

Systematic Literature Review on Green IT Practice and Executional Factors

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Abstract— Green ICT practice is immediately turning into a key business component for many organisations. Thus, this study aims to examine Green IT practice research in the literature. At the same time this study emphasises that the practice of implementing Green IT can be applied by any organisation. For that purpose, a Systematic Literature Review (SLR) method is used in which 57 out of 150 studies meet the search criteria. From that number 18 studies focus on Green IT practice. Based on the analysis of the studies, 17 factors are identified as motivators for organisations to apply Green IT practice. Therefore, this paper will be a useful guide for organisations to bring in greener technologies in the application of Information Technology.

Keywords— *Green IT, Green IT practice, Organisation, Systematic Literature Review.*

1. Introduction

Green Information Technology (IT) has become the latest buzzword in the field of IT management. However, a common understanding concerning the coverage and scope of Green IT is still missing in research and practice [27]. The implementation of Green IT is a multifaceted construct that is intended to address both IT and non-IT related sustainability problems [7]. The terms ‘green’, ‘eco-efficiency’ and ‘sustainability’ are widely used among researchers in the field [17]. More importantly the significance of Green IT has been strongly suggested in practitioner reports ([2]; [8]; [10]; [11]) and emerging academic articles ([3]; [6]; [7]).

In definition, Green IT is “a systematic application of ecological-sustainability criteria (such as pollution prevention, product stewardship, use of clean technologies) to the creation, sourcing, use, and disposal of the IT technical infrastructure as well as within the IT human and managerial

practices” [19].

According to [15] Green IT practices may create value for organisations and society. Such practices enable these organisations to operate in a more sustainable way not only by saving energy, paper, water, transportation, physical space, maintenance and waste, but also by improving their image, respecting the environment, and enriching their employees. The implementation of Green IT practice is usually motivated by potential economic benefits when this technology is used. Green IT practices are also triggered by a concern towards the planet, even if the economic benefits may not be reachable in the short term [14]. Through its implementation, organisations can take advantage of the emerging and upcoming Green IT practice research in order to tackle sustainable development issues. At the same time, improving productivity, reducing costs, enhancing sustainability, and avoiding poor environmental practices to reduce waste, energy inefficiency, and carbon emissions often have positive returns on investment ([4]; [9]).

The aim of this Systematic Literature Review (SLR) is to identify studies relating to Green IT practices. By doing so, it is hoped that this article will reduce the time and effort in finding the body of knowledge of related literature among those who are motivated to contribute to this topic. This paper also provides useful information for conservation policies, and identifies the largest gaps to be filled by future research. Nevertheless, the immediate result of this review is significant in determining the current “state of the art” research in identifying the implementation of Green IT practices in organisations.

This paper reports the findings of the SLR study and is organised as follows: section 2 describes the SLR process which involves five stages (methodology). Section 3 discusses the results that

answer the research questions (RQs) and finally, section 4 concludes the study.

2. Methodology

Systematic literature review (SLR) is a means or ways to conduct a literature review based on the question or topic area or phenomenon of interest [12]. SLR is also a tool that aims to produce a scientific summary of the evidence in a particular area, in contrast to “traditional” or narrative review [21]. In order to achieve the end result, there are six stages that need reviewing and some of which with iteration. Adapted from [23], the stages illustrated in Figure 1 are important and serve as guidance when conducting the actual review.

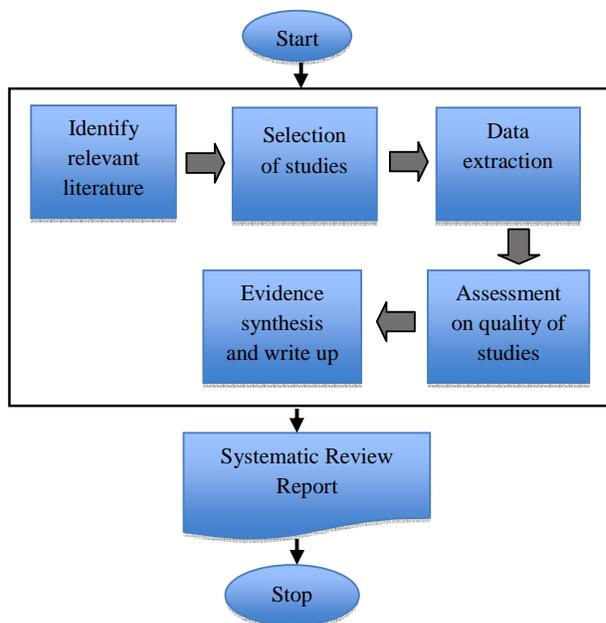


Figure 1. Stages in a Systematic Review Process

2.1 Research Questions

SLR requires the formulation of research questions (RQs) that are used to guide the search and extraction processes. The formulation of these RQs should include five elements [21] as described in Table 1. The first stage in locating studies relevant to the research questions that need to be addressed is to identify search terms that will be used in the search process. These search terms can be regarded as the key elements that underlie the research questions [13]. The five PICOC (Population, Intervention, Comparison, Outcome and Context) components can be considered as principle key

elements in the research question. Following the SLR, this paper takes into consideration all empirical studies that focus on Green IT practice within a business organisation.

Table 1. Research Questions as Structured by the PICOC Criteria

No	Criteria	Description
1.	Population (P)	Executive level personnel in the organisation.
2.	Intervention (I)	Green IT practice.
3.	Comparison (C)	Null.
4.	Outcomes (O)	Organisational sustainability.
5.	Context (C)	Business organisations.

Table 1 highlights the major search terms based on the PICOC criteria that address the study’s research elements. These major search terms serve as a basis to derive relevant research terms that are used in the search process of primary and secondary sources. This paper reports on the first two main research questions formulated for the SLR. In order to identify and evaluate all the available research on Green IT practices within business organisations; the following research questions are formulated:

- RQ1: What research has been conducted on Green IT practices?
To answer this research question, this study intends to seek existing research conducted on Green IT practices, which can benefit current and future research in this area.
- RQ2: What factors influence organisations to implement Green IT practices?
With regards to this research question, this study intends to identify the factors that cause organisations to apply Green IT practice as their norm.

2.2 Conducting the Review

The first strategy in identifying relevant literature is to develop a search string that will be used the search. According to [16], in identifying relevant literature, a comprehensive and exhaustive search for studies to be included in the review is carried out. Other than the primary search terms (see Table 1), this stage involves the use of synonyms,

alternate spellings, and abbreviations of the search terms derived from the previous stage. Once the search terms have been identified, all the key words will be compiled into a search string that will be used in the search process. The searching can be done by using Boolean operators OR and AND. Operator OR used to group the diverse forms (e.g. synonyms and alternate spellings) of individual search terms. Meanwhile the AND operator is used to link all the different search terms into a single search string.

The process of identifying relevant literature involves two stages. The search process has to be a rigorous one, which can be split into two; a primary and a secondary search phase. The primary phase focuses on identification through primary source of related literature. Five processes are involved in this stage: i) identify potentially relevant sources, ii) exclude irrelevant citations (screening title and abstract), iii) retrieve relevant hard copies, iv) exclude irrelevant citations (screening of full text), v) include studies in systematic review. This is to ensure that relevant studies can be captured as much as possible. In order for the SLR to be regarded as reliable, the review process needs to be both transparent and to a degree, repeatable [13]. The entire primary sources are usually derived from online databases, search engines, conference proceedings, peer reviews and journals. Usually, all online databases, search engines and PhD theses support the search string, excluding Google Scholar. The Google Scholar search engine simply, does not support the length of string for the research. The primary literature in this study considers articles that are published from 1992 onwards, as the idea of Green IT began in 1992 with the launch of the Energy Star by the US Environmental Protection Agency (EPA).

