It has not been presented as a thesis in any other university and all source of material used for this thesis are duly acknowledged.

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This is to certify that the above declaration made by the candidate is correct to the best of my knowledge.

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## **Abstract**

Information and communication technology (ICT) is becoming an important part of all our personal and professional lives and it is at the heart of the digital economy. The usage of ICT is growing from time to time. However, the exponential growth in computing is increasing consumption of significant amounts of electricity and generation of electronic waste (e-waste). Such waste makes IT to be considered as one of the sectors contributing towards climate change. To address the impact of ICT on environment, Green Information Technology (Green Computing) is seen as a solution in modern world. In order to successfully adopt green IT understanding readiness level of organizations is very important. A measure of organizational preparedness or capability to adopt green IT is g-readiness. Therefore, the major purpose of this research is to assess the g-readiness of government organizations to adopt green IT in Ethiopia. The study helps to systematically analyze the ability of the organizations to adopt green IT, to determine existing gaps and potential challenges that help to identify what is working well and what needs improvement for adopting green IT. The case study method was employed to assess the g-readiness of government organizations to adopt green IT. A questionnaire and interview were used to collect data on g-readiness constructs. A total of 155 questionnaires were collected from two giant government organizations in Ethiopia and analyzed using SPSS software. And ten key personnel working in the selected organizations were interviewed and the data was analyzed using open coding method.

The result of the study shows that overall g-readiness of the two organizations is very low. Attitude of g-readiness construct scored higher mean value than the others. Policy, practice, technology and governance g-readiness constructs scored below average and the score of the policy construct is the least from all constructs. The findings of qualitative analysis show that higher level IT professionals in the sample organizations have better understanding of green IT than lower level experts. Based on the findings of the study, recommendation is suggested to approach green IT initiatives based on life cycle of IT equipment so that the organization will improve their readiness level for successful adoption of green IT.

## **List of Acronyms**

CRGE	Climate Resilient Green Economy Strategy
EEE	Electrical and Electronic Equipment
E-waste	Electronic waste
Green IT	Green Information Technology
ICT	Information and Communication Technology
IT	Information technology
MCIT	Ministry of Communication and Information Technology
PCA	Principal Component Analysis
TOE	Technology-Organization-Environment

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# **CHAPETR ONE: Introduction**

## **1.1 Background to the Study**

In this era of information society, enterprises are increasingly depending on Information technology (IT) to facilitate business, to get competitive advantage, to provide better services and to carry out the organization's mission to achieve their business goal. However, the exponential growth in computing results in consuming significant amounts of electricity (Guster et al., 2009) and releasing carbon dioxide (CO<sub>2</sub>), which contributes to greenhouse gas emissions, strengthening the alarming danger of energy shortage and e-waste generation. According to Rivoire et al.(2007), information technology is responsible for generating 2% of carbon footprint through massive consumption of energy. Therefore, IT has been regarded as one of the sectors contributing towards climate change. To address this problem, Green Information Technology (Green Computing) is seen as a solution in the modern world.

Green computing refers to the practice of using ICT resources more efficiently while maintaining or increasing overall performance (Kolbasuk, 2007). According to Murugesan (2008, p.3), Green Computing is defined as the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems including monitors, printers and storage devices, efficiently and effectively with minimal or no impact on the environment. Green computing practices such as power management, virtualization, cloud computing, optimizing data center design, recycling, proper electronic waste disposal, and optimization of the IT infrastructure helps to meet sustainability requirements in IT services. Going green is a major concern of the modern world with respect to the world-wide desire to reduce the negative impact on the environment.

Ethiopia is one of the Sub-Saharan African countries which aspires to be a middle-income economy by 2025 and is striving to introduce and sustain a green economy development plan (CRGE, 2011). For its green growth economy the country developed a strategy which is named as Climate Resilient Green Economy (CRGE) strategy. The country launched this strategy in 2011 as a central element in its aim to become a low carbon middle income economy by 2025 (CRGE, 2011).

The CRGE strategy indicates how the development goals can be reached while maintaining greenhouse gas emissions in 2030 to its 2011 levels. With its economic transformation ongoing, it

is estimated that the country's demand for electricity increases by up to 20-25% annually. According to (UNEP, 2015), Ethiopia has been working towards targeted goals for climate resilience and an additional 60 million jobs in its green economy by 2035. According to UNEP (2014) green job is defined as decent jobs that reduce consumption of energy and raw materials, limit greenhouse gas emissions, minimize waste and pollution, and protect and restore ecosystems. Therefore, as information technology is considered as enabler for organization to achieve their goal; the efficient use of IT resources is crucial to contribute to the country's strategy toward sustainable green economy. The efficient use of IT resources with no or minimal impact on the environment is achieved by implementing green computing. Therefore, strategic approach to green IT is important for the country to achieve green growth development.

## **1.2 Problem Statement**

Information and communication technology (ICT) is becoming an important part of all our personal and professional lives and it is at the heart of the digital economies. In Ethiopia the usage of information technology is increasing and the penetration of electrical and electronic equipment (EEE) which includes computer products is rapidly increasing in the country which results in generation of e-waste. The government recognized the critical role of ICT to provide service through utilization of ICT (MCIT, 2009). It is stated on the country's national ICT policy that "The final goal of the ICT policy is by effective utilization of ICT, to bring about significant development nation-wide in all sectors and in all citizens walks of life. " This shows government's commitment to use ICT widely in the country. One of the implications for this is the establishment of ICT village that is expected for its major contribution to growth of ICT in the country. The government also considered ICT as one of major components of the Sustainable Development and Poverty Reduction Program and to use it in all sectors of the economy (Adam, 2010). The national ICT policy clearly stated to work on the social and economic well-being of the people of Ethiopia through opportunities created by ICT achieving rapid and sustainable socio-economic development (MCIT, 2009).

The country's ICT policy and green development strategy will be the focus of this study on how they deal with the impact of ICT on the environment. IT can be a problem to the environment though it is a problem solver to the environment. Therefore, strategic approach of using

information technology in environmental friendly way is very important to the country towards sustainable development. The efficient use of IT resource with no or minimal impact on the environment is achieved by adopting green computing. However, before adopting green computing, the readiness level of organizations is very important in order to identify what works well and what needs improvement for successful adoption of green computing.

Therefore, this research aims to indentify the current readiness of government organizations to adopt green computing.

### **1.3 Research Questions**

This study intends to address the following research questions:

- What is the level of readiness of government organizations to adopt green computing?
- What are the challenges that might hinder from successful adoption of green computing?

### **1.4 Research Objectives**

#### **General Objective**

The main objective of this research is to assess readiness of government organizations to adopt green computing in Ethiopia and to provide recommendation for successful adoption of green computing.

#### **Specific Objectives**

- To assess the attitude of organizations towards green computing
- To assess the readiness of organizational policy in the area of IT sourcing, IT operations and IT end-of-life management to adopt green computing.
- To assess the readiness of organizational practice in the area of IT sourcing, IT operations and IT end-of-life management to adopt green computing.
- To assess green technologies adopted by the organizations
- To assess how organizations govern green computing initiatives
- To assess the challenges that might prevent the organization from successful adoption of green computing

## 1.5 Scope of the Study

Green approach is also gaining attention in the area of software engineering researchers to design energy efficient software (Harbla et al., 2013). However, in this research green computing focuses on IT equipment lifecycle which covers IT sourcing, use and end of IT life management (disposal).

## 1.6 Significance of the Study

This study has made the first contribution to assess the g-readiness of organizations to adopt green computing in the country. A readiness assessment is a systematic analysis of an organizations ability to apply change or to determine existing gaps or potential problems to implement change. Assessing g-readiness of the organization helps to identify what is working well and what needs improvement. For practitioners who want to adopt green computing, the study helps to identify which area of green IT readiness works well and which needs improvement. Adoption of green computing has two major benefits: environmental benefits and economic benefits that helps to lower energy and efficient use of hardware. The organizations can use this study to identify the current gap for successful adoption of green IT. For researchers, this study contributes to the limited knowledge of green IT in the country for further study.

## 1.7 Organization of the Study

**Chapter One:** discusses the background, the objective, the research question and the problem statement with the significance of the study.

**Chapter Two:** deals with literature review that covers topics such as ICT and environment which is the broader concept of the study, green computing, green computing readiness, benefits of green computing, green computing initiatives, green computing challenges, widely used green computing frameworks , green computing practices worldwide and in Ethiopia. These topics are important to support the theoretical background of the study and to identify the gap.

**Chapter Three:** discusses research design and methodology used to address the problem statement and to answer the research questions which include general insight on existing research methods, what research method was employed and the reason it is selected, sample size selection

procedures and techniques, data collection techniques and data analysis methods.

**Chapter Four:** presents data analysis and interpretation of the case study data. The chapter provides also discussion of the result and recommendation.

**Chapter Five:** summarizes the findings from the study, limitation of study and direction for future study.

## **CHAPTER TWO: Conceptual Framework and Review of Related Works**

The objective of this chapter is to review previous studies on ICT use and its impact on environment, Green Computing, Benefits of Green Computing, Green Computing initiatives, Green Computing readiness, Green computing practices and Green computing framework based on the overall objective of the research. These topics are important to support the theoretical background of the study and to identify gap.

### **2.1 ICT Use and Its Impact on Environment**

All aspects of our life and business processes are strongly dependent on Information Technology. ICT has a key role in organizations productivity while maintaining environmental sustainability (Osseyranet al., 2013). The usage of ICT is growing from time to time. According to (Webb, 2008), ICT continues to grow and is expected to reach 8.7 percent of global GDP by year 2020. Enterprises are increasingly depending on Information Technology to facilitate business, to get competitive advantage and to carry out the organization's mission to achieve their business goal.

However, the rapid growth in IT infrastructure has led to the increase in power consumption which in turn increases extra demand in energy which resulted in generation of greenhouse gases (Webber et al., 2009). Information technology is responsible for generating more than 2% of carbon footprint through massive consumption of energy which is roughly the same as the amount generated by airline industry and forecasted to be triple in year 2020 (Rivoire et al., 2007, Guster et al., 2009). In addition, electronic products are becoming obsolete with in shortest period as a result of the rapid change of technology. This resulted in e-waste increase which is one of the major causes of the environment problem (Ruth, 2009). And also some of the metals that are used when producing computers are hazardous which create issue on the environment if disposed improperly. The metals also can create health problem when informally handled and recycled (Ongondo et al., 2011). Ruth (2009) identified how IT is causing problem to environment and disused how IT can help to reduce the environmental impact. According to this study 70% of all hazardous waste is e-waste.

Therefore, ICT can be cause of environmental problem and can be part of solutions to solve environmental issues (Nanath & Pillai, 2012).

The impact of ICT on the environment should not be neglected. Andrew (2010, p. 1392) also stated the impact of ICT on environment by saying that “The direct impact of ICT on the environment is much greater than is generally realized”.

To address the impact of ICT on the environment, Green Information Technology (Green IT) has been introduced to reshape IT into environmentally friendly way (Chetty et al., 2009). To solve the impact of IT on the environment Lee et al. (2013) designed strategy in two ways: the first strategy is by greening of IT itself which focuses on reduction of energy and CO2 emission from IT products, and proper disposal of e-waste. The second strategy is greening by IT which is utilizing IT for greening purposes.

In Ethiopia, the government recognized the critical role of ICT to provide efficient and effective public service through effective utilization of ICT (MCIT, 2009). It is stated on the country’s national ICT policy that “the final goal of the ICT policy is by effective utilization of ICT, to bring about significant development nation-wide in all sectors and in all citizens walks of life’. The government considered ICT as one of major components of the Sustainable Development and Poverty Reduction Program and to use it in all sectors of the economy (Adam, 2010). Therefore to meet the green growth of the country, in the development process of ICT, the efficient use of IT resources by no or minimal impact on environmental should be considered. The strategic way of using ICT resource efficiently with no or minimal impact on the environment that supports sustainable development is called Green Computing. Green computing is becoming popular in the modern world. To adopt green computing successfully understanding organizational preparedness is very important.

## **2.2 Green Computing - Definition**

Green computing or Green IT is the study and practice of using ICT resources more efficiently while maintaining or increasing overall performance. By using all equipment in an optimal way, it is possible to reduce its cost as well as potential impact on the environment (Forge et al., 2009). Green Computing is based on the triple bottom line that considers social responsibility, economic feasibility and the impact on the environment.

The aim of Green Computing is to make the whole process within computer life cycle more concerned with environmental, economic, and social issues. Green Computing is one of the initiatives that are introduced to reduce carbon dioxide emission by IT device. Green Computing adoption is motivated by the concern to the environment though the benefits might not be tangible unlike the adoption of IT which is usually motivated by the potential economic benefits of using technology (Molla et al., 2009).

Green Computing is gaining attention in the area of IT management research and it is considered as strategic direction for business sustainable development (Loeseret al., 2011, Reimsbach-Kounatze, 2009).

Different authors defined Green Computing in different ways. Below are some of the definitions.

“Green IT refers to environmentally sound IT. It’s the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems —such as monitors, printers, storage devices, and networking and communications systems—efficiently and effectively with minimal or no impact on the environment. Green IT also strives to achieve economic viability and improved system performance and use, while abiding by our social and ethical responsibilities. Thus, green IT includes the dimensions of environmental sustainability, the economics of energy efficiency, and the total cost of ownership, which includes the cost of disposal and recycling” Murugesan (2008: pages 25-26).

“Green Computing is the practice of designing, manufacturing, using and disposing of computer, servers and associated subsystems efficiently and effectively with minimal or no impact on the environment, with a strong focus on improving energy efficiency and equipment utilization through steps such as designing energy efficient chips, virtualization, reducing data center energy consumption, using renewable energy to power data centers, and reducing electronic waste. IT for green is the use of information systems to enhance sustainability across the economy, with a focus on IT as a solution.” (Cai et al., 2013, p. 3)

Green Computing is defined as the use of IT resources in an energy-efficient and cost-effective manner (Bose & Luo, 2011, p. 39).

Green Computing is “an initiative to encourage individuals, groups, and organizations engaged in the use of ICT to consider environmental problems and find solutions to them” (Chai-Arayalert et al., 2011).

From the above listed definitions, in this paper the researcher used the definition by Murugesan (2008) which is highly cited. This definition is based on the full life cycle of computers and other IT equipment and it incorporates the social and ethical responsibilities of using IT resources. The author defined the life cycle of computers as Green Computing domains which are Green design, Green manufacturing, Green use, and Green disposal of IT Systems Murugesan (2008: pages 2526). The four domain are described below.

Green design- considers about designing energy efficient and environmentally sounds equipment, computers, servers and cooling equipment.

Green manufacturing - every process in manufacturing electronic machineries, computers and other associate subsystems should imply minimal or no impact on environment.

Green use - is reducing the energy consumption of data centers, computers and other information systems and using them in an environmentally friendly manner

Green disposal - is about repairing and recycling computers and electronic equipment that might be old or unwanted.

## **2.3 Benefits of Green Computing**

The two main benefits for green IT implementation are reducing operating cost and protecting the environment. Adopting Green IT will reduce costs of energy use, hardware and management and support in addition to environmental benefits (Bose & Luo, 2011). And also Brooks et al. (2012) described the benefits of Green Computing as “environmental benefits and cost reduction benefits. Green Computing practices such as power management, virtualization, cloud computing, improving cooling technology of data centers, recycling, electronic waste disposal, and optimization of the IT infrastructure help to meet sustainability requirements in IT services. By applying virtualization organization can reduce future costs of server purchase, data center space, operational cost, and cost of cooling system. Green Computing strategy is to reduce the use of energy and relevant costs while maintaining or increasing performance.

Therefore, it can be argued that Green Computing aims at cost reduction as well as environmental protection (Nishant et al., 2012).

## **2.4 Green Computing Readiness (G-readiness)**

Readiness is capability or preparedness of an organization to undertake transformation process or change. G-readiness is organizational capability to adopt green IT. It is a measure of organizational preparedness for adopting green IT. Without clear understanding of G-readiness, organizations may approach Green Computing initiatives as ad hoc and in a reactive manner which is undesirable (Molla et al., 2008).

According to Molla et al. (2011) G-readiness is defined as “an organization’s capability in Greening IT (that is applying environmental criteria to its IT technical infrastructure as well as within its IT human and management practices across the key areas of IT creation, sourcing, operations, and disposal) in order to reduce IT, business process, and supply chain related emissions, waste and water use; improve energy efficiency; and generate green economic rent”.

According to the study by Molla et al. (2008) there is lack of G-readiness framework that had not got research attention. Molla et al. (2008) developed G-readiness for the first time based on the concept of e-readiness. E-readiness is the capability of an organization to successfully adopt e-business (Molla et al., 2006). The insight of e-readiness leads the researcher to develop Green Computing readiness framework (g-readiness). They developed the main pillars of g-readiness framework that helps organization to evaluate their readiness for adopting green IT. The model addressed five dimensions of g-readiness namely as: - attitude, policy, practice, governance and technology which are described below. The authors argue that G-readiness is equally required with e-readiness to execute e-business successfully in green economy. According to the study G-readiness is critical capability to succeed in green digital economy. By including the five dimensions of G-readiness, Molla et al. (2009) defined G-readiness as “G-readiness is an organization’s capability as demonstrated through the combination of attitude, policy, practice, technology and governance in applying environmental criteria to its IT technical infrastructure as well as within its IT human infrastructure and management across the key areas of IT sourcing, operations and disposal to solve both IT and non-IT (by using IT) related sustainability problems.”

The five constructs of G-readiness defined by Molla et al. (2009) are described below

**Attitude:** refers to the characteristics of business, IT leaders and professionals that measure the strategic economical, regulatory, social and environmental awareness related to IT usage (Molla et al., 2008). Attitude describes how we think, rather than how we act, and it is about attitude or culture (Philipson, 2010). Attitude is a crucial starting point for desiring change. Then commitment and action to change will follow. Green ICT Attitude refers to the extent in which management and IT professional are aware and concerned about the impact of ICT on environment and climate change. Attitude is defined as the major influential factor for use of technologies and hence on Green IT implementation.

**Policy:** Policy readiness measures the extent to which green and sustainability policies are developed throughout an organization.

The policy defines the administration of Green IT initiatives, budget allocation and resource administration. It takes into account the required roles and responsibilities, skills, deliverables and targets and methodology used. The main areas to assess g-readiness policy are IT sourcing, IT operations and services and IT end-of-life management.

**IT sourcing:** is the extent to which an organization has adopted an environmentally preferable policy or guidance for buying IT equipment and services.

**IT operations and services:** encompasses the extent to which the services provided by the IT infrastructure support issues encapsulated in business sustainability. Some of the policy considerations include PC power management; policy on staff computer usage and environmental policy (InfoTech, 2008b).

**IT end-of-life management:** refers to the policies and regulations related to the disposal and settlement of IT equipment in organizations. In certain regions, end-of-life recycling is required by the provisions of law (Elliot, 2008, InfoTech 2008b). So, IT end-of-life management can tell us the extent to which the organizations has developed policy or guidance on disposal of IT equipment.

**Practice:** In addition to having developed green ICT policies organization have to put the policies in action. According to the study by Molla et al. (2009) organization can have policies in place that are not yet practiced. Green ICT practices are things we do.

There are many practices that help greening of ICT that have no additional cost. The simplest practices that are most effective and do not need additional purchase of hardware are turning off computer while not in use for more than few hours, duplex printing and printing only if necessary , recycling printing papers and using IT equipment for longer period of time. According to Molla (2009) IT sourcing, IT operations and services and IT end of life management are the main area of green ICT practice assessment.

According to Molla (2009) addressing the following issues can indicate the readiness of an organization towards Green Computing practice. Data collection on vendors green rating, the extent of contracts awarded to suppliers that use green technology, auditing the power consumption of existing systems, IT projects implemented to reduce power consumption requirements ,IT projects implemented to maximize power utilization (PC power management),the extent of enforcement of PC power management ,the energy rating of implemented technologies, actions taken to reduce ITs carbon footprint, projects implemented to monitor enterprise carbon footprint, the extent that equipment is recycled.

In particular, the sourcing and ICT infrastructure design and energy consumption audit and monitoring are important subcomponents of Green ICT practice.

**Technology:** Green ICT technology refers to technologies for reducing energy consumption of data center, IT assets, cooling systems and optimizing energy usage and using IT to reduce organizational environmental foot print.

Green ICT technology readiness can be measured by assessing the extent to which an organization has green business infrastructure (Molla & Cooper, 2010). These technologies are green power sources, development of green ICT standards across the enterprise, server consolidation and virtualization, extent that applications and technologies are retired for greener technologies and extent of solutions development to support enterprise wide green initiatives.

**Governance:** Green ICT Governance deals with how we administer green IT initiatives. It is the Organization's ICT management capability to develop environmental sound criteria and frameworks to guide IT sourcing, IT operations and services and IT end of life management. For governance to be actualize green ICT, it has to have clear structures in place where the role for coordinating green ICT initiatives are defined and the CEO plays a leading role in green ICT

initiatives. Responsibilities are clearly defined within each green ICT initiative which necessitates establishment of metrics for assessing the impact of green ICT initiatives and setting targets to reduce the organizations carbon footprint. Governance would realize much where ICT department is responsible for its own electricity bill (Molla et al., 2009).

## **2.5 Green Computing Initiatives / Practices Worldwide**

The first Green Computing initiative started back in 1992 with the introduction of Green Computing when the U.S. Environmental Protection Agency (EPA) launched Energy Star. It was voluntary labeling program that aims to minimize energy consumption in computer products without compromising performance. The ENERGY STAR label is now on major appliances, office equipment, lighting, home electronics, and more. This resulted in the adoption of sleep mode in computer monitors and electronics appliance (Jena, 2010). However, according to HM GOVERNMENT (2008), UK government was one of the first governments to look seriously on its IT process to implement green practice throughout the government.

The practices defined were switched off computers overnight, defaulting printer to double side printing and data center cooling efficiency. The UK government continued its greening practice commitment and launched a strategy to reduce waste generation, water use and greenhouse gas emissions by applying cost effective and energy efficient IT system. The strategy defined how ICT can contribute to government commitment towards green practice.

The Info Tech Research Info-Tech (2009) examined the impact and adoption rates of 11 Green Computing initiatives in mid-size organizations around the world that represent 12 countries and 8 industries. The 11 Green Computing initiatives described in the study were server virtualization and consolidation, storage consolidation, desktop virtualization, existing server room upgrades, new server room builds, IT energy measurement, PC power management, printer consolidation, remote conferencing, telecommuting and IT equipment recycling. Storage consolidation, remote conferencing and telecommuting projects are identifies as most popular initiatives being adopted which results in immediate cost reduction and environmental protection benefits. Info tech categorized the above listed green initiatives for moving towards Green Computing into four groups as Consolidation & Virtualization, Energy Efficiency, Travel Reduction, and Asset Disposal.

On the study by Murugesan (2008), Green Computing strategies are described as reducing energy consumption by PCs: by switching of computers when idle we reduce energy consumption and save money, enabling power management features - The US Environmental Protection Agency (EPA) estimated that providing computers with a sleep mode reduces their energy use by 60-70 %, turning off systems when not in use and the most basic energy conservation method are using thin- client computer and greening Data Centers: There are actions to increase data center efficiency by using new energy efficient equipment, improving airflow management to reduce cooling requirements, investing in energy management software, and adopting environmentally friendly designs for data centers and new measures to control data centers' energy consumption, energy conservation and virtualization.

In developing countries, the level of Green Computing maturity is low. The study on practice of Green Computing in developing and developed countries shows that developed countries seriously adopted green IT policy however there is lack of awareness on Green Computing in developing countries.

The study indicated how e-waste is increasing in developing country and recommended to work on green IT policy and strategy to achieve sustainable development (Ramessur et al., 2014). Similarly the study by Wabwoba et.al. (2012) indicated that Green Computing maturity level in developing economies is lower than that of developed economies. The study compared the findings in developing countries (Kenya and Indonesia) with the finding of developed countries (Australia, USA, New Zealand).

## **2.6 Green Computing Challenges**

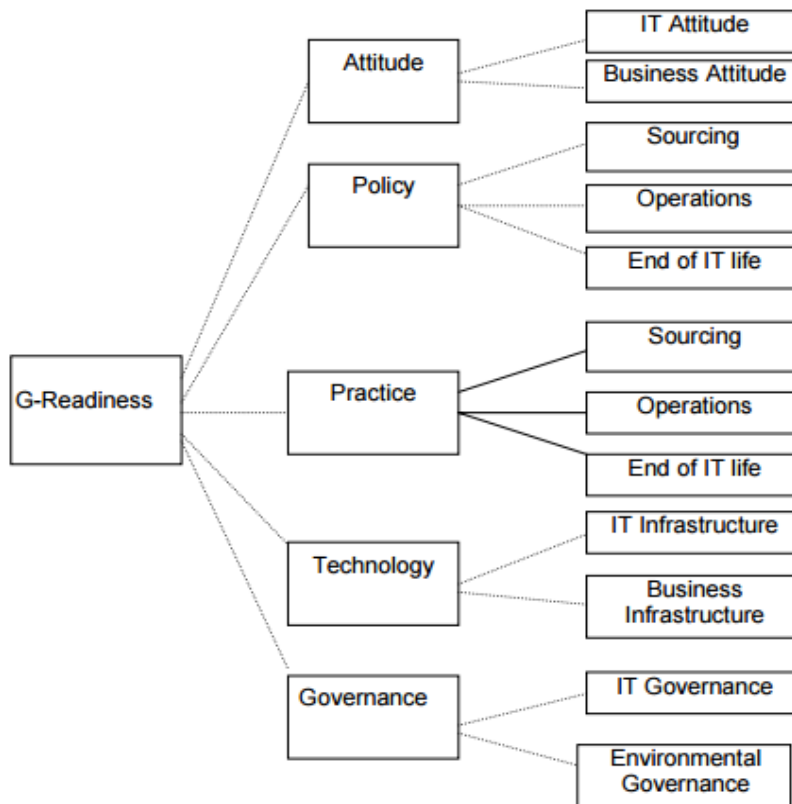
The challenges of adopting Green Computing are described in different literature (Suryawanshi&Narkhede, 2013), (Wabwoba et.al. 2012), (Paruchuri, 2011). Some of the main challenges are: insufficient knowledge of Green Computing that means there is lack of knowledge of on energy consumption of IT equipment and on the benefits of green IT, lack of Green Computing skilled human resource, lack of support and guidance from management, lack of motivation, lack of training of managers and users, lack of awareness, insufficient knowledge of education systems review policy, funding , legal framework, rapid technology changes ,

organization resistance to change, not realizing significant environmental gains and poor decision-making process in organizations.

## 2.7 Green Computing Frameworks

### 2.7.1 G-Readiness Model

The G-readiness framework helps organization to evaluate their readiness to adopt green IT. Molla’s G-readiness framework is specifically designed to assess the preparedness or readiness of organizations to adopt Green Computing. Molla’s G-readiness framework consists of five readiness constructs – attitude, policy, practice, technology and governance (Fig 2.1). Without clear understanding of g-readiness, it is difficult for organizations to be successful in the adoption of Green Computing. G-readiness framework helps organization to know the current status of g-readiness which helps to identify the current status, gap and challenges on Green Computing initiatives.



**Fig 2.1 G-readiness Framework (Molla et al., 2008)**

## **2.7.2 Technology-Organization-Environment (TOE) Framework**

Technology-organization-environment (TOE) framework was introduced by (Tornatzky& Fleischer, 1990) to analyze the adoption of new information technology at organizational level. According to this framework, technology adoption is influenced by three key determinants - environmental context, organizational context, and technological context.

**Technological Context** - relates to the technology use and technical skills available in an organization. Its main focus is on how the nature/characteristics of technology can influence the adoption process (Thiesse et al., 2011; pp. 331).

**Organizational Context** – according to Teo et al.(2009) organizational context refers to organizational structure, firm size and scope, organizational culture, presence of innovation, informal communication, centralization, formalization, and strategic behavior of top management.

**Environmental Context** – is the arena surrounding a firm that includes multiple stakeholders such as industry, competitors, suppliers, customers, government regulations, market structure and characteristics, and the external support available for adoption of new technology. Environmental factors can influence how a firm interprets the need for innovation, the diffusion of new technology in organization and its capability for deploying it (Assimakopoulos& Wu, 2010).

## **2.7.3 The Connection Research-RMIT Green Computing Framework**

The Connection Research-RMIT Green Computing Framework was developed by Connection Research, in conjunction with RMIT University in Melbourne. It takes a holistic view of Green Computing and sustainability across organizations. The framework contains four vertical components or pillars and five horizontal components or actions. The pillars are based on the different functional components of Green Computing. This framework helps to understand components of Green Computing. All of the subcategories are identified and explained in Philipson (2010).

This Green Computing framework is used by many organizations to categorize the many aspects of Green Computing. It is also used extensively by business partners to conduct surveys into Green Computing usage patterns and in conducting Green Computing benchmarking (Philipson, 2010).

From the listed frameworks, G-readiness framework is adopted in this study. The researcher found Molla's G-readiness framework as the most relevant framework based on the objective of the study. The rationale behind using this framework are the following: most other Green Computing frameworks that exist in the literature are mostly relevant to Green Computing adoption but not for G-readiness framework and the questionnaire of this framework are already validated and tested (Molla et al., 2009). This will increase the validity of the research when compared with developing the questionnaire from scratch.

## **2.8 Related Works**

A study by Theodoros (2010) was aimed to assess existing and potential states of E-waste on three selected TVET colleges in Addis Ababa. According to the finding of the study there is no legal and institutional framework for the disposal of e-waste, there is large accumulation of e-waste and lack of awareness. As solutions the study recommended to develop standard and regulations to manage e-waste, to create awareness and setting standard with control mechanism of importation EEE.

This study didn't consider the whole life cycle of IT equipment to tackle with e-waste management problem. Without a broad concept of IT life cycle and its link to the environment, it will be difficult to be effective in e-waste management. Because the IT life cycles are enter related and affect one another. Therefore, this study helps to fill this gap by studying the readiness of organization to adopt green IT and then to give recommendation on how to be successful in Green IT adoption. To address the issue of e-waste the entire life cycle of IT equipment should be considered. Green Computing considers every part of the IT life cycle including e-waste management.

A study carried out jointly by the Germany-based Öko-Institute.V. and PAN-Ethiopia, an Ethiopian NGO, Amara et al. (2013), was aimed to generate reliable data on e-waste and the practice and management options. The result of the study shows that there is no e-waste management system in place. However, the study recognized the promising effort done by MCIT to establish de manufacturing center for environmental sound e-waste management system. The study recommended to develop a national e-waste strategy and to take into account the whole cycle of electrical and electronic products. However, the concept and clear approach to Green Computing is not included in the study. Without clear understanding Green Computing,

approaching to tackle the impact of ICT on the environment will be very difficult. There, this study will fill the gap to the knowledge of Green Computing.

A study by Schleicher et al. (2015) aimed to assist the Ethiopian government in particular on proposal for efficient and effective e-waste collection system in Ethiopia. The study included all type of e-waste including computers. It assessed e-waste management system of four Ethiopian cities: Addis Ababa, Dire Dawa, Hawassa and Jigjiga. The findings of the study show that e-waste collection system is still in its early stages. It stated the e-waste collection system established in Addis Ababa by the federal government to collect from federal offices and the absence of e-waste disposal strategy in the regions and city administration offices. The study suggested to integrate the e-waste management system to the existing waste disposal systems and to explore various financial mechanism to collect e-waste.

The study clearly shows the current situation of e-waste management in Ethiopia. However to manage e-waste, understanding the life cycle of electronic equipment is very important which is employed by adopting Green Computing. Green computing helps to control the penetration of used electronics in the country, IT use and then disposal.

## **CHAPTER THREE: Research Methodology**

This chapter discusses the research design, population of the study, sampling for the study including selection technique and size, data collection methods, data analysis and presentation method. The main objective of this research is to study the Green Computing readiness (G-readiness) of organizations to adopt Green Computing.

### **3.1 Research Design**

A research design is a logical approach that used to link the research question and research process that helps to address the research question. It consists of research methods, data collection activities and data analysis method. In this research, case study method is employed to assess the readiness of government organizations to adopt green IT. Case study method offers the benefit of studying phenomena in detail and in their real-life context particularly in situations where there are many more variables of interest than there are observations (Yin, 2009). In this study the phenomenon that is going to be studied in depth and in its real-life context is readiness of organizations to adopt green IT. According to Yin (2009) a case study indicates empirical inquiry that investigates a phenomenon within its real-life context and in which multiple sources of evidence are used.

Case study can be single or multiple. In this study, two giant organizations were considered used to avoid the limitations with a single case study. The limitations with a single case study are the representativeness of the selected case and its difficulty to do cross case comparison analysis (Yin, 2009). Case study is common research method and particularly important for IS research because of the focus on operational and strategic rather than technical issues (Dubé& d Paré, 2003).

Combinations of quantitative and qualitative research approach were used for the case study. Quantitative and qualitative data collection method can be used in case study to explore the objective of the study and to better answer the research question (Yin, 2009, Creswell, 2007). Quantitative methods work best in investigating association and variations of variables and to collect large amount of data from large population, whereas qualitative methods are effective to gather in-depth view into the processes and events that lead up to the observed variation.

In addition the use of two or more sources of evidence allows triangulation of findings which, according to Yin (2009), is a major strength of the case study design.

In this study two public organizations are selected for the case study. The two organizations are the Ministry of communication and information technology and Ethio Telecom. The reason for focusing on government organizations is because the green growth strategy of the country (CRGE) is initiated and developed by the government. The other important selecting criterion is these two organizations have critical role in the development of information technology in the entire country. The ministry develops ICT policy, design various programs, mobilize resources, guide and monitor implementation. Ethio Telecom is the only telecom company in the country that provides telecom service in the entire country on voice, internet and data. It is an integrated telecommunications solutions provider in the country. In addition these organizations have large national data centers and networked branch offices with area coverage from federal to woredas. They have influential role in the development of information technology in the country and in implementation of ICT best practices. So assessing the readiness level of these organizations to adopt Green Computing is very important to implement Green Computing in all government and private organizations which has strong positive impact on the green growth of the country.

## **3.2 Sampling Design**

### **3.2.1 Target Population**

The target populations of this study are IT Managers, team leaders in IT departments and IT professionals working at the selected organizations.

### **3.2.2 Sampling Technique and Sample Size**

A single population proportion formula was used to quantify the appropriate sample size from the total population for quantitative data collection for each organization. The following sampling techniques are used to calculate the sample size based on the sampling formula (Cochran, 1977). First the total population of IT professionals ( $N$  in the formula) in the organization is determined from the organization's HR department, then the sample size  $n$  is calculated by single population proportion formula using confidence interval and marginal error and finally the questionnaire is randomly distributed to  $n$  number of IT staff. Simple random method is used when each unit of the members has equal chance in the population.

So, in this study all the IT professionals in the selected department of the organization have equal chance of selection for the study. The following formula is single population proportion formula used in this study.

$$n_0 = \frac{(Z_{\alpha/2})^2 Pq}{e^2} , \quad n = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

Where

$n_0$  = Sample Size

$n$  = calculated (actual sample size)

$e$  = the desired level of precision

$p$  = is estimated proportion of an attribute in the population

$q = 1 - p$

$z$  = normal curve that cuts an area  $\alpha$  (the value read from statistical table)

The actual sample size is calculated for the two selected organizations based on the above sampling calculation formula with 90% confidence interval and 5% marginal error.

### Sample Size

**Table 3.1 Sample Size**

Organizational name	Total Population Size	Calculated Sample size
Ethio Telecom	164	103
MCIT	70	55
Total	234	158

Source: Own survey, 2016

For the qualitative data study, interviewees were selected using purposive sampling technique. Purposive sampling is used to select key personnel that can be representative for the whole population and believed to have necessary knowledge and experience on the topic area.

Interview was conducted with key personnel in senior and middle managerial positions in the IT department head office of the organizations. A total of ten key personnel were interviewed who are key personnel in senior and middle managerial positions in the IT department of organizations at head office. They have main role and decision makers in the IT department.

### **3.3 Data Collection Method**

Two methods of data collection were employed in this study: the questionnaire survey method and the interview method. The survey method was selected because it works best to collect large amounts of data from large populations and to investigate associations and variations of variables, and the interview is selected to gather an in-depth view of the observed data.

According to Kaplan & Duchon (1988), the advantage of using different data sources by different methods from different sources provides a wider range of coverage that may result in a fuller picture of the research problem. As a result, this study used questionnaires and interviews as methods of data collection for better results.

For a quantitative approach, Molla et al. (2011) questionnaire was adopted for data collection. This questionnaire is already tested and validated. The questionnaire has eight sections which are based on the constructs of Molla's G-readiness framework. The demographic information of the respondents was included. The questionnaire was handed to respondents by the researcher.

For a qualitative approach, a semi-structured interview was conducted to gain insight into the readiness of the organization to adopt Green Computing. Semi-structured interviews were conducted with key personnel in the IT department of Ethio Telecom and the Ministry of Communications and Information Technology. The aim of conducting the interview was to get an in-depth view of the subject under the study and to supplement the results found from the quantitative approach. The interview results were analyzed using open coding. The reliability of the interview was obtained by asking the participant to repeat the key points in the interview and checking the information from the next participant.

The interview questions conducted focus on the factors attitude, policy, practice, technology, and governance that indicate Green Computing readiness.

When the researcher presented the research question and objective to the respondent before asking the interview question, the level of their understanding was different on the concept of Green Computing. Some of them understood Green Computing just as designing a green data center, for

some it was just working on IT hardware disposal, for some of them it was just about power management. The researcher explained the concept of green IT in terms of IT hardware life cycle.

### **3.4 Data Collection Instruments**

Three instruments were used to collect the required data - survey questionnaire, interview guide, and document analysis.

#### **3.4.1 Survey Questionnaire**

Molla's G-readiness framework questionnaire was adopted with minor customization to meet the Ethiopian context. Molla's G-readiness framework is specifically designed to assess the preparedness or readiness of organizations to adopt Green Computing which exactly meets the objective of the study compared to other frameworks reviewed in the literature review part. Molla's G-readiness was developed based on understandings from existing literatures on e-readiness and Green IT issues (Molla & Licker (2005), Mitchell (2008), InfoTech (2008a), InfoTech 2007b). The researcher found Molla's G-readiness framework as the most relevant framework based on the objective of this study compared to the framework discussed in the literature review part of this study. The rationale behind using this framework are the following: 1) the author of Molla's G-readiness framework has published many studies in Green Computing area 2) most other Green Computing frameworks that exist in the literature are mostly relevant to Green Computing adoption but not for G-readiness framework. 3) The questionnaire used in this framework are already validated and tested. This will increase the validity of the research when compared with developing the questionnaire from scratch.

Therefore, based on the above mentioned points, the questionnaire used in Molla's G-readiness framework was used for quantitative data collection. According to this framework, the questionnaire consists of eight sections (see Appendix A).

**Section One:** is mainly concerned with finding out the concern or attitude of the organization towards Green Computing.

**Section Two:** is mainly concerned with assessing the policy readiness of the organizations in the area of IT sourcing, IT operations and services and IT end-of-life management.

IT sourcing: is the extent to which an organization has adopted an environmentally preferable policy or guidance for buying IT equipments and services.

IT operations and services: describe the power management, staff computer usage policy, and environmental policy.

IT end-of-life management: describes the extent to which the organizations has developed policy or guidance on disposal of IT equipments.

**Section Three:** is mainly concerned with assessing to what extent the organization implemented policy into action on the area of IT sourcing, IT operations and services and IT end-of-life management. According to (Molla, 2009, p16), addressing the following issues can indicate the readiness of an organization towards Green Computing practice.

- The extent of contracts awarded to suppliers that use green technology
- Auditing the power consumption of existing systems
- IT projects implemented to reduce power consumption requirements
- IT projects implemented to maximize power utilization (PC power management)
- The extent of enforcement of PC power management
- The energy rating of implemented technologies
- Actions taken to reduce ITs carbon footprint
- Projects implemented to monitor enterprise carbon footprint. The extent that equipment is recycled.

**Section Four:** is mainly concerned with green technologies adopted by the organizations. These include the following points as indicators to measure the G-readiness of an organization from technology dimension. “

- The extent to which an organization has a green business infrastructure and green power sources
- The development of Green IT standards across the enterprise
- Server consolidation and virtualization
- The extent that applications and technologies are retired for greener technologies
- The extent of solutions development to support enterprise wide green initiatives. “

**Section Five:** concerned on assessing the extent to which the organizations administered green IT initiatives. According to (Molla, 2009), the following points can measure the governance dimension of Green Computing readiness of an organization.”

- Clearly defined roles, responsibilities, accountability and control for Green IT initiatives
- Existence of standard administrative processes for developing Green IT initiatives
- Establishment of metrics for assessing the impact of Green IT initiatives
- Allocation of budgetary and other resources for Green IT
- The role of CIOs in enterprise wide green initiatives
- The responsibility of IT in electricity costs. “

**Section Six:** concerned on assessing the perception of the respondents on readiness of their organizations to Adopt Green IT.

**Section Seven:** concerned on assessing the factors that might prevent your organization from adopting green IT.

**Section Eight:** is about demographic information of the respondents

The modification was made on the adopted questionnaire after experts review. Questionnaire items that are too early to ask, relevant to advanced stage of green IT adoption and advanced in Ethiopia’s IT were removed. For examples items like “Our business has set CO2 targets to reduce our corporate carbon footprint, Prefers hardware vendors that offer end of IT life "take-back" options , Relocation of data center near clean source of energy , Green supply chain management policy “ were removed. Some of the items were re-phrased to make it clear for the respondents. .For example, “End of Life management policy” is rephrased to “IT Hardware End of Life management policy “.

### **3.4.2 Interview Guide**

Interview guide is commonly used for case study research (Yin, 2009). It gives an opportunity to get in-depth insights into the topic from key personnel experience and opinion (Creswell, 2007).

Interview data was gathered on the organization readiness on green IT Adoption in the dimension of attitude, practice, technology, policy and governance. The interview was used to get an in-depth view of the subject under the study and to support the result found from quantitative approach.

### **3.5 Data Analysis and Presentation**

Quantitative data was analyzed and presented using graphical representation, frequency distribution, and mean calculation. Correlations and regressions analyses were used to investigate how the variables are interrelated and how they impact one another. SPSS software was used to this end.

Qualitative data was analyzed by using open coding method. In this study the coding steps described in Creswell (2007) were followed.

In open coding process the first step is to record the interview text in a computer or by hand. The second step is reading through all the recorded note to get what the general idea of what the participant is saying; and, on the third step, detail analysis is done through the open coding process. Open coding is the process of breaking down, conceptualizing and categorizing full description of filed or interview notes.

### **3.6 Validity and Reliability of Research Instrument**

Validity and reliability are the attributes that measure quality of a research. They address issues regarding the quality of data and the appropriateness of method used.

#### **Reliability**

Reliability refers to the degree to which measures are without bias and ensure consistent measurement across time and variable items in the instruments (Sekaran&Bougie, 2010). According to Leedy&Ormrod (2010) reliability is defined as consistency with which a measuring instrument yields a certain result when the entity being measured has not changed. Crobranch alpha was used to measure the reliability and consistency of dependent and independent variables (Cronbach, 1951). According to Wiley S. (2003) the weakest value of alpha is less than 0.6. Alpha values more than 0.7 is acceptable. Thus, in this study Crobranch's Alpha was computed to assess the internal consistency of the items in the questionnaire.

## **Validity**

The two types of validity measure used in this research are content and construct validity (Kerlinger & Lee, 2000). Content validity concerned with the degree to which the scale items represent the domain of the concept under the study. Though the instrument used is already validated, in this research it is pre-tested by five IT professionals working in different organizations to validate the content to measure whether each item under the constructs would accurately measure the given construct. Based on the experts' feedback the instrument was modified. Construct validity is concerned with the extent to which an instrument may be said to measure a theoretical construct.

## **CHAPTER FOUR: Data Presentation, Analysis and Discussion**

The previous chapter elaborated research methodology that was used in this study. In this chapter data gathered from different sources are analyzed, presented and interpreted based on the specific objective of the research. As outlined in the first chapter, the main objective of this study is to assess g-readiness of government organizations to adopt Green Computing. Thus, two government organizations, the Ministry of Communication and information technology and Ethio Telecom, were selected for the case study. These two organizations have critical role in the development of information technology in government and private organizations.

To assess the g-readiness, Molla's G-readiness framework was adopted to study the dimensions of G-readiness. The data was obtained from different sources through open ended questionnaire and semi- structured interview. The analysis and discussion of data will be carried out in two parts. First quantitative analysis will be discussed based on the data gathered from the questionnaire and secondly qualitative analysis will be discussed based on data collected through interview. Finally discussion of the findings is summarized and based on the research findings recommendation is suggested.

### **4.1 Reliability and Validity Test**

Validity and reliability are the attributes that measure quality of a research. They address issues regarding the quality of data and the appropriateness of method used.

#### **Reliability**

A reliability test helps to ensure that measures are free from error and therefore yield consistent results. According to Leedy & Ormrod (2010) reliability is defined as consistency with which a measuring instrument yields a certain result when the entity being measured has not changed.

Cronbach's coefficient alpha is the most common index of reliability (Cortina, 1993). According to Sekaran (2003) the weakest value of alpha is less than 0.6. Alpha values more than 0.7 is acceptable. To investigate reliability of this study, cronbach's coefficient alpha was computed using SPSS 20. The overall score of alpha value for the questionnaire is 0.886 (Table 4.1) which is greater than 0.7. Therefore the reliability of the questionnaire is at acceptable level.

**Table 4.1 Reliability test for all variables**

Cronbach's Alpha	N of Items
.886	59

Source: Own survey, 2016

### **Reliability Test for Individual Variables**

The reliability measure was conducted for each variable as indicated in Table 4.2. The alpha values for each variable indicate that the survey is internally consistent for each variable.

**Table 4.2 Reliability test for individual variables**

Variable	No. Of Items	Cronbach's Alpha
Attitude	11	.787
Policy	9	.941
Practice	12	.903
Technology	9	.832
Governance	8	.920
Readiness	3	.730
Challenge	7	.793

Source: Own survey, 2016

### **Validity**

Validity refers to the ability of an instrument to measure what it is intended to measure (Kerlinger & Lee, 2000). The two types of validity measures used in this research are content and construct validity. Content validity assesses how well the survey instrument items address the problem being investigated. In order to assess the content validity of this research, five IT professionals working in governmental, non-governmental and higher education evaluated the questionnaire items. They have experience on Green Computing practice in different ways. They suggested removing some of the items that do not work in the context of Ethiopia and re-phrased some items to make them clear for the respondents. Based on the experts' feedback the instrument was modified.

Construct validity implies that the empirical evidence generated by a measure is consistent with the theoretical logic of the concepts. In order to test construct validity convergent and discriminant validity were conducted base on correlation matrix.

## **4.2 Description of Collected Data**

To maximize the response rate of the survey a total of 190 paper based questionnaires were distributed to the participants in the selected organizations for the calculated 158 sample size. The entire questionnaire was paper based and delivered by hand by the researcher. This created opportunity for the researcher to provide a brief introduction to the respondents about the objective of the research and to explain how the output will contribute on the adoption of Green IT in particular to their respective organization and in general to the Green development goal of the country. All the respondents were IT professionals working at the head quarter of the IT office of the selected organizations. Of the 190 questionnaire distributed, 125 questionnaire were distributed to Ethio telecom staff to get better response for the calculated 103 sample size. A total of 110 (88% response rate) were returned. However 6 responses were incomplete and so discarded from the analysis. So, a total of 104 responses were used for data analyses that represent Ethio Telecom IT staff. Of the total distributed 190 questionnaire, 65 questionnaires were distributed to Ministry of Communication and Information Technology IT staff. 56 questionnaire were collected which indicate 86% response rate. However 5 questionnaires were incomplete and therefore discarded. Therefore a total of 51 questionnaires were used for MCIT. Interview was conducted with key personnel in senior and middle managerial positions in the head office of IT department of the organizations. A total of 10 staff were interviewed for this study.

### **4.2.1 Demographic Characteristics of Respondents**

In this section the demographic profile of respondents gathered from the survey questionnaire will be presented in frequency and percentage of the sample (Table 4.3).

**Table 4.3 Demographic Characteristics of respondents**

<b>Gender</b>	<b>Frequency</b>	<b>Percentage</b>
Female	32	20.6
Male	123	79.4
Total	155	100.0
<b>Educational Level</b>		
Bachelors	123	79.4
Diploma	1	0.6
Masters	31	20.0
Total	155	100.0
<b>Years of Work Experience</b>		
<5	24	15.5
5-10	89	57.4
11-15	32	20.6
>15	10	6.5
Total	155	100
<b>Organization</b>		
Ethio Telecom	104	67.1
MCIT	51	32.9
Total	155	100.0

Source: Own survey, 2016

#### **4.2.2 Descriptive Analysis of G-Readiness Constructs**

In this study the assessment of G-readiness is based on Molla's G-readiness framework which consists of five readiness dimensions – attitude, policy, practice, technology and governance. G-readiness is organizational capability to adopt green IT. In the next section, descriptive analysis of g-readiness constructs will be presented.

##### **4.2.2.1 Attitude towards Green Computing**

The first objective of this study was to assess the attitude of the organizations towards Green Computing. Attitude is one of the major factors on the acceptance and use of technology which is followed by commitment and action. In that regard, respondents were asked to assess their organizations attitude towards Green Computing.

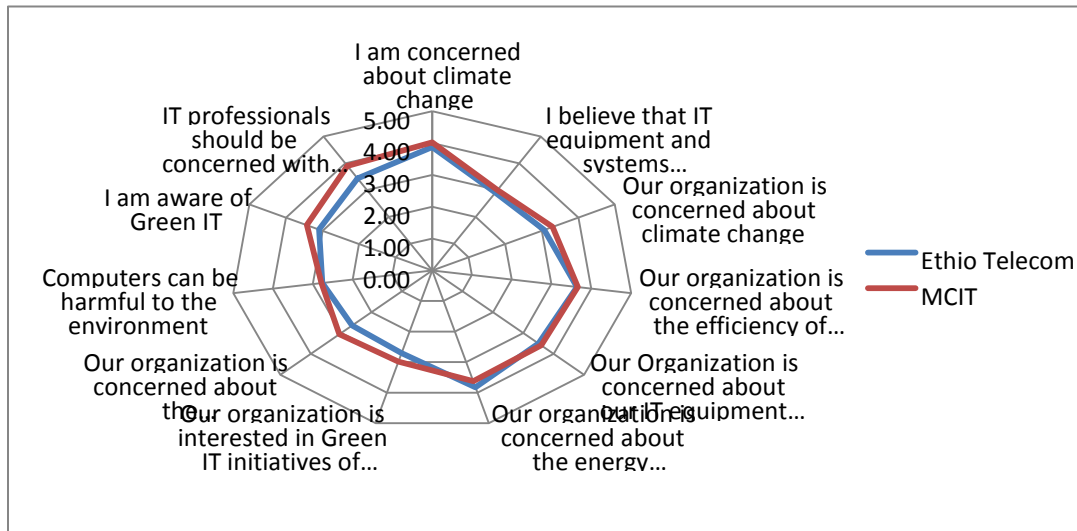
The study revealed that the majority of the respondents (73%) are concerned about the climate change. 80% of the respondents agree that their organization is concerned about the climate change. 60% responded that they are aware of green IT. On the other hand, more than half of the respondents do not believe the impact of IT on the environment. About 69% disagree to the survey item computers can be harm-full to the environment. The result indicated that Green Computing awareness training is required to educate the IT staff. The training will help to clearly understand Green Computing and helps them to be aware and concerned about the impact of IT on the environment. The attitude construct is summarized in the Table 4.4.

**Table 4.4 G-readiness Attitude Construct Frequency and Percentage**

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I am concerned about climate change	5(3.2)	12(7.7)	25(16.1)	61(39.4)	52(33.54)
I believe that IT equipment and systems contribute to greenhouse gas emissions	35(22.58)	26(16.77)	26(16.77)	50(32.25)	18(11.6)
Our organization is concerned about climate change	9(5.80)	12(7.74)	91(58.70)	34(21.93)	9(5.80)
Our organization is concerned about the efficiency of powering our IT infrastructure (Storage Servers, network )	4(2.58)	9(5.80)	42(27.09)	82(52.90)	18(11.61)
Our Organization is concerned about our IT equipment energy consumption	4(2.58)	13(8.38)	51(32.90)	71(45.80)	16(10.32)
Our organization is concerned about the energy consumption of cooling and lighting our data centers	6(3.87)	10(6.45)	25(16.12)	88(56.77)	26
Our organization is interested in Green IT initiatives of our IT suppliers	16(10.32)	57(36.77)	38(24.51)	31(20)	13(8.38)
Our organization is concerned about the environmental impact of discarding IT at the end of its life	12(7.74)	50(32.25)	60(38.70)	27(17.41)	6(3.87)
Computers can be harmful to the environment	39(25.16)	30(19.35)	25(16.12)	50(32.25)	11(7.09)
I am aware of Green IT	20(12.90)	34(21.93)	20(12.90)	56(36.12)	25(16.12)
IT professionals should be concerned with controlling the power consumption of IT equipment	29(18.70)	9(5.80)	8(5.16)	60(38.70)	49(31.61)

Source: Own survey, 2016

Figure 4.1 illustrates the overall result (mean of each item) of organizations attitude towards Green Computing. The result indicates that the g-readiness attitude construct is similar in the two organizations.



**Fig 4.1 Level of G-readiness Attitude Construct in the two organizations (Source: Own survey, 2016)**

#### 4.2.2.2 Green IT Readiness Policy

The second objective of this study is to assess organizational policy in the area of IT sourcing, IT operations and IT end-of-life management to adopt Green Computing. Policy readiness measures the extent to which green and sustainability information technology policies are developed throughout the selected organizations. It is one of g-readiness dimension to assess an organization’s g-readiness to adopt Green Computing. The items under this construct measures if the organizations put in place policy or guidance in IT purchasing, IT usage and operation and IT end of life management. Therefore, respondents were asked to assess the policy readiness of their organization to adopt Green Computing.

The result indicated that although there are some initiation on developing green data center and efficient disposal of e-waste, the overall score of the items under this construct show that there is no indication of policy developed or implemented in place to give environmental consideration of information technology in IT sourcing, usage and disposal. The majority (more than 60%) responded that there is no policy at all on IT purchasing, on the usage of IT in an energy efficient manner and IT hardware disposal policy. Hence, organization should focus on the development of

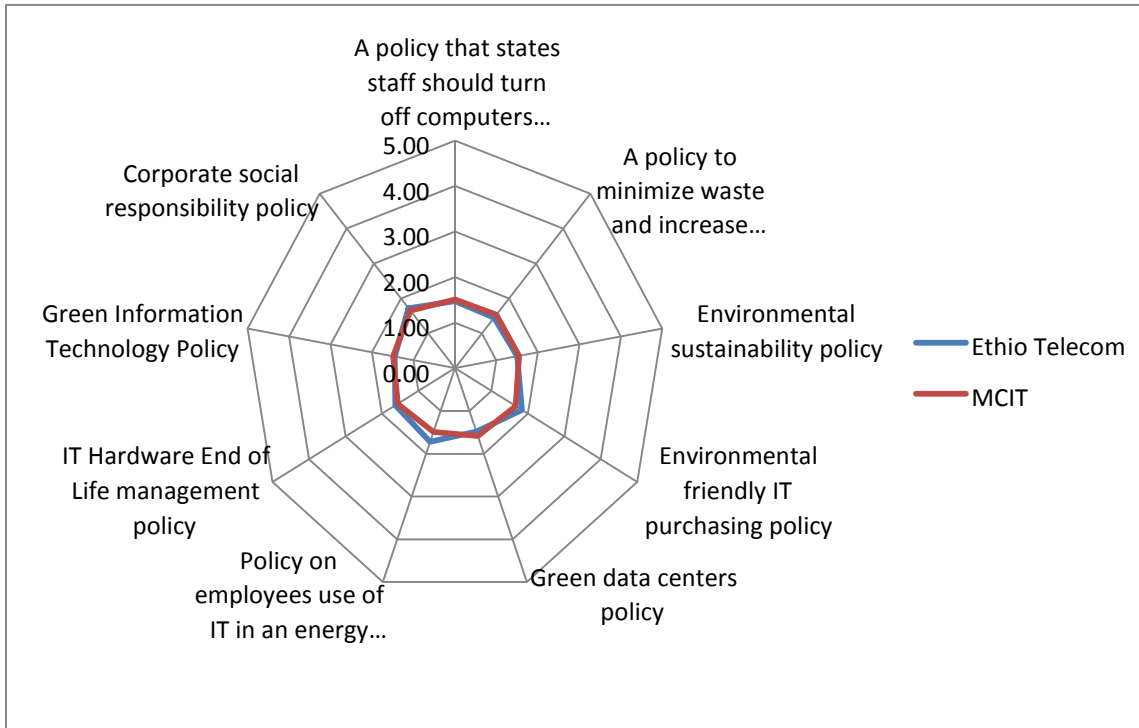
IT policies on ICT usage for minimal or no impact on the environment. The policy should be based on the IT equipment life cycle which is sourcing, usage and disposal (Table 4.5).

**Table 4.5 G-Readiness Policy Construct Frequency and Percentage**

<b>Items</b>	<b>Not at all</b>	<b>Small extent</b>	<b>Moderate extent</b>	<b>Great extent</b>	<b>Very great extent</b>
A policy that states staff should turn off computers when they are not in use	112 (72.3)	24(15.5)	9(5.8)	7(4.5)	3(1.9)
A policy to minimize waste and increase recycling policy	111(71.6)	24(15.4)	11(7.09)	9(5.8)	0
Environmental sustainability policy	109(70.3)	19(12.3)	21(13.5)	5(3.2)	1
Environmental friendly IT purchasing policy	95(61.3)	17(11.0)	30(19.4)	8(5.2)	5(3.2)
Green data centers policy	110(71.0)	23(14.8)	13(8.4)	5(3.2)	4(2.6)
Policy on employees use of IT in an energy efficient manner	101(65.2)	14(9.0)	34(21.9)	6(3.9)	
IT Hardware End of Life management policy	100(64.5)	25(16.1)	21(13.5)	8(5.2)	1(0.6)
Green Information Technology Policy	114(73.5)	17(11.0)	17(11.0)	7(4.5)	0
Corporate social responsibility policy	94(60.6)	29(18.7)	19(12.3)	11(7.1)	2(1.3)

Source: Own survey, 2016

Figure 4.2 illustrates the overall result (mean of each item) of organizations policy on purchasing, on the usage of IT in an energy efficient manner and IT hardware disposal at the end of hardware life time. The result indicates the g-readiness policy construct is very low for both organizations. That means there is no policy in place to handle the usage of IT in environmental friendly way.



**Fig 4.2 Level of G-readiness Policy Construct in the two Organizations (Source: Own survey, 2016)**

### 4.2.2.3 G-readiness Practice

In chapter one it was pointed out that to understand the g-readiness of the organizations, one of the objectives was to assess the current readiness in IT purchasing, IT usage and disposal. G-readiness practice refers to the extent to which an organization translated Green ICT concerns into practices.

In this section, the findings are presented under the main area of green ICT practice assessment. These include IT sourcing, IT operations and services and IT end of life management.

## IT sourcing

IT sourcing is one of the g-readiness practices area that need to be considered. The respondents were asked to assess whether their organization considers the environment in IT procurement, whether it preferences of IT suppliers green track record.

Accordingly, the majority of the respondents (65%) rate their organization to less extent on considering the environment during IT procurement. Similarly, about 68% of the respondents rate their organization to small extent and not at all on preference of IT suppliers that have a green track record. Hence, the organizations should give due attention on procurement of IT hardware as this will impact the usage and disposal of IT hardware (Table 4.6, Table 4.7, Table 4.8).

**Table 4.6 G-Readiness Practice – IT Sourcing (Frequency and Percentage)**

Items	Not at all	Small extent	Moderate extent	Great extent	Very great extent
Gives weight to environmental considerations in IT procurement	61(39.4)	40(25.8)	26(16.8)	24(15.5)	4(2.6)
Preference of IT suppliers that have a green track record	82(52.9)	26(16.8)	24(15.5)	21(13.5)	2(1.3)

Source: Own survey, 2016

## IT Operations and Services

**Table 4.7 Readiness Practice - IT Operations and services (Frequency and Percentage)**

Items	Not at all	Small extent	Moderate extent	Great extent	Very great extent
Print on both sides of the paper (duplex printing) if necessary	66(42.6)	34(21.9)	30(19.4)	17(11.0)	8(5.2)
Turn off all peripherals devices (printer, scanner, projector, etc.) when not in use for a long time	48(31.0)	54(38.8)	25(16.1)	15(9.7)	13(8.4)
Shortens IT equipment refresh periods to gain access to more energy efficient equipment	55(35.5)	50(32.3)	36(23.2)	10(6.5)	4(2.6)
Considers environmental factors in the design of the site infrastructure (and network) of data centers servers ,storage	53(34.2)	26(16.8)	48(31.0)	26(16.8)	2(1.3)
Audits the power efficiency of existing IT system and technologies	88(56.8)	16(10.3)	37(23.9)	13(8.4)	1(0.6)
Switches off data center lights and equipment when not needed	91(58.7)	20(12.9)	26(16.8)	17(11.0)	1(0.6)
Enforces PC power management	81(52.3)	28(18.1)	31(20.0)	15(9.7)	0
Analyzes energy bill separately from the overall corporate bill	111(71.6)	14(9.0)	22(14.2)	5(3.2)	3(1.9)

Source: Own survey, 2016

## IT end of life management

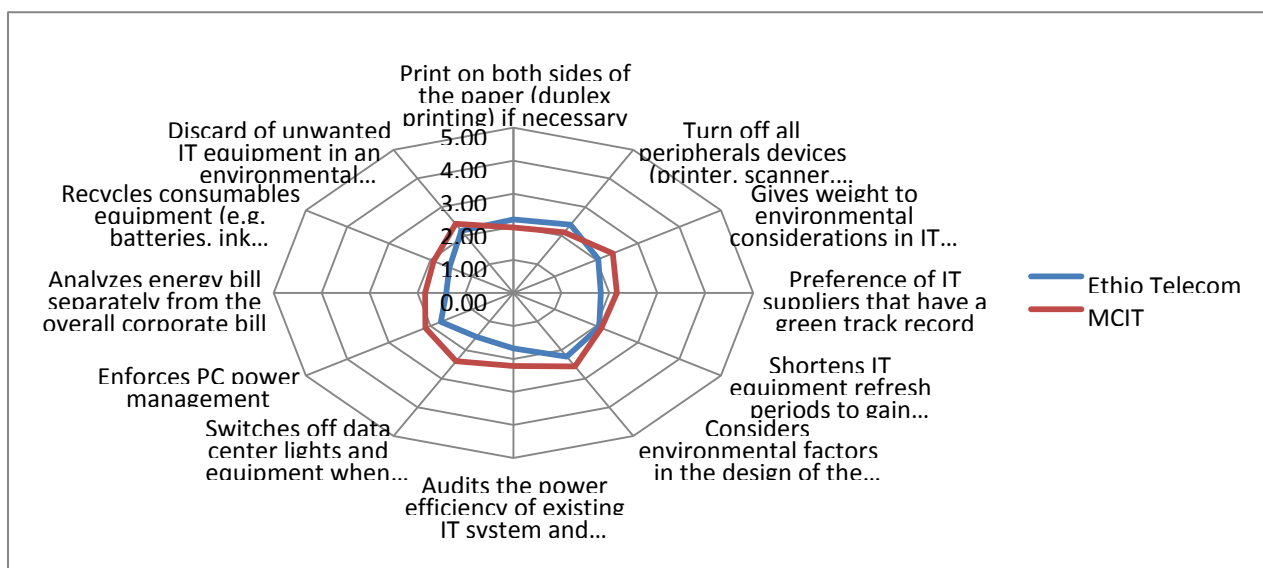
**Table 4.8 G-Readiness Practice – IT End Of Life Management (Frequency and Percentage)**

Items	Not at all	Small extent	Moderate extent	Great extent	Very great extent
Recycles consumables equipment (e.g. batteries, ink cartridges, and paper )	100(64.5)	25(16.1)	13(8.4)	16(10.3)	1(0.6)
Discard of unwanted IT equipment in an environmental friendly way	63(40.6)	27(17.4)	39(25.2)	15(9.7)	11(7.1)

Source: Own survey, 2016

Figure 4.3 illustrates the overall result (mean of each item) of organizations current practice in main area of g-readiness practices. The result indicates the g-readiness is practice less. The majority (more than 60%) responded that there is no G-readiness practice at all or the practice is in small extent.

The overall result shows that green IT practice in the organization is very low. Even the simpler practices that don't need additional cost are not practiced in the organization. According to the survey result about more than 60% of the respondents rated the green IT practice as not at all practiced and practice to small extent. This indicates green IT training and awareness need to be conducted for the IT staff so that they can start practicing Green Computing from the simpler one like printing on both side, switch off computers when they are not in use for longer time.



**Fig 4.3 Level of G-readiness Practice Construct in the two Organizations (Source: Own survey, 2016)**

#### 4.2.2.4 Green IT Adopted by the Organizations

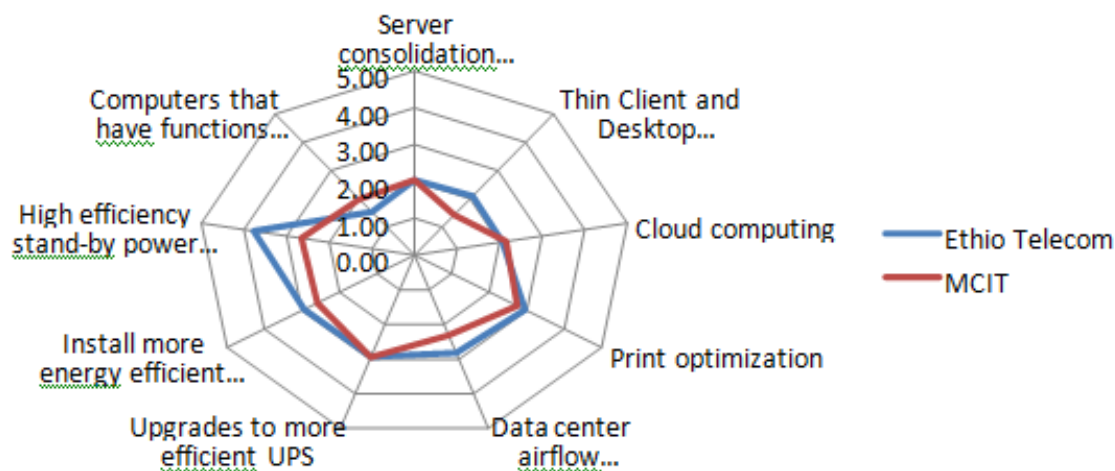
One of the objectives of this study was to assess the green IT adopted by the organization which is one of the indicator of the organizations green IT readiness. Green ICT technology refers to technologies for reducing energy consumption of data center, IT assists, cooling systems and optimizing energy usage and using IT to reduce organizational environmental foot print. Green ICT technology readiness can be measured by assessing the extent to which an organization has green business infrastructure and green power sources, development of green ICT standards across the enterprise, server consolidation and virtualization, extent that application and technologies are retired for greener technologies and extent of solutions development to support enterprise wide green initiatives. The survey result found out that the adoption of green IT technologies is very low (Table 4.9).

**Table 4.9 G-Readiness Technology Construct Frequency and Percentage**

Items	Not at all	Small extent	Moderate extent	Great extent	Great extent
Server consolidation and virtualization	76(49.0)	33(21.3)	21(13.5)	21(13.5)	4(2.6)
Thin Client and Desktop Virtualization	63(40.6)	44(28.4)	34(21.9)	10(6.5)	4(2.6)
Cloud computing	90(58.1)	25(16.1)	18(11.6)	13(8.4)	9(5.8)
Print optimization	29(18.7)	26(16.8)	41(26.5)	52(33.5)	7(4.5)
Data center airflow management	56(36.1)	15(9.7)	36(23.2)	23(14.8)	25(16.1)
Upgrades to more efficient UPS	47(30.3)	14(9.0)	27(17.4)	37(23.9)	30(19.4)
Install more energy efficient lights	48(31.0)	23(14.8)	28(18.1)	20(12.9)	36(23.2)
High efficiency stand-by power system	26(16.8)	14(9.0)	36(23.2)	30(19.4)	49(31.6)
Computers that have functions to monitors workloads and to shut down components when unused	99(63.9)	25(16.1)	14(9.0)	16(10.3)	1(0.6)

Source: Own survey, 2016

Figure 4.4 illustrates the overall result (mean of each item) of the organizations information technology readiness to adopt Green Computing. The results show that most of the technologies listed in the survey are adopted is small extent or not at all.



**Fig 4.4 Level of G-readiness Technology construct in the two Organizations (Source: Own survey, 2016)**

#### 4.2.2.5 Governance on Green IT Initiatives in the Organization

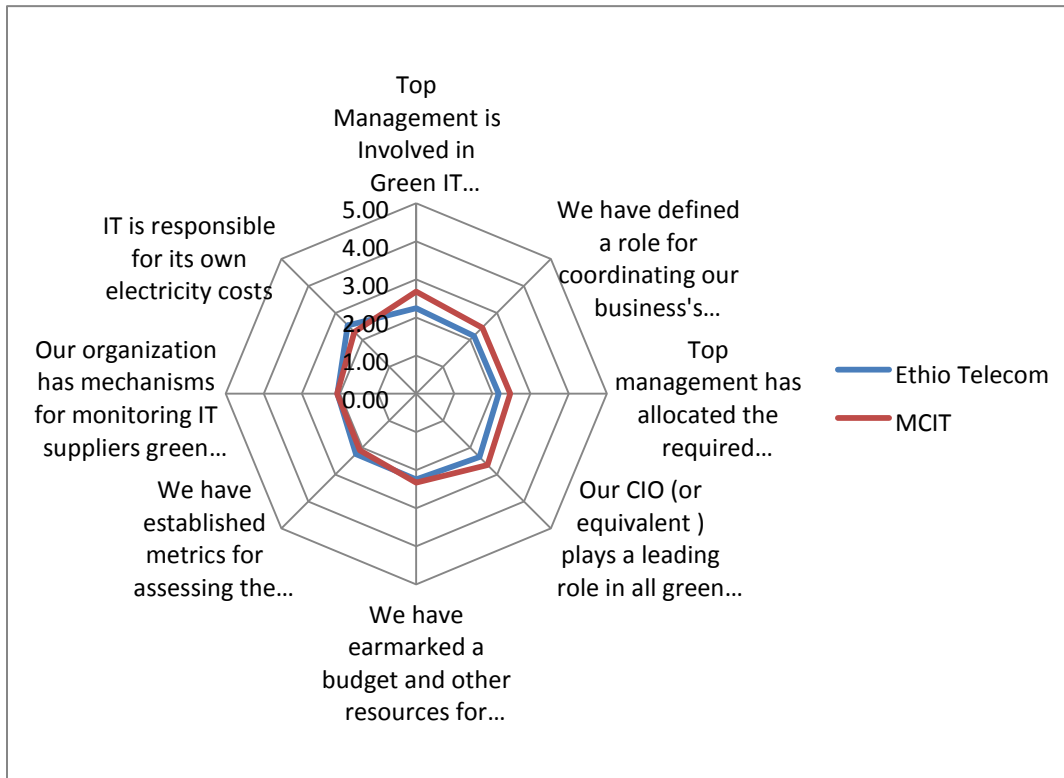
On the survey respondents were asked to assess the Green IT governance of their organizations. Green ICT Governance deals with how the organizations administer green IT initiatives. According to the survey result the majority responded that top management involvement in green IT initiatives is very low (58% responded disagree).

**Table 4.10 G-Readiness Governance Construct Frequency and Percentage**

Items	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
Top management is involved in Green IT initiative	26(16.77)	65(41.9)	43(27.7)	19(12.3)	2(1.3)
We have defined a role for coordinating our business's green initiatives	37(23.87)	64(41.3)	36(23.2)	15(9.7)	3(1.9)
Top management has allocated the required resources to adopt Green IT	55(35.5)	35(22.6)	40(25.6)	19(12.3)	6(3.9)
Our CIO (or equivalent ) plays a leading role in all green (IT and non-IT ) initiatives	23(14.8)	70(45.2)	41(26.5)	12(7.7)	9(5.8)
We have earmarked a budget and other resources for Green IT	46(29.7)	48(31.0)	39(25.2)	16(10.3)	6(3.9)
We have established metrics for assessing the impact of Green IT initiatives	44(28.4)	63(40.6)	27(17.4)	16(10.3)	5(3.2)
Our organization has mechanisms for monitoring IT suppliers green performance	70(45.2)	34(21.9)	26(16.8)	20(12.9)	5(3.2)
IT is responsible for its own electricity costs	43(27.7)	27(17.4)	60(38.7)	21(13.5)	4(2.6)

Source: Own survey, 2016

Figure 4.5 illustrates the overall result (mean of each item) of the organizations g-readiness governance construct. The results show result the majority responded that top management involvement in green IT initiatives is very low.

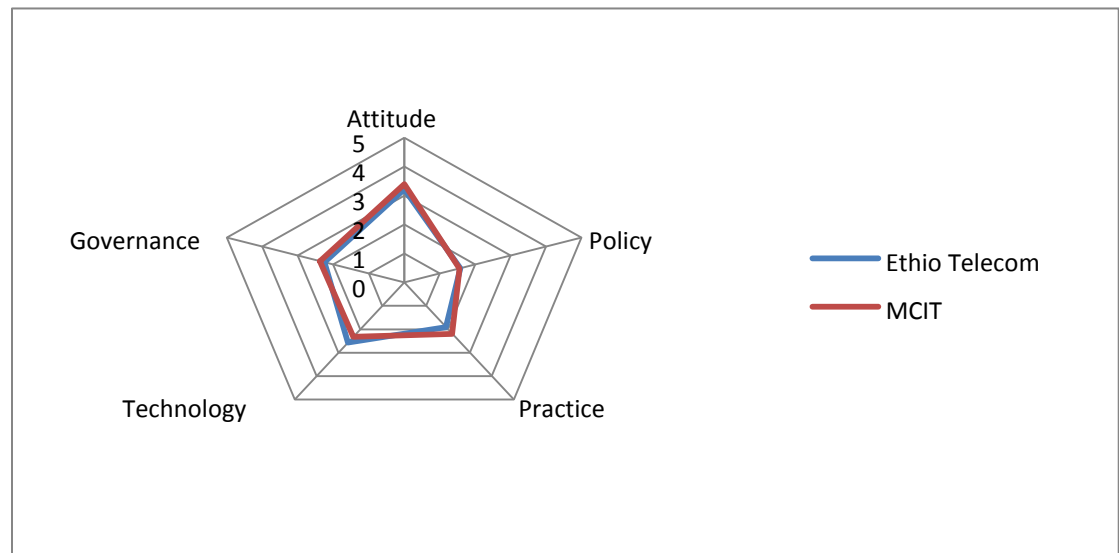


**Fig 4.5 Level of G-readiness Governance Construct in the two Organizations (Source: Own survey, 2016)**

#### 4.2.2.6 Overall G-readiness Level of the Two Organizations

In the above sections, the detail of the survey result of each g-readiness constructs was presented and discussed at construct items level. In this section the overall g-readiness level of the organizations is done by calculating the average score of each construct and the overall analysis of qualitative analysis will be presented to support the qualitative data. Figure 4.6 illustrates that the overall result of the g-readiness constructs within the two organizations. With five dimensions and five point Likert scale the maximum score is 25. In this study the overall average score is 11.53 for Ethio Telecom and 11.85 for MCIT. The average scores of both organizations are lower than the average and the two organizations share similar level of g-readiness. As illustrated in Fig

4.6, the highest averaged score is 3.4 for attitude. Policy, practice, technology and governance scored below average. From this the policy construct has list value which is 1.56. The result shows that g-readiness level is low in all dimensions in the two organizations.



**Fig 4.6 Mean of Mean value for each Construct (Source: Own survey, 2016)**

The interview data was used and analyzed to get an in-depth view of the subject under the study and to support the result found from quantitative approach. The findings result is presented below.

The findings show that there are some green IT initiatives that don't consider the life cycle of IT equipment. The detail of the interview analysis is presented below. In order to understand their organization attitude towards environmental sound IT practices, most of the respondents answered that their organization has positive attitude on making IT services environmental friendly. They stated the initiation towards designing green data center, IT hardware disposal and power management.

One of the interviewee replied:

*“we have been working on a project to design green data center. We started this project before 4 years however it is delayed due to different reason. We have done requirement design and risk assessment.”*

When asked by the researcher to elaborate more on this if it is government initiative, the respondent said the organization started by its own. There is no force from the government side. As per the information from the respondent, the aim of green data center project is to be a model for its own and other organization in Ethiopia. At the time of this interview the green data center design project is ready for bid.

Similarly, one of the respondents replied as

*“Our organization has been working towards designing green data center in the IT Park. We already started the project”.*

From the visit of IT park the researcher observed that the ministry have been working towards designing standard data center for the country. Developing Green Computing policy is very important to use it as guidance in every green IT projects.

Regarding the current practice of IT disposal one of the interviewee responded:

*“In order to address a growing e-waste problem, the Ministry of Finance and Economic Development has written a circular to all Federal Minister to handover stored end of life IT hardware to MCIT. As a result the ministry established DE manufacturing center in Akaki area for proper disposal of e-waste.”*

The respondent added that the fast growing of E-waste in the country is challenging the center to provide the service on time for all government organizations.

This issue is confirmed by other respondent and the researcher observed large number of e-waste disposal request letters from different federal organizations. Currently the e-waste disposal initiation is not included private sector.

Overall it is understandable that challenge on managing the e-waste product will negatively affect the adoption of Green Computing. To decrease the fast growing of e-waste the approach should be started from the IT hardware life cycle. That means from design, manufacturing, use and disposal. There should be a control on IT equipment age that are imported to the country. As per from information from literature developed countries are sending their used IT equipment to developing countries (Ramessur et al., 2014). They asked if there is a way to control the service year on IT

hardware entering to the country. The respondent answered that main concern to control imported IT equipment is security wise.

One of the interviewee replied:

*“We focus on type approval. We inspect electronic items security wise. We don’t consider the age of the item.”*

We can see that giving not much attention to the age of the IT equipment imported to the country can be one the major factors that contribute to e-waste growth in the county.

They were also asked if there is any initiative to control the power consumption. One of the interviewee replied:

*“Our organization main concern today is designing standard data center that we believe will improve the power usage of IT resources”.*

Similarly, another interviewee from the other organization stated the importance of designing standard green data center to reduce power consumption.

They were also asked if there are any initiatives or trainings provided to end user to reduce the power consumption. One of the interviewee replied:

*“User training is very important for improvement of IT usage. So far we didn’t provide training on this. However, we need to consider in the future training on proper use of IT equipments including shutting down computer while not in use”.*

Other interviewees also answered that the user may practices this by themselves however there is no formal communication to the users from IT department to practice efficient use of IT like shutdown computers when not in use. However it is essential to train end users to shut down the computer while not in use, to print only if necessary and, to use duplex printing.

IT power bill is not managed by IT department in both organizations. Regarding the questions asked if any green technology is implemented, virtual servers and thin clients are implemented in small extent.

To conclude from qualitative finding from the interview data, the key personnel have positive attitude on Green Computing adoption. There are some initiatives like preparation of Green Data center design, thin client implementation is small extent, virtual server implementation at Ethio telecom and de manufacturing center in Akaki to manage E-waste disposal. However there is no strategy or policy in place to approach on the use of IT on environmentally sound way. The organizations do not follow the life cycle approach. This will negatively impact the adoption of green IT.

Therefore, it is recommended to start the green IT initiatives from very simple practices like shutting down IT equipment when not in use for more than specific time, giving due attention on IT procurement, print optimizations. These practices do not need additional cost. They can be implemented with current available resources.

Overall descriptive analysis results show that organization attitude is better when compare to other g-readiness constructs.

### **4.2.3 Green IT Adoption Challenges**

The respondents were requested on the challenges that might prevent their organization from adopting green IT. Figure 4.7 shows the survey result.

The rank of the items shows that inadequate skill or less awareness on Green Computing. The items are ranked according to their summation percentage on the score of agree and strongly agree. Accordingly, cost of green IT solution ranked first. This result shows that the respondents have inadequate skill and less awareness on Green Computing practice. The cost of green IT shouldn't be the main challenge because simple Green Computing practices such as shutting down computers while not in use, double printing or printing only if necessary, switching off data center lights and equipment when not needed can be implemented by the current ICT resource of the organizations. Cost of Green IT solutions (92%), No budget is allocated (88%), Lack of government incentive (83%), Lack of top management support (59%), Organizational resistance to change (47%), No enforcement (49%), inadequate skill (44%). There are some Green IT practices that can be implemented with the current resources without additional cost (Table 4.11).

**Table 4.11 Factors that might prevent Organization from Adopting Green IT**

	Cost of Green IT solutions	No budget is allocated for Green IT	Inadequate skill or training in Green IT area	Organizational resistance to change	No enforcement by the Government	Lack of Government incentives for Green IT implementation	Lack of Government incentives for Green IT implementation
Strongly Agree	62.7	52.9	29	31	11.8	51	7.8
Agree	29.4	35.3	15	16	33.3	32	51
Neutral	3.9	7.8	4	2	33.3	15	17.6
Disagree	0	0	0	0	11.8	2	21.6
Strongly Disagree	3.9	3.9	3	2	9.8	2	2

### 4.3 Multiple Regression

Regression analysis is a mathematical measure of the average relationship between two or more variables in terms of the original units of the data. Regression clearly indicates the cause and effect relationship between the variables. In regression, the variable corresponding to cause is taken as independent variable and the variable corresponding to effect is taken as dependent variable (Rawlings et al., 2001). In this study the dependent variable is G-readiness and independent variables are Attitude, Policy, Practice, Technology and governance. Table 4.13 shows the overall relationship between the variables.

Before presenting the regression models, one should check multicollinearity. Multicollinearity is occurred when the independent variables are highly correlated. This can be checked by the VIF (Variance inflation factor) in the regression analysis. The value of VIF above 10 indicates the presence of multicollinearity. In this study the VIF values is examined for all the variables and the value is below the acceptable threshold 10 (Table 4.12). This shows that there are no variables that have excessive correlations between them.

**Table 4.12 Model Summaries – Multiple Regressions**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.800 <sup>a</sup>	.640	.628	.568
a. Predictors: (Constant), Attitude, Policy , Practice, Technology, Governance				

**Source: Own survey, 2016**

The Table 4.13 above shows that the correlation coefficient,  $R=0.800$ , means that there is a positive correlation between the dependent variable (G-readiness) and the independent variables (Attitude, Policy, Practice, Technology, Governance). A higher value of R Square approaching 1 indicates a better model (Pallant, 2001). In this study the calculated value of R Square is 0.640 which indicates that 64% the variance in the dependent variable is explained by the five independent variables. 36% of the dependent variable left unexplained. That means there are other additional factors that determine the g-readiness level of an organization. The ANOVA table (Table 4.13) helps to assess the statistical significance of the result. In this study the statistical value (Sig =.000) shows the model is significant.

**Table 4.13 ANOVA**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	85.473	5	17.095	53.024	.000 <sup>b</sup>
	Residual	48.037	149	.322		
	Total	133.510	154			

- a. Dependent Variable: Readiness To Adopt Green IT
- b. Predictors: (Constant), Attitude, Policy , Practice, Technology, Governance

In the coefficients table (Table 4.14), the standardized coefficients (beta) value indicates how much each independent variable contributes to the change in the dependent variable (Pallant, 2001). If the beta value is less than 0.05 it indicates that the independent variable doesn't make significant contribution to the dependent variable. In Table 4.14, the largest beta coefficient is -.743 which is for governance variable. This means that the governance variable makes strongest unique contribution to explaining the dependent variable g-readiness level. The beta value for technology variable shows the lowest, indicating that it made the least contribution. The significance value of

policy and governance is .000 which indicates these two variables made a unique and statistically significant contribution to the prediction of g-readiness level.

**Table 4.14 Coefficients**

Model	Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
(Constant)	3.284	.046		72.004	.000					
Policy	-.288	.049	-.310	-5.841	.000	-.186	-.432	-.287	.858	1.165
Governance	-.692	.048	-.743	-14.343	.000	-.731	-.762	-.705	.900	1.111
Attitude	.082	.052	.088	1.586	.115	.189	.129	.078	.784	1.275
Technology	-.074	.047	-.079	-1.563	.120	-.089	-.127	-.077	.944	1.059
Practice	.075	.046	.081	1.626	.106	.192	.132	.080	.973	1.028

a. Dependent Variable: Readiness to adopt Green IT

#### 4.4 Discussion of the Result

According to the description analysis result of g-readiness constructs, overall g-readiness of the two organizations is very low. As illustrated in Fig 4.6, attitude g-readiness construct scored higher than the others. Policy, practice, technology and governance g-readiness constructs scored below average. From this the policy construct scored the least value. The findings from qualitative data analysis also supported the quantitative data analysis result.

The findings of qualitative analysis show that the organizations have started on adoption of green IT and positive attitude towards the impact ICT on the environment.

Higher level IT professionals in the organizations have better understanding than lower level experts on green IT.

However, the organizations approach to green IT is not based on the equipment life cycle. They mainly focused on the designing of green data center. And also the ministry established de-manufacturing center to manage e-waste. However, the ministry started the e-waste management not as part of Green Computing initiative. The de-manufacturing center is established to solve the electronic waste disposal issue within government organizations. This can be taken as good

initiative towards adoption of green IT. However, Green IT is not only about designing green data center or managing e-waste. Green IT practice should include all the life cycle of hardware from designing, manufacture use and disposal. It includes how we procure, use and dispose IT equipment.

The model summary of the regression analysis shows that there is a positive correlation between the dependent and independent variables. The result shows that 64% the variance in the dependent variable is explained by the five independents variable. The result leaves 36% unexplained.

The overall result shows that g-readiness level is low in all dimensions in the two organizations which lead to answer the question what approach should the organization follow to improve the current level of G-readiness. The result of this research supports the findings of other research done in developing countries. The study by Wabwoba et.al. (2012) indicated that green readiness level in developing economies is lower than that of developed economies. The study compared the findings in developing countries (Kenya and Indonesia) with the finding of developed countries (Australia, USA, and New Zealand). Similarly this study also supports the study by Ramessur et al. (2014) on e-waste management. The study indicated how e-waste is increasing in developing country and recommended to work on green IT policy and strategy to achieve sustainable development.

## **CHAPTER FIVE: Conclusion and Recommendations**

### **5.1 Conclusion**

As outlined in Chapter one, the main objective of this research is to determine the level of g-readiness of government organizations. The study helps to systematically analyze the ability of the organizations to adopt green IT, to determine existing gaps and potential challenges. It helps to identify what is working well and what needs improvement. To better understand the g-readiness the researcher reviewed different literature and adopted the widely used Molla's g-readiness framework. Survey and interview data were used as source of data. This chapter outlines the main research findings and its academic contribution and practical implication. Finally, it highlights the limitation of the research, discusses and provides guidance or further studies.

The major findings of this research are summarized in the following paragraphs.

The majority of the respondents are concerned about the climate change. However their awareness on Green Computing is low. The higher officials in the IT departments have better understanding than lower level experts on green IT. According to the survey result the majority responded that top management involvement in green IT initiatives is very low (58% responded disagree). The findings show that there are some initiations on developing green data center and efficient disposal of e-waste. The overall score of the items under policy construct show that there is no indication of policy developed or implemented in place to give environmental consideration of information technology in IT sourcing, usage and disposal.

The overall green IT practices in the organization is very low and there is no significant difference between the two organizations. Even the simpler practices that don't need additional cost are not practiced in the organizations. The survey result found out that the adoption of green IT technologies is very low. There is limited usage of virtualization and thin client. Green data center project is ready for bid at Ethio telecom and Green Data center design in the IT Park by MCIT is at initial stage. Overall the two organizations share similar level of g-readiness. . The overall level of green IT practice is lower in the organization.

The challenges that might prevent from successful adoption of green IT were identified from this study. The challenges are cost of Green IT solutions; no budget is allocated for Green IT,

inadequate skill or training in Green IT area, organizational resistance to change, no enforcement by the Government, lack of Government incentives for Green IT implementation and lack of top management support.

## **5.2 Recommendations**

Based on the findings of this study the following points are recommended.

- **Green Policy Development**

Policies and strategies should be developed on IT procurement, IT use and disposal. The policy will make individuals and organizations responsible to consider the environment on procurement of IT equipment. By setting guidance on IT purchasing organizations can reduce the environmental impact of IT. The policy should also include how to control the penetration of used items to the country. It should also consider responsible IT disposal practices including reuse, refurbishing and recycling.

- **Training for IT Professional**

According to the findings of the study the awareness and knowledge of IT professionals on Green Computing is low. Therefore, it is recommended that conducting training on Green Computing is very important to increase the awareness and knowledge of IT professional. The training should focus on the impact of ICT on the environment, Green Computing technologies, how to optimize energy efficiency of data centers, power management, proper way of IT equipment procurement, usage, disposal and recycling. Once the IT staff gain better knowledge on Green Computing they will train their users for better result.

- **Implement Simple Green Computing Practices**

Green Computing practice implementation such as turn off equipment when not in use, duplex printing, use of network printers, and print only if necessary are recommended to improve the current level of g-readiness. These practices can be implemented with the current resources that help to reduce administration and hardware costs. In addition, it is also recommended to create a system that manages IT equipment energy bill separately.

- **Consider Green Computing Technologies**

In order to improve the current level of green information technologies usage, it is recommended to consider implementation of server consolidation and virtualization, thin client, data center optimization, power management software. These Green Computing technologies help to reduce administration and hardware costs in addition to reducing environmental impact of information technology.

- **Performance of Existing E-waste Management System**

It is recommended to assess the performance of the current e-waste management system and consider including private sectors in e-waste management for successful disposal of e-waste throughout the country. To properly manage e-waste, organizations should consider the life cycle of hardware from designing, manufacture, use and disposal. Also considering proper IT equipment procurement will positively impact e-waste management.

- **Top Management Support**

Top management support is most important and critical for a project success in any organization according to different studies. Therefore, to increase the current level of green IT readiness, organizations should consider including Green Computing agenda in top management meeting.

### **5.3 Study Limitations**

The measurement tool for the survey data were Likert scale. Even though Likert scale is the most universal method for survey data and easily understood, the distance between each choice is not known and not equal. This can affect the respondents answer. Improving the measurement tool will improve the quality of the research. The other limitation is it is difficult to generalize the g-readiness level of Ethiopia. Including other organizations may produce different result.

### **5.4 Suggestions for Future Research**

This study was conducted to assess the readiness of organizations to adopt green IT. The result of the research shows 64% of the variance in the dependent variable (g-readiness level) is explained by the five independent variables (attitude, policy, technology, practice and governance). Further research is needed to explore the 36% of g-readiness level which is left unexplained. In addition, as a continuation to these study future research can be done on developing green IT adoption framework that will be suitable for the country's context for successful adoption of green IT.

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## Appendix A – Questionnaire

**ADDIS ABABA UNIVERSITY**  
**COLLEGE OF NATURAL SCIENCES**  
**SCHOOL OF INFORMATION SCIENCE**

This study is conducted in partial fulfillment of the requirement of the Degree of Master of Science in Information Science at Addis Ababa University on a research title “Assessing Green Computing Readiness in Government Organizations: A Multiple Case Study”.

The objective of this research is to assess the readiness of selected organizations in Ethiopia towards adopting Green Computing. Your organization is selected based on its strong role in the development of ICT in the Country. Your honest response and dedicated cooperation to these questionnaires will strongly contribute to the result of this study. The final outcome of the research will help organizations to identify the level of their preparedness to adopt Green Computing, which is believed to directly contribute to the green growth goal of the country.

Please note that the data of your organization will only be used for academic purposes and will not be shared with anyone outside of the research interest.

Thank you in advance for your kind participation and support.

Sincerely yours,

Kassech Mamo

Email: [kassechmamo56@gmail.com](mailto:kassechmamo56@gmail.com)

Advisor: Dr. Elizabeth Ayalew, School of Information Science, AAU

## General Instructions

Please follow separate instructions for each section to respond to the statements given. For instance, for sections 1 and 5, put a tick mark (√) under the appropriate column which shows your choice against each statement. If you strongly disagree with a statement, you put a tick under 'strongly disagree'; if you are neutral, you put a tick under 'neutral'. In section 4, if you know a certain technology is deployed well, you put the mark under 'To a very great extent'; if it is not deployed at all, you put the mark under 'not at all'.

<b>Section One : G-readiness Attitude</b>						
<b>'Strongly disagree' to 'Strongly agree'</b>						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	I am concerned about climate change					
2	I believe that IT equipment and systems contribute to greenhouse gas emissions					
3	Our organization is concerned about climate change					
4	Our organization is concerned about the efficiency of powering our IT infrastructure (Storage Servers, network )					
5	Our Organization is concerned about our IT equipment energy consumption					
6	Our organization is concerned about the energy consumption of cooling and lighting our data centers					
7	Our organization is interested in Green IT initiatives of our IT suppliers					
8	Our organization is concerned about the environmental impact of discarding IT equipment at the end of its life					
9	Computers can be harmful to the environment					
10	I am aware of Green IT					
11	IT professionals should be concerned with controlling the power consumption of IT equipment					

<b>Section Two: G-readiness Policy</b>						
<b>'Not at all developed' to 'Developed to a very great extent'</b>						
	Our Organization has	Not at all	Small extent	Moderate extent	Great extent	Very great extent
12	A policy that states staff should turn off computers when they are not in use					
13	A policy to minimize waste and increase recycling policy					
14	Environmental sustainability policy					
15	Environmental friendly IT equipment purchasing policy					
16	Green data centers policy					
17	Policy on employees use of IT in an energy efficient manner					
18	IT Hardware End of Life management policy					
19	Green Information Technology Policy					
20	Corporate social responsibility policy					

<b>Section Three: G-readiness Practice</b>						
<b>'Not at all Practiced' to 'Practiced to a very great extent'</b>						
	Please rate the following practices in your organization	Not at all	Small extent	Moderate extent	Great extent	Very great extent
21	Print on both sides of the paper (duplex printing) if necessary					
22	Turn off all peripherals devices (printer, scanner, projector, etc.) when not in use for a long time					
23	Gives weight to environmental considerations in IT procurement					
24	Preference of IT suppliers that have a green track record					

25	Shortens IT equipment refresh periods to gain access to more energy efficient equipment					
26	Considers environmental factors in the design of the site infrastructure (and network) of data centers' servers ,storage, etc.					
27	Audits the power efficiency of existing IT system and technologies					
28	Switches off data center lights and equipment when not needed					
29	Enforces PC power management					
30	Analyzes power bill separately from the overall corporate bill					
31	Recycles consumables equipment (e.g. batteries, ink cartridges, and paper )					
32	Discard of unwanted IT equipment in an environmental friendly way					

<b>Section Four: G-readiness Technology</b>						
<b>'Not at all' to 'Deployed to a very great extent'</b>						
		Not at all	Small extent	Moderate extent	Great extent	Very great extent
	Our organization has the following technologies deployed					
33	Server consolidation and virtualization					
34	Thin-Client and Desktop Virtualization					
35	Cloud computing					
36	Print optimization					
37	Data center airflow management					
38	Upgrades to more efficient UPS					
39	Install more energy efficient lights					
40	High efficiency stand-by power system					
41	Computers that have functions to monitors workloads and to shut down components when unused					

<b>Section Five: G-readiness Governance</b>						
<b>'Strongly Disagree' to 'Strongly Agree'</b>						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
42	Top management is involved in Green IT initiative					
43	Our organization have defined a role for coordinating our business's green initiatives					
44	Top management has allocated the required resources to adopt Green IT					
45	Our CIO (or equivalent ) plays a leading role in all green (IT and non-IT ) initiatives					
46	Our organization have earmarked a budget and other resources for Green IT					
47	Our organization have established metrics for assessing the impact of Green IT initiatives					
48	Our organization has mechanisms for monitoring IT suppliers green performance					
49	IT department is responsible for its own electricity costs					

<b>Section Six : Readiness to Adopt Green IT</b>						
<b>'Strongly Disagree' to 'Strongly Agree'</b>						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
50	Our organization has the financial resources to adopt Green IT					
51	Our organization has the necessary skills to adopt Green IT					
52	In my opinion our organization is ready to adopt Green IT					

<b>Section Seven :</b> Please rate the following factors that might prevent your organization from adopting green IT						
<b>'Strongly Disagree' to 'Strongly Agree'</b>						
		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
53	Cost of Green IT solutions					
54	No budget is allocated for Green IT					
55	Inadequate skill or training in Green IT area					
56	Organizational resistance to change					
57	No enforcement by the Government					
58	Lack of Government incentives for Green IT implementation					
59	Lack of top management support					

**Section Eight:** Demographic Information

1. Organization \_\_\_\_\_ Department/Section \_\_\_\_\_

2. Gender \_\_\_\_\_ Male \_\_\_\_\_ Female

3. Educational Level

- \_\_\_ Diploma
- \_\_\_ Bachelors
- \_\_\_ Masters
- \_\_\_ PhD
- \_\_\_ Other

4. Work Experience

\_\_\_\_\_ < 5 years      \_\_\_\_\_ 5-10 years      \_\_\_\_\_ 11-15 years      \_\_\_\_\_ >15 years

Any Comment or Suggestion

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