Lappeenranta University of Technology
School of Engineering Science
Degree Program in Computer Science

Farniba Khan

A Framework and a Web Application for Self-assessment of Sustainable Green ICT Practices in SMEs

2018

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ABSTRACT

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Keywords: Green ICT, Green ICT in organizations, Green ICT maturity model, Sustainability in organizations and Sustainable ICT maturity model.

Several maturity models have been proposed for tracking Green ICT practices in organizations. However, due to the lack of Green ICT knowledge, organizations specially SMEs tend to ignore them. Diversely, the increasing interest for Green ICT practices in organizations depend on attaining environment-friendly atmosphere and sustaining business goals. SMEs in the world try to follow some common strategies for Green ICT. Therefore, this research proposes a framework that combines existing Green ICT and sustainable ICT maturity models by mapping with the strategies that businesses are already following. A web application has been developed to identify the present situation of Green ICT practices and improvement suggestions for SMEs out of this framework. The results have been analyzed in two different countries and a survey has been conducted to attain SMEs' perception about sustainable development of businesses through this application.

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LIST OF SYMBOLS AND ABBREVIATIONS

CEO	Chief Executive Officer
CSR	Corporate Social Responsibility
E-waste	Electronic Waste
EMAS	Eco-Management and Audit Scheme
EMS	Environmental Management System
EU	European Union
GeSI	Global e-Sustainability Initiative
GIIC	Global Information Infrastructure Commission
ICT	Information and Communication Technology
IT	Information Technology
ISO	International Organization for Standardization
SME	Small and Medium Sized Enterprise
UN	United Nation

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1 INTRODUCTION

Information and communication technology (ICT) is considered as an essential part of businesses which results in significant amount of electricity consumption and releases carbon dioxide (CO2) that leads to greenhouse gas emissions and e-waste generation [2]. According to the European Commission, with the increase of ICT usage, it is anticipated that by 2012, the energy consumption by ICT equipment will rise to 25%, along with the expansion in greenhouse gas emissions [3][4]. Green ICT or any efficient way of using ICT can be considered as solution to this problem. It can be characterized as a composition of activities that limit the negative effect of ICT on the environment and enhance the positive effect ICT can have. Again, it can be defined as any activity that considers the direct, indirect and systemic impact of ICT on the nature [2].

In recent year, organizations exhibit increasing amount of consciousness about their responsibility towards environment. However, the reason behind this awareness not only depends on organization's willingness to acquire environment-friendly atmosphere, but also achieving and sustaining business goal such as cost reduction, social value of businesses and many others.

Many models and tools or applications have been implemented for Green ICT and sustainable ICT in organizations. However, organizations especially small and medium sized enterprises (SMEs) find difficulties to follow those models. The reason behind these is constraint in financial assets, absence of specialist knowledge and lack of awareness. Though few studies provide information about Green ICT practices in SMEs, but those are not sufficient to serve sustainable business benefits from the practices of usage of ICT equipment that organizations already following.

This thesis aims to provide a framework from the combination of existing Green ICT and sustainable ICT maturity model and maps with the Green ICT practices that SMEs are already following, develop a web application out of that framework and analyze the SMEs perception about sustainable Green ICT practices of that application.

1.1 Background and Related Works

The use of ICT is growing with the rapid advancement of the modern world. However, the increasing usage of ICT equipment contributes to remarkable amount of electricity consumption and produce electronic wastes (e-waste) that eventually generate greenhouse gas emission. In a report of the Global e-Sustainability Initiative, it is mentioned that ICT is accountable for 2% of global CO2-emissions, while ICT solutions have the prospect to minimize global CO2 emissions by up to 16% [2]. Such effect of ICT emits leads to climate change.

To solve this problem, Green ICT is considered as an enabler in the current world. It can be defined as a collection of actions that limits the negative effect of ICT and enhances the positive effect ICT can have on environment. In other words, any activities that consider the direct, indirect and systemic influence of ICT on the nature [2].

In recent years, organizations exhibit increasing amount of consciousness about their responsibility towards environment. However, the reason behind this awareness not only depends on organizations willingness to acquire environment-friendly atmosphere, but also achieving and sustaining business goal such as cost reduction, social value of businesses and many others. Most of the large organizations have their own corporate social report for sustainability that employees are bound to follow. For example, Eco-Management and Audit Scheme (EMAS), Environmental Management System (EMS), ISO 14001 standard, provides systematic way to enhance environmental sustainability in organizations [5]. However, SMEs are lack of those policies. Again, many models and tools have been proposed for green ICT in organizations. The models are categorized into several levels with unique characteristics which help organizations to assess their accomplished responsibilities towards environment [2]. However, organizations specially SMEs find difficulties to follow these models. The reason behind these is constraint in financial assets, absence of specialist knowledge and lack of awareness [5]. Though few studies provide information about green ICT practices in SMEs, those are not sufficient to serve sustainable business benefits from the practices of usage of ICT equipment that organizations are already following.

SMEs around the world try to follow some common strategies such as virtualization and consolidation, energy efficiency and disposal of ICT equipment for greening ICT and sustain their businesses. However, a framework is required so that SMEs can be concerned about their present situation of green ICT practices and able to progress from the current situation by following those strategies.

By providing a framework and a web application with the characteristics of existing Green ICT and sustainable ICT maturity models and mapping those models with existing approaches of SMEs for Green ICT can help SMEs to assess their situation and improve business profits.

1.2 Aim of the research

This research proposes a framework which provides combination of existing Green ICT and sustainable ICT maturity models to provide a way to SMEs to facilitate organizational benefits and environment-friendly atmosphere. Therefore, the framework maps different maturity levels from these models, with the parameters that SMEs are following now-a-days for sustaining their businesses.

A web application has been developed out of the framework so that SMEs can assess their current level of Green ICT practices and get recommendation for improvement.

Finally, a survey has been conducted to acquire information about SMEs' perception about the usefulness of the application in respect to sustainability aspect.

1.3 Research Methodology

To fulfill the aim of the research, design science methodology is used. It is a methodology to design and development of artefact and includes investigation of the utilization of the artefacts to explain a practical issue [6]. In this research, this methodology is comprised of several sequential steps. They steps are shown in figure 1.

Figure 1. Design Science Methodology

Firstly, the problem has been formulated and a framework has been developed from systematic literature study. After that a web application has been developed from that framework. This application provides self-assessment and improvement of sustainable green ICT practices in SMEs. It has been tested and two surveys has been conducted to understand the usefulness of the application and possibility of achieving sustainability through this application. The test has been conducted in eight SMEs in Finland and Bangladesh. Then, the result has been analyzed based on the context of Sustainable Green ICT practices in developed and developing countries.

1.4 Delimitation

This thesis is limited to SMEs only. Moreover, the scope of this thesis focuses mainly on ICT usage management in SMEs for a greener and sustainable future. In addition, the web application has been tested only by software companies in both Bangladesh and Finland.

1.5 Structure of the thesis

The thesis is organized into following chapters:

Chapter 2: Background and Related Works

Chapter two firstly, provides the impacts of ICT and the concept of corporate social responsibility (CSR). Moreover, the review on the drivers for adopting green ICT for sustainability in organizations is reviewed. In addition, existing models for Green ICT and sustainable ICT as well as previously implemented Green ICT assessment application has been reviewed.

Chapter 3: Development of the framework

Chapter 3 presents a framework to answer the research questions based on the systematic literature review.

Chapter 4: Development of GreenSME Application

Chapter four explains the step by step implementation of the "GreenSME" web application. This involves formulation of the questionnaires out of the framework, usability design, development and testing of the application in real SMEs.

Chapter 5: Results and Discussions

In this chapter, based on the responses given by the IT specialists or CEOs, in 8 SMEs in Finland and Bangladesh, the usefulness of the application and possibility of implementing sustainability aspects been analyzed in the context of sustainability aspects of Green ICT practices of developed and developing countries.

Chapter 6: Conclusion

Chapter 6 presents the outcome and future work for this thesis. A list of references and appendices are also followed by this chapter.

2 BACKGROUND AND RELATED WORKS

Global Information Infrastructure Commission (GIIC) provides an announcement in the Tokyo Declaration that “ICT has historically been viewed as a tool to advance productivity. We found and confirmed that the use of ICT can change the behavior of business and consumers, and through these changes, ICT can help the environment without sacrificing economic output” [4][7]. However, many people find IT infrastructures as harmful because those equipment consumes noticeable amount of electricity, which eventually leads to global warming [8]. Although ICT equipment are responsible for climate change, Green ICT is considered as a solution to this problem.

However, it is difficult for organizations to implement green and sustainable ICT strategies. To properly ingrate green ICT strategies for sustainable development, firstly the impacts of ICT and the concept of CSR need to be understood. Moreover, organizations often try to find out their benefits as an outcome of green and sustainable practices of ICT. Therefore, in this chapter the review on the drivers for adopting green ICT for sustainability is reviewed. In addition, existing model for Green ICT and sustainable ICT maturity model as well as previously implemented Green ICT assessment tool has been reviewed.

2.1 ICT and its impacts

ICT equipment, for example, computers, laptops, printers, and servers, are considered as an essential part of the current business world. The use of ICT is growing with the rapid advancement of digitalization and web-based services. However, the increasing usage of ICT equipment contributes to remarkable amount of electricity consumption and produce electronic wastes (e-waste) that eventually generate green-house gas emission [2]. Moreover, according to the report of Smarter 2030, ICT can empower a 20% diminishment of worldwide CO2 emissions by 2030, holding outflows at 2015 levels. This implies it can conceivably maintain a tradeoff between financial thriving and ecological protection. The exploration demonstrates the ICT division's discharges "impression" is relied upon to decline to 1.97% of worldwide outflows by 2030, contrasted with 2.3% out of 2020 [9].

Green ICT is considered as a possible solution to this problem. It can be characterized as a composition of activities that limit the negative effect of ICT on the environment and enhance the positive effect ICT can have. Again, it can be defined as any activity that considers the direct, indirect and systemic impact of ICT on the nature [2]. In an organization, it indicates to environment friendly and sustainable practices while using ICT equipment. The practices of green ICT result in reducing carbon emissions from ICT resources and therefore provides an environment friendly atmosphere. The practices of efficient usage of ICT equipment include turning off computers after office hour, disposal of electronic wastes and many others in an organization [8].

2.2 Corporate Social Responsibility

The idea and business consciousness of CSR has advanced extensively since it initially developed in the 1950s [10]. In [11], Holmes and Watts of the World Business Council for Sustainable Development gave a statement about CSR as the procedure with obligation by business to act ethically and add finance related change while upgrading the individual fulfillment of the workforce, their families and additionally of the neighborhood network and society at large. Lying behind this definition is the conviction that the organization's primary target as characterized in the field of corporate fund – amplifying investor esteem – is not sustainable on the grounds as it overlooks different characters (or 'stakeholders', for example, creditors, customers, debtors, environmental interests and future generations) [12].

The most well-known statement of sustainable development is referred to as “meet the needs of the present without compromising the ability of future generations to satisfy their own needs” [13]. Moreover, it needs to fulfill the three dimensions, which are the social, economic and environmental [13]. CSR is, however, an expansion of the hypothesis of sustainable development. It is the act of the hypothesis of reusing resources, which expects organizations to modify the activity method of 'Benefit arranged', yet to accomplish the financial benefits, social advantage and ecological benefit. Therefore, the more CSR the companies possess can bring good financial and social benefit. In the meantime, CSR can upgrade the organization's social reputation. However, completion of social responsibility

depends largely upon organization’s profitability. The organizations have more financial capacity to do CSR towards the administration, the workers, social welfare and nature if the financial benefit grows higher [14]. Therefore, large companies possess more CSR reports for sustainability for employees than SMEs.

2.3 Drivers for adopting Green ICT practices in organizations

From the motivation of CSR, organizations, now-a-days, are bound to take systematic approaches to protect the environment. This responsibility is fulfilled by practicing and encouraging the employees about environment-friendly acquisition of information technologies. Moreover, performing such responsibilities towards environment enables integration of different organizations for solving social and environmental issues in their business tasks, and in addition satisfies needs of their stakeholders [15].

As per a study in [16], six benefits had found out when respondents clarify the reason behind their embracement in green ICT activities. Those are: reducing power consumption, diminished consumables utilization, expanded benefits for the organization, reducing costs or speculations, taking care of stakeholders' requirements and acknowledging credits or discounts from nearby utilities. Reduction of expenses is the prominent factor driving execution crosswise over activities: the capability to reduce utilization of power and different consumables, both of which are picked by the greater part of respondents. Considerably, activities with the greatest reception have diminishing power and consumables use are found as the most popular explanation behind usage, since reduction in power and consumables contribute to significant amount of cost reduction [17].

2.4 Existing frameworks for Green ICT and sustainable ICT

Many maturity models or frameworks exist for green ICT. Some of the well-known models are, Green IT Readiness Framework, Green IS Framework, Holistic approach to Green IT, SICT maturity model, SURF Green ICT maturity model. Description for each of these models have been presented in the sub-sections below:

2.4.1 Green IT Readiness Framework

Green IT Readiness is characterized as an organization's ability in Green ICT framework by decreasing functional, business processes, waste utilization, enhancing vitality effectiveness [18]. It is composed of the five segments of Green IT Attitude, Policy, Practice, Technology, and Governance. These segments are useful for estimating Green IT capabilities in an organization. One of the limitations of the framework maturity level cannot be measured. Moreover, it does not present predefined procedures to take since it is more suitable to display an organization in what aspects it is ready for Green IT and in which it is not.

Considering the sustainability aspects, economic and environmental aspects are present in all five components. However, social aspects are absent in these components since this framework is mainly focused on environmental issues. The conclusions drawn from the investigation were that the current components are suitable in the development of G-readiness framework, however no exploration was done in extra components, which could be important since IT is emerging [19].

2.4.2 Green IS Framework

The Green IS framework was developed by Butler in 2011. This framework is useful for organizations to provide ways for adopting green ICT strategies in various domains. Since most of the companies now-a-days aim to adopt Green ICT strategies as part of their management systems and this framework is particularly aligned to satisfy this objective to reduce overall greenhouse gas emission [19].

Several different domains such as, people, processes and Green IT are presented and discussed in this framework. However, the framework is unable to provide any detailed information about its usability in real life. Organizations have to decide by their own depending on their needs to assess the key areas. Reports can be conducted describing the advancement in each of these areas. However, this framework is unable to provide any template for such evaluation [19].

While considering the sustainability aspects, it covers all the three main dimensions of sustainability (environmental, economic and social). However, one of the major limitations of this framework is it is unable to provide any information about the validation of the framework [19].

2.4.3 Holistic approach to Green IT by Murugesan and Gangadharan

Murugesan and Gangadharan have proposed a framework to deal with the ecological effects of IT thoroughly and proficiently. This framework consists of six domains to achieve sustainability in green IT. They are green design of IT systems, green manufacturing of IT systems, green use of IT systems, green IT strategies and policies and green standards and metrics. The framework presents how these elements are interconnected with each other. Moreover, it fulfills three main dimensions of sustainability. However, this framework fails to provide any measurement or a maturity level and validation. In addition, the usability of the framework in an investigation or what should be the result of applying is not mentioned [19].

2.4.4 SICT maturity model

One of the well-known model is SICT maturity model, that provides an essential tool to assess and arrange the maturity of sustainability of organizations [19]. It contributes to an explanatory value-based model for assessing, arranging and planning for SICT capabilities [20]. The framework has direct and indirect effect on the three main dimensions of sustainability- environmental, social and economic [18]. To understand the business priorities and main drivers for SICT in an organization, interviews have been conducted with senior management authority. It is recommended that both IT and other departments should take necessary actions for sustainable development of IT. Moreover, medium-sized employees need to be involved in making decisions for developing sustainability capabilities. Furthermore, sustainability should not be a way for reducing cost, however, the whole organization requires to be educated to improve the sustainability of IT [18].

2.4.5 SURF green ICT maturity model

SURF Green ICT Maturity Model (SGIMM) is a tool developed for higher educational institutions. It is a self-evaluation tool for higher educational associations, assessing the abilities of green ICT in ecological effect challenging. The model consists of several parameters that allows organizations for self-assessing their organization [21]. The categorizes are, green ICT in the association, greening of ICT, greening of activities with ICT, and greening of essential procedures with ICT. Each category has several attributes. Each attribute has a maturity level with a description of what it contains. The main aim of this framework is to cultivate an inside exchange in associations, encouraging concurrence on analysis of the present circumstance (the general development level), and defining development activities [22]. The model has been evaluated in a survey of green ICT experts [23]. The center of this survey was to decide the importance of the attributes used in the framework and whether their illustration was right. The framework covers environmental, social and economic dimensions, where the social dimension, is directly involved with only ‘community collaboration.' For the improvement of the SGIMM framework, it is suggested that based on a combination of interviews, common sense and literature, the categories to be added need to be determined and later it can be added to the SGIMM [18].

From the description of the frameworks in section (2.4.1-2.4.5), it has been found that, most of the frameworks deal with ecological effects of IT and useful for estimating Green IT capabilities in organizations. However, each of the framework is different from the other and has some limitations. For example, some of them are unable to measure maturity level of organization, while some of them fail to provide any validation information and how to use the framework in real life. Again, in some of the frameworks no exploration has been made for extra components of IT which is useful since IT is growing rapidly. Therefore, there is a need for a framework that satisfies all these features.

2.5 Existing application for Green ICT assessment in SMEs

In [24], a framework was chosen from literature review for green ICT in SME and a self-assessment tool was proposed out of that framework. Few questions were developed, and

the answers were given marks based on the choice. However, this tool is inadequate to provide feedback on improvement of green ICT practices in SMEs. Therefore, the authors recommend testing this tool on more organizations and documentary evidence for validation in future.

Another self-assessment tool for evaluating environmental responsibility of SMEs was presented in [5]. A set of questionnaires was prepared for determining the level and recommendation was suggested to go to the next level. However, this tool mainly focused on the environmental aspect of sustainability. Moreover, country-wise and organization type wise variation was not considered.

In addition, many other applications have proposed in [25], [26], [27] to investigate for the evaluation of organization's green ICT initiatives. These tools provide a basic guideline of the effect of green ICT in businesses. However, these tools are not sufficient to track progress on improving green ICT practices in organizations [28].

3 DEVELOPMENT OF THE FRAMEWORK

This chapter presents the systematic literature review approaches applied for developing the framework and finally the whole framework has been displayed.

3.1 Systematic Literature Review

The systematic literature review (SLR) methodology was executed for data collection, extraction, investigation, and synthesis [29] for developing the framework for assessing green ICT practices in an SME. According to the statement of Kitchenham and Charters, SLR is "a means of identifying, analyzing and interpreting all available data relevant to particular research question or topic area, or phenomenon of interest" in an impartial style. Three stages are followed for the SLR approach: planning, executing and reporting the review [30].

Four different queries were executed to the selected databases mentioned below in table 1. The main criteria for selecting these papers was to find different maturity models and the approaches that organizations are following for green ICT. Since it is not possible to read the large number of papers, therefore, at first, the title of the paper is skimmed to find useful papers. Next the abstract, then conclusion and at the end the content of those articles have been skimmed that focuses on green ICT in organizations. Moreover, AND and OR logical operations have been performed to find appropriate papers that focus on either Green or Sustainable ICT maturity model in organizations. Furthermore, after careful observations from those papers, 21 papers were finally selected for detailed data extraction for developing the framework. The finally selected papers are not only from the last column, but also selected from other columns accoding to the relevancy with the research.

Table 1. Search Result from databases

Database	**Green ICT**	**Green ICT in organizations**	**Green ICT maturity model**	**Sustainable ICT maturity model**	**Green ICT| Sustainable ICT + maturity model + organizations**
IEEE Explorer	760	41	5	12	5

Springer	11,659	5,934	665	1216	11
ScienceDirect	7,827	3,348	476	986	2
Emerald Insight	1038	932	193	784	3

The data collected from these papers are green and Sustainable ICT maturity levels, ICT equipment that are used in majority of the organizations and the strategies that SMEs are following for green ICT practices while using ICT equipment. These data have been used to design the framework.

Investigation of literature based on the two research questions for developing the framework are as follows:

Q1) What are the green ICT maturity models presented in the literature?

The green ICT maturity model is specified maturity in various levels each described by a particular characteristics. It generally refers to maturity of five levels, starting from level 1 to level 5, where level 1 is the lowest and level 4 is the highest level. In ascending order, these levels are defined as initial, managed, defined, quantitatively managed and optimizing respectively. The benefit of these maturity models is that they permits benchmarking in various enterprises [24]. Foogooa, Bokhoree and Dookhitram analyzed several Green ICT maturity models and based on the reviews, proposed a generalized green ICT model. The model consists of different levels where the lower indicates no awareness regarding organizations therefore no plan for implementing green ICT strategies and higher level is set to accomplish goals such as include measured metrics and many others [24].

On the other hand, in [28], the paper shows a demonstration of sustainable development for project management in organizations. In view of the ideas of sustainability, the model evaluates the level of sustainability as assets, business approaches, plan of action and items/administrations.

Q2) What are the parameters that the organizations follow for green ICT practices?

Several common ICT equipment that almost every organization possesses are desktop pc, laptop, monitors, thin clients, printers and multifunctional devices [31]. Besides, an outline of green ICT adoption approaches in SMEs around the globe is shown in [32] where several parameters are server virtualization and consolidation, existing server room redesigns, assembling new server room, estimation of energy consumption by ICT equipment, power management of PC and printer, consolidation of printers, remote conferencing, and IT hardware reusing and disposing. The effect of actualizing these procedures help organizations to diminish cost and thus reduce greenhouse gas emissions. Moreover, common strategies and equipment that are used by almost all organizations are listed in [33]. Eight parameters have been finalized based on those for developing the framework. They are: power management of computers, reduction of computers for power management, power management of imaging equipment (printers/scanners/photocopiers), paper saving from ICT equipment, power management of video conferencing suite, IT load reduction management of server, cooling management of ICT equipment and management of e-waste disposal.

From the search results of table-1, supporting texts have also been gathered for each of the eight parameters to develop the framework. Reference texts for each of the parameters have been presented in table-2.

3.2 Reference Texts for Framework

The following text has been selected as a reference for developing the framework. Sources have been mentioned beside reference texts.

Table 2. Reference Texts for Framework Development

Parameter	Reference Texts	Sources
Power management of computers	Turning off computers during inactivity is the best option for power and cost saving. Plugging computers into electrical outlets consumes energy. Therefore, it is recommended to unplug computers from electrical outlets when turned off. An automated shutdown software is required for those who forget to shut down computers. Screensaver is enabled to decrease energy consumption by computers. Nonetheless, screensaver consumes same amount of energy when the computers are kept on in active mode. It is suggested to turn off computers when inactivity is observed. Moreover, the Climate Savers Computing Initiatives proposes setting display and system to put in low power mode and sleep after certain time of latency. For better user experience with optimized energy usage, Energy Star suggests enabling display and system to enter sleep mode after 5 to 20 minutes and 30 to 60 minutes respectively.	[32], [33], [34]
Reduction of computers for power management	It is desirable to have the ratio of employee and computer set as 1:1 in an organization for less power consumption. Desktop PCs consume more energy than laptops. Thin client PC consumes five times less energy consumption than desktop PC since it has few parts than desktop PC and generates low heat.	[34], [35], [16]

Management of powering off imaging equipment (printers, scanners, photocopiers)	Consolidation of imaging equipment can reduce electricity cost significantly. To automatically turn off printers/scanners/photocopiers when not in use, smart power strips are used for electricity consumption reduction. Organizations possess instructions set for employees to turn on power saving attributes on their equipment. In some organizations, equipment has achieved Energy star certification label which means that those equipment are designed to save energy. Therefore, employees encounter less energy when they use these equipment by automatically set to enter low-power mode during inactivity.	[33], [37], [31]
Paper and energy saving from ICT equipment	According to a study in the universities in Kenya, organizations have centralized printers and they efficiently manage printing requests [10]. It is recommended that the ratio of number of employees and printers, scanners, photocopiers in an office should be 10:1. Therefore, it is suggested to consolidate single printers, scanners, copiers into multi-functional equipment and make the equipment easily accessible by all employees. Energy star label can be found in many equipment. Energy star printers reduces paper consumption by automatically print on both side of the paper. However, it is recommended that if the printer carries automatic duplexing setting, then users are advised to change that to double-sided printing to save energy. Moreover, locked printing feature are suggested to be enabled in printers and other imaging equipment.	[36], [31], [16], [33]

Power Management of video conferencing suite	According to findings in one research paper, it is suggested to the employees to turn off video conferencing suite at night since in another study it has been exhibited that during standby mode, video conferencing suite consumes significant amount of energy that is not visible sometimes. It is advisable to change screens to standby mode in the middle of calls instead of displaying a static picture since studies have found that the screen consumes highest amount of energy in a video-conferencing suite. Moreover, the paper also recommends that investment in power control equipment with this type of devices can aware employees about the advantages of turning off equipment after office hour and during weekend. In addition, automated the shutdown process is required to powering down video conferencing suite after certain time of inactivity.	[37]
IT Load Reduction Management of Server	According to a study conducted in US, around 25% of moderate size organizations have officially finished some type of server consolidation or virtualization, and another half are anticipating these activities within a year. By combining unique, independent servers to a solitary physical server, those servers can work more efficiently and decline energy expenses up to 40%. It is observed that 15%-30% servers are left unused in a data center. However, they consume energy. The utilization rate of a usual server is about 5 to 15 percent. However, it consumes full power. Therefore, energy star rated servers are recommended to use by organizations that draws 30 percent less energy than a normal server.	[16], [38]

Cooling management of ICT equipment	According to the responses of interviewees in the universities of Kenya, it has been found that virtualization or rack servers enablement is encouraged in the organization. Some other responded that ICT equipment are kept at lowest attainable temperature. Moreover, they stated that instructions have been given to them for cooling those equipment. On the other hand, some interviewees replied they possess some physical servers in their organization.	[36]
Management of E-waste disposal	By donating electronics where the lifecycle of the equipment has not finished yet can be a good option. Moreover, reusing is an option to reduce e-waste pollution. Computer Aid international is a charity that set specific container for disposing electronic equipment from regular waste in office. The European Community WEEE (Waste Electrical and Electronic Equipment) directive has set specific recommendation about reusing wasted electrical equipment. In compliances with the producer pays guideline, the WEEE orders to put the duty on the producer and sellers of electrical equipment to gather and reuse electronic equipment. There are numerous electronics reusing associations which figure out how consumables can be reused. An investigation was led in India on 100 people of several professions to comprehend their consciousness about e-waste managing. The greater part of the general population in study use different types of electronic equipment where everyone except 1%, of the interviewees were having PC or tablet pc. Again, other than 3% all the respondent was having mobile phones alongside different gadgets. However, at most 19 % of	[39], [31], [35], [40]

	interviewees know to manage their electronic devices in which 7 % stated to return it to the producer and 12 % said to go for re-using to some association. 21% were of conclusion to dispose the electronics as regular waste. 23% of people concurred that they don't have any knowledge about how to process e-waste.	

3.3 Description of the levels of the framework

A framework is specified as a collection of theoretical aspects arranged in a manner that more systematic knowledge of the occurrence can be achieved [41]. This research proposes a five level of maturity framework based on the suggested framework in [18], [42], [21], [24] for SMEs. From the lower level, the levels are defined as initial, repeatable, defined, quantitatively managed and optimized. The characteristics of each the levels are given below in table 3:

Table 3. Characteristics of the level of the Framework

Level	**State**	**Description**
0	Initial	No awareness, no implementation of Green ICT & sustainable actions
1	Repeatable	Minimal awareness of Green ICT, immature initiatives than limits the non-sustainable actions.
2	Defined	Informal initiatives of Green ICT strategies and elimination of the cause of non-sustainable effects.
3	Quantitatively Managed	Formal, measured and control Green ICT strategies for favorable sustainability effects
4	Optimized	Optimized environmental impacts for sustainable development

3.4 Selected Parameters for Sustainable Green ICT practices

Eight parameters have been finalized based on the literatures presented in [28] for developing the framework. They are: power management of computers, reduction of computers for power management, power management of Imaging equipment (Printers/scanners/photocopiers), paper saving from ICT equipment, power management of video conferencing suite, IT load reduction management of server, cooling management of ICT equipment and management of e-waste disposal.

3.5 Overview of the whole framework

A framework has been developed by mapping different levels and the parameters that businesses follow for Greening and sustainable ICT practices are presented below. The criteria for each level of the parameters have been set based on the text presented in table 2. In table-4, below, the left column displays parameters and the top row represents level number. Moreover, description of each level and sources of the reference text have also specified.

Table 4. The detailed framework

Parameter	**Level 0**	**Level 1**	**Level 2**	**Level 3**	**Level 4**
Description of the levels	No awareness, no implementation of Green ICT & sustainable actions	Minimal awareness of Green ICT, immature initiatives than limits the non-sustainable actions.	Informal initiatives of Green ICT strategies and elimination of the cause of non-sustainable effects.	Formal, measured and control Green ICT strategies for favorable sustainability effects	Optimized environmental impacts for sustainable development

Power management of computers	Computers are not turned off manually after office hour. No screen-saver, standby, sleep, manual or automated software is used to turn off computers.	Computers are turn off manually only after office hour. Active screensaver mode is enabled when inactivity is observed. Computers are not set to sleep mode.	Computers are turned off manually after office hour. Active screensaver is removed. Display and the system enter to sleep mode but the time to enter the sleep mode is not known.	Employees turn off devices manually when not in use for certain time. Display set to enter sleep mode more than 20 minutes of inactivity. Computers are set to enter system standby or sleep mode after more than 60 minutes of inactivity.	Automated shutdown software turns off computers automatically after certain time set period. Display enters sleep mode after 5 to 20 minutes and system enters standby or sleep mode after 30 to 60 minutes of inactivity.
Reduction of number of computers for power management	Number of computers used by each employee has not considered	Multiple desktop PCs/laptops are allocated for each employee	Multiple laptops are allocated for each employee no desktop PC exists.	Only one laptop is allocated for each employee.	Thin client PCs or Energy star rated devices are used.

Power Management of Imaging Equipment (Printers, Scanners, Photocopiers)	Devices are not turned off after office hour. No low power mode or sleep mode is enabled in devices	Devices are turned off manually after office hour and enter to low power mode after certain time of inactivity.	Devices are turned off manually after office hour and enter to sleep mode after certain time in low power mode during inactivity	Timer switches are used to turn off devices during inactivity	Smart power strips are used for power management such as, turn off devices, low power and sleep mode.
Paper and energy saving from ICT equipment	Do not have any practices for paper saving.	Savings made by presetting duplex, booklet and greyscale defaults.	Use "Print on collect"/centralizing equipment other than private use facility shared by employees.	Locked print feature is enabled.	Energy star rated devices are used. Replace devices with network multi-functional devices (combined printers/copiers/scanners)
Power Management of Video Conferencing Suite	Video conferencing suite is not turn off after office hour.	Video conferencing suite set to standby mode after office hour.	Manually shuts down the video conferencing suite after office hour	Screens enter standby mode in between calls than displaying static image.	Automatically shuts down by using power management equipment with devices which can be

					turned on by user after office hour.
IT Load Reduction Management of Server	Several single independent servers with low utilization or no server exists	Decommission of unused servers	Aware or plan of virtualization/rack servers but no implementation	Consolidate lightly used servers to independent servers to run different workloads to a single physical server e.g., virtualization	Energy efficient server is used
Cooling management of ICT equipment	Do not have any plan for cooling management of ICT equipment	Planning but no implementation	Enclosures are used on all sides of server racks to lessen the blending of cool and hot air.	Different speed fan drives are utilized in AC units for cooling.	Efficiently deploy air-flow maintenance devices such as structured cabling systems, diffusers and blanking panels

Management of E-waste disposal	E-wastes are disposed with regular trash	E-wastes are disposed in the appropriate container, separating from general waste.	Sell to second hand shop or donate	Return to the producer/suppliers from where the device was purchased	Go for recycling to WEEE recovery business organization in the locality. Organizations are inclined to use Energy Star rated products.

4 DEVELOPMENT OF THE APPLICATION

To use the information in the framework in Table-4 in real SMEs, a web application is developed based on the framework. The name of the web application is GreenSME. The details about the application has below discussed in this section.

4.1 Application Overview

The GreenSME application is intended to be used by IT Specialists or CEOs of SMEs to assess their status of Green ICT practice level. Moreover, based on the status, the application provides recommendations on how to improve in Green ICT practices by suggesting immediate actions to perform and guidelines to go to the next level.

4.2 Application Design

Usability design approach has been followed, for example, personas, scenarios, journey map and digital prototyping have been created and online interviews has been conducted with IT specialists of eight SMEs in Finland and Bangladesh to obtain an overview of those organizations, for example, number of employees, organization type, organization's goal and problems.

- **Creating Persona**

Persona is a well-known approach in software development. It is done by representing a person from the targeted user group through the description of text and photos of the user. The purpose of creating persona is to understand the needs, feelings and emotions of the prospective user for making better software designing decisions [43].

Before creating personas, a detailed analysis of the target user has been made. Online interviews have been conducted with one IT specialist and one employee (web developer) of eight SMEs of Dhaka, Bangladesh and Helsinki, Finland respectively. The goal of these interviews was to obtain an overview of those people. The interview mainly focused on collecting basic information such as, participant's occupation, age, desire and problems, basic details of organizations (number of employees, year of establishment, organization

type). Based on the collected data, the persona has been designed using the tool available at https://xtensio.com/.

Figure 2. Persona of an IT specialist and a software developer of an SME

- **Scenarios for Personas**

In this research, after creating the personas, scenarios have been made for each persona to present sequential actions of the system to fulfill their requirements. Two of the scenarios are presented as follows.

Table-5. Scenarios for Persona

Scenario	Task to Perform
Albert is an IT specialist of a start-up Finnish organization at Lappeenranta. He is very concerned about managing the use of ICT equipment by the employees for organizational benefits.	Albert goes to the "GreenSME" application, participate in the test, compare current situation of ICT equipment management of his organization with others and get guidelines for improvement.
Janna is a young web developer who works at a SME in Lappeenranta. She is concerned about the bad effect of carbon emission from ICT equipment and wants a healthy working environment. She also wants her colleagues to think about this issue.	Janna asks for suggestions about her concern to the IT specialist of the organization. The IT specialist goes to the "GreenSME" application, provides the current practices of managing ICT equipment through participating in the questionnaire, get improvement suggestions for healthy environment and aware employees to follow those guidelines.

- **Designing Journey Map**

By combining various processes of customer journey, a generalized definition has been given by researchers. According to that, customer journey is a technique that investigates the service procedure, manage and again design by following a customer journey viewpoint. [44].

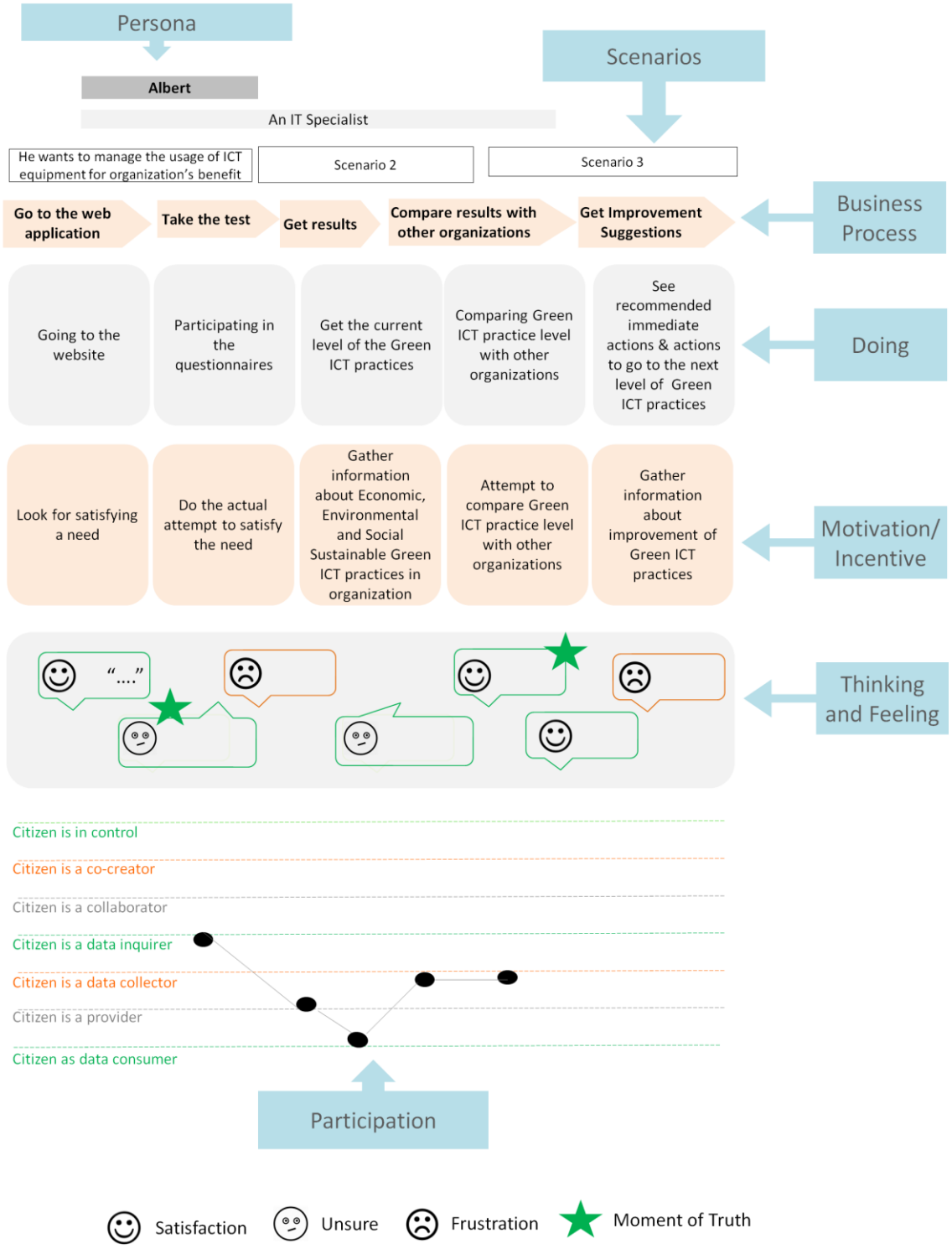

Figure 3. Journey Map of a Persona

- **Prototype Design**

In this research, digital prototyping has been performed before developing the actual web application. It is a progressive way to deal with application development that helps developers to distribute complex task into simple understandable sections to meet user requirements and rethink the product specification along the process [45].

After careful observation among several tools, the Balsamic tool is used for prototype development. The prototype highlights all the available pages of the web application. Screenshots of the pages of the prototype are can be found in the Appendix 2.

4.3 Application Architecture

Figure 4. Architecture of GreenSME Application.

The GreenSME application architecture defines the interactions between application, middleware systems and databases so that they can work together. Like other web application, it has two sides- server side and client side. For the client-side coding languages, HTML, CSS and JavaScript are used which provide front-end design and PHP is used in the server side. PHP is also used to connect with MySQL databases. The MySQL database is used to store information of the levels of SMEs.

The whole application has been developed using AWS Cloud9 IDE (Integrated Development Environment). It is a cloud-based development environment provided by Amazon to write, use, debug and compile code using browsers. This IDE supports almost 40 programming languages. Furthermore, since it allows free hosting of the developed web

application, provided by Amazon itself, therefore, the website link has been sent to multiple SMEs in Finland and Bangladesh through online. The responses from those SMEs are easy to save and keep track for analysis using this IDE [46].

4.4 Features Implemented in the Application

- Participation in the questionnaires

This application mainly consists of set of questionnaires. These questionnaires are based on each of the parameters and its description mentioned in table 4. For example, for the first parameter “Power management of computers”, following questions have been formulated that match with each of the level descriptions of this parameter.

1. Do you have practices to turn off computers after office hour?
   - o Yes
   - o No
2. Which of the following practices do you have in case of inactivity?
   - o Turn off
   - o Screen saver
   - o Sleep
   - o None of the above
3. After how much time do you put display and system of computers into sleep mode respectively?
   - o More than 20 minutes, more than 60 minutes
   - o More than 20 minutes, 30 - 60 minutes
   - o 5 - 20 minutes, 30 - 60 minutes
   - o 5 - 20 minutes, More than 60 minutes
   - o Don't know
4. Do you use automated software to turn off your computers?
   - o Yes
   - o No

Questions for other parameters, have been given in the Appendix 1. The questions are written in clear, concise, and uncomplicated language and acronyms, technical terms are avoided that may confuse the respondents. In some cases, definitions have been provided to include technical terms. In that way, it is ensured that the respondents can answer questions easily, and they are more inclined to answer all the questions. Since, the questions need to be match with the description of the levels of the framework, therefore, closed-ended questions are formularized so that respondents can choose from pre-specified answer choices which are easy to quantify. To keep respondents focused, limited number of questions have been asked and the application requires all questions to be answered to avoid missing key data [47].

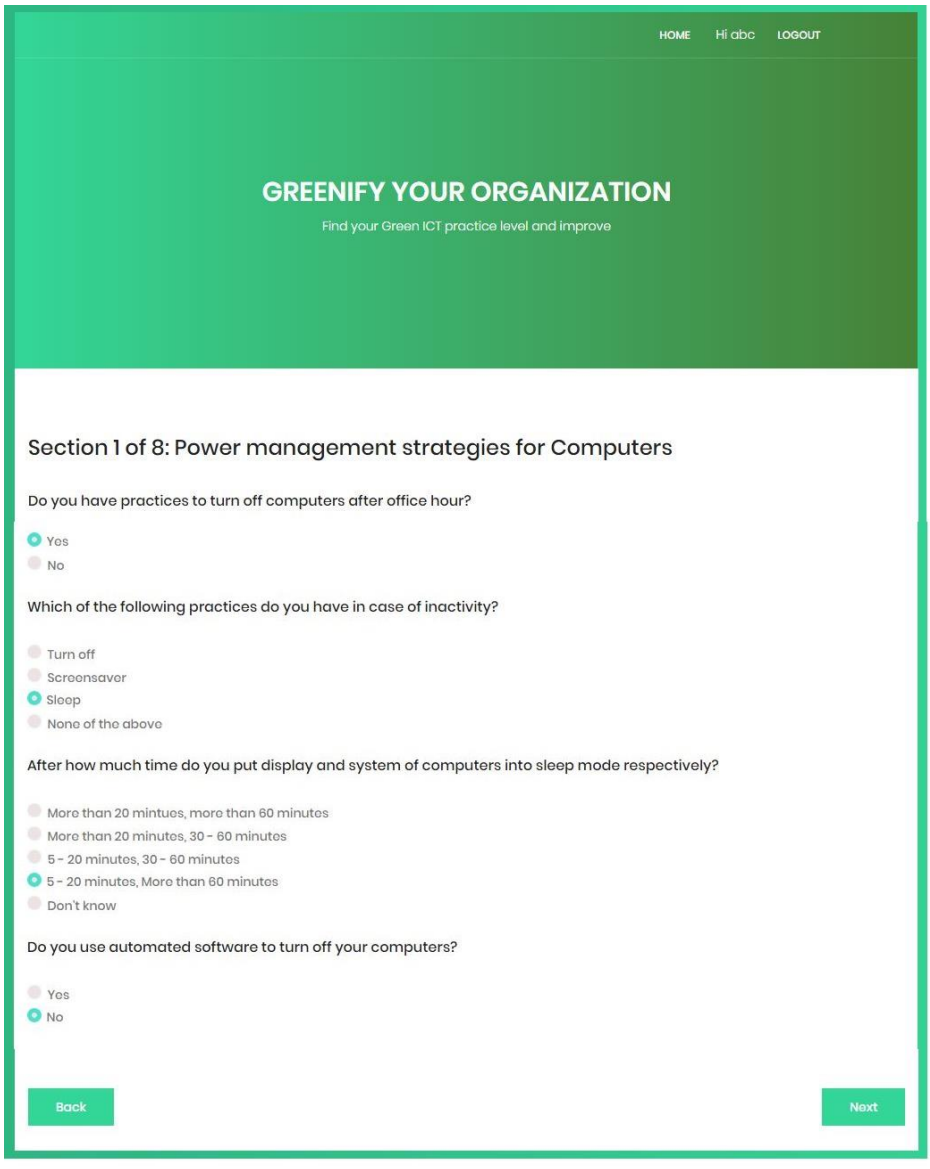

Figure 5. Questionnaire for Power Management of Computers Parameters

- Visualization of the current Green ICT practice level of SME

A simple logic has been developed to calculate the current level of Green ICT practices of SME from the selected options of the questions. The logic is presented below in a diagram:

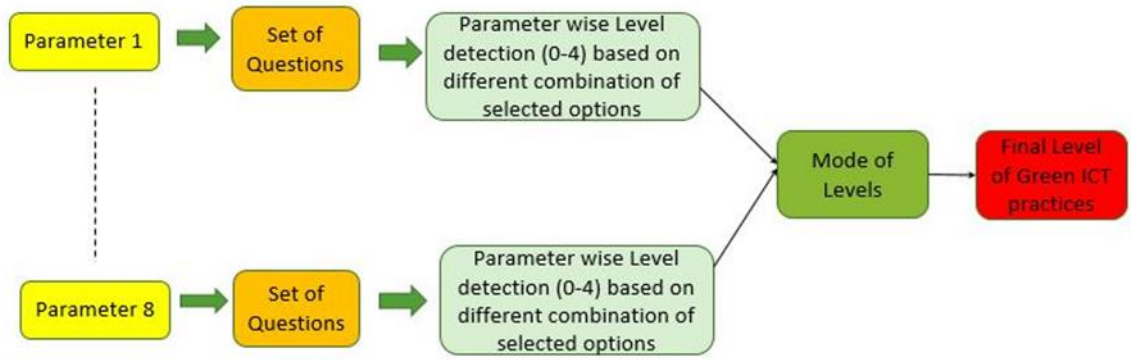

Figure 6. Calculation logic for Green ICT practice level detection

As shown in the figure 6, couple of questions are set for each of the parameter. Each option in a question has assigned a level that matches with the framework. Different combination of selected option for each parameter provides level ranging from 0-4. These logics have been implemented through JavaScript in the application. For example, considering the first parameter, "power management of computers", four questions are set. A scenario has been given as an example about how the calculation logic is developed for this parameter.

Table 6. Sample Responses of an SME for "Power Management of Computers" parameter

Question No.	**Question**	**Option**	**Level**	**Selected Option by SME**
1	Do you have practices to turn off computers after office hour?	a. Yes	1	✓
		b. No	0	

2	Which of the following practices do you have in case of inactivity?	a. Turn off		
		b. Screen saver	1	
		c. Sleep	2	✓
		d. None of the above	0	
3	After how much time do you put display and system of computers into sleep mode respectively?	a. More than 20 minutes, more than 60 minutes	1	
		b. More than 20 minutes, 30 - 60 minutes	2	
		c. 5 - 20 minutes, 30 - 60 minutes	3	✓
		d. 5 - 20 minutes, More than 60 minutes	4	
		e. Don't know	0	
4	Do you use automated software to turn off your computers?	a. Yes	4	
		b. No	3	✓
Aggregated Level for “Power Management of Computers”			3	

From table-6, result of an SME has been shown for “Power management of Computers” parameter. Four questions are formularized under this parameter. According to the selection by the SME, the individual level for this parameter is “3”. As a summary, it indicates that, the SME has practices turning off computers after office hour, during inactivity sleep mode is active on computers. Moreover, time for putting display and the

system into sleep mode are after 5-20 minutes and 30-60 minutes respectively. However, no automated software is used inside the SME to turn off computers automatically.

According to the combination of the selected options, it matches with the description level 3 of this parameter in the framework. Therefore, the aggregated level for this parameter is 3. Moreover, based on the selected option for each of the questions, a new question will appear. For example, if a respondent selects something other than (a) for question 2, then question 3 will not appear. The calculation logic varies in that way.

An example has been shown in table 7 about how the calculation logic for level detection has been developed for the above-mentioned scenario:

Table 7. A sample response of questions for "Power Management of Computers" parameter

	Question 1	**Question 2**	**Question 3**	**Question 4**	**Level**
Option	a	c	c	b	
Description of selected options	Computers are turned off after office hour	During inactivity sleep mode is active on computers	Time for putting display and the system into sleep mode are after 5-20 minutes and 30-60 minutes respectively.	No automated software is used inside the SME to turn off computers automatically	3

If only one of the option changes, the level will also change. Therefore, the combinations can be many for detecting level. For example, if a respondent selects option a for question number 4, the level will be "4". The calculation logic for this scenario is given in table 8:

Table 8. Another response of questions for “Power Management of Computers” parameter

	Question 1	Question 2	Question 3	Question 4	Level
Option	a	c	c	a	
Description of selected options	Computers are turned off after office hour	During inactivity sleep mode is active on computers	Time for putting display and the system into sleep mode are after 5-20 minutes and 30-60 minutes respectively.	Automated software is used inside the SME to turn off computers automatically	4

This logic has been implemented in the code using AND operation in JavaScript. After calculating level for each of the eight parameters in the way mentioned above, the mode operation is performed to provide an overall Green ICT practice level. Mode operation is chosen for detecting the aggregated level because it provides the most frequently appeared level. Moreover, since an SME can be in different level for different parameters, therefore it is difficult to provide an exact level from those parameter wise levels. Hence, this approach is followed to provide an overall Green ICT practice level to SME.

Table 9. Scenario for Green ICT practice levels for different parameters for an SME

Parameter	**Green ICT Practice Level**
Power management of computers	1
Reduction of computers for power management	1
Power Management of Imaging Equipment	1
Paper saving from ICT equipment	1
Power management of video conferencing suite	2
IT Load Reduction Management of Server	3
Cooling management of ICT equipment	2

Management of E-waste disposal	0
Aggregated/Final Level	**1**

From the table 9, among the eight parameters, four of the parameters are in level “1”. According to mode operation, which defines the most frequently appeared level, the aggregated level for the above scenario is “1”.

In the application, a detailed list of current situations of Green ICT practices are provided at the end of the test in the application. It displays the current level of green ICT practices and provides a tag line (such as, Novice, Beginner, Expert and many others) to indicate level 0 to 4 respectively. It aware end-users about their current level and encourages for improvement. (see figure 7)

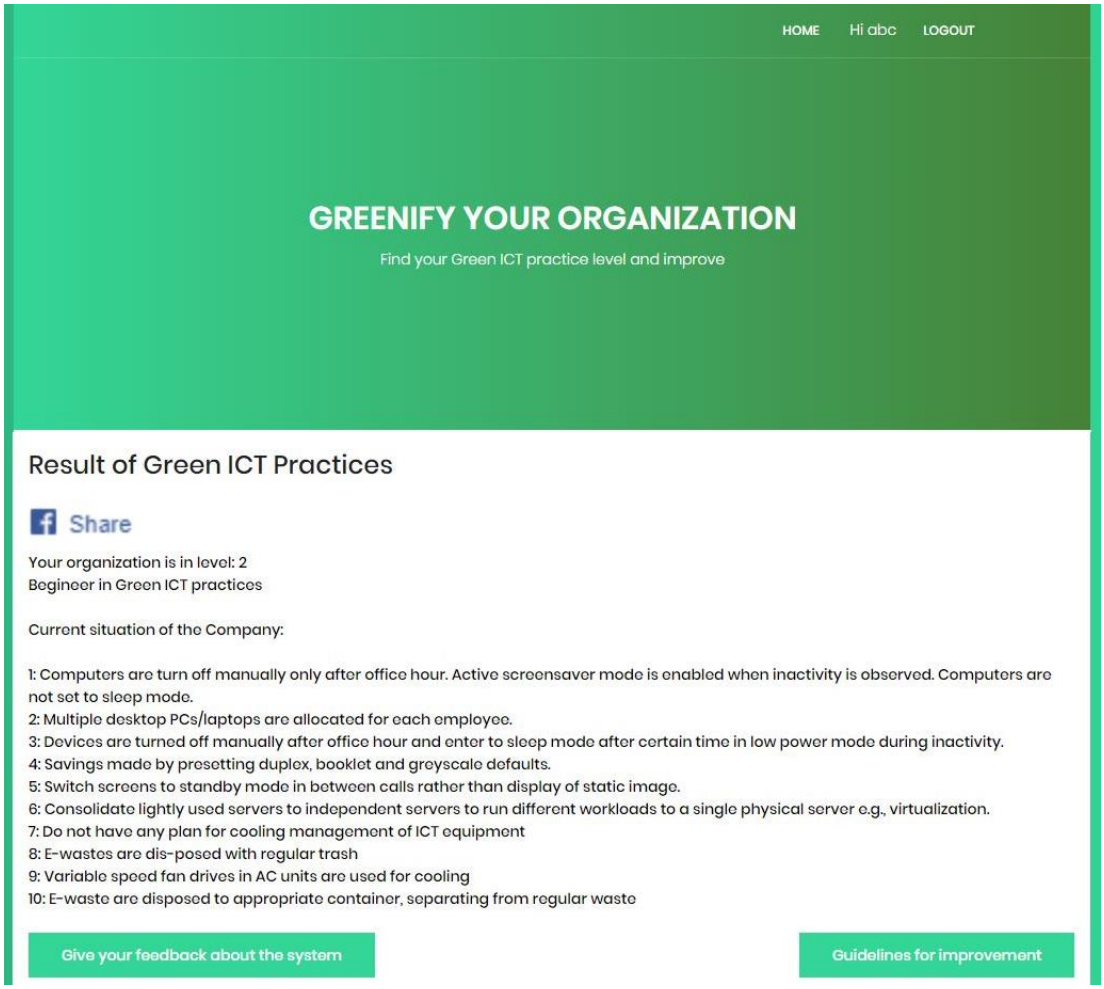

Figure 7. Detailed list of practices for Green ICT situation of an SME

- Comparison of Green ICT practice level with other organizations

Upon detecting the level for Green ICT practices, a comparison has been made with other SMEs who already took the test through this application. For the other SMEs levels, the most frequently appeared level is determined as the overall level for all other SMEs. Suppose, eight SMEs participated in testing the application. Their Green ICT practice levels are “1”, “3”, “4”, “2”, “2”, “3”, “2”, “2” respectively. Since, most of the SMEs are in level 2, therefore, the overall level for all other SMEs are set as “2”. This is the implementation of the mode operation logic.

In the application, the comparison has been made through graphical representation through bar charts. The chart is implemented from https://canvasjs.com/html5-javascript-bar-chart/. The page can be accessible after a logged in user completes answering all the questions.

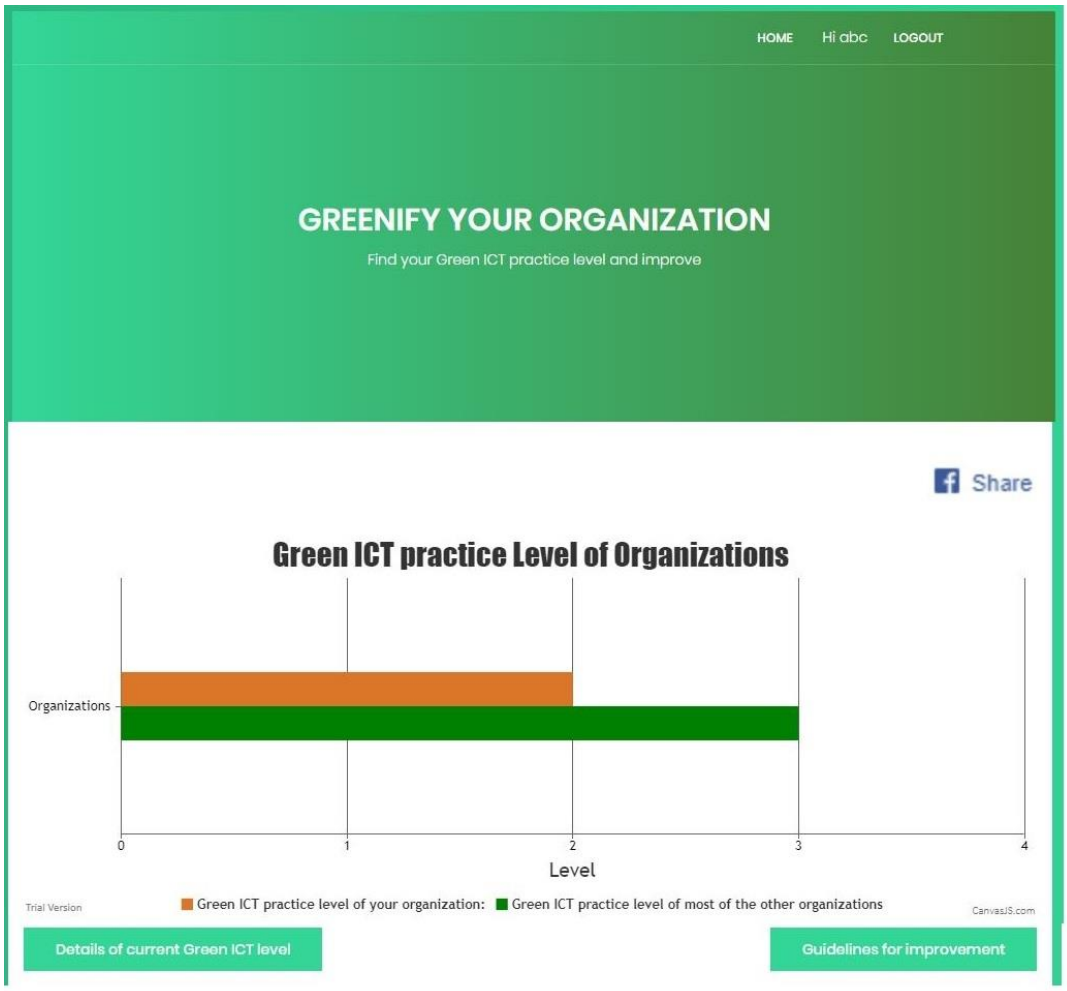

Figure 8. Results and comparison of Green ICT practice levels of SMEs

- Improvement Suggestions

Based on the current level, guidelines for improvement are provided. Improvement are suggested both parameter wise and overall. For the parameter improvement wise suggestions, at first the level is determined for that parameters. Then immediate actions are suggested. Finally, an overall guideline is provided for that specific parameter to go to the nearest next level.

Different parameters can be in different levels and an SME cannot go to the next level until it fulfills the all strategies of its present level in each of the parameter. For that, an overall improvement suggestion is also provided to user for taking steps to go to the next level with the combination of all the parameters.

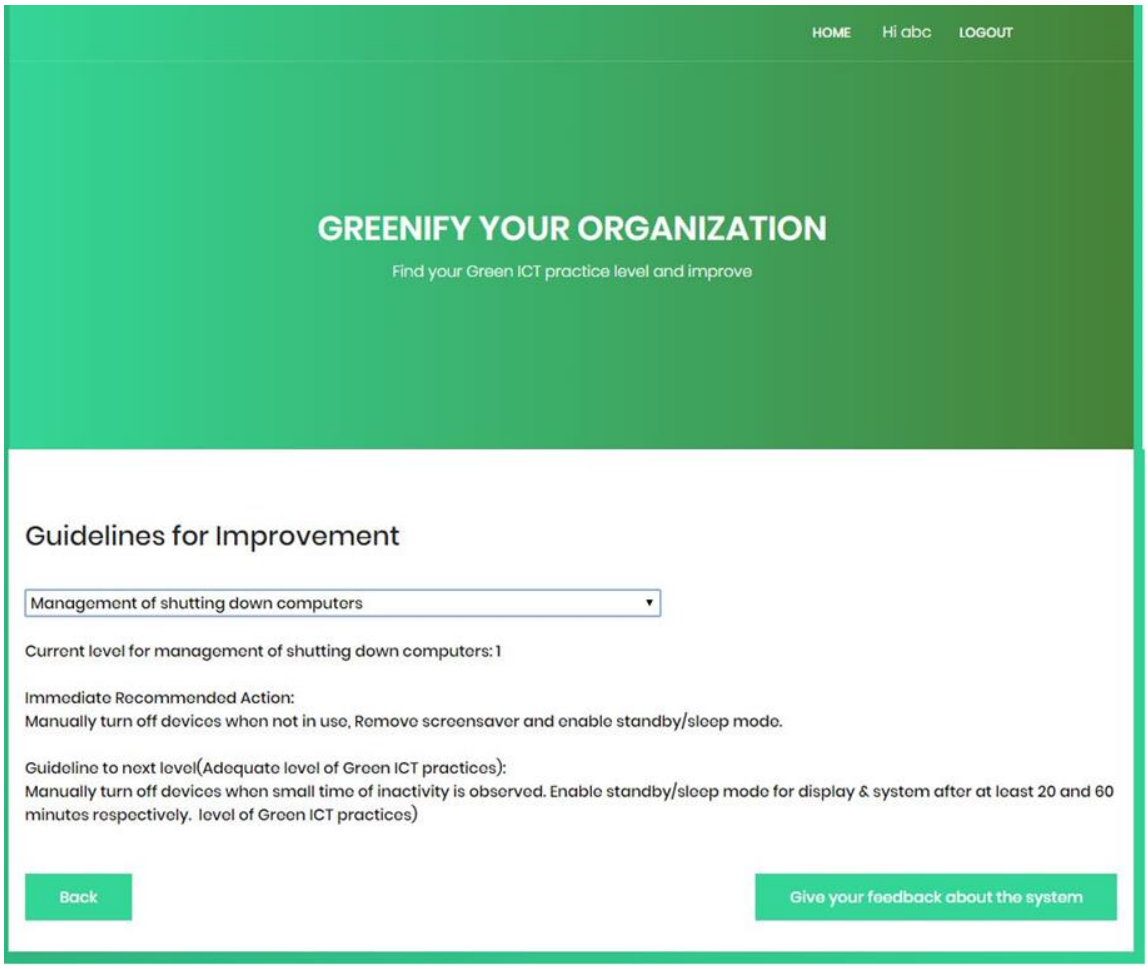

Figure 9. Parameter wise "Guidelines for Improvement" page

- Social Media Sharing Feature

A special feature is included to share the status of Green ICT practices of an SME through social media such as Facebook. The reason behind including this feature is to provide a way to the SME so that the social image of the organization can be increased in the business community. The Facebook sharing feature can be found when a logged in user submits answers for each of the questions.