As secondary search is necessary to ensure that the primary search has not missed any relevant literature. The activity required at this stage is to keep repeating the review of reference list of the literature retrieved at the primary stage. This activity is iteratively repeated on new literature found. This means that the search process has to be carefully documented. As noted by [1], tracing studies are required for studies that use SLR.

2.3 Inclusion and Exclusion Criteria

Initially, each paper retrieved will go through the reading process on i) title, ii) abstract and

keywords, and iii) full text. Nevertheless, the final studies selected will be determined from the inclusion and exclusion criteria. The results are then compared and if any disagreement persists, a discussion will be conducted. The selection of studies went through five phases which are in Table 2.

Table 1: Inclusion Phase

Phase	Description
Phase 1	Identify potentially relevant sources (from online databases or manual search) (n =150)
Phase 2	Selection: Studies screened (title) (n = 150)
Phase 3	Selection: Studies screened (abstract) (n =125)
Phase 4	Selection: Studies screened (full text) (n =65)
Phase 5	Studies included in the synthesis (n =57)

At the beginning of the study, 150 articles were selected from primary online databases, search engines and PhD dissertations and theses. In the next phase, only 57 out of those studies met the inclusion criteria. The function of the inclusion and exclusion criteria, is to ensure that only relevant articles are selected in the SLR.

Table 2: Inclusion and Exclusion Criteria

Inclusion criteria	<ul style="list-style-type: none"> • Aimed - Green IT practice and organisational sustainability. • The period from 1992 onwards. • Domain - Green IT practice and focuses on organisational sustainability and business organisations. • Methods - quantitative, qualitative, mix mode that blend both, case studies or experimental. • Types - article, conference paper, book chapter or peer review. • Language - English language only.
Exclusion criteria	<ul style="list-style-type: none"> • Studies that do not match with the research question (RQ) are excluded. • Studies that are written in another language aside from English are excluded. • Studies that contain videos are not included. • Studies that involve own assumption or personal view are disregarded. • Studies presented by authors without supporting evidence are eliminated.

At the initial selection stage process, all the articles extracted go through a screening process. Screening involves looking at the title and abstract in order to identify relevant articles. An article that fulfils the minimum requirement for the inclusion is selected. Articles are then reviewed, and a decision to either include or remove the article from the library is made. In this stage, 125 articles were selected out of the 150 articles found in the database. The last part of the selection criteria involves all articles being reviewed in detail. The articles are produced in hard copy and read. If an article does not meet the inclusion criteria, it is thus discarded from the database. In the final result, only 57 out of the 125 articles were selected. Figure 2, illustrates the approaches of conducting searches and the selection of related studies.

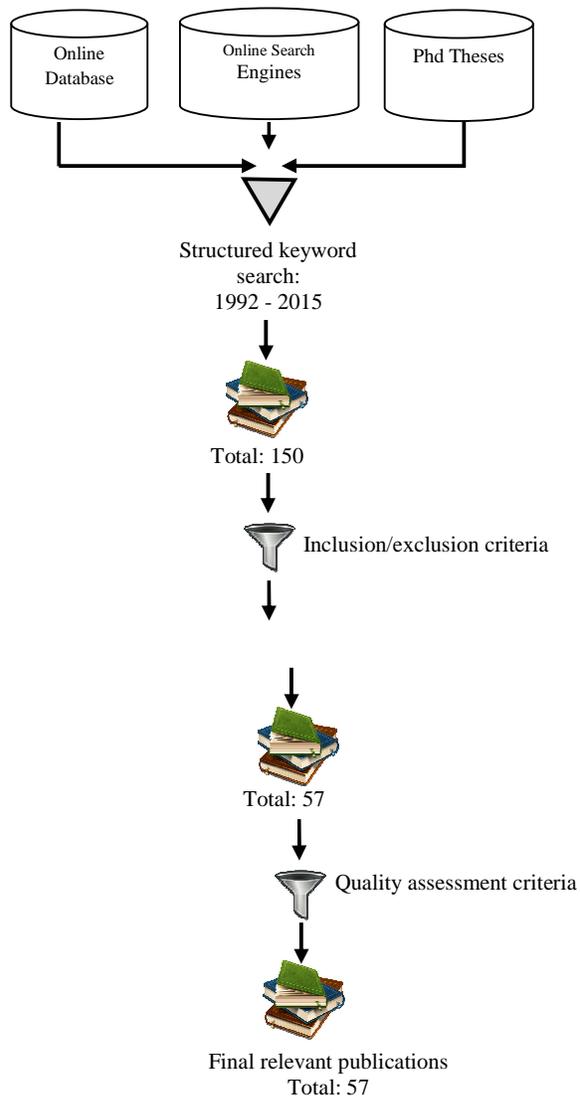


Figure 1: Publication Collection Method Flow

2.4 Quality Assessment

In order to expedite the data extraction process, a form was designed to be used in gathering evidence that is related to the research questions and to measure the quality of the primary studies. A checklist outlining the important criteria expected from the primary study was developed. The checklist helps in a “less biased” selection in terms of the quality of a study. The checklist which is adapted from [13] and [24] is utilised in the evaluation of the research articles (see Table 4). The checklist is divided into four items; which are design, conduct, analysis and conclusion. Several questions related to the individual study are enquired for each of the items. Each question in the checklist is assigned with a ratio scale for measure the quality of quantitative and qualitative studies. The scale is: Yes = 1 point; No = 0 point; Partially = 0.5 point. The weight is accumulated and the total result score for each study ranges between 0 (very poor) and 7 (very good) [25].

Table 3: Quality Assessment Criteria

Item	Answer
Design	
Was the article referred?	Yes/No/Partially
Is/Are the aim(s) of study clearly stated?	Yes/No/Partially
What population was being studied?	Yes/No/Partially
How was the sample obtained (e.g. postal, interview, web-based)	Yes/No/Partially
Is/Are the measure(s) used in the study fully defined?	Yes/No/Partially
Conduct	
Are the data collection adequately described?	Yes/No/Partially
Is the purpose of the data analysis clear?	
Analysis	
What was the response rate?	Yes/No/Partially
Was the denominator (i.e. the population size) reported?	Yes/No/Partially
Are the study's participants or observation units adequately described? For example, SE experience, type (student, practitioner, consultant) nationality, task experience and other relevant variables.	Yes/No/Partially
Conclusion	
Are all the study's questions answered?	Yes/No/Partially

Item	Answer
Are the findings credible? For example, the study was methodologically explained so that the findings are	Yes/No/Partially

The first, second and third criteria are the minimum qualities selected to exclude papers which do not meet the objective of the SLR. Meanwhile, the other seven criteria (4-10) cover the issue of methodology, data collection and tools that used for finding. Criteria 11 and 12 relate to the credibility of the papers which assures that each individual study is valid and meaningful.

2.5 Data Collection and Analysis

In the data extraction process, a form was designed to gather evidence relating to the research, questions posed in the studies and to measure the quality of the primary studies. According to [13], a data extraction process needs to be performed by two or more researchers, referred to as the “extractor” and “data checker”. This is done in order to minimise the element of biasness in the selection of primary studies. Meanwhile, for quality purposes, the appointed supervisor is tasked to check some of the extracted data randomly and a meeting is organised to compare and cross-check the data extracted by the main researcher and the supervisor. Data extraction is carried out on all papers that pass the screening process stage. A checklist is developed in order to list the important quality criteria expected from the primary studies [22]. The data extraction form is designed to collect all the information needed to address the review questions and quality criteria. According to [22], the data from each of the studies selected have to be recorded using a data extraction form and saved into an individual word document file. Each of the studies is assigned a unique identification number on the data extraction form for reference purposes. The studies are then stored as a file holding the unique ID for future reference.

The data extraction from designed for the SLR study is shown in Table 5. The form consists of three sections: i) Study’s Information Data, ii) Data Relevant to Answering the Research Questions, and iii) Quality Assessment Checklist.

Table 4: Data Extraction Form

Data Item	Description
Study’s Information Data	
Study ID	Refers to the unique identification given to

Data Item	Description
	the article.
Title	Refers to the label of the article.
Year of publication	Refers to the article’s publication year.
Reference type	Refers to whether the publication is in the form of a journal/ conference/ thesis /unpublished work.
Publisher	Refers to the name of the publisher, or proceeding.
Data Relevant to Answering the Research Questions	
RQ1: What research have been conducted on Green IT practice?	Research questions to focus on.
RQ2: What factors influence organisations to implement Green IT practices?	
Quality Assessment Checklist	

3. Discussion

3.1 RQ1: “What research have been conducted on Green IT practices?”

Based on the finding, 18 studies out of the selected 57 discuss on Green IT practices. Each of the articles converses on a different area and perspective of Green IT practices. Majority of the research conducted on Green IT practices focus on environmental issues. Apart from the environment, the research carried out concentrate on knowledge management, sustainability, economic and business performance, virtualisation, strategic implementation, risk and supply chain. The 18 studies identified are conducted in different industries, namely; hotel, banking, Small Medium Enterprises (SMEs), food, investment and manufacturing. The studies are published between the years 2009 until 2015. This finding can concludes that Green IT practice is a new field which is rapidly gaining the interest of researchers in the last five years. Based on an analysis on the types of research approaches employed in these studies, 47% of the studies used a survey (quantitative) method to analyse the data, whereas 11% and 10% used an interview method and case study (qualitative) respectively. Prominent authors in the field of Green IT who produce more than one article in this area, are Molla, Abareshi, & Cooper.

Table 6, summarises the 18 papers that focus on Green IT practices.

Table 5 : Studies on Green IT Practice

Title	Author/Year	Area
Knowledge Management Framework using Green IT to implement sustainable entrepreneur ecosystem	Uddin, Hindu, Shah, Abubakar & Saba, (2015)	Knowledge Management
Integrative framework for assessing firms' potential to undertake Green IT initiatives via virtualisation - A theoretical perspective	Bose & Luo, (2011)	Virtualisation
Sustainable IT services: Assessing the impact of green computing practices	Harmon & Auseklis, (2009)	Sustainable IT
Green practices-IS alignment and environmental performance: The mediating effects of coordination	Ryoo & Koo, (2013)	Economic Performance, Environment Performance
Environmental intelligence and its impact on collaborative business	Trivedi & Unhelkar, (2013)	Environment Sustainability
Green practices in restaurants: Impact on firm performance	Perramon, Alonso-Almeida, Llach, & Bagur-Femenias, (2014)	Firm Performance
Small business in a small country: Attitudes to "Green" IT	Coffey, Tate, & Toland, (2013)	Environment Sustainability
A proposed model for business sustainability based on business and information technology	Ullah, Lai, & Marjoribans, (2013)	Business Sustainability
The influence of Green practices on supply chain performance: A case study approach	Azevedo, Carvalho, & Cruz Machado, (2011)	Supply Chain Performance
Impact of adoption of Green IT practices on organisational performance	Ainin, Naqshbandi, & Dezdar, (2015)	Organisational Performance,

Title	Author/Year	Area
Bridging the gap of Green IT/IS and sustainable consumption	Khor, Thurasamy, Ahmad, Halim, & May-Chiun, (2015)	Environment Sustainability
Green IT Maturity: developing a framework based on practices and actions	Lunardi, Alves, & Salles, (2013)	Environment Sustainability
Analysis of Green Information Technology in Dell and Toshiba	Pichetpongsa & Campeanu, (2011)	Strategic Implementation
Influence processes for practicing Green Information Technology: Elaboration Likelihood Model	Esfahani, Rahman, Zakaria, (2015)	Pro-Environment
Risk identification in Green IT practice	Chou, (2013)	Risk
Green IT beliefs and pro-environmental IT practices among IT professionals	Molla, Abareshi, & Cooper, (2014)	Pro-Environment
IT and Eco-sustainability: Developing and validating a Green IT Readiness Model	Molla, Cooper, & Pittayachawan, (2009)	Eco-sustainability
Study of Green IT: Present to Future	Kumar, (2015)	Green Computing

3.2 RQ2: "What factors influence organisations to implement Green IT practices?"

This section discusses on the factors that influence organisations to implement Green IT practices. From the SLR, five articles discuss on the factors which are; i) [9] with six factors, ii) [20] with five factors, iii) [26] with four factors, iv) [18] with six factors, and v) [5] with nine factors. A total of 17 factors have been sourced from the five papers mentioned. Table 7, lists the publications, which include the names of the authors and the factors discussed in their articles.

Table 6 : Factors of Green IT Practice

Author(s)	Factors
Harmon & Auseklis (2009)	1. Data centre infrastructure. 2. Power and workload management. 3. Thermal load management. 4. Virtualisation. 5. Cloud computing and cloud services.

Author(s)	Factors
	6. Product design.
Perramon et al., (2014)	<ol style="list-style-type: none"> 1. Government regulations. 2. Customer influence. 3. The desire to attract new customers or enter new market. 4. The need to keep up with competitors. 5. Social pressures.
Trivedi & Unhelkar, (2013)	<ol style="list-style-type: none"> 1. Right network. 2. Virtualisation. 3. Cloud computing and cloud services. 4. Anytime, anywhere technologies.
Molla (2009b)	<ol style="list-style-type: none"> 1. Monitoring practice. 2. Sourcing practice. 3. Network critical physical infrastructure (NCPI). 4. Power and workload management. 5. Policy. 6. Technical Infrastructure.
Coffey et al., (2013)	<ol style="list-style-type: none"> 1. Government regulations. 2. Financial attitude. 3. Strategic thinking. 4. Approach to implementing Green IT. 5. The supply chain effect. 6. Leadership commitment. 7. Gaining employee support. 8. Environmental reporting. 9. Environmental education and training.

3.3 Limitation of the Study

Although this study adheres to the methodology suggested by [12], it is still with some restrictions. To elaborate the selection of keywords, and the inclusion and exclusion criteria are based on researcher judgment.

One of its further limitations is that all the articles selected are from well-known databases which allow access in the retrieval of the articles only. Articles which are inaccessible are automatically dropped. Hence, to improve future research, this study suggests the inclusion of the entire online databases and outlets used by practitioners to publish their articles on Green IT. Furthermore, the selection criteria include only completed research papers. Additionally, all the articles selected are determined and judged based on researcher knowledge and guideline that came after.

Although, a meeting for consensus was set up, researcher biasness still presents an associated risk, which should be minimised when assessing the contribution of each paper.

4. Conclusion

Based on the paper's critical examination of academic journals and conference proceedings in the field of Green IT, some significant themes in Green IT practices appear to require further investigation. Although Green IT practices are the focus of many, less awareness is observed among organisations to implement these practices. Nearly half of the studies examined focus on the environment, which is synonymous with "green". Hence, as its first testimonial for future research, this paper suggests the focus on other areas rather than just the environment as a research subject and context. An organisation can be a good example of an area to focus on in determining the contribution of Green IT practice to the system itself. When an organisation has a positive view of Green IT practice, it will lead to a greater concern towards energy consumption and the environmental impact of IT applications. The limitation of the research conducted also provides some direction for future research. Based on the finding, focusing more on the contributions and measurements of Green IT in any area is apparently much required.

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