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Towards a Green IS Taxonomy

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Abstract
This paper proposes a set of categories and topics to guide the formation of a taxonomy of Green IS in an endeavor to stimulate efforts to determine the scope and content the field. The resulting taxonomy will complement the SIGGreen Statement of basic Green IS principles. The suggested categories for the taxonomy presented in this paper include the greening of core IS activities supplemented with additional topics drawn from the emerging body of Green IS literature, outcomes of workshops, conference presentations and meetings of SIGGreen as well as the authors experience and communication with fellow members of SIGGreen. It is hoped that others will engage in a constructive effort to further develop the taxonomy and that it will be used to support the application of IS toward global and local initiatives for Sustainable Development.

Keywords: Green IS, Taxonomy, Sustainable Development

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INTRODUCTION

As a specialization within the field of Information Systems (IS), Green IS encapsulates the responsibility of IS researchers and practitioners towards environmentally sustainable development. There is a growing community of IS scholars who are accepting this responsibility and creating an emerging body of Green IS knowledge over a disparate range of topics. They have formed a special interest group (SIGGreen), of the Association for Information Systems (AIS) as an international community of academics pursuing Green IS research. The members of SIGGreen have composed and published a statement of its beliefs that "*it is incumbent upon them, as IS professionals, to apply their knowledge and expertise towards global sustainable development*"[1]. To accompany SIGGreen's Statement of basic principles, SIGGreen has held workshops[2] to determine the scope and content of Green IS.

The aim of this paper is to provide a concrete basis for this scoping effort and to stimulate its continued development. We begin with an examination of the environmental responsibilities that impact activities that form the core of the IS discipline as identified by Sidorova et al (2008) and others. We then draw on the emerging Green IS literature, in particular the extensive review of Melville (2020) and Elliot (2011), and add items from a content analysis of 52 key Green IS publications. We also draw topics from emerging research presented at SIGGreen workshops to identify additional candidate categories for Green IS that are not presented in the IS core and existing Green IS literature. Following the example of Hasan's (2012) analysis of IS as a force for climate change using Activity and Complexity Theories, the emphasis is on IS-mediated activities rather than just the topics and technologies themselves. Examples from published Green IS projects are used to illustrate topics within each category in an attempt to map out where Green IS has been and where it may go. The taxonomy presented here is intended as a "work in progress" to stimulate its further development by IS scholars.

This paper takes a conceptual approach to the development of a taxonomy of Green IS topics, grouped into categories that reflect both conventional IS and emerging topics within Green IS. Within the 11 identified categories, IS-based activities and innovative solutions, that support and sustain human endeavors in environmentally responsible ways, are provided to exemplify the topics within each category. In order to look to the future of this developing and critical field of IS research a deliberate effort is made to include topics of embryonic research, which have been discussed at conferences, workshops, SIGGreen meetings or via personal correspondence with authors. The intended audience includes IS and non-IS academics, practitioners, business leaders and policy makers. The hope is to develop a general understanding and context of what we, as IS scholars, mean by Green IS and what Green IS could or should be; and maybe to stimulate a discussion whether we should continue to use the term "Green IS". The taxonomy could lead to a public document explaining Green IS in layman's terms to complement the SIGGreen Statement.

THE GREEN IS STATEMENT

The SIGGreen Statement is a short document setting out the responsibilities of IS professionals, researchers and practitioners, in respect of the adverse environmental changes that are resulting from human activities. It suggests that we have an obligation to combine our specialized knowledge and skills with those of other professions to find solutions that will

[1] http://siggreen.wikispaces.com/file/view/GreenIS_Statement_August2012.pdf
[2] See Http://siggreen.wikispaces.com

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help mitigate or even reverse detrimental environmental changes as well as allow people and organizations in developing resilience and adapting to environmental changes that are not mitigated. Having been involved in the drafting of the SIGGreen Statement, we make the following observations:

