

Green IT Segment Analysis: An Academic Literature Review

Research-in-Progress

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Abstract

Research on Green Information Technology (IT) is becoming a prevalent research theme in Green Information Systems (IS) research. This article provides a review of 98 papers published on Green IT between 2007–2013 to facilitate future research and to provide a retrospective analysis of existing knowledge and gaps thereof. While some researchers have discussed phenomena such as Green IT, motivation of Green IT and the Green IT adoption lifecycle, others have researched the importance of Green IT implementation within the organisational and individual level. Throughout the literature, scholars are trying to portray a constructive relationship between IT and the environment. Through our analysis, we can provide an assessment of the status of information systems literature on Green IT and, we provide taxonomy of segments of Green IT publications. Future research opportunities are identified based on the review.

Keywords

Green IT, Green IS, Literature Review, Green IT Research Area, Research Agenda

Introduction

We live in an Information Technology (IT) era where computers, data centers, servers, internet and other machineries are used in almost all industries. Their goal is to assist organizations in being smart, increasing profitability and operational efficiency and increasingly to help them to become or remain sustainable in the competitive global market. From a sustainability viewpoint, however, the high usage of technology brings out several issues, such as extreme power consumption (Guster et al. 2009; Niyato et al. 2009) and an expanding carbon footprint that has a detrimental effect on the environment (Forrest et al. 2008; Fuchs 2008). Increasingly, these issues induce a demand for environmental sustainability concerns because of global societal concerns about energy usage, climate change, and the consequences of these changes. These concerns are important to the IT sectors because high usage of technology does contribute to the increase of greenhouse gas emissions (Ruth 2009).

In response to these challenges, the term Green IT has been coined with reference to initiatives that are focused on reshaping IT into environmentally friendly forms (Chetty et al. 2009; Chetty et al. 2008; Huang 2009; Melville 2010). Green IT promotes the design and manufacturing and management of IT equipment and services that consume minimal energy throughout their entire life-cycle (Murugesan 2008). Therefore, it can be argued that Green IT refers to the use of IT resources in an energy-efficient as well as cost-effective manner. The term 'Green IT' also spurs the hope that IT will be an effective means for organizations looking to make significant steps in the reduction of the environmental impact of their operations (Harmon and Auseklis 2009; Hasan et al. 2009; Murugesan 2008; Vykoukal et al. 2009). Indeed, it would appear that the implementation of Green IT is becoming a norm rather than a passing fashion (Bachour and Chasteen 2010).

For the purpose of clarification it should be noted that 'Green IT' addresses the direct impact of energy consumption and waste associated with the use of hardware and software (Boudreau et al. 2008), whereas the related term 'Green IS' refers to information systems that can be developed with or without Green IT

to support environmental sustainability initiatives (Boudreau et al. 2008; Jenkin et al. 2011). Some scholars have attempted to separate Green IT from Green IS (Brooks et al. 2012; Dedrick 2010; Erek et al. 2012) with some considering Green IT as a part of Green IS (Brooks et al. 2012; Melville 2010), while others find these terms to be interchangeable (Huang 2008; Mithas et al. 2010). Therefore, it can be argued that both Green IT and Green IS are umbrella terms covering a wide range of practices and policies, and consistent with Malhotra et al. (2013) and Osch and Avital (2010), we use Green IT and Green IS as synonyms.

Scholars argue that Green IT is a relatively nascent research area (Lei and Ngai 2013; Nanath and Pillai 2012b) with the number of studies growing fast because of the emergence and importance of this as a research topic (Lei and Ngai 2013). Therefore, it is imperative to consolidate and integrating the emerging body of knowledge in the Green IT research area. This is important because in any emergent field, initially a clear direction is lacking as is an understanding of most relevant or important theoretical foundations (Palekar and Sedera 2013). The same holds true for the vastly increasing amount of Green IT studies, conceptualizations and proposals. In order to proceed further in this field, especially in the formative stages of discipline development, careful reviews and normative advice is needed to identify relevant streams of research and identify emerging bodies of knowledge and gaps thereof.

Accordingly, the goal of this paper is to assist with developing the field of Green IT research. Specifically, in this paper we summarize existing findings concerning the “green content of IT” and the impact on the environment and business operations in terms of cost minimization and gaining competitive advantage as reported in the literature. In conducting an archival analysis, we address two main research questions: (1) What are the Green IT/IS messages conveyed by the researchers between 2007 and 2013 and, (2) How can the field move forward to fill some of the critical gaps remaining in this research area?

This literature review-in-progress paper aims to lead researchers and practitioners to understand the current trend and anticipated future directions of Green IT. It will also inform corporate practice as contemporary organizations incorporate environmental sustainability in their corporate vision in an attempt to address the many challenges and uncertainties of Green IT adoption (Hobby et al. 2009; Seidel et al. 2010). It provides research implications for researchers interested in the Green IT research area. The literature review focuses on the comprehensive review of articles of Green IT and Green IS to provide a better understanding of trends in the research and to gain further benefits by identifying noticeable gaps in literature surrounding Green IT. As an in-progress paper, we also seek to receive feedback on important dimensions of archival analysis that we may have missed in our work so far, and which would be important for the further development.

Research Method

Our review of the literature began with a search of the ‘senior scholars’ basket-of-eight journals’ (<http://aisnet.org/general/custom.asp?page=SeniorScholarBasket>). Since the number of Green IT related publications in top journals were limited, it was decided to expand the search and collect articles/publications from practitioner publications (Professional), other academic journals (Communications of the ACM), books, peer-reviewed magazines, IEEE/ACM conference proceedings, and IS conference proceedings including ICIS, PACIS, AMCIS, ACIS and ECIS. Additionally, we expanded the search by also reviewing literature from cross-discipline sources such as information systems, ecology and environmental science, business and law. The following keywords were used to search: “Green, Green IT, Green IS, sustainable IT, environmentally friendly IT, Green computer and Green ICT”. The timeframe for our review were the years 2007 to 2013. The rationale was that it appeared to us that 2007 was the year when researchers began to explore these phenomena in IS/IT research. Brooks et al. (2010) found that the term “Green IT” appeared at the CIO magazine for the first time in 2007. This was also corroborated by us, finding only two papers (Mingay 2007; Vlek and Steg 2007) appeared in 2007. Thus we consider 2007 as the start year of our literature review. In conducting the literature search, several academic databases and search engines were used such as ACM Digital Library, Science Direct, Emerald, Google Scholar, Emerald Engineering Database, InfoSci collection and IEEE Xplore Digital Library. Through these searches, we identified a set of 98 relevant papers that provided an overview of or focused on a particular aspect of Green IT, which we considered for further analysis.

Our initial review of this batch of articles provided broad categories of research areas including *strong reference* to Green IT; articles with *peripheral* reference to Green IT and finally articles which addressed themes of Green IT *without specific reference*. This broad taxonomy was then used for further reviews

and refined to the segmentations labelled as Core of Green IT, Periphery topic & Beyond Green IT, which we will discuss further below in this paper.

Analysis, Findings and Discussion

This section summarizes the results obtained for the review of the literature from 2007 to 2013. The purpose of the analysis was to identify if researchers focus on certain categories and also to determine if the research trends were changing over time. Articles were analyzed on the basis of their segmentation described above.

Brief Overview of Green IT Literature

The Green IT literature to date is largely constructed on basis of case studies and surveys of current practices. A significant amount of research has been performed on Green IT implementation, the motivation for Green IT, organizational readiness and capability to adopt Green IT, with these and related topics all being analyzed by various methods of analysis, such as case studies, interviews and surveys. We found that most studies reporting on empirical studies collected data at the organizational level (Cai et al. 2013; Cater-Steel and Tan 2011; Molla 2009; Molla and Abareshi 2012; Molla et al. 2009a; Nanath and Pillai 2012b). We also found studies that considered data from both organizations and individuals (Ansari et al. 2010), from individuals/end users (Chetty et al. 2009; Chetty et al. 2008; Chow and Chen 2009; Sarkar and Young 2009; Woodruff et al. 2008). In terms of methods employed, we found studies perusing, online surveys (Chai-Arayalert and Nakata 2011; Kuo and Dick 2010; Molla and Abareshi 2011b), analyses of secondary source data (Chai-Arayalert and Nakata 2011; Jain et al. 2011; Molla 2009; Molla et al. 2009b) and also examples of combination of mixed method inquiries (Nazari and Karim 2012).

Publications per Year

Table 1 provides a list showing the total number of articles from journals, conferences, and other sources such as books, peer-reviewed magazines, IEEE/ACM conference proceedings on a year-by-year basis from 2007 to 2013. The data suggests an increasing interest in Green IT since 2007, with recent years depicts showing an incremental decline in research interest as measured by published papers. However, we note that recent data (e.g. 2014) may also be skewed due to the time required to publish articles. In other words, we may see further articles appearing in retrospect.

Year	Journal Article	Conference Article	Others	Total
2007	1	-	1	2
2008	4	6	1	11
2009	5	13	3	21
2010	6	11	-	17
2011	10	7	-	17
2012	7	6	2	15
2013	9	5	-	14
Total	42	48	7	98

Table 1. Distribution of Review Sample by Publication Year

Publications by Country

Next, we examined the data sources for Green IT research by noting which particular countries were studied by each research team. Most studies tend to focus on developed nations such as Australia (Cater-Steel and Tan 2011; Hasan et al. 2009; Huang 2008; Molla 2009; Molla and Abareshi 2011b; Molla et al. 2009a; Molla et al. 2009b; Sarkar and Young 2009; Woodruff et al. 2008), USA (Bose and Luo 2012; Chetty et al. 2009; Chetty et al. 2008; Marett et al. 2013; Molla et al. 2009a; Woodruff et al. 2008), UK (Bhamra 2012; Chai-Arayalert and Nakata 2011), Sweden (Bengtsson and Ågerfalk 2011; Nazari and Karim 2012), New Zealand (Molla 2009), The Netherlands (Collins et al. 2007). A lesser number of studies gave consideration to still developing nations such as China (Cai et al. 2013; Zhiwei 2012), Morocco (Hanne 2011), Hong Kong (Chow and Chen 2009), Serbia (Kovačić et al. 2008), South Africa (Lamb 2011), India (Datta et al. 2010) and Bangladesh (Ansari et al. 2010). From our data sample, only five analytical articles (Kuo and Dick 2010; Molla 2009; Molla et al. 2009a; Trimi and Park 2013; Woodruff et al. 2008) collected data from multiple countries simultaneously.

The rise of major developing nations such as India and China, each of which has burgeoning business opportunities featuring high level IT usage at the beginning of the 21st century, has brought with it an accompanying increase of environmental pressures. Hence, it becomes all the more imperative to have an expansion in the implementation of Green IT studies throughout the region. It will also be important to identify other up-and-coming developing nations where imminent industrialization will soon be adding to global environmental costs.

Publications by Theoretical Framework

In understanding the trends of Green IT research, it is important to address the issue of theoretical Frameworks perused to understand Green IT phenomena. Table 2 depicts the theoretical frameworks that have been used in the Green IT research area. Eighteen theories and twelve frameworks have been identified from the literature. Most of these were used only once except ‘technology organization environment’, ‘institutional theory’, ‘actor network theory’, ‘motivation theory’, which were used by multiple research teams. Few studies consider more than one theory in order to analyze a particular trait of Green IT in one article. For example, Butler (2011) considers institutional theory and Organizational Theory, while Koo et al. (2013) use motivation theory and reference group theory and Bose and Luo (2011) employ the theories of technology–organization–environment, process virtualization, and diffusion of innovation. Lei and Ngai (2013), in their literature review paper, have identified fifteen theoretical frameworks from the literature and according to their purposes, the theoretical frameworks are classified into the categories called: taxonomy, general Green IT initiatives, and specific type of Green IT initiatives. Howard et al. (2012) synthesize frameworks in the Green IS research area in order to investigate “how organizations can use the existing Green IS frameworks to achieve strong environmental sustainability” and distribute the identified frameworks into extractions of inclusions into the synthesized framework and categorized them into a three-tier framework with three layers of granularity.

Our work adds to the existing literature reviews through our focus on the analysis of theories and framework used by Green IT/IS researchers without any subsequent classifications, aside from dividing them into the two broad categories of theory and framework. It gives due consideration to the most recently articles published in Green IT/IS literature for the purpose of further exposition to serve as a reference for justifying the selection of any particular theory or framework. Table 2 summarizes our analysis of theory use in Green IT papers.

	Theories/ Frameworks	Reference	Explanation
Theories	Technology Organization Environment	(Bose and Luo 2011)	to assess GIT initiatives and the GIT implementation stages at the organisational level
		(Lei and Ngai 2013)	to discuss Green IT adoption
		(Nedbal et al. 2011a)	to incorporate implementation success and technology acceptance
	Institutional Theory	(Butler 2011)	to explain the forces acting upon organisations from both within the institutional environment and the organisational fields in relation to environmental sustainability and regulatory compliance
		(Sarkar and Young 2009)	to understand the drivers of corporate environmentalism and to analyse how the external social pressure influences organisation’s behaviour and policy-making
	Organisational Theory	(Butler 2011)	to clarify and bring into perspective the responses that organisations make from within in response to such forces
	Actor Network Theory	(Bengtsson and Ågerfalk 2011)	to investigate the effects of a sustainability initiative in the municipality of Uppsala, Sweden and to understand the driving forces for sustainability initiative and the roles of human and non-human actants in that process of the initiative
		(Aoun et al. 2011)	to study the use of collaborative technologies for eco-mobilisation among Environmental Non-Governmental Organisations (ENGOS) to achieve shared environmental goals
	Theory of Reasoned Action	(Chow and Chen 2009)	to examine the belief and behavior of IT users in green computing
		(Sarkar and	to understand how managerial attitudes and subjective norms

		Young 2009)	influence the strategic initiatives of an organisation
Natural Resource-Based View	(Dao et al. 2011)	to integrate IT resources with HRM and SCM resources, which influences the firms to develop sustainability capabilities	
	(Rahim and Rahman 2013)	to identify the relationship between Natural Resource-Based View (NRBV) and Green IT capability	
Process-virtualization	(Bose and Luo 2011)	to assist business managers to adopt Green IT	
Diffusion of innovation	(Bose and Luo 2011)	to assess Green IT initiatives and the Green IT implementation stages at the organizational level	
	(Nedbal et al. 2011a)	to link outsourcing with sustainable IS to examine the possibilities of organizations engaging in green and sustainable initiatives	
Theory of Planned Behavior	(Chow and Chen 2009)	to examine the belief and behavior of IT users in green computing (TPB is an extension to the model of TRA)	
Motivation Theory	(Koo et al. 2013)	to explain the relationship between motivation aspects and perceived usefulness and 'group theory' to analyse how the reference group moderates the relationship	
	(Molla and Abareshi 2011b)	to identify the motivations (influential factors) to adopt Green IT in organisations and analyses organizational eco-sustainability influence the adoption of Green IT	
	(Molla and Abareshi 2012)	to investigate the motivational factors to influence Green IT adoption by organisations	
Reference Group Theory	(Koo et al. 2013)	to analyse how the reference group moderates the relationship	
Stakeholder Theory	(Cai et al. 2013)	to identify the political factors (public concerns and regulatory forces) and economic factors (cost reduction and differentiation) for the adoption of Green IT	
Extended Model of Goal-directed Behavior	(Loock et al. 2013)	to outline how information systems plays a key part in encouraging energy saving measures within domestic settings and to emphasize the importance of the goal setting initiatives that were required to affect these outcomes. (argues that EMGB is redefinition of TPB)	
Theory of Absorptive Capacity	(Cooper and Molla 2012)	to study IT organisation's Green IT capability	
Resource-Dependence Theory	(Datta et al. 2010)	to understand the nature of the exchange relationship between IT Services Provider and client organization	
Transaction Cost Theory	(Nedbal et al. 2011a)	for the integration of outsourcing success	
Socio-technical System Theory	(Seidel et al. 2013)	to study how an organizational work system can be transformed in order to attain environmental sustainability targets.	
Theory of Practice	(Taha Ijab et al. 2011)	to identify how Green IS as practice emerged in organisation	
Frame works	Balanced Scorecard	(Jain et al. 2011)	A balanced scorecard (BSC) is proposed to align Green IT initiatives with performance measurement indicators. BSC provides a framework with four dimensions: the financial dimension, the internal operations, the customer dimension, the innovation and learning dimension
	Belief–Action–Outcome Framework	(Gholami et al. 2013)	to study the motivational drivers of a company for Green IS adoption and to identify the impact on the firm's environmental performance
(Melville		to study how society and organizations shape beliefs about green	

		2010)	products (belief), what are the actions taken to develop green products (action), and what are the impacts of these belief and actions environment and organization (outcome).
G-Readiness Framework	(Molla et al. 2008)		G-readiness is a measure of preparedness to be environmentally responsive and competitive, based on the concept of e-readiness frameworks, to help organisations evaluate their readiness for adopting Green IT
Energy Efficiency and Low Carbon Enabler Green IT Framework	(Uddin and Rahman 2012)		energy efficiency and low carbon enabler green IT framework for large and complex server farms to save consumption of electricity and reduce the emission of green house gases to lower the effects of global warming.
Implementation Framework	(Mann et al. 2009)		a practical three step implementation framework with a unique sustainability-based feedback mechanism in order to understand what combination of Green IT practices might optimally benefit in various scenarios
U-Commerce	(Pitt et al. 2011)		four dimensions of U-Commerce (also referred to as u-space) proving that the organizations are trying to pursue and elevate environmentally sound strategies by using the unique characteristics of smartphones
Political–Economic Framework	(Cai et al. 2013)		to identify the political factors (public concerns and regulatory forces) and economic factors (cost reduction and differentiation) for the adoption of Green IT and IT for Green
Green IT Alignment Framework	(Erek et al. 2011)		Strategic Green IT Alignment Framework can guide the decision-makers to select an appropriate Green IT strategy in order to achieve corporate sustainability targets and to leverage with competitiveness
Business Transformation Framework	(Elliot 2011)		Business transformation framework addresses the key issues of uncertainty: what is environmental sustainability, major challenges of environmental sustainability and what is being done about these challenges, also what needs to be done.
Green IS Lifecycle Framework	(Ijab et al. 2010)		to conceptualise ‘Green IS’ and to do so offers a theoretical framework called Green IS Lifecycle Framework (GISLF)”, based on what, where, how & when to inscribe Green in IS. In the proposed framework what indicates - “the inscription and enactment of values of eco-sustainability”, where indicates - “spirit, practice and impact”, how indicates - “design and development” and when indicates “pre-use, use, post-use”
Functional Affordance Framework	(Seidel et al. 2013)		to identify important functional affordances originating in information systems
Green IT Value Model	(Chou and Chou 2012)		Green IT value model which depicts the relationship among these components and the impacts of Green IT. Awareness, translation, comprehension, and Green IT value are the four major components of the Green IT value model

Table 2. Theoretical Frameworks used in Green IT Literature

Segmentation of Green IT Research

Next, we segmented articles pertaining to (1) the core of Green IT, (2) periphery topics, and (3) articles considered beyond the scope of Green IT. Articles categorized as Core Green IT focus on fundamental concepts of Green IT including describing what Green IT is, how it is causing problems to the environment and also how IT can be transformed into Green IT. Periphery topics examine lifecycles, motivations and initiatives surrounding Green IT. Beyond Green IT topics address further themes of Green IT such as awareness, cost of implementation, readiness and capability of organization, and typically consider a wider scenario in which Green IT is included instead of specifically referring or focusing on Green IT itself. This category includes articles realizing the future of Green IT, identifying the

challenges of Green IT, analyzing the costing of Green IT implementation and reviewing published literatures in relevant research area. Table 3 summarizes the results of the classification. We discuss each segment in turn.

Segmentation	Subcategories	Indication	Reference
Core of Green IT	Green IT	What is Green IT	(Bose and Luo 2012; Capra and Merlo 2009; Mann et al. 2009; Molla and Abareshi 2011b; Murugesan 2008; Ruth 2009)
	IT and Environment	How IT is affecting environmental sustainability?	(Ansari et al. 2010; Bose and Luo 2011; Butler 2011; Cooper and Molla 2012; Fuchs 2008; Koo et al. 2013; Molla and Abareshi 2011a; Molla and Abareshi 2011b; Murugesan 2008; Nedbal et al. 2011a; Ruth 2009; Trimi and Park 2013)
		How IT can help to promote environmental sustainability?	(Butler 2011; Chen et al. 2009; Cooper and Molla 2012; Jenkin et al. 2011; Kuo and Dick 2010; Lee et al. 2013; Mithas et al. 2010; Molla and Abareshi 2011a; Molla and Cooper 2010; Nedbal et al. 2011b; Rahim and Rahman 2013; Ruth 2009; Sarkar and Young 2009; Sayeed and Gill 2009; Seidel et al. 2010; Thirupathi Rao et al. 2010; Trimi and Park 2013; Zhang et al. 2010)
Periphery	Motivation	Green IT for operational cost reduction	(Herrick and Ritschard 2009; Kuo and Dick 2010; Marett et al. 2013; Molla and Abareshi 2011b; Murugesan 2008; Sayeed and Gill 2009; Vykoukal et al. 2009)
		Green IT for environment sustainability	(Brocke et al. 2012; Cai et al. 2013; Elliot 2011; Fuchs 2008; Gholami et al. 2013; Murugesan 2008; Watson et al. 2010)
		Green IT for regulatory compliance	(Cai et al. 2013; Chen et al. 2009)
	Lifecycle	Pre-adoption	(Chou 2013; Dao et al. 2011; Datta et al. 2010; Hanne 2011; Harmon and Auseklis 2009; Herrick and Ritschard 2009; Kovačić et al. 2008; Kuo and Dick 2010; Lamb 2011; Molla and Abareshi 2011b; Molla and Cooper 2010; Molla et al. 2009a; Nazari and Karim 2012; Trimi and Park 2013)
		Adoption	(Cater-Steel and Tan 2011; Cooper and Molla 2012; Datta et al. 2010; Gholami et al. 2013; Hasan et al. 2009; Huang 2008; Mithas et al. 2010; Rao et al. 2011; Sarkar and Young 2009; Taha Ijab et al. 2011; Woodruff et al. 2008)
		Post-adoption	(Nanath and Pillai 2012b)
	Initiatives	Technical Solution	(Doh et al. 2010; Hasan et al. 2009; Krikke 2008; Murugesan 2008; Ruth 2009; Seidel et al. 2013; Vykoukal et al. 2009; Zhang et al. 2010)
		Soft Solution	(Ansari et al. 2010; Chetty et al. 2009; Chetty et al. 2008; Chow and Chen 2009; Elliot 2011; Erek et al. 2011; Hasan et al. 2009; Herrick and Ritschard 2009; Woodruff et al. 2008)
	Adoption Level	Macro Level (Region/Country)	(Marett et al. 2013)
		Mezzo Level (Organization)	(Cai et al. 2013; Esty and Winston 2009; Molla 2008; Molla 2009; Molla et al. 2008; Nanath and Pillai 2012b; Rawai et al. 2013)

