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GREEN INFORMATION SYSTEMS DESIGN FRAMEWORK: A SYSTEMATIC LITERATURE REVIEW

[1]SHIREEN MUHAMMAD, [2]YUSMADI YAH JUSOH,
[3]JAMILAH DIN, [4]ROZI NOR HAIZAN NOR

[1]Faculty of Communication, Visual Art & Computing, Universiti Selangor, Malaysia
[2, 3, 4]Faculty of Computer Science and Information Technology, Universiti Putra Malaysia, Malaysia
E-mail: [1]shireen@unisel.edu.my, [2]yusmadi@upm.edu.my, [3]jamilah@upm.edu.my, [4]rozi@upm.edu.my

ABSTRACT

The research on information systems (IS) and environmental sustainability has grown under the notion of green IS. Hence, it is important to comprehend the concept of green IS and to ascertain existing frameworks for designing it. This paper presents the definition and taxonomy of green IS, areas of green IS research currently being addressed by IS academics and research directions for future studies on green IS design framework. This paper follows systematic literature review (SLR) procedures with snowballing approach as the main method. Relevant articles were mainly selected by referring to the Association of Information Systems (AIS) and thus, are relevant to the IS academic community. This paper synthesized the six elements for green IS design framework namely context, goals, roles, design principles, functions and features. This provides a foundation for the future green IS design framework. The evidence indicates that there is absence of metrics in measuring green IS design, which is valuable in assessing such systems.

Keywords: *Design, Framework, Green IS, Snowballing, Systematic Literature Review*

1. INTRODUCTION

The term sustainable development was first articulated by the International Union for Conservation of Nature (IUCN) in the World Conservation Strategy (IUCN, UNEP and WWF 1980). The World Commission on Environment and Development, in their Brundtland Report (1987) afterwards defined sustainability development as a development that meets the needs of the present without compromising the ability of the future generations to meet their own needs. And finally, the European Commission, at the World Summit on Sustainable Development in 2002 (UN, 2002) has formulated the three pillars of sustainable development: social, environmental and economic responsibilities as symbolized by the summit theme of people, planet and prosperity.

In connection to the sustainability obligations, the IS discipline, being based on the establishments of various disciplines, has a focal role in addressing challenging environmental issues in light of the field's involvement in designing, building, deploying, evaluating, managing and studying IS to address such complex issues (AIS SIG Green Statement on Environmental Change 2012). Accordingly, the effect of IS on environmental sustainability has became a hot topic of study and grown under the notion of green IS.

Green IS literatures persistently quote sustainable development in their discussions and arguments [1], [2] and [3] as it is believe that the greening efforts would be played and better assisted by green IS [4, 5] through automation, transformation and information. Having placing green IS in environmental standpoint and recognizing the potentials of green IS, IS researchers are offered with prospects to investigate and deliver solutions for environmentally sustainable individuals, organizations and society.

In this paper, green IS is defined and further illustrated in a taxonomy; existing green IS research and design frameworks are discussed; and finally, future research gaps are identified. The paper is organized as follows: *Section 2* introduces the method applied for this SLR, *Section 3* summarizes the procedures planned, *Section 4* recaps the conducted procedures and *Section 5* presents results of the review by answering research questions. *Section 6* finally states the conclusion and future work.

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2. METHOD

The review is mainly conducted based on the "light" version of SLR as proposed by [6] and [7], containing the most important steps as depicted in *Figure 1*. The first phase involved planning the review by identifying the need for a review, specifying research questions and developing a review protocol. The second phase comprised of conducting the review of which, primary literatures were identified, selected, assessed and analyzed. The review is concluded in the third phase where findings were reported. Literatures were managed with the assistance of *Microsoft Excel* and *Endnote* reference manager.

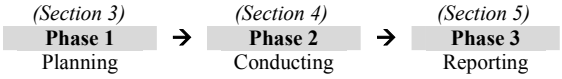

Figure 1: *Adopted review process*

3. PHASE 1: PLANNING THE REVIEW

Results of this phase are clearly defined purposes and procedures of the review as summarized in *Section 3.1*, *3.2* and *3.3*.

3.1. Identifying the Need for a Review

Despite of the growing awareness by researchers on the issues of green IS, the concept of green IS is equivocal and the design frameworks for green IS are hitherto to be discovered. This review is to address these gaps.

3.2. Specifying the Research Question(s)

The research questions specifically addressed by the review are:

RQ1: What is green IS? The review intends to clarify the concept of green IS, including definition and taxonomy.

RQ2: Which areas of green IS are currently being addressed by IS academics? The review intends to understand existing research pertaining green IS and its design frameworks.

RQ3: What research directions have arisen for future studies on green IS design framework? The review intends to identify future research gaps to position new research activities.

3.3. Developing a Review Protocol

The output of this activity is a detailed review protocol that specifies the procedures that will be used to perform a planned SLR as itemized in *Section 3.3.1*, *3.3.2*, *3.3.3* and *3.3.4*.

3.3.1. Selecting timeframe

Searches were conducted for specific literatures published between 2008 and present (2014) or 2015. The start year of 2008 is chosen as the term green IS was found to be used for the first time in 2008 by [2], [8] and [9] and while the end year are defined by the databases referred.

3.3.2. Selecting sources

By repeating practices of [10], [11] and [12], sources relevant to IS were selected by referring to the Association of Information Systems (AIS) eLibrary, IEEE and SCImago – see *Appendix A*.

3.3.3. Identifying search query

Keywords were derived from research questions *RQ1*, *RQ2* and *RQ3* as shown in *Table 1*. Search strings are formed using Boolean *OR* to connect related synonyms and *AND* to include the three sets of keywords. Hence, the resulting initial search query is *"(A1* ***OR*** *A2* ***OR*** *A3* ***OR*** *A4* ***OR*** *A5* ***OR*** *A6)* ***AND*** *(B1* ***OR*** *B2* ***OR*** *B3* ***OR*** *B4* ***OR*** *B5)* ***AND*** *(C1* ***OR*** *C2* ***OR*** *C3)".*

Table 1: Search expressions

1st set	
ID	**Expression**
A1	Environmental information systems
A2	Environmental IS
A3	Green information systems
A4	Green IS
A5	Sustainable information systems
A6	Sustainable IS
2nd set	
ID	**Expression**
B1	Abstraction
B2	Concept
B3	Conception
B4	Idea
B5	Notion
3rd set	
ID	**Expression**
C1	Framework
C2	Structure
C3	Composition

3.3.4. Selecting literatures

In order to identify literatures that are in line with the aims of the review, inclusion and

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exclusion criteria were defined as presented in *Table 2*.

Table 2: Inclusion and exclusion criteria

ID	Inclusion criteria
CI1	Published between 2008 to present (2014) or 2015.
CI2	Published in the listed sources in *Appendix A*.
CI3	Written in English.
CI4	Stating the term *green information systems*/*green IS* in title/keyword/abstract.

ID	Exclusion criteria
CE1	Unmatched with the inclusion criteria.
CE2	Only citation or abstract available.
CE3	About secondary study.
CE4	Not contributing to new reference finding.
CE5	External to green IS design framework research field.

4. PHASE 2: CONDUCTING THE REVIEW

Search for primary literatures can be carried out using database search (*Procedure 1*) but this alone is inadequate for a full SLR. Other sources must also be searched, including reference lists from relevant primary literatures [6]. Plus, it is very difficult to formulate good search strings, since all too often the terminology used is unstandardized and resulting a large number of irrelevant papers. The latter creates substantial manual work. As an answer, snowballing (*Procedure 2*) is expected to complement database search [13] and hence, adopted in this review.

4.1. Procedure 1

Procedure 1 was commenced from *SD3*, *SD1*, *SD4* and *SD2* in sequence. To control redundancy, any result that is found similar to the earlier database's result was not declared as the later' database's result. Albeit the review has defined initial search query, it was not every time applicable since not every database is able to execute all three sets of keyword in chorus, except for *SD1* and *SD4*. Thus, to find the best query for each database, several search attempts have been made and queries that managed to provide the most relevant results were used. For instance in the case of *SD2*, a very limited number of results were retrieved when using the complete string, and this has justifies a much simpler string – only *A3*. Each database also works uniquely in filtering: *SD3* permits discipline definition, e.g. *computer science*; *SD4* allows finer search by defining discipline: *computer science* and subdiscipline: *information systems and application*; while the rest are not capable of performing these tweaks.

As a result, there were 253 references found that were subsequently scrutinized for *CI1*, *CI2* and *CI3*; resulting 14 initially included references. The relevance of these references was assessed by introducing *CI4*. *Table 3* summarizes the result where the small total number of finally included references, i.e. 9; demonstrates *Procedure 1* merely is insufficient for a full SLR.

Table 3: Procedure 1 result summary

Source ID	Found	Initially included (CI1-, CI2- and CI3-compliant)	Excluded (CI4-incompliant)	Finally included
SD3	24	8	2	6
SD1	144	5	3	2
SD4	41	0	0	0
SD2	44	1	0	1
Total	**253**	**14**	**5**	**9**

4.2. Procedure 2

Procedure 2 adopted three steps from [13] as depicted in *Figure 2*.

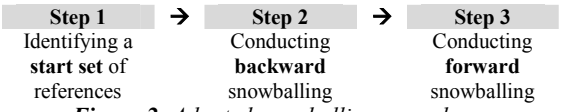

Figure 2: *Adopted snowballing procedures*

4.2.1. Start set of references

Procedure 2 requires a start set of references, which should be from leading journals in the area [14]. All 9 references finalized in *Procedure 1* have met this criterion and therefore qualified as shown in *Table 4*.

Table 4: Start set of references for Procedure 2

	Ref. ID	Source ID	SJR Quartile
1	R01	SJ14	Q1
2	R02	SJ10	Q1
3	R03	SJ02	Q2
4	R04	SJ17	Q1
5	R08	SJ02	Q2
6	R09	SJ02	Q2
7	R10	SJ14	Q1
8	R12	SJ17	Q1
9	R13	SJ02	Q2

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4.2.2. The snowballing

To assure generous number of results, inclusion criterion specified for both backward and forward snowballing is limited to *CI4*. Any result that is similar to *Procedure 1*'s result or earlier iteration's result was not declared as the later iteration's result. While for the exclusion purpose, *CE2* was deployed. Included references for each run is regarded as the start set for the next run.

The procedure started with backward snowballing in three runs: *Iteration 1*, *2* and *3*. *Iteration 1* and *2* found 17 and 3 new references, respectively; while *Iteration 3* has not discovered any new reference and hence, backward snowballing is concluded with a total of 20 new references found. The number of new references found decreases in each iteration indicates that the procedure was initiated from a good start set [13].

Subsequently, forward snowballing took place in a single run where the references citing the 28 references in the start set were evaluated. The procedure has found 56 related references in which, 19 are repeated and 3 are *CE2*-compliant, resulting 34 new references found. *Table 5* summarizes *Procedure 2* results.

Table 5: Procedure 2 result summary

	No. of references			
		Removed		
Backward snowballing	**Found (CI4-compliant)**	**Repeated**	**CE2-compliant**	**Included**
Iteration 1	22	2	3	17
Iteration 2	12	8	1	3
Iteration 3	5	5	0	0
Sub total	**39**	**15**	**4**	**20**
Forward snowballing				
Iteration 4	56	19	3	34
Sub total	**56**	**19**	**3**	**34**
Total	**95**	**34**	**7**	**54**

Backward snowballing revealed that there are 5 *CE4*-compliant start references found in *Iteration 1*: *R10*, *Iteration 2*: *R21, R31, R34* and *Iteration 3*: *R35*. Although they did not contribute to new reference finding, they cannot be merely ignored as on the other hand, they were cited by others too, except for *R10* and hence, *R10* as one of *Procedure 1* results is removed from the forward snowballing start set reference list, totaling 28 references.

In addition, forward snowballing has identified 1 *CE4*-compliant start reference: *R02* from *Procedure 1* result. Hence, *R02* was removed from the list. Furthermore at this stage, *Procedure 2* results were reexamined for *CI2*-compliance that was previously ignored at the beginning of the procedure. Each reference was measured to the ratio of *CI2-compliant=1* point, *CI2-incompliant=0* point. Reference with total quality *score=0* was removed. Accordingly, 11 references: *R16*, *R17*, *R21*, *R25*, *R43*, *R53*, *R64*, *R65*, *R67*, *R72* and *R73* were removed from the list, remaining 50 identified references. *Table 6* summarizes *Procedure 1* and *2* results while *Appendix B* provides the list of selected references.

Table 6: Procedure 1 and 2 result summary

	No. of references			
		Removed		
Procedure	**Initially selected**	**CE4-compliant**	**CI2-incompliant**	**Finally selected**
1	9	2	0	7
2	54	0	11	43
Total	**63**	**2**	**11**	**50**

4.3. Quality Assessment

As the review aimed to include primary studies, *CE3* is implemented by which each 50 references was assessed to the following ratio of *CE3-compliant=1* point, *CE3-incompliant=0* point. Reference with total quality *score=1* was removed, resulting 27 (54%) primary references and 23 (46%) secondary references.

The review has identified 27 primary references. To further satisfy the review's green IS interpretation, mapping between Díez and McIntosh [15]'s life-cycle stage of IS and the green IS processes is done and has directed to the identification of focuses for each primary reference, *P1*: pre-implementation (design); *P2*: implementation (acceptance, adoption, use, implementation and diffusion); and *P3*: post-implementation (evaluation, assessment and continued use). Note that *P0* was introduced to classify studies on investment, strategy, management, motivation and the alike.

For the final review purposes, references focusing on *P0*, *P2* and *P3* were excluded by means of *CE5*, resulting 10 references shortlisted for quality assessment.

The quality assessment is done during the data extraction activity to ensure that the included references made valuable contributions to the review. The quality assessment instrument proposed by [16] was adopted as it is found to be most applicable to most types of study. The instrument provides 11 criteria (see *Appendix C*)

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to measure the extent of confidence that a particular reference's findings could make a valuable contribution to the review. The grading for each of the eleven criteria was done on a dichotomous – *Yes* or *No* – scale. In the *P1* final set, each of the included references has been assessed regarding their quality. As a result, *R38*, *R54* and *R68* were removed as they covered less than 80% by *Yes* answers of the quality assessment criteria (see *Appendix D*). This has made possible for the review to finally establish 7 anchor references: *R01*, *R04*, *R12*, *R22*, *R42*, *R46* and *R62* as presented in *Appendix E*.

The intricate process is summarized in *Figure 3*.

Figure 3: Phase 2: Conducting the review

4.4. Data Extraction

Data was extracted from each of the selected primary reference according to a pre-defined extraction form (see *Appendix F*). This form enables recording the full details of the articles under review and to be specific about how each of them addressed research questions. *Appendix G* presents the data extraction results.

5. PHASE 3: REPORTING

The earliest reference found is a conference paper in *SC08* 2009 proceedings while the first journal articles have been published in 2010 (*SJ02* and *SJ17*). Note that the research area of green IS has been officially introduced to IS research community by *SJ17* in 2010 and their call for research on Information Systems and Environmental Sustainability has contributed to the peak of publications in 2011. In 2013, *SJ17* again dedicated a special issue on IS & Environmental Sustainability in Vol. 37 No. 4. *Figure 4* shows the span of 50 publications in these areas through 2008 to 2014 categorized by their type (journal: 15 articles and conference: 35 papers). While *Table 7* and *8* respectively provide an overview on journal and conference proceedings categorized based on publish year. All the included articles are provided in *Appendix B*.

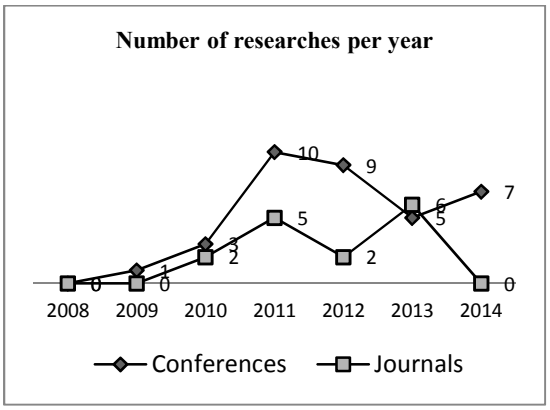

Figure 4: Number of publications in Green IS from 2008 to 2014

Table 7: Researches published in journals

Source ID	'08	'09	'10	'11	'12	'13	'14	Total
SJ01	0	0	0	0	0	2	0	**2**
SJ02	0	0	1	1	1	1	0	**4**
SJ04	0	0	0	1	0	0	0	**1**
SJ06	0	0	0	0	0	1	0	**1**
SJ14	0	0	0	1	0	0	0	**1**
SJ17	0	0	1	0	0	2	0	**3**
SJ18	0	0	0	1	0	0	0	**1**
SJ19	0	0	0	1	1	0	0	**2**
Total	**0**	**0**	**2**	**5**	**2**	**6**	**0**	**15**

Table 8: Researches published in conferences

Source ID	'08	'09	'10	'11	'12	'13	'14	Total
SC01	0	0	2	1	2	1	2	**8**
SC02	0	0	0	1	1	0	0	**2**
SC03	0	0	0	0	0	1	0	**1**
SC04	0	0	0	0	0	0	1	**1**
SC05	0	0	0	3	0	1	2	**6**
SC06	0	0	0	0	0	1	1	**2**
SC07	0	0	0	0	1	1	0	**2**
SC08	0	1	0	1	4	0	1	**7**
SC09	0	0	0	1	0	0	0	**1**
SC10	0	0	0	2	0	0	0	**2**
SC11	0	0	1	0	0	0	0	**1**
SC12	0	0	0	1	1	0	0	**2**
Total	**0**	**1**	**3**	**10**	**9**	**5**	**7**	**35**

This section will continue to deliberate results synthesis for each research questions in

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order to fulfill the objectives of this review as presented in the following sub-sections.

5.1. *RQ1*: What is Green IS?

The term "green" is used most often to refer to new technology and products that improve the sustainability of the natural environment (Simula, Lehtimaki & Salo 2009 in Ijab, Molla [5]. Although the industry associates IT/IS and sustainability with diverse media-friendly labels, including green IT and green IS, these jargons are considered young to the IS domain vocabulary with no universal definition being applied. Plus, ambiguities in understanding what constitutes green IS can deter the development of green IS theories, models and measurements [5]. For those reasons, this section will shed the light by contrasting green IS with its "next-to-kin" terminology, the green IT by answering *RQ1*, which explicates the concept of green IS, including definition and taxonomy.

5.1.1. Scope

[17] and [18] emphasized that green IT is an "umbrella term" referring to both IT and IS. While in contradict, [4] and [19] argued that green IS is inclusive of green IT with regards to the definition of IS [4]: a set of people, processes, software, and IT.

5.1.2. Green IT

Green IT refers to environmentally sound IT [17]. Based on literatures, researchers agreed on the fact that green IT is dealing with the sourcing [18], designing [5, 17, 18, 20], manufacturing [17, 21] or production [18, 22], using [17, 18, 22] or operating [21], managing [20] and disposing [17, 18, 21] of IT equipment [21], and IT technical infrastructure [18, 21] or hardware [20] namely computers, servers, monitors, printers, storage devices, and networking and communications systems [17] and the human and managerial components of the IT infrastructure [18] efficiently and effectively with minimal or no environmental impacts [17, 21, 22] by means of reducing related IT, business process and supply chain related emissions and waste and improve energy efficiency [18].

5.1.3. Green IS

[1, 2, 6, 19 and 20] collectively defined green IS as the use or deployment or implementation; design [5, 9] and development [5]; the investment [21] and management [21]; the reuse [5] and disuse [5] of IS in improving the flow and management of information [20] in order to support sustainable business processes [1, 6]; minimize the negative environmental impacts of IS, business operations, and IS-enabled products and services [21] and furthermore achieve environmental goals [22].

5.1.4. Roles

By the environmental standpoint, [1, 21 and 22] clearly recognized that IT contributes to the problem while IS contributes to the solution. Hence, what are the potential roles of green IS? By applying the roles of IS (Zuboff, 1984 in [5]): automate, transform and informate; alongside the eco-goals [23, 24]: eco-efficiency, eco-effectiveness and eco-equity, Hasan and Alony [24] linked these notions and introduced the green IS efforts: eco-efficiency which involves automation of existing functions by using IT; eco-effectiveness that radically change (transform) current and unsustainable behaviors; and eco-equity that directed at information flow, in which providing information to consumers and businesses about the ecological impact of various activities and disseminating information as a mobilizing force to influence decisions and policy makers.

5.1.5. Definition and taxonomy

From the arguments, it is obvious that green IS is greater than green IT in terms of scope, components, processes and thus plays clearer roles (see *Table 9*). The term green IS is hence defined as:

People activities in the investment, management, design, development, implementation, reuse and disuse of IS to achieve eco-efficiency, eco-effectiveness and eco-equity through automation, transformation and information respectively.

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Table 9: Green IS taxonomy

Comparable components		Comparable processes		Green IS goals-roles relationships	
Green IS	**Green IT**	Green IS	**Green IT**	**Eco-goals**	**Corresponding IS roles**
People	Human	Investing	Sourcing	Eco-efficiency	Automation
Processes	Management	Managing	Managing	Eco-effectiveness	Transformation
Software	N/A	Designing	Designing	Eco-equity	Information
IT	Hardware / IT infrastructure	Developing	Manufacturing / production		
		Using / deploying / implementing	Using / operating		
		Reusing	N/A		
		Disusing	Disposing		

5.2. *RQ2*: Which Areas of Green IS are Currently Being Addressed by IS Academics?

While IS will be a major element in the transition to a sustainable economy [1], it is believe that the greening efforts would be played and better assisted by green IS [4, 5] by inscribing green values in the spirit of an IS at the time of design and development [5]. However, relatively few research examined the frameworks for designing green IS and to date, focus is primarily in the organization or macro-level setting [21, 25-27].

From the macro-level, the review found for example, *R01* has focused on how to support organization in coping with rapid and complex environmental regulation changes from global institutional environment through automation and informing. His study has directed to the identification of green IS roles, namely sense-making, decision making and knowledge creation. Later, *R42* have also provided design principles for automation and informing green IS in logistics by incorporating integrative model *R01* and u-constructs [28]; while *R12* have contributed to the emergence of functional affordances (sense-making and sustainable practicing) a green IS should retain in leading organization en route transformation through environmentally sustainable work practices. Devised from this upshot, *R46* added to the fact that sense-making is the functional affordance that is to be supported by green IS if it is to be used for sustainability reporting. They further offered meta requirements, meta design (features and design principles) and design method for this class of green IS. Except for *R12* that believe in organization transformation as an approach to achieve environmentally sustainable work practice, the remaining researchers have instigated their studies from the fact that organizational environmentally sustainable efforts involve real-time and enormous amount of data that calls for automation and informing.

On the other hand, from the individual or micro-level view, the review found for examples, *R04* and *R22*, focused their studies on using green IS for motivating individuals to be energy efficient, in which they concluded that particular features, namely feedback, goal settings and defaults play significance roles in achieving this motivation. Whereas *R62* conducted a single national cluster study to show which user groups for electric vehicle (EV) in China exist, how they differ in their technological and environmental behaviour whereby their particular needs may be used as a guideline to design a user-centric Green IS.

The review concludes that there are six common elements that constructed a Green IS design namely context, goals, roles, design principles, functions and features. **Context.** There are two contexts of design: macro- (*R01*, *R12, R42*) and micro-level (R04, R12, R22, R62). **Goals.** Each research is conducted to study on the design of green IS that supports environmental regulation compliance (*R01*), environmental sustainable work practices (*R12*), ubiquitous environmental sustainable business process (*R42*), ubiquitous environmental sustainable reporting (*R46*), environmental sustainable behavior (*R62*, energy-efficient behavior (*R04* and *R22*). **Roles.** A green IS, depending on its respective goal, might plays sense-making (*R01*, *R12*, *R42*, R46), decision making (*R01*, *R42*, *R46*), knowledge sharing/creation (*R01*, *R46),* sustainable practicing (*R12*), reflective disclosure (sense-making) (*R12*, *R46*), information democratization (sense-making) (*R12*, *R46*), output management (sustainable practicing) (*R12), and* delocalization (sustainable practicing) role (*R12).* **Design principles**. A green IS needs to provide the following capabilities: monitoring, analysis and presentation or reporting (*R12*, *R42*, *R46*); information access and interaction or diffusion (*R12*, *R42*, *R46);* configuration and controlling (*R12*, *R04*, R22); file sharing and communication (*R12*); accurate, rich, and timely data collection (*R42*)*;* transparency and reliability

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(*R42*, *R46*); performant and persistent data structure (*R42*); interfaces for data integration (*R42*); ubiquitous delegated data collection (*R46*); data validation (*R46*); automated input interfaces (*R46*); data interpretation module (*R46*); data evaluation and plausibility (*R46*); customizable and flexible information patterns (*R46*); and environmental indicator distribution (*R46*). These are further detail-up by R01 and R12 in the form of features and functions.

5.3. *RQ3*: What Research Directions have Arisen for Future Studies on Green IS Design Framework?

The review believes that previous researches have paid limited attention to the development of theoretical frameworks surrounding the design of green IS. Although researchers have started to consider green IS design, the overall body of research is immature. Every single research is limited in scope and may not apply to other Green IS in the sense that, each research is responding to specific context of either organisation or individual. Although they share comparable design elements, they are not integrated for general class of green IS. What notably absent is the lack of study on dimensions of general green IS covering both micro- and macro levels.

6. CONCLUSION

In reviewing green IS design framework, both SLR and snowballing approaches were adopted to fulfills research objectives. IS scholarly literatures were reviewed to identify answers. Based on results, high-level research agendas for future green IS design research were provided. It is hope that this review will provide researchers with a foundation to study this important phenomenon.

REFERENCES

[1] Esty, D.C. and S. Andrew, *Winston. 2006.* Green to Gold: How Smart Companies Use Environmental Strategy to Innovate, Create Value, and Build Competitive Advantage, 2006.

[2] Boudreau, M.-C., R. Watson, and A. Chen, *From green IT to green IS.* Cutter Benchmark Review, 2008. **8**(5): p. 5-11.

[3] Pernici, B., et al., *What IS can do for environmental sustainability: a report from CAiSE'11 panel on Green and sustainable IS.* Communications of the Association for Information Systems, 2012. **30**(1): p. 18.

[4] Watson, R.T., M.-C. Boudreau, and A.J. Chen, *Information systems and environmentally sustainable development: energy informatics and new directions for the IS community.* Management Information Systems Quarterly, 2010. **34**(1): p. 4.

[5] Ijab, M.T., et al., *Seeking the "Green" in "Green IS": A spirit, practice and impact perspective.* 2010.

[6] Keele, S., *Guidelines for performing systematic literature reviews in software engineering*. 2007, Technical report, EBSE Technical Report EBSE-2007-01.

[7] Stapić, Z., et al. *Performing systematic literature review in software engineering*. in *Proceedings of the Central European Conference on Information and Intelligent Systems*. 2012.

[8] Pernici, B., D. Ardagna, and C. Cappiello, *Business process design: Towards service-based green information systems*, in *E-Government Ict Professionalism and Competences Service Science*. 2008, Springer. p. 195-203.

[9] Boudreau, M.-C., A. Chen, and M. Huber, *Green IS: Building sustainable business practices.* Information Systems: A Global Text, 2008: p. 1-17.

[10] Esfahani, M.D., A.A. Rahman, and N.H. Zakaria, *The Status Quo and the Prospect of Green IT and Green IS: A Systematic Literature Review.* Journal of Soft Computing and Decision Support Systems, 2015. **2**(1): p. 18-34.

[11] Wang, X., S. Brooks, and S. Sarker, *A Review of Green IS Research and Directions for Future Studies.* Communications of the Association for Information Systems, 2015. **37**(1): p. 21.

[12] Brooks, S., X. Wang, and S. Sarker, *Unpacking Green IS: A Review of the Existing Literature and Directions for the Future*, in *Green Business Process Management*. 2012, Springer. p. 15-37.

[13] Wohlin, C., *Guidelines for Snowballing in Systematic Literature Studies and a Replication in Software Engineering.* 2014.

[14] Jalali, S. and C. Wohlin. *Systematic literature studies: database searches vs. backward snowballing*. in *Proceedings of the ACM-IEEE international symposium on Empirical software engineering and measurement*. 2012. ACM.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[15] Díez, E. and B.S. McIntosh, *A review of the factors which influence the use and usefulness of information systems.* Environmental Modelling & Software, 2009. **24**(5): p. 588-602.
[16] Dyba, T., T. Dingsoyr, and G.K. Hanssen. *Applying systematic reviews to diverse study types: An experience report*. in *Empirical Software Engineering and Measurement, 2007. ESEM 2007. First International Symposium on Empirical Software Engineering and Measurement.* 2007. IEEE.
[17] Murugesan, S., *Harnessing green IT: Principles and practices.* IT professional, 2008. **10**(1): p. 24-33.
[18] Molla, A., V.A. Cooper, and S. Pittayachawan, *IT and Eco-sustainability: Developing and Validating a Green IT Readiness Model.* ICIS 2009 Proceedings, 2009: p. Paper 141.
[19] Butler, T., *Towards a practice-oriented green IS framework.* 2011.
[20] Sarkis, J., C. Koo, and R.T. Watson, *Green information systems & technologies-this generation and beyond: Introduction to the special issue.* Information Systems Frontiers, 2013. **15**(5): p. 695-704.
[21] Loeser, F., *Green IT and Green IS: Definition of Constructs and Overview of Current Practices.* 2013.
[22] Dedrick, J., *Green IS: concepts and issues for information systems research.* Communications of the Association for Information Systems, 2010. **27**(1): p. 11-18.
[23] DeSimone, L.D. and F. Popoff, *Eco-efficiency: the business link to sustainable development*. 2000: MIT press.
[24] Hasan, H.M. and I. Alony, *Suggesting a practical agenda for Green IS-recent solutions within a framework of efficiency, information, and effectiveness.* 2011.
[25] Jenkin, T.A., J. Webster, and L. McShane, *An agenda for 'Green'information technology and systems research.* Information and Organization, 2011. **21**(1): p. 17-40.
[26] Wati, Y. and C. Koo. *Toward green IS adoption behaviors: A self-determination perspective*. in *System Science (HICSS), 2012 45th Hawaii International Conference on*. 2012. IEEE.
[27] Wacker, A., et al., *Identifying Main User Groups for Green IS–An Empirical Study of Electric Vehicles in China.* Thirty Fifth International Conference on Information Systems, 2014.
[28] Junglas, I. and R.T. Watson, *The u-constructs: four information drives.* Communications of the Association for Information systems, 2006. **17**(1): p. 26.