- The SIGGreen Statement is based on the premise that, as IS professionals we have respect for Environmental Scientists and accept the work published in their peer-reviewed journals on the impact of human activity on our planet.
- This impact includes global warming but also other interconnected significant effects so the SIGGreen Statement uses the more general term "Environmental Change" rather than restricting our concerns to "Climate Change".
- We should use our judgment to determine where we can mitigate or even reverse environmental degradation or where we must support effort to adapt to and develop resilience to inevitable change.
- For too long IS has been relatively insular and inward looking and in Green IS we have an opportunity to take on the social, corporate and global responsibility of the IS profession and apply our knowledge and expertise for the greater good.
- SIGGreen has undertaken to inspire environmentally responsible actions by IS professionals and it is hoped that professional bodies such as the AIS will endorse the Statement.

The drafting of the Statement was driven by a group of highly motivated Green IS researchers who are mindful of the global push for Sustainable Development (SD).

THE MOTIVATION FOR, AND IMPORTANCE OF, GREEN IS

The United Nations (UN) leads global attention on SD identifying it as a critical issue for all citizens of the world. This underlines the motivation for the Green IS effort. The 1987 UN definition of SD, "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Brundtland 1987, p. 1) is widely accepted. The UN commitment to SD was reinforced in 2012 in the document "The Future We Want"[3] which begins "*We, the heads of State and Government and high level representatives, having met at Rio de Janeiro, Brazil, from 20-22 June 2012, with full participation of civil society, renew our commitment to sustainable development, and to ensure the promotion of economically, socially and environmentally sustainable future for our planet and for present and future generations*." Green IS sits comfortably at the interconnection between the economical, social and environmental aspects of SD and has much to contribute to sustainable outcomes in the face of climate change and other environmental challenges.

As articulated in the SIGGreen Statement, "*the Information Systems discipline can have a central role in creating an ecologically sustainable society because of the field's five decades of experience in designing, building, deploying, evaluating, managing, and studying information systems to resolve complex problems*". Among IS scholars it is well accepted that IS can be key enablers for activities that drive the mitigation of, and adaptation and resilience to, climate change (Aoun 2011). However, outside the field of IS, most of the treatises on climate change say little about their beneficial role in climate change initiatives and programs. When the topic of climate change held centre stage on the international arena with the release of the Stern Report in the UK (Stern 2006) and the Al Gore documentary, An Inconvenient Truth (Gore 2006), there was surprisingly little mention of either IT or IS.

[3] http://www.un.org/en/sustainablefuture/

There have been several reports (e.g. Velte *et al* 2004, ACS 2007, Gartner 2007, Fujitsu 2011) which see information and communications technologies (ICT) as major polluters through the energy used over the life-cycle of ICT devices and through e-waste. However, this negative aspect can be balanced against the enormous potential of information systems to contribute innovative solutions to both the mitigation of, and adaptation and resilience to, climate change and other environmental problems (see e.g. Watson *et al* 2010; Melville 2010; Elliot 2011). This would not only be in the traditional IS functions of organizations but also in the business and societal transformations made possible by the Internet; and the exciting potential of pervasive and ubiquitous social media. For example strategic use of IS in smart motor systems, logistics, buildings, and grids is estimated to reduce approximately 7.8 billion tonnes (Gt) carbon dioxide equivalent (CO2e), which can translate into approximately €600 billion ($US 946.5 billion) of cost savings (The Climate Group 2008). The Green IS Taxonomy aims to reflect this breadth of application.

Green IS represents a new awareness of IS' responsibility in the global context. For many decades ICT-based systems have been driving a continuing evolution of innovation for all human activities, transforming the ways we do things at home, at work and in the larger society. We now recognize that the use of ICT consumes energy, and most energy production releases Green House Gases (GHG), which are a major cause of global warming and potentially damaging climate change (IPCC, 2012). While there is an imperative to limit GHG emissions, simply turning off the technology is not an option. There is no denying that we need to look for ways to limit the emissions caused by ICT use (popularly called the "Greening of IT" or simply "Green IT"). However, we should also seek ways to use ICT to reduce the harmful environmental and social impacts of all human activity (popularly called the "Greening by IT"). As IS is a field which addresses the human and organizational issues associated with ICT, researchers in IS have taken up the "Greening by IT" cause and called it "Green IS", which Boudreau, Chen and Huber (2008) described as "the design and implementation of information systems that contribute to sustainability of business processes".