		Micro Level (Individual)	(Chetty et al. 2009; Chetty et al. 2008; Chow and Chen 2009; Kovačić et al. 2008; Loock et al. 2013; Sarkar and Young 2009; Woodruff et al. 2008)
Beyond Green IT	Pre-implementation	Awareness	(Ansari et al. 2010; Chou 2013)
		Organizational readiness to adopt Green IT	(Molla and Cooper 2010; Molla et al. 2008; Molla et al. 2009a)
		Organizational Capability to adopt Green IT	(Cooper and Molla 2012; Dao et al. 2011; Rahim and Rahman 2013)
	Challenges	Cost of implementation	(Molla 2009; Seidel et al. 2010)
		Conflicts ¹	(Hobby et al. 2009)
	Others	Measuring Green IT in society	(Zhiwei 2012)
		Green to create value, and for competitive advantage	(Esty and Winston 2009)
		Unaddressed concerns	(Brocke et al. 2012; Brocke et al. 2013)
		Literature reviews	(Brooks et al. 2010; Brooks et al. 2012; Corbett 2010; Elliot 2011; Howard and Lubbe 2012; Jenkin et al. 2011; Lei and Ngai 2013; Malhotra et al. 2013; Nanath and Pillai 2012a; Stolze et al. 2012)

Table 3. Segmentation of Publications

Core of Green IT

Murugesan (2008) argues that Green IT is indicative of environmentally sound Information Technology. Information Technology is essentially the design, implementation and management of computers at both the individual and industry level. Green IT has multiple aspects like environmental sustainability, energy efficiency economics and the cost of disposal and recycling. According to Nanath and Pillai (2012b) there are two aspects of Green IT with IT being the cause of environmental issue and the other using IT/IS to resolve the issue.

It is worth mentioning that there are direct and indirect effects of Green IT (Nanath and Pillai 2012b). The direct effect occurs by reducing environmental impact of IT and indirect effect occurs by using IT to support the initiatives promoting sustainability (Nanath and Pillai 2012b). The primary goal of the Green IT strategy is to reduce energy use and relevant costs whilst managing the continuously increasing requirements for performance. Green IT can be considered as an optimal use of information and communication technology to manage enterprise activities in an environmentally sustainable manner. Eastwood (2009) describes Green IT as “a collection of strategic and tactical initiatives that directly reduces the carbon footprint of an organization’s computing operation”.

Murugesan (2008) proposes that there are four stages in the Green IT cycle: Green design, Green manufacturing, Green use, Green disposal and donation of IT systems. Green use focuses on reducing the energy consumption associated with the computer and other information systems and use them in an environmentally sound manner. Green design considers designing energy efficient equipment, computers, servers and cooling equipment. Green disposal proposes repairing and recycling computers and electronic equipment that may be old or unwanted. Green manufacturing refers to manufacturing electronic machineries, computers and other associated subsystems with minimal impact or having no impact on the environment.

In reviewing the literature, which at this point focuses heavily on how IT can help and analyses indicate that Green IT has already had a measurably positive effect on efforts to reduce energy consumption since its recommendations have been applied. Another prominent theme featured in these analyses is a recurring emphasis on the various ways that Green IT has been responsible for detrimental outcomes resulting from the overuse of information networks.

¹ Conflicts between environmental sustainability and high performance of IT

Periphery

The motivation category contains articles pertaining to cost reduction, government legislation and awareness of environmental issues. Many scholars have identified the most important drivers of Green IT as economical, regulatory and ethical (Molla 2008; Murugesan 2008). According to Bose and Luo (2011) the primary drivers of Green IT are: reducing costs due to budget cuts (cost), complying with the local law (legislation) and reducing consumption due to resource restrictions (environment). The two major benefits of Green IT implementation has been identified as reduced operating cost and protection for the environment. In discussing Green IT benefits, Brooks et al. (2012) say “here are two major categories of benefits: environmental benefits and cost reduction benefits”. Therefore, it is evident that Green IT aims at cost reduction as well as environmental protection.

The lifecycle category contains articles reflecting pre-adoption (decisions to implement Green IT or deciding whether Green IT is necessary for the organization and considering cost to implement Green IT), post-adoption (analyzing benefits/effect after adoption and actions in order to continue Green IT implementation) and management (manage to continue Green IT initiatives within organization and other managerial perspective of Green IT). The main topics focused on by the past research includes: explorations of influential factors for adoption decisions (Harmon et al. 2010; Kuo and Dick 2010; Molla and Abareshi 2011b; Murugesan 2008; Nazari and Karim 2012; Sarkar and Young 2009) , the adoption process (Bose and Luo 2011) and the importance of Green IT adoption in developing countries (Hanne 2011). Also identifying factors that are highly influential to extent of Green IT practice in organization (Cater-Steel and Tan 2011; Gholami et al. 2013; Kuo and Dick 2010), analysis of the risks of adoption (Chou 2013), discusses Green IT management issue (Cooper and Molla 2012) and illustrates the managerial attitude to Green IT adoption (Sarkar and Young 2009). Furthermore research was conducted to identify the relationship between Natural Resource-Based View (NRBV) and Green IT capability (Rahim and Rahman 2013), to develop sustainability capabilities of firms (Dao et al. 2011). Some researchers address the problems encountered after implementing Green IT within organization and propose sustainability models to address the issue (Nanath and Pillai 2012b). Others analyze the readiness of organizations to adopt Green IT (Molla 2008; Molla et al. 2008). Most of the research performed in this area is from the organizational perspective with few considering individual motivation and behavioral attitude towards Green IT (Chetty et al. 2009; Chetty et al. 2008).

A significant amount of research has been performed on investigating Green IT initiatives. The initiatives range from technical solutions for more sustainable IT to a soft solution approach to promote Green IT. The technical solution focuses on the energy-efficient equipment and eco-friendly hardware in terms of using, designing and manufacturing, and disposing (Murugesan 2008).

Vykoukal et al. (2009) find IT can be ‘Green’ by using energy efficient equipment, improving airflow management systems to reduce cooling requirements and considering virtualization technology. Author states that “Grid technology provides enterprises with the opportunity to build up their own Green IT solution relatively fast by interconnecting existing computing and storage capacity into a grid. Another option for enterprises is to purchase grid resources on-demand from external service providers that have already launched Green IT initiatives”. Ruth (2009) identifies that data centers and servers; e-waste, software etc. are causing problems mostly by power consumption, raw materials, spaces and discusses the technical improvement to reduce the environmental impact. Krikke (2008) also describes major impacts of e-waste (waste of hazardous electronic equipment) on the environment and suggests recycling e-waste as a solution. Furthermore, Doh et al. (2010) discuss the requirements for real deployment of ZEUS (Zero Energy for Unused Servers) on data centers as a technical solution. Zhang et al. (2010) propose two new heuristic task scheduling algorithms, namely Shortest Task First for Computer with Minimal Energy First with Speed Adjustment (STFCMEF-SA) algorithm and Longest Task First for Computer with Minimal Energy First with Speed Adjustment (LTFCMEF-SA) algorithm to reduce energy consumption of the server, data center and cloud computing.

On the other side, soft solutions draw the attention of behavioural attitudes like paperless offices, less printing or printing on both sides (Ansari et al. 2010), video and mobile conferencing. Apart from explaining environmentally friendly hardware, many scholars propose soft solutions to promote Green IT. Vlek and Steg (2007) identify many challenges of human behaviors and environmental sustainability, including the significant effect of behavioural and/or environmental changes on human well-being. Hasan et al. (2009) mention examples of being paperless, such as with e-business, online surveys, e-books, online news and digital archiving. Woodruff et al. (2008) explore the intention of end users to be

green d through exploration of existing “Green” lifestyles. Scholars consider education and training for the soft solutions (Herrick and Ritschard 2009) and focus on IT users' belief and behavior towards Green computing (Chow and Chen 2009).

A significant amount of articles consider both technical solutions and soft solutions for Green IT implementation. Hasan et al. (2009) blame ‘internet’ as one of the main reasons for environmental issues and proposes many strategies to convert ICT as solutions for the environmental problems. Chetty et al. (2009) explore the combination of new computing systems with better power management and power management habits of end users as a high potential for energy savings. While discussing how e-waste is causing an environmental problem, Ansari et al. (2010) suggest a soft solution like printing both sides within the organization.

Kovačić et al. (2008) mention that factors influencing IT innovations adoption have been studied at three levels: macro level (regions and countries), mezzo level (organizations/industries) and micro level (individuals and households), which after consideration have then been placed under the appropriate segmentations in the periphery section. This is done to differentiate among the three levels where ‘macro level’ contemplates Green IT adoption across country or region level, mezzo level refers to Green IT adoption at organization or industry level and ‘micro level’ reflects Green IT adoption by individuals. An overview of the research sample reveals a scarcity of available studies attempting to specifically analyze macro content at a deeper level, as only (Marett et al. 2013) have attempted to analyze the factors for successful and sustained use of Green IS in the trucking industry in USA. A common finding across the existing studies is that the bulk of studies consider mezzo level or organization level (Jenkin et al. 2011). A third consistent finding has been the lack of discussion and depiction of micro level with few references to Green IT adoption by individual (Loock et al. 2013).

Beyond Green IT

The ‘beyond Green IT’ category contains articles pertaining to pre-implementation, challenges and others addressing measuring of Green IT and extensive benefits of Green IT. Articles which do not readily fit into core of Green IT and Periphery segments, yet have a legitimate relationship with Green IT have been included in this segment. Most of the researches performed in the area were from the perspective of pre-implementation of Green IT which has been further classified into awareness, organizational readiness to adopt Green IT, and organizational capability to adopt Green IT. Due to limitation of word, we are not describing each substances of ‘beyond Green IT’ section in table 3, as we believe it is self-descriptor.

Several articles reviewed the literature of Green IT (Brooks et al. 2010; Corbett 2010; Lei and Ngai 2013; Nanath and Pillai 2012a) and Green IS (Brooks et al. 2012; Howard and Lubbe 2012). Furthermore the dimensions of Green IT and theoretical frameworks to investigate Green IT adoption were investigated. Our review is different to all other review papers as we create the segmentation to draw the overall picture of Green IT and also gather all other papers that exist in the literature. Table 4 summarizes these reviews.

Reference	Description
Brooks et al. (2010)	involves a comprehensive review of both the practitioner and academic literatures of Green IT to identify noticeable gaps in literature and to provide academic research directions within the Green IT research area
Corbett (2010)	considers a small-scale examination of practitioner literature on Green IT and converses several dimensions of value related to Green IT
Elliot (2011)	analyses and synthesizes relevant literature to develop a framework for IT-enabled business transformation and claims that this holistic, trans disciplinary, integrative framework addresses the key issues of uncertainty: what is environmental sustainability, major challenges of environmental sustainability and what is being done about these challenges including what needs to be done. Author considers business transformation due to its potential capacity for innovation and change—locally, nationally and globally, business transformation is recognized as being a critical contributor in realizing the challenges of environmental sustainability
Jenkin et al. (2011)	reviews literature of both Green IT and Green IS, and proposes a multilevel research framework to develop propositions and to identify important future research areas
Brooks et al. (2012)	reviews both the practitioner and academic literature of Green IS and tries to identify the current states and trends in Green IS research. This study also attempts to identify overlaps and differences between academia and practice to find noticeable similarities or gaps in order to propose more focused direction to Green IS researchers

Howard and Lubbe (2012)	provides a synthesis of Green IS frameworks in the relevant research area to investigate “how organisations can use the existing Green IS frameworks to achieve strong environmental sustainability
Nanath and Pillai (2012a)	a comprehensive review of literatures on Green IT and it comes up with three dimensions of Green IT: business value (profitability, optimization, efficiency etc.), negative impacts of computing (power, energy, e-waste etc.) and IT as a tool for environmental awareness (strategic alignment, motivation, blogs etc.)
Stolze et al. (2012)	focuses on the global top journals from the AIS Basket of Six and the primarily German-language journal <i>Wirtschaftsinformatik</i> (WI), this article aims to identify the different research streams and research traditions within the global IS discipline
Malhotra et al. (2013)	discusses three publications of the special Issue ‘IS & Environmental sustainability’ and dispenses the articles into three transformation themes: (1) green IS for organizational transformations (Seidel et al. 2013), (2) green IS for supply-side transformations (Marett et al. 2013), and (3) green IS for consumption-side transformations (Loock et al. 2013)
Lei and Ngai (2013)	focuses on a literature review of the adoption of Green IT and discourses the status of information systems literature on Green IT and the Technology–Organization–Environment (TOE) theory to investigate Green IT adoption

Table 4. Identified Papers Expressing a Holistic Review on Green IT

Research Gap Analysis and Future Work

The literature review undertakes a comprehensive assessment of articles circulated in the fields of Green IT and Green IS in order to provide a better understanding of the trends in the research, and identify any noticeable gaps in publications that reference Green IT and Green IS.

Problems associated with Green IT can be resolved with further analysis and development of existing theories. The absence of a theoretical framework has been identified as a major gap in Green IT literature, since limited numbers of publications present theories related to Green IT. As Nanath and Pillai (2012a) mention only 22% of the overall publications contribute to theory. Bose and Luo (2011) support the contention that a major gap in the literature of Green IT exists due to the lack of a theoretical framework. Besides the absence of theory, reviews of prior literature illustrates further gaps in this research area. Few studies investigate the issues managing Green IT after implementation, not many studies in complete lifecycle of Green IT (pre-adoption to post adoption). Furthermore, more focus on regulatory motivation of Green IT, Green IT policy disclosure and regulations, empirical studies on what is actually happening within organization, and regulation of discloser is required.

This study has attempted to identify the research trends and emerging areas in the Green IT field and identify any gaps in the literature for future researches to take place. Future research can be directed towards replication across more studies and across different disciplines. Further insight is able to be obtained through reviewing contemporary Green IT and Green IS literature. Additional research should be directed towards performing an analysis on the real challenges to manage Green IT through the interviewing of vendors, consultants, researchers and users.

Conclusion and Implication

This study-in-progress has identified the established and emerging areas in the Green IT field and identifies gaps in the literature for future research to take place. The purpose of this study is to review the practitioner and academic literature to provide a summary of published research and to pinpoint the current trend of Green IT research in the Information System discipline. Literature shows that scholars are beginning to pay more attention to this interesting and imperative topic, with a more rigorous effort are needed to fully understand the welfares and challenges of Green IT. This research also detects the urgency of addressing the identified gaps.

Several limitations that are apparent in the study include that only 98 articles that were specified above were studied. The obvious criticism is directed towards the reliability and generalizability of the analysis. Not all Green IT papers are accounted for, although we argue that examining 98 articles are useful for a nascent research area. This study cannot assert that the result would be similar if the sample size considers supplementary numbers of articles. Despite these limitations, this study makes several contributions to the Green IT research field. It opens up various opportunities for establishing cumulative knowledge to the discipline and will help researchers to identify potential focuses in future studies.

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