- Tracking results of previously taken test

Moreover, a user can take the test as many times he wants. He can track the records of previously taken test by clicking on the" See previous button" in the Home Page (figure 11).

4.5 User Interaction with Application

There are several pages in the application. At first in the" Home Page" (see figure 11), user needs to click on" take the test" button to start the test. Then he/she needs to complete answering all the questions in separate sections. However, a user must be logged in before answering those questions. If he/she is a new user, then he/she needs to register by providing some basic information about the company which will be kept anonymous.

After answering all those questions, when a user clicks on" Finish" button, he/she will get current Green ICT level of his/her SME. He/she will also get improvement suggestions for each of the individual parameters by clicking on" Guidelines for improvement" button. Moreover, user will be able to track records of previously taken test from the homepage. This can be done by clicking on the" See previous results" test. However, a user must be logged in before viewing the previous test results.

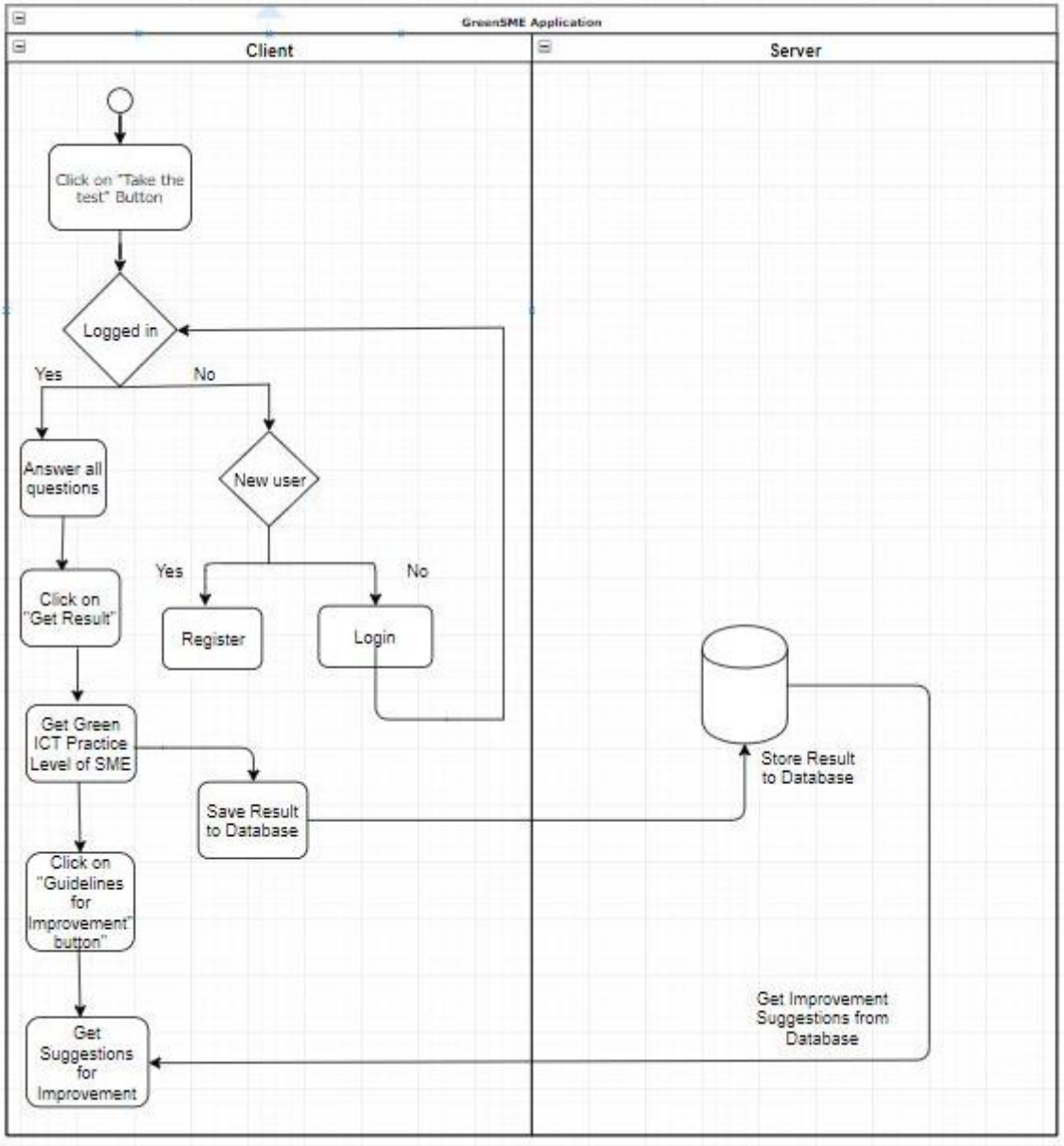

Figure 10. Process overview of user interaction with GreenSME Application

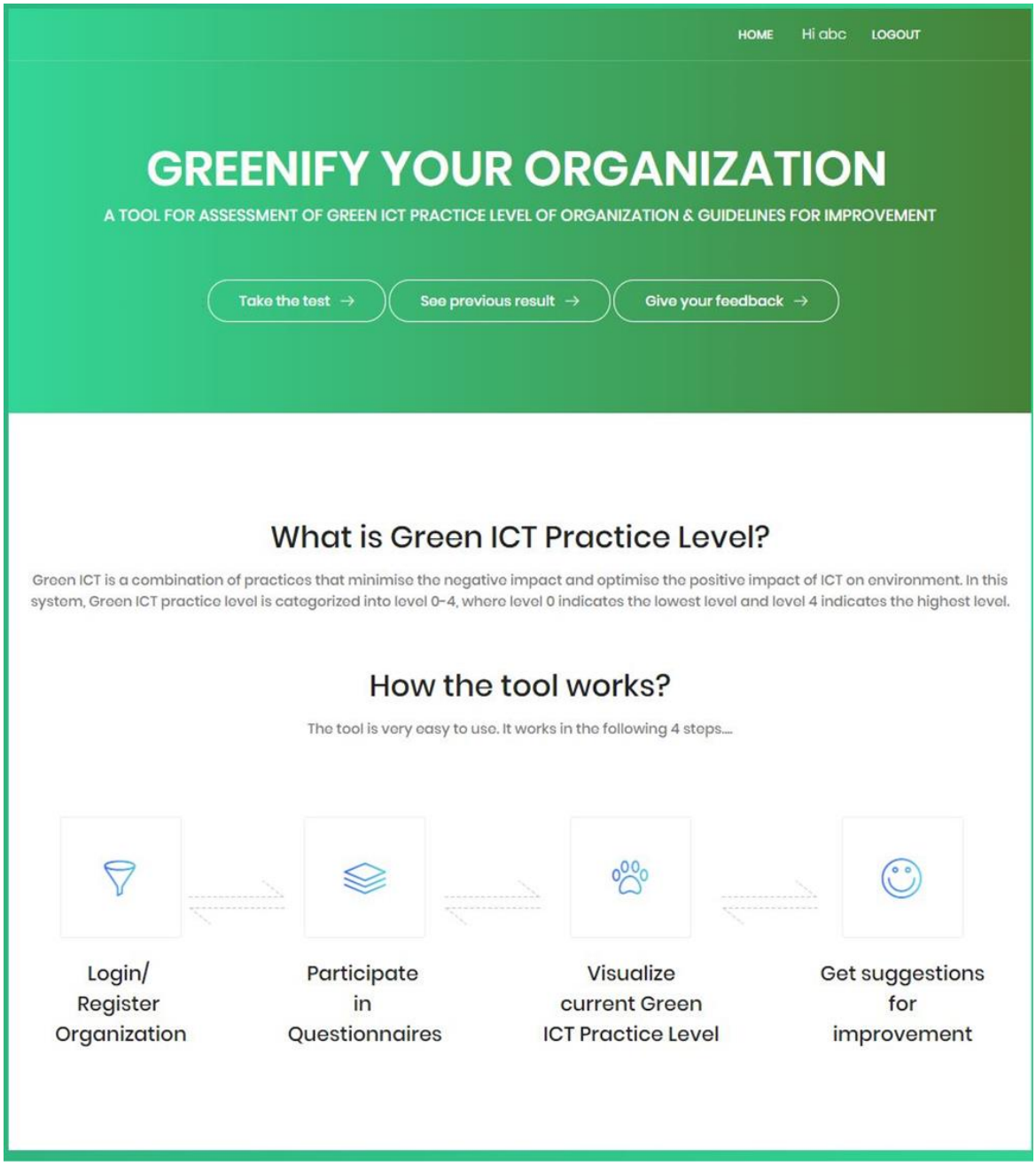

Figure 11. Landing/Home Page of GreenSME Application

5 RESULTS AND DISCUSSIONS

The GreenSME Application has been tested in eight SMEs (four in Finland and four in Bangladesh) by the IT specialists. The number of employees in the start-up companies are around 10-12 and in the regular sized SMEs are around 50-100. The SMEs are software companies. At first online interviews have been conducted with SMEs to know the basic information such as, organization's employee size, problems and goals of their business etc. However, organizations identify is kept anonymous for this research. Next, a request with website link of the application has been sent to the organizations to participate in the testing. This request has been sent through e-mail to several organizations. The request form can be found in the appendix 3.

5.1 SMEs responses from the Application

In the table-10, SME 1 and 2 are medium sized organizations in Finland, where number of employees are less than 250. SME 3 and 4 have employees about less than 50, therefore they are small-sized enterprises. On the other hand, SME 5 & 6 are medium sized and SME 7 & 8 are small sized enterprises, where the number of employees is less than 50 and 150 respectively.

Table-10. Results from the SMEs

Country	Finland				Bangladesh			
SMEs	SME 1	SME 2	SME 3	SME 4	SME 5	SME 6	SME 7	SME 8
Number of Employees	72	100	15	35	65	90	12	20
Power Management of Computers	2	2	2	2	2	2	1	1

Reduction of number of computers for power management	2	3	1	2	1	1	1	1
Power Management of Imaging Equipment	3	3	1	1	2	1	0	1
Paper Saving from ICT equipment	2	3	1	1	2	2	0	0
Power Management of Video Conferencing Suite	2	2	0	0	0	1	0	0
IT Load Reduction Management of Server	1	0	1	0	0	0	0	0
Cooling Management of ICT equipment	2	3	0	1	0	0	0	0
Management of E-waste disposal	1	2	1	1	0	0	0	0
Aggregated/ Final Level	2	3	1	1	0	0	0	0

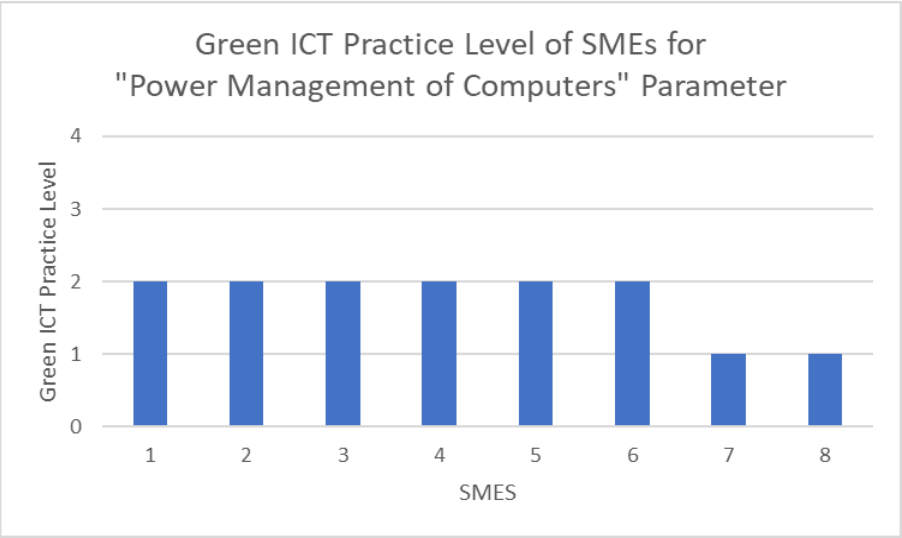

Figure 12. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for "Power Management of Computers" Parameters

Considering the "Power management of computers" parameter, most of the organizations (1 - 6) are in level 2, which indicates that computers are turned off after office hour and put into sleep mode during inactivity. This feature is visible in medium-sized and start-up SMEs in Finland. However, in Bangladesh, in the medium-sized SMEs (5 & 6), this practice is observed. In the start-up companies in Bangladesh (7 & 8), the level is 1 for this parameter which means that though computers are turned off manually after office hour, instead of sleep, screensaver is set in case of inactivity.

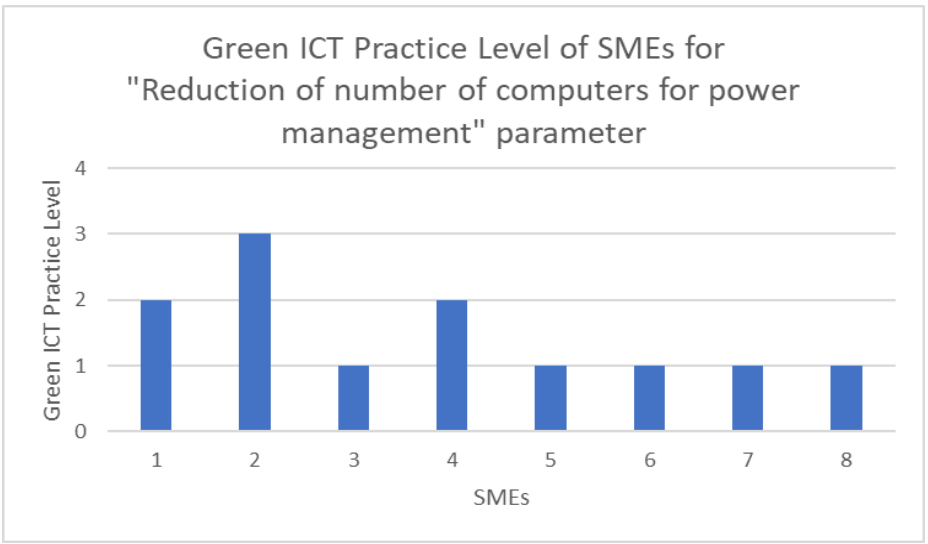

Figure 13. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for "Reduction of number of computers for power management" Parameters

For the ”Reduction of number of computers for power management” parameter, it can be seen that SME 2 in Finland possesses the highest level 3, where only one laptop is allocated for each employee.. However, the same sized organization is SME 1 is in level 2, which indicates that multiple laptops are allocated for each employee no desktop PC exists. Therefore, it can be said that medium-sized sized SMEs are trying to reduce the use of desktop PCs by their employees and practices of using laptop PC is observed now-a-days. On the other hand, considering the SMEs in Bangladesh, all the start-ups and medium-sized sized companies are in level 1, which means that multiple desktop PCs/laptops are allocated for each employee. Therefore, there is less concern about the reduction of number of computers for power management.

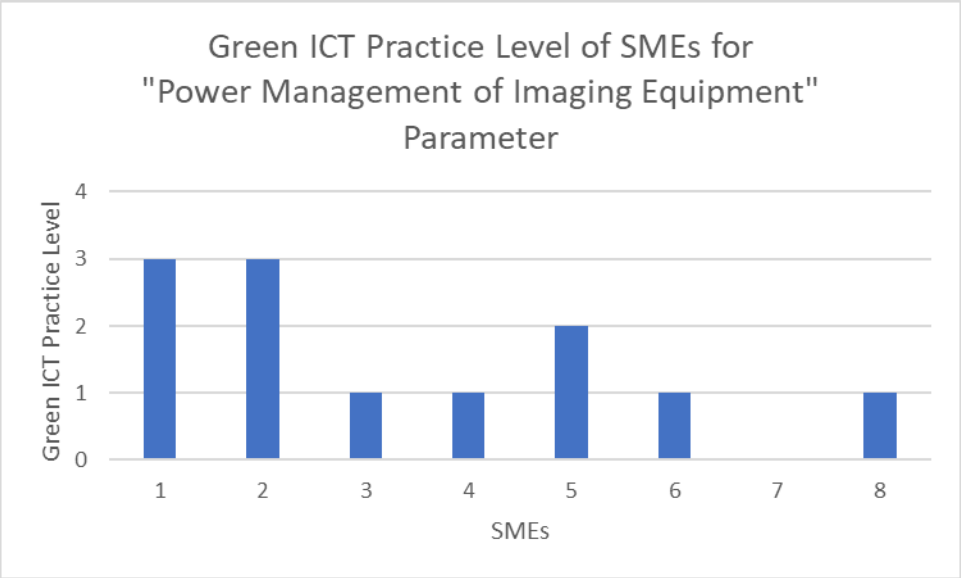

Figure 14. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for “Power management of Imaging Equipment” Parameters

According to the graph in figure14, it can be seen that in the SME 1 and 2 in Finland where number of employees are around 100, the green ICT practice level is ”3”. It refers that timer switches are used to turn off devices during inactivity. However, SME 3 and 4, which are small sized SMEs in Finland, which are in level 1. Practices such as, turn off devices manually after office hour and enter to low power mode after certain time of inactivity is observed. On the other hand, SMEs in developing country, Bangladesh, possesses mostly in between 0-2 level. These means that imaging equipment like printers, scanners, phtotocopiers are not turned off after office hour and no low power or sleep

mode is enabled during inactivity. SME 6 and 8 which are medium-sized sized and small sized companies are in level 1, where imaging equipment are turned off manually after office hour and put into low power mode during inactivity. Moreover, SME 5, which is also a medium-sized organization, is in level 2, that means, devices are turned off manually after office hour and enter to low power mode after certain time of inactivity.

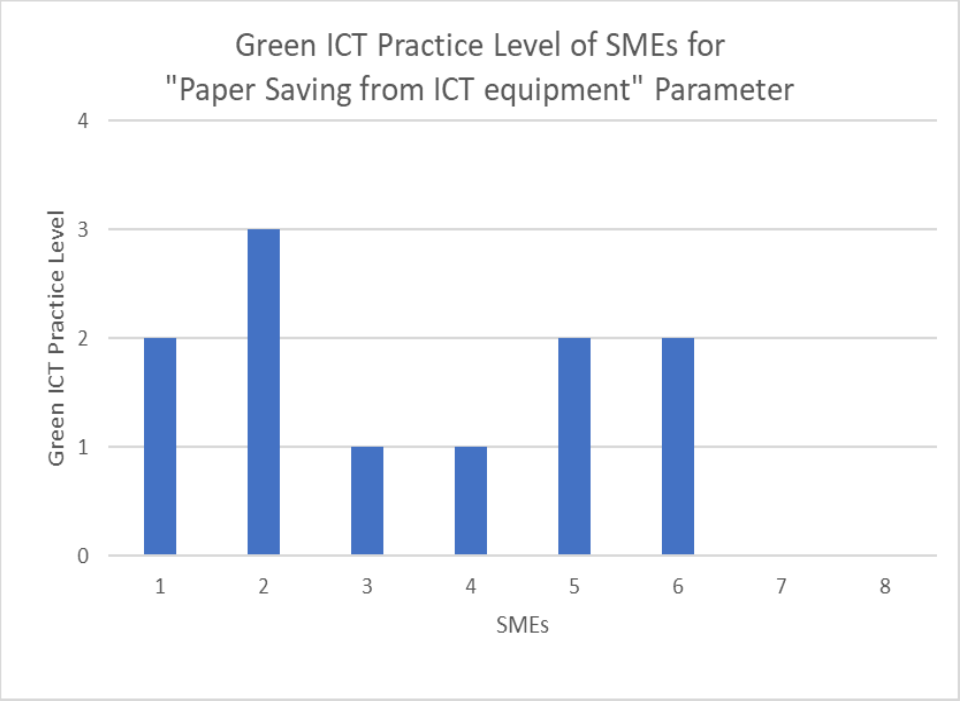

Figure 15. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for "Paper Saving from ICT Equipment" Parameters

In figure 15, medium sized companies SME 1 and 2 in Finland, are in level 2 and 3 respectively which indicates that imaging equipment kept centrally so that one equipment can be used by multiple employees. Moreover, locked printing feature is used some times. In addition, SME 5 and 6, medium sized companies in Bangladesh, are also in level 2, where centralized imaging equipment is used but locked printing feature is not observed in the equipment. However, small sized enterprises SME 7 and 8 of Bangladesh, do not follow any strategies for paper saving, therefore nothing has been shown in the graph. On the other hand SME 3 and 4, though also small-sized enterprises, savings are made by presetting duplex, booklet and greyscale defaults.

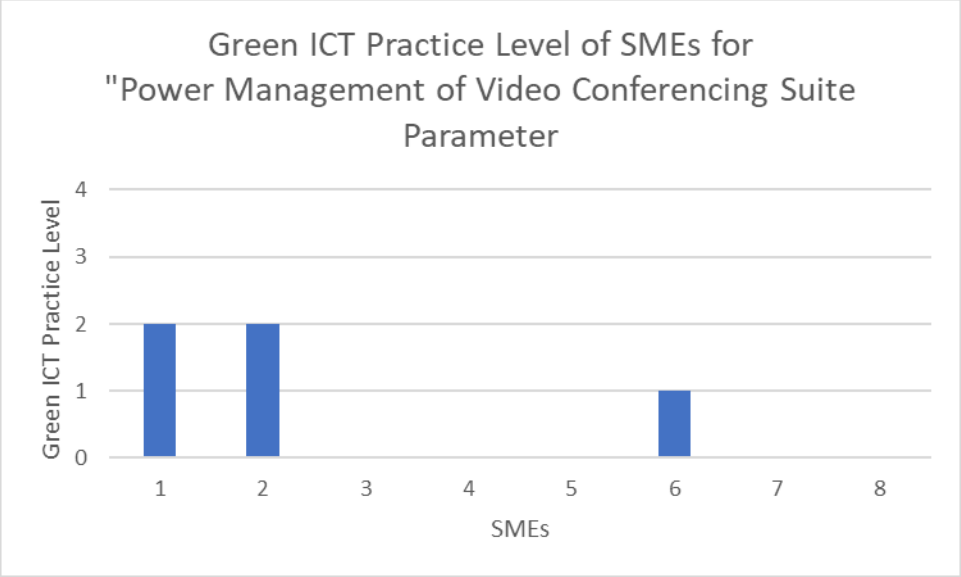

Figure 16. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for "Power Management of Video Conferencing Suite" Parameters

Considering the figure 16, it can be seen that, medium sized enterprises such as, SME 1 and 2, are in level 2, for the power management of video conferencing suite parameter. It means that, video conferencing suites are manually turned off after office hour. On the other hand, both in small sized enterprises in Finland and Bangladesh are in level 0 since they do not have video conferencing suite and in case they have they do not turn off it after office hour, rarely put it to sleep mode after office hour.

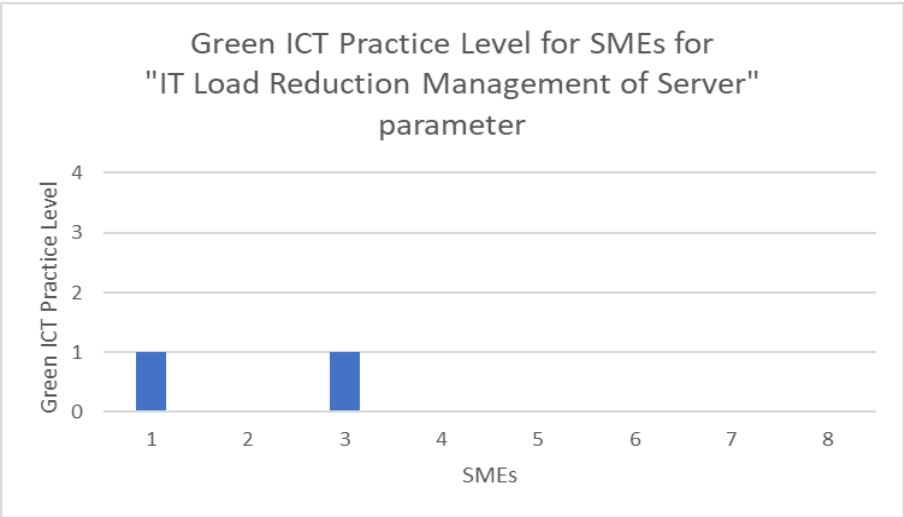

Figure 17. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for "IT load reduction management of servers" Parameter

From figure 17, it is clearly observed the levels are very low in all the SMEs for IT load reduction management of servers parameter. Only in SME 1 and 3 which are medium and small sized enterprises, the level is 1, which means that decomssion of unused servers is implemented. However, in most of the other SMEs in Finland and Bangladesh, the level is 0, which indicates that several single independent servers with low utilization or no server exists in the organization. However, no strategies are followed to consolidate or virtualize the server.

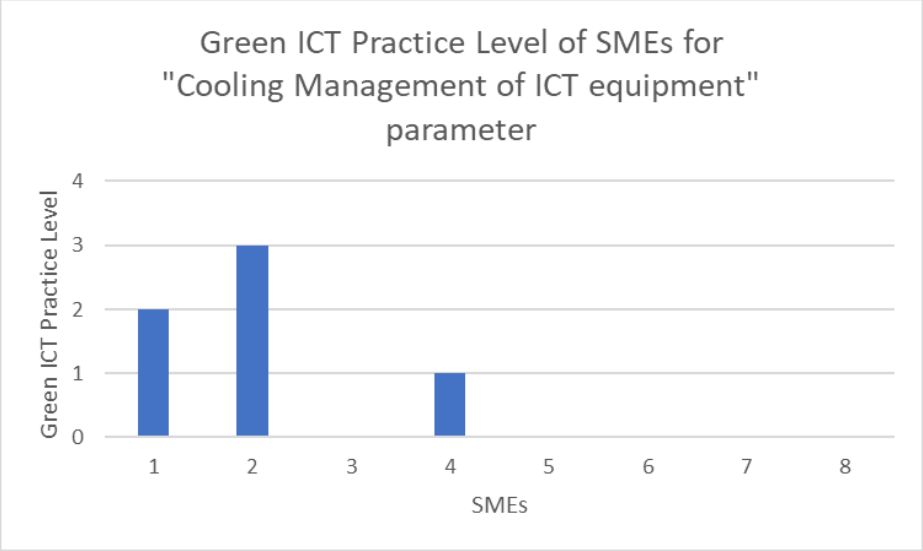

Figure 18. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-for "Cooling management of ICT equipment" Parameters

In figure 18, the highest level observed for cooling management of ICT equipment parameter exists in SME 2, which is 3. It refers that variable speed fan drives are used in AC units for cooling management. However, this is not common, in all SMEs in Finland, because all the other SMEs are in between 0-2 level. SME 1 which a medium sized organization possesses level 2, that indicates enclosures are used around server racks to reduce the mixing of cold air and hot exhaust air. Other small organizations in Finland are either in level 0 or 1, which means SMEs have no plan to take any initiatives for cooling management of ICT equipment. In case they possess, no implementation is observed.

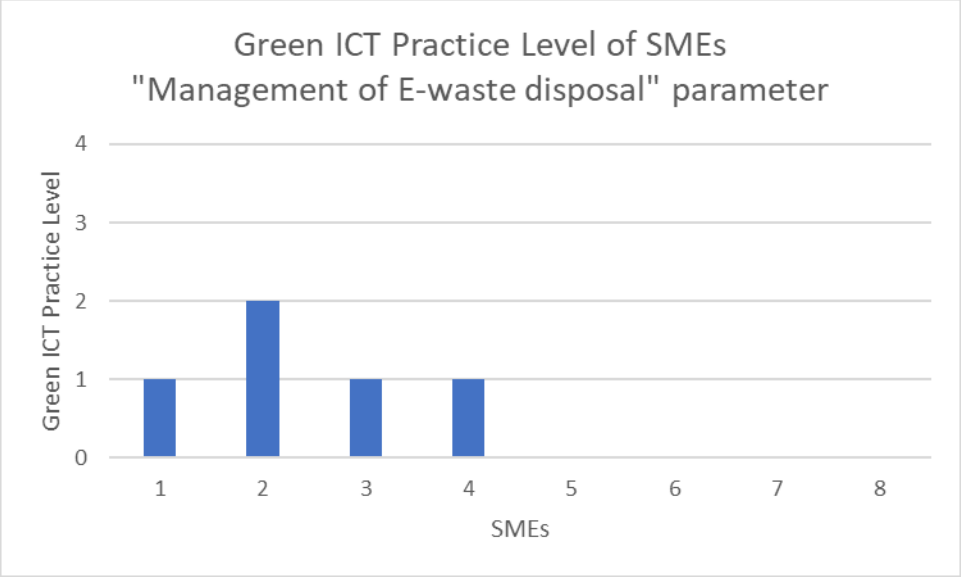

Figure 19. Green ICT Practice Level of SMEs of Finland (SME 1-4) & Bangladesh (5-8) for "Management of E-waste disposal" Parameters

Moreover, considering the management of E-waste disposal parameter, in Finland, which is a developed country, all the organizations are in level 1, except SME 2, that means e-wastes are disposed into appropriate container, separating from the medium-sized wastes where as in developing country, Bangladesh, e-wastes are disposed with medium-sized wastes, often not disposed at all. However, in only SME 2, which is a medium-sized enterprise, it is in level 2, which is better in managing e-waste disposal. e-wastes are sold to second hand shop or donate to charity organizations in the SME.

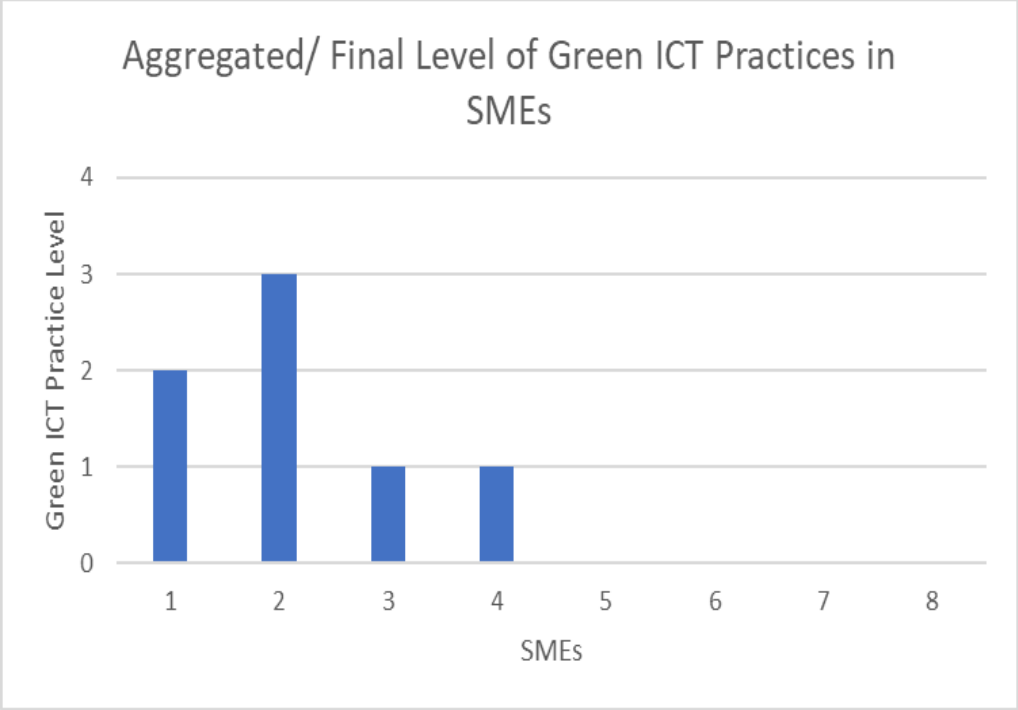

Figure 20. "Aggregated/Final Level of Green ICT Practice Level of SMEs" (SME 1-4 in Finland, SME 5-8 in Bangladesh)

In figure 20, the final level of Green ICT of the SMEs in Bangladesh is 0, therefore nothing has been shown in the graph. The overall level indicates that SMEs in Finland are in the higher level where SMEs in Bangladesh are in the lowest level of Green ICT practices. Though, in some cases, medium sized SMEs in Bangladesh is in the similar levels as the start-up or small sized enterprises, in Finland, considering all the parameters the overall or aggregated level for the SMEs in Bangladesh are still in very low level. To summarize, SMEs in developed countries like Finland possess better practices of Green ICT than developing countries like Bangladesh. According to [48], the main barriers for implementing green ICT in developing country is highlighted. According to survey conducted in the developing country, Kenya, the lack of green ICT trained human resource is found as the main barrier to implementation of green ICT practices.

The alternate hindrances to green ICT implementation inherited from the survey are incorporate absence of budget distribution to green ICT, lack of schemes for green ICT, absence of high management best administration bolster, absence of workshops and seminars for increase awareness about Green ICT execution, dependence on donations for acquiring ICT equipment, quick changes of technologies, absence of knowledge about

where to start for Green ICT, presence of legislation that blocks execution of green ICT, general association protection from change, dread of inability to acknowledge noteworthy ecological effects etc. [48].

5.2 Survey Results about usability of GreenSME Application

After that eight SMEs participated in the testing, a google survey forms' link has been sent to these SMEs to provide their feedback about usability of the application.

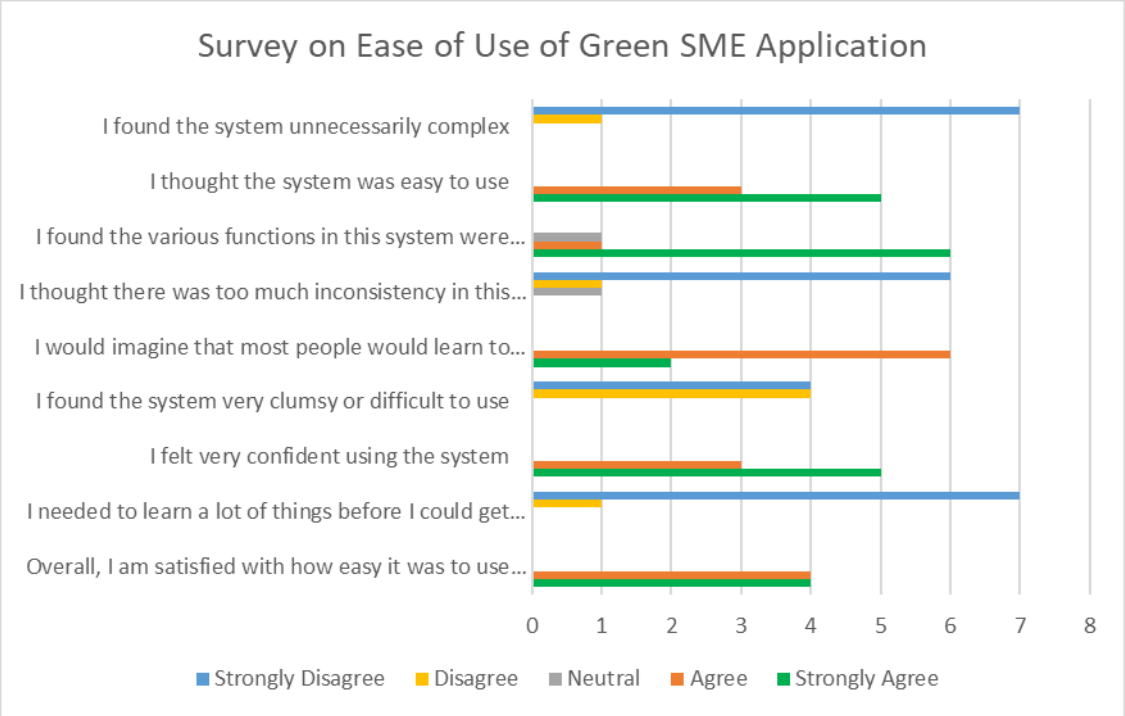

Figure 21. Survey on usability of GreenSME Application

The survey is conducted to understand the usability of the application. The responded found the application very easy to use. Moreover, they added that they need not to learn many things before using it. Overall, the participants provided positive responses about the ease of use of the application.

5.3 Survey Results about SME's Perception about GreenSME Application

After the application has been tested by the SMEs, a survey has been conducted to understand SMEs' perception about the possibility to achieve sustainability through the GreenSME application. Survey questionnaire have been made to know whether by practicing the actions suggested in the application can provide economic, environmental and social benefits to sustain the business. Most of the SMEs believe the recommendation provided are helpful for reducing cost of their businesses and raising environmental awareness among employees to efficiently use ICT equipment. However, since some of the SMEs are in low level of Green ICT practices, neutral responses have been found about the social sustainability aspects of the application, for example, they may not want to publish their low levels Green ICT practice results in social media.

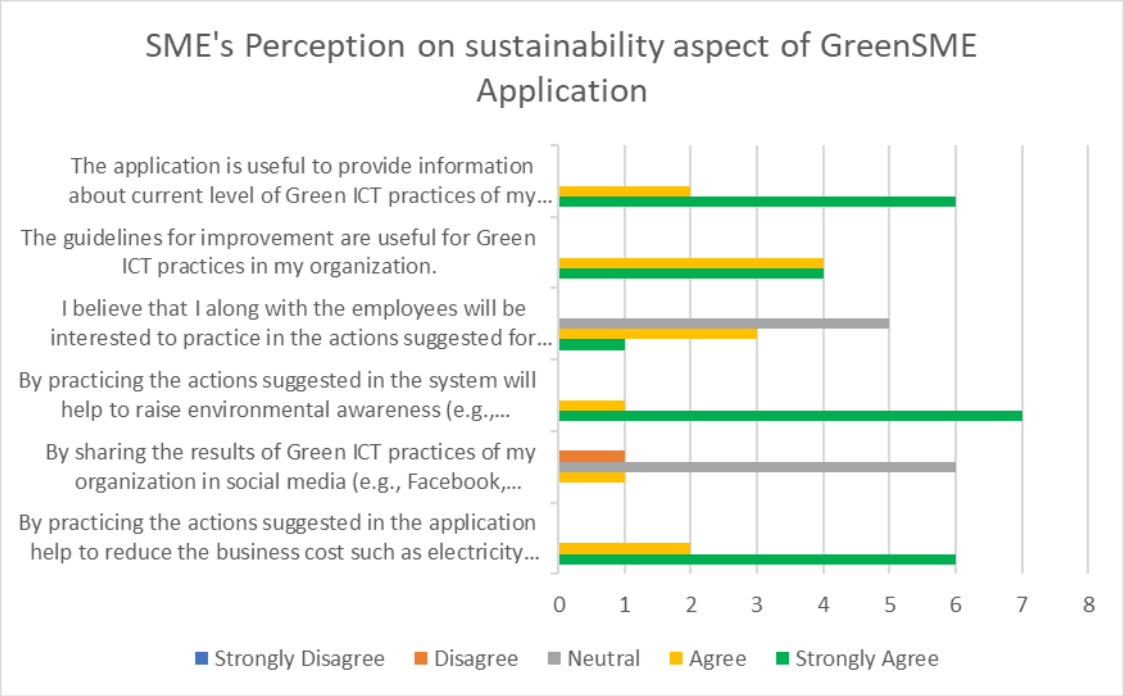

Figure 22. Perception of SMEs about sustainability aspects of GreenSME Application

5.4 Sustainability Analysis of GreenSME Application

A sustainability analysis model was presented by Becker to analysis the systemic effects of a software on the five dimensions of sustainability [49]. The dimensions are, individual, environmental, technical, economic and social [49].

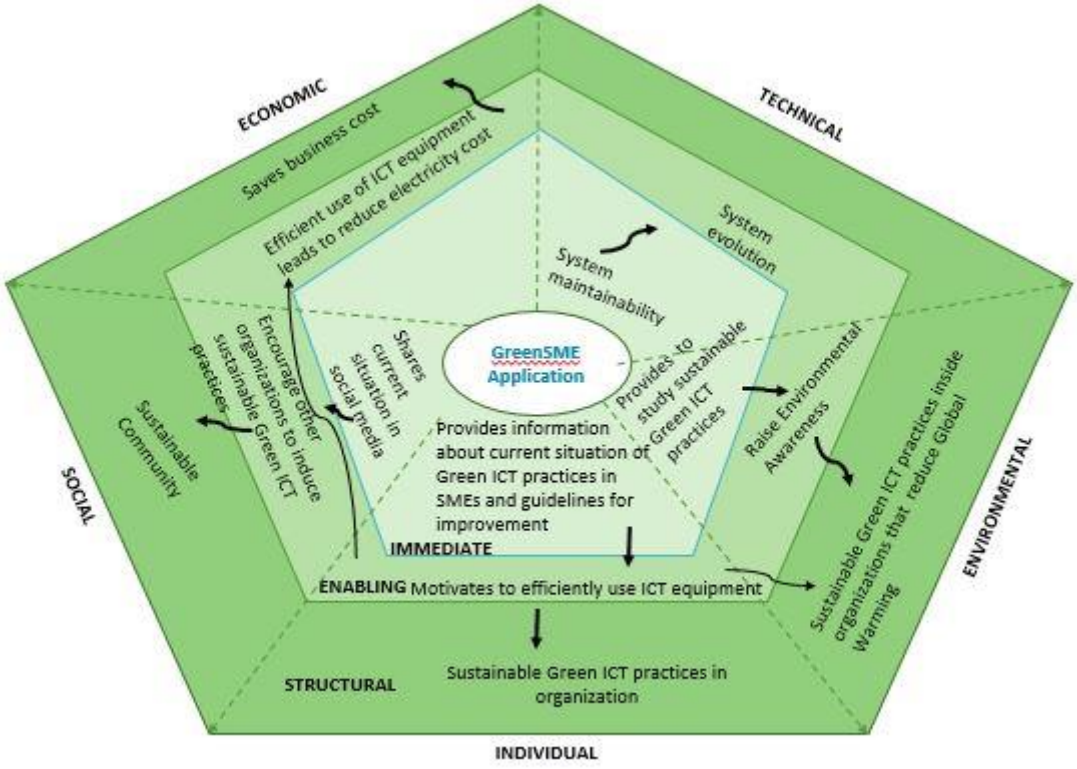

Figure 23. Immediate, enabling and structural effects of GreenSME application in five sustainability dimensions [49]

From the individual perspective of sustainability, the application provides information about current situation of Green ICT practices in SMEs and guidelines for improvement, motivates to efficiently use ICT equipment, thus leads to a sustainable life-style. Moreover, by practicing the actions suggested in the application, raise environmental awareness among employees, which eventually contribute to reduce global warming. Therefore, the application can satisfy the environmental aspect of sustainability. From the social aspect, the application has possibilities to enable a sustainable business community by sharing the results of Green ICT practice level in social media. The goal of this application is to, motivate SMEs to efficiently use ICT equipment which could result in less electricity cost,

consequently, reduces business costs. In addition, the application is developed in an extensible style which ensures the technical sustainability of the system. Thus, the application has positive impacts regarding individual, economic, environmental, social and technical aspects of sustainability.

6 CONCLUSION

This paper proposes a framework by mapping ICT Greening maturity level with the strategies that SMEs now-a-days are following for Green ICT. A web application has been developed out of the framework for self-assessment and improvement of sustainable Green ICT practices in SMEs. Results from the application provided by the participants in eight SMEs of Finland and Bangladesh, have been analyzed in the context of Green ICT practices in developed and developing countries and it has been found that due to the lack of Green ICT knowledge and practices, SMEs in developing countries exists in the low level of Green ICT practices than developed countries. Moreover, sustainability aspects of the application have been analyzed through survey. The result indicates that participants have provided positive responses towards the prospects of sustainability of their business through this application. They believe that the information provided in this application is helpful for economic, environmental and social benefits to sustain their businesses. Moreover, according to the model provided in [49], the application satisfies individual, economic, environmental, social and technical aspects of sustainability.

The limitations of this thesis are: 1) This research is limited to only SMEs. 2) Scope of this research focuses mainly on ICT usage management in SMEs for a greener and sustainable future. 3) The web application has been tested only by software companies. Therefore, testing the application in different types of organizations and further analysis on providing improvement suggestion has left undone for future work.

This research is under peer-reviewed process for an open-access publication in a journal. Moreover, it is available online as a preprint of the manuscript—in advance of peer review and formal publication in the journal which can be found at [50].

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Appendix 1. Questionnaire

Section 1: Power Management of Computers

1. Do you have practices to turn off computers after office hour?
o Yes
o No
2. Which of the following practices do you have in case of inactivity?
o Turn off
o Screen saver
o Sleep
o None of the above
3. After how much time do you put display and system of computers into sleep mode respectively?
o More than 20 minutes, more than 60 minutes
o More than 20 minutes, 30 - 60 minutes
o 5 - 20 minutes, 30 - 60 minutes
o 5 - 20 minutes, More than 60 minutes
o Don't know
4. Do you use automated software to turn off your computers?
o Yes
o No

Section 2: Reduction of number of computers for power management

5. Have you taken any consideration to reduce the number of computers in your organization?
o Yes
o No
6. Which of the following situation exists in the company?
o Multiple desktop / laptop allocated for each employee
o Multiple laptops are allocated for each employee, but no desktop PC exists

Appendix 1. Questionnaire (Continues)

o One laptop is allocated for each employee

7. Do you use thin client or energy star rated computers in your company?

o Yes

o No

o Don't know

Section 3: Power Management of Imaging equipment (Printers/scanners/photocopiers)

8. Do you have practices to turn off (printers/scanners/photocopiers) after office hour?

o Yes

o No

9. Which of the following practices do you have when printers/scanners/photocopiers remain inactive?

o Turn off

o Screen saver

o Sleep

o None of the above

10. Have your (printers/scanners/photocopiers) enabled to sleep mode when idle in power saving mode?

o Yes

o No

11. Which of the following do you use to turn off devices/power management of (printers/scanners/photocopiers)?

o Timer switch

o Smart Power Strip

o None of the above

Section 4: Paper saving from ICT equipment

12. Which of the following practices do you have for paper saving from ICT equipment?

Appendix 1. Questionnaire (Continues)

o Do not have any practices yet

o Use recycled paper for printing

o Set duplex booklet and grayscale defaults for printing

o Others

13. Which of the following do you maintain for printers?

o Private use of printers

o Collect / centralized

14. Do you have locked printing feature enabled in the imaging equipment (e.g., printer)?

o Yes

o No

15. Do you use energy star rated imaging equipment (e.g., printer)? *

o Yes

o No

o Don't know

16. Do you use multifunctional imaging equipment in your organization (e.g., printer)? *

o Yes

o No

Section 5: Power Management of video conferencing suite

17. Do you use video conferencing suite in your organization?

o Yes

o No

18. Do you have practices to turn off video conferencing suite after office hour?

o Yes

o No

Appendix 1. Questionnaire (Continues)

19. Do you have practices to standby video conferencing suite after office hour?o Yes

o No

20. Which of the following practices do you have in between calls?

o Static image is displayed

o Screen is switched to standby mode

21. Do you use automated software to power down devices?

o Yes

o No

Section 6: IT Load Management of Server

22. Do you have several independent servers with low utilization in your organization?

o Yes

o No

23. Do you decompose your unused servers?

o Yes

o No

24. Have you implemented virtualization with these servers?

o Planning but not implemented yet

o Yes

o Do not have plan to virtualize

25. Do you use energy efficient servers?

o Yes

o No

o Don't know

Section 7: Cooling Management of ICT equipment

26. Have you implemented any practices for ICT cooling management?

o Planning but not implemented yet

Appendix 1. Questionnaire (Continues)

o Yes

o Do not have any plan

27. Which of the following have you implemented for cooling management of ICT equipment?

o Enclosures on all sides of server racks

o Different speed fan drives in AC units

o Airflow maintenance devices (for example- structured cabling system, diffusers and blanking panels)

o None of the above

Section 8: Management of E-waste disposal

28. How do you dispose e-wastes produced in your company?

o Dispose with medium-sized trash

o Dispose to appropriate container, separating from medium-sized waste

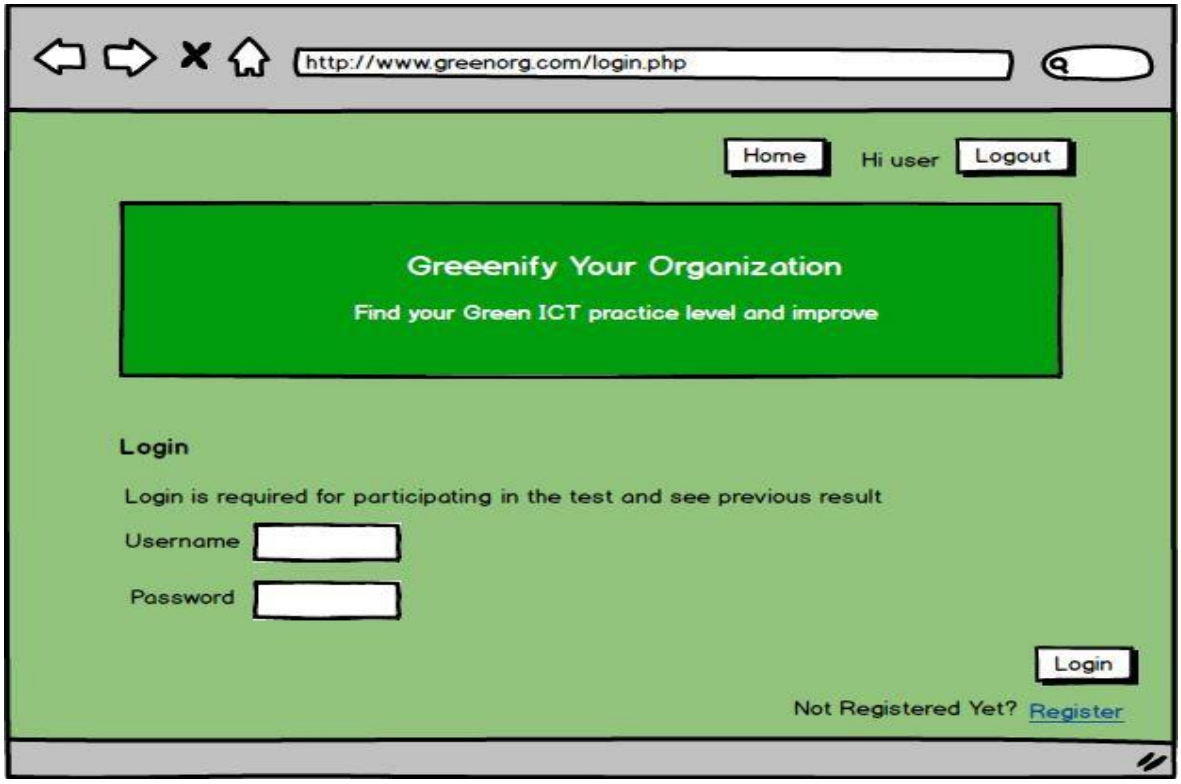
o Sell to second hand shop or donate

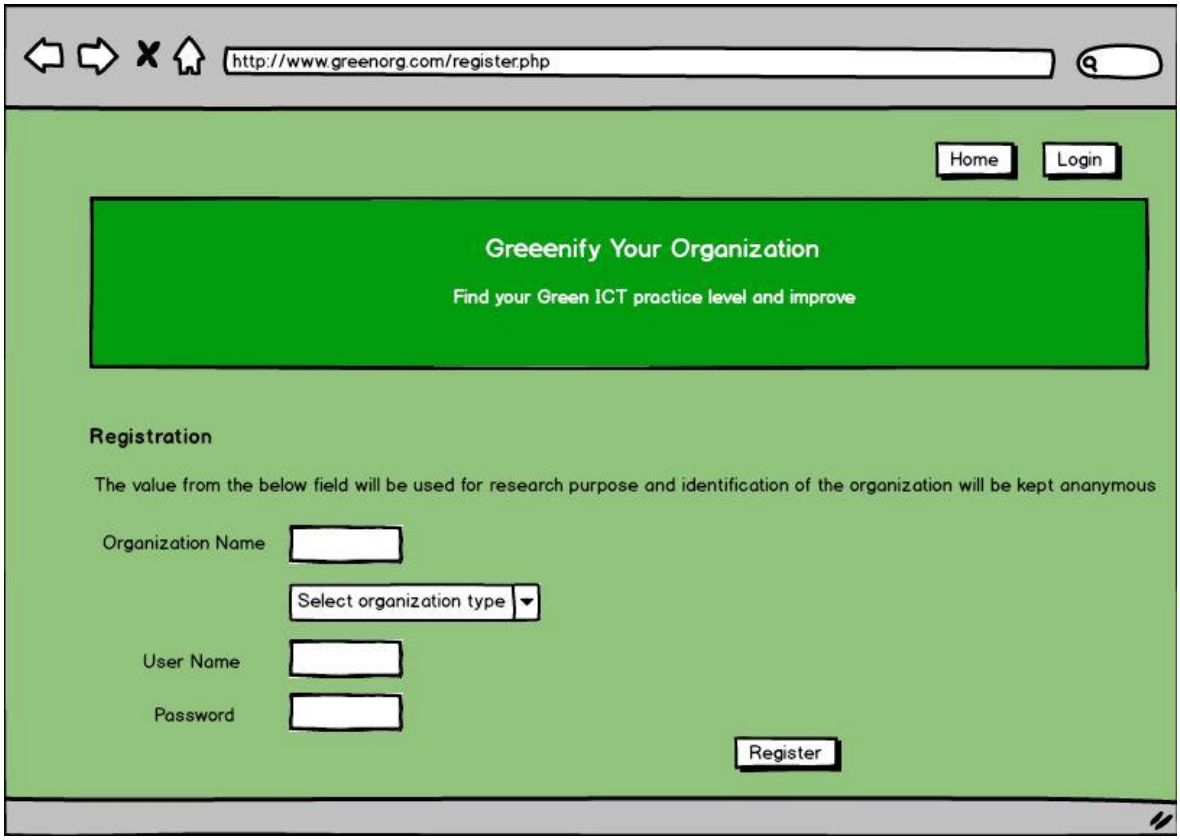
o Return to the producer/supplier

o Recycling through WEEE business organization in the locality

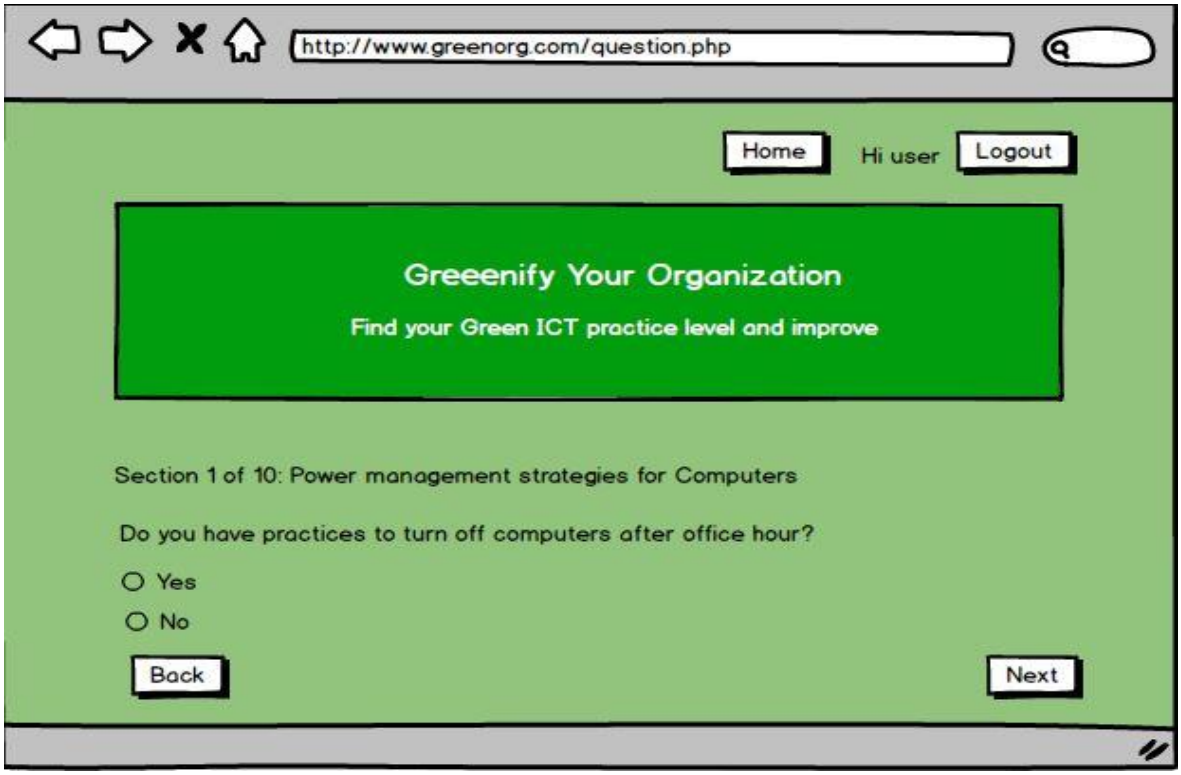
Appendix 2. Screenshots of the Prototype

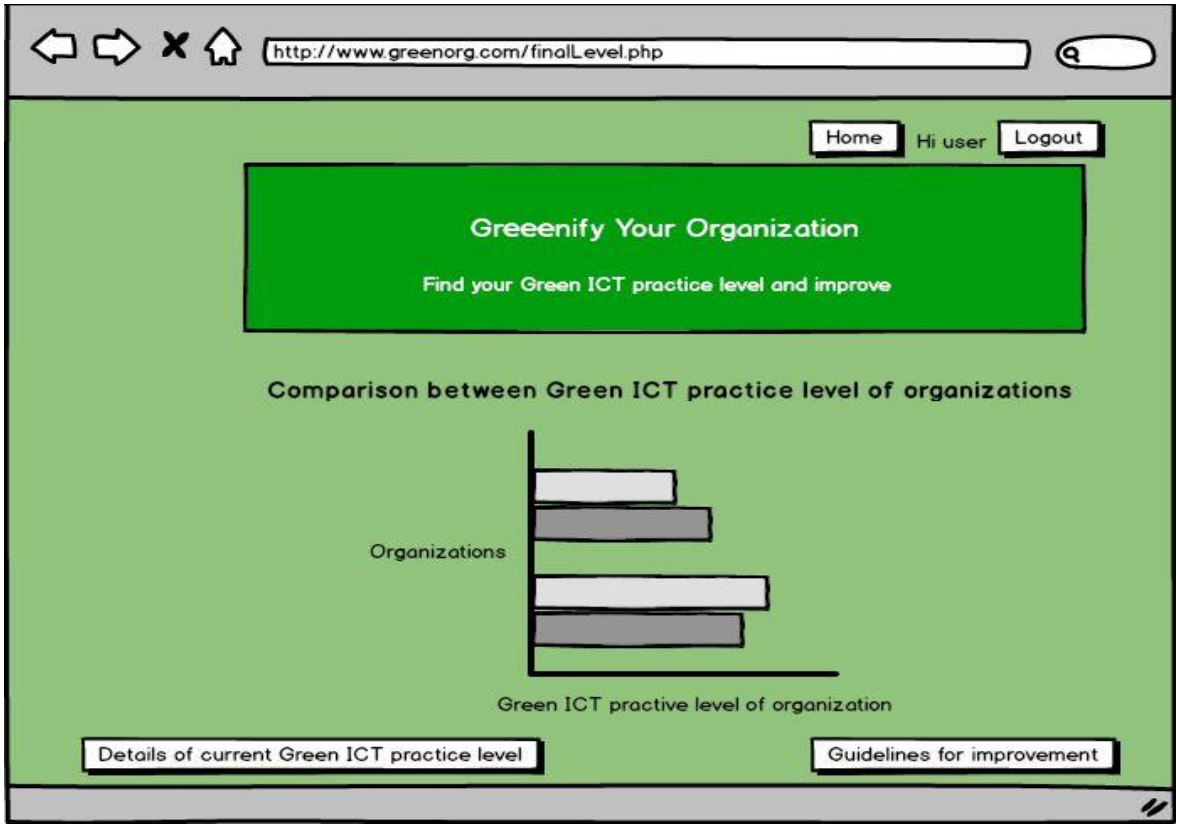
Appendix 2. (Continues)





Appendix 2. (Continues)





Appendix 2. (Continues)

Appendix 3: Consent for Web Application Testing

LUT
Lappeenranta
University of Technology

May 22, 2018

Dear Sir/Madam,

I am a final semester Master Degree Student, currently doing my Master Thesis at Lappeenranta University of Technology (LUT), Finland. As a part of my Master thesis, I have developed a system to detect the Greening ICT practice level in Small Medium Enterprises (SMEs). Therefore, I want your participation to test the system and provide your feedback. Since a part of a SME, you are in an ideal position to provide me accurate information in evaluating the framework.

The testing will take around 20 minutes and expected to answer by IT specialist of the company. I am simply trying to collect data regarding Green ICT practices inside SMEs. Your responses to the questions will be used for the research and identification of your company will be kept anonymous.

Your participation as a representative of the company will be a valuable addition to the research and findings could lead to greater understanding of Green ICT practices and improvements in SMEs.

Please participate in the testing at your earliest possible time. The link for the system:

https://greenorg-farniba.c9users.io/

After participating in the testing of the system, please provide your feedback in the two links below about the usefulness of the system and how beneficial is the system in accordance with your business goals. The link for the survey:

1. https://docs.google.com/forms/d/e/1FAIpQLSdD3oLUNlh7tn1Zf2PG9MKEJFCD0Yy50MJBjXvll2yh4g4cWw/viewform?usp=sf_link
2. https://docs.google.com/forms/d/e/1FAIpQLSdU-V7o1x77PqoGuEbxiXLmAhG4vqT0WXheENBtrr-nJk4keg/viewform?usp=sf_link

If you have any questions please do not hesitate to contact me. My Email Address: farniba.khan@student.lut.fi

Thank you very much for your time and consideration.

Best Regards,

Farniba Khan