The Green IS message was driven home in the Smart 2020 project (GeSI, 2008), a UN media release (UN, 2007) and the CCCI report (Ghose *et al*, 2008, p1) which promoted the notion that "*we live in a massive, inter-connected Planet Earth Supply Chain and IS provides a range of tools to model, manage and optimize this supply chain*". Hasan and Meloche (2013) report evidence from the subjective opinions of IS professionals that identify ICT support for "teleworking and teleconferencing", "monitoring, optimizing, and modeling" and "influencing human understanding and behavior" as key Green IS topics. Ijab, Molla and Cooper (2012) report case studies of such systems and associated practices within an organization. The content analysis of the literature depicted in the Appendix and described below reveals other topics. However, for a general appraisal of Green IS topics it is difficult to know where the boundary of Green IS lies.

Over the last few years, there have been numerous special issues of IS journals, conference tracks, conference panel sessions and workshops in areas related to Green IS although many do not use this term explicitly. For example, the Information Systems Journal in 2012 announced a call for a special issue on "Information Systems addressing the Challenges of Environmental Sustainability" similar to the 2010 MIS Quarterly special issue on "Information Systems and Environmental Sustainability". While these titles are more explicit than "Green IS", three issues are worth raising. Firstly, it is not clear whether "Information Systems" are meant as the artifact, the discipline or both. Secondly, the term "sustainability" implies that we want to keep what we now have, including the disparity between the developed and developing world. We prefer the tem "sustainable development" as it implies

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change and improvement. Thirdly, although the term Green IS is not so explicit, it has gained some currency of use and is more malleable to its meaning and scope. With these notes, we proceed with the taxonomy.

A DRAFT TAXONOMY OF GREEN IS

This draft taxonomy is the result of an attempt to organize Green IS topics in categories of IS activities, drawn from the literature, own experiences and discussions with fellow Green IS researchers at conferences and other meetings. The process for the determination of these categories has been an iterative one where an initial set of categories was determined from these sources and presented at several Green IS workshops and seminars where feedback and suggestions from other Green IS researchers have been used to refine them until they were generally accepted. This has resulted in 11 categories where the first four align traditionally IS topics and the others have, to some extent, been taken into IS because of the growing environmental concerns.

We begin with the challenge of determining what environmental responsibilities, i.e. Green issues, impact core IS topics and activities. The IS discipline has struggled with its diversity (Benbasat and Weber 1996) and fragmented adhocracy (Banville and Landry 1989) for several decades over which there have been many attempts to establish its identity and scope. Among this body of work, we select that of Sidorova et al (2008) as it provides a comprehensive list of topics in five areas: (1) IT and organizations; (2) IS development; (3) IT and individuals; (4) IT and markets; and (5) IT and groups. The emphasis on IT means that the Green issues of many of the topics in areas 1, 3, 4 and 5 fall into the realm of Green IT which we nominate as category (#8) of the Green IS taxonomy informed by the content analysis of 15 Green IT papers shown in the Appendix. Those topics that remain from areas 1, 3, 4 and 5 of Sidorovoa et al's paper, once we remove those that would relate to Green IT, are included in Categories 1, 2 and 3 of the Taxonomy. Area 2 in the Sidorova et al paper, IS Development (ISD), is not currently one that contributes much to the Green IS literature but we include it as a category (#4) in the taxonomy due to its importance to IS. The content analysis of 37 Green IS articles, together with the author's knowledge of Green IS conference tracks, special issues of journals and personal contacts, resulted in the remaining categories. The resulting categories, descriptions, examples and topics within them, are as follows:

1. Creating, Managing and Using Information

The significance of the word 'information' in the general term IT arose decades ago from the fundamental capability of digital data-processing systems to generate copious quantities of information. This capability applies to activities of Green IS that include:

- Using information systems to capture, simulate, process and disseminate data for environmental management and planning (Avouris & Page, 1995)
- Using information systems to reliably inform the public of the Science, Economics, Health, Politics of Environmental Change (e.g. Watson *et al* 2011)
- Building knowledge repositories of the findings of Environmental Change Research (e.g. Liaqut A. 2011)
- Crowd sourcing of information and solutions on Environmental Change (e.g. Pitt *et al* 2011)
- e-Research and big data support for Environmental Change (e.g. Buchhorn & McNamara 2006)

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Environmental Informatics: The use of IS in environmental management has a long tradition. Research, albeit outside the IS field, has focused on IS applications that capture, simulate, process and disseminate heterogeneous and often remote data from environmental objects to facilitate environmental management and planning (Avouris & Page 1995). Thus, the development and utility of a broad spectrum of environmental information systems such as geographical information systems, monitoring and control, computational evaluation and analysis, planning and decision support systems have been researched (Huang & Chang 2003). Hence, IS and their systemic power for multidimensional and multi-scale data analysis and environmental system modelling are seen as catalysts for sustainable development strategies.

Informing the Public: Scientists have been warning of the potential detrimental consequences of human activity on the environment for decades. However, there was little wide-spread public interest until around the time that the Kyoto Protocol, adopted in Kyoto, Japan, in 1997 was due to come into force in 2005. This was followed by the release of the Stern report in 2006 and the release of the Al Gore film "An Inconvenient Truth". By that time, there was rapid global coverage of news and current affairs in media that was still generally expensive and controlled by large news corporations. This meant that official and mainstream views dominated the publically available information and support for climate change mitigation endeavors was generally popular. More recently, the second generation of the Internet (Web 2.0) has opened up public debate to anyone and everyone including vocal climate change skeptics. The ICT tools to manipulate data are readily available to the extent that almost anyone can present graphs of numbers to support any argument they care to make. With the Global Financial Crises and harsher economic conditions, the voice of the skeptics rivals that of the climate sciences. The problem with a lack of general science literacy among the public has meant the average citizen is no longer sure who to believe and their immediate economic concerns often out-weigh their concerns for future generations. IS can play a role to garner support for the mainstream science by helping present the well established climate change science in ways that are meaningful to the general public.

Building knowledge repositories: The e-research movement has looked for ways to use information systems to make huge sets of research data available to others in the field of environmental change. Systems now have the functionality and capacity to store quantitative data and qualitative data including text, images and video. Global access to these data repositories has been made easier by the rise of cloud computing. New ways of tagging all forms of data make it easier to search and manipulate these collections to better inform ongoing research and decision making for both mitigation and adaptation activities.

Crowd sourcing of information and solutions: The current trend of Web 2.0 is in the empowering of the end user and the individual. Applications such as Wikipedia© are leading to the democratization of knowledge where all sides of an issue can be aired and considered valid. This is seen as the co-creation of knowledge and is facilitated by activities such as blogging and self-publishing. The phenomenon of crowd sourcing uses the Internet to elicit solutions to problems from any people who care to participate. This is known as the wisdom in the crowd and is supported by online applications such as Freelancer, Kickstart©, Ushadhidi© and Kaggle©. The more common term is the wisdom of the crowd which assumes that if a large enough group of people independently are asked to decide on a matter, then the decision will be a good one. This is perhaps the most exciting social development for solving wicked problems such as climate change as it opens up the solution space to everyone.

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2. Supporting and Transforming Human Enterprises

Since the 1960s when banks and insurance companies began to use mainframe computers to crunch numbers of customer accounts, information systems have transformed the way human enterprises work. For most of the time IS has been viewed as a way to make businesses more efficient, save costs and innovate for competitive advantage. Sustainability is a more recent concern with topics such as:

- Green Business Process Management (BPM) (e.g. Ghose *et al* 2010; Houy *et al* 2011)
- Monitoring and Recording the Environmental impact of Business Processes (e.g. Caldille & Parmigiami 2004:, Velte *et al* 2008)
- Improving efficiency of business processes to lower GHG emissions (Petrini & Pozzebon 2009)
- G-readiness and compliance (Molla *et al* 2009; Butler & McGovern 2009)

Improving efficiency of business operations: Operating a business today is complicated and the difference between success and failure is often a mix of good management and luck. The management textbooks stress the need to be both efficient and effective. Information systems are a huge factor in driving the efficiency gains for business that rely heavily on a wide range of computer-based applications. Being efficient has environmental benefits as business activities can produce the same effect with the use of fewer resources. Business Process Management (BPM) systems can help firms by designing, managing, sensing, measuring and monitoring more efficient processes particularly in the areas of logistics and supply chains. A recent book (vom Brocke *et al* 2012) contains a wealth of information about the contribution of BPM to environmental sustainability.

Chen, Boudreau and Watson (2008) developed an insightful conceptual model that clarifies the roles of IS in the pursuit of enterprise ecological sustainability. They show how, under different institutional pressures, IS can be leveraged to achieve eco-efficiency through automating, eco-equity through information flows, and eco-effectiveness through organizational transformations. The work of Daly and Butler (2009) also takes an IS perspective using Institutional Theory to develop a set of theoretical propositions which specify the effect that regulatory, normative and cultural-cognitive elements have in shaping environmental responsibility in organizations.

Other prominent Green IS research addresses issues of the use of IT in information systems for ecological and environmental sustainability (Chen *et al* 2008, Daly & Butler 2009, Melville 2010), energy and cost efficiency (Sayeed & Gill 2008, Molla *et al* 2009), as well as environmental monitoring (Velte *et al* 2008), and compliance management (Butler & McGovern 2009).

3. Decision Support for Environmentally Sustainable Development

The IS literature contains large numbers of articles on how business, government and community organizations all rely on information systems to support their decision making. Implications of environmental changes are complicating that process. In particular Governments, and other public bodies that have responsibilities for the welfare of their citizens, are facing decision-making for the future where environmental uncertainties contribute levels of complexity not previously experienced (Smith *et al* 2011). Green IS should be particularly concerned with:

- Incorporating environmental data into modeling of past, current and future scenarios (e.g. Tebaldi *et al* 2006)

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- Integrating knowledge across diverse Information Infrastructures for comprehensive planning for adaptation to environmental changes (e.g. Smith & Hasan 2012)

Modeling future scenarios: Modeling is a key tool of climate changes scientists and most of these models are run on high performance computers. Governments and communities are also involved in complex predictive modeling in respect of programs to help citizens adapt to the adverse effects of climate change. One useful tool has been Geographical Information Systems (GIS) which provide the underlying maps on which to display concentrations of population and GHG emissions, transport corridors, utility locations, changes in sea-levels and vegetation and many other elements that need to be considered in adaptation planning.

Decision support for climate change projects: Computer-based decision support systems have been available since the 1980s and are particularly useful to aid decision makers in complex contexts such as medical diagnoses where many bits of information need to be considered. These systems consist of a database of all known information in a particular domain and a generic engine by means of which users can traverse this data to solve a particular problem using a structures series of if/then questions. Modern decision support tools are more sophisticated but still work best when the domain is bounded and well specified. The challenge for climate change problems is to create decision support tools that can work across many domains. With such complexity, the use of heuristics, probabilities and other non-exact techniques are needed across integrated information infrastructures.

4. Green ISD

An information system will normally include an IT artifact but is a more holistic socio-technical system that serves a particular purpose and is a cohesive combination of processes, hardware, software, storage, devices and human factors. Information systems development (ISD) is a core IS activity aimed at designing and producing this type of system. There are at least two ISD topics that could be included in Green IS:

- Greening the ISD process
- Designing the products of ISD to be environmentally sustainable

In respect of the first topic, a well known IS textbook states that “Developing new systems and modifying existing ones in an environmentally sensitive way is becoming increasingly important for many IS Departments” (Stair & Reynolds 2010 p545). Open Source development provides an example of Green ISD whereby physical boundaries are transcended, tangible resources are replaced with electronic resources; and eco-effectiveness are embedded throughout the product lifecycle (Watson et. al. 2008). However overall there is little published IS research in this area.

In respect of the second topic, some aspects of information systems that are designed to be environmentally sustainable could be:

- Designing systems for the “Green Cloud” (see e.g. Baliga et al 2011)
- Applying good usability guidelines interfaces so that information is readable on screen and hence reduce the need for paper printouts

There is, however, a scarcity of work published in the IS literature to date that deal with topics of incorporating green issues into the design and development of information systems.

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5. Changing Attitudes and Behaviors

This category has not been traditionally part of the IS landscape but has arisen with the advent of social media. With respect to Green IS we can look at topics such as:

- Providing platforms for advocacy (Hasan *et al* 2009)
- Distribution and presentation of the transformation that can change behaviors
- Monitoring changes of attitudes and behaviors
- Evaluating the consequences and impacts of changed attitudes and behaviors

Advocacy: The most spectacular activities of Web 2.0 are those enabled by social media. Applications such as Facebook©, MySpace© and LinkedIn© facilitate the formation of online groups who can advertise their views and recruit like-minded people to their cause from anywhere in the world. Mobile online devices allow the capture of images, audio and video to be uploaded to applications such as Flickr© and Youtube© for public display so that information on what is happening spreads rapidly across the globe. There is now nowhere to hide for those who pollute and groups of protestors can be easily mobilized. An example of one online advocacy group is www.greenwashing.com.

Changing attitudes and behaviors through information: Supportive of the positive Green IS view of ICT, is a series of papers presented at the Workshop on Ubiquitous Sustainability (Hasbrouck *et al* 2007). These papers demonstrate an understanding of emerging practices through which technologies are able to align with environmental values. Many of the papers presented ways of designing innovative but often quite simple systems to influence behavior towards greener outcomes. These included ways to sense and display energy consumption and other carbon emitting events in the home (LeBlanc 2007; Brush 2007; Stringer *et al* 2007), at the office (Bray 2007) and in the town (Hooker *et al* 2007; Ljungblad 2007). Greener actions and uses of technologies have been shown to increase by providing information incorporated in stories (Oehlberg *et al* 2007) and by playing games (Millecevic 2007).

6. Resource Informatics

Information systems have a major role to play in monitoring and reducing the use of resources, particularly those that are scarce and non-renewable.

The field of *Energy Informatics* championed by Professor Rick Watson and others (Watson *et al* 2010) proposes information systems can work with energy delivery systems to create efficiencies that substantially reduce our use of energy. The rise of smart metering of energy supplies is part of this movement. While society has an energy consumption problem, most organizations have particularly poor environmental practices resulting in "many forms of waste; unused resources, energy inefficiency, noise, friction, and emissions are all waste products that subtract from economic efficiency. Energy informatics is concerned with analyzing, designing, and implementing systems to increase the efficiency of energy demand and supply systems. This requires collection and analysis of energy data sets to support optimization of energy distribution and consumption networks" (Watson *et al* 2010 p 24). Using information systems to reduce energy consumption is popular with managers as there is an obvious cost saving that comes with the use of less energy as energy prices rise.

Other researchers are expected to follow the example of Energy Informatics with respect to other resources such as metals, minerals, water, forest, agriculture, soil, oceans etc. One particular area related to the use of ICT is to reduce our reliance on paper (see e.g. Tenhunen & Penttinen 2010) with the increasing usability of e-readers and tablets.

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7. Meeting and collaborating virtually: reducing the need to travel

One of the aims of SIGGreen is to be environmentally responsible in the conduct of its own activities and so its leaders have designed and conducted various programs of scholarly activities using technologies and methods in a deliberate endeavor to do so. This has lead to embryonic research into topics such as:

- The viability, usability, effectiveness of online collaboration tools
- Concerns of security, identity, acceptability of boundary crossing activities
- Demonstrating the challenges and merits of virtual, F2F and hybrid team activities

Meeting and collaborating virtually: Virtual meetings (audio or video) have been possible for several decades but until recently these were either high quality but expensive or low quality at low cost or free. With the rise of VOIP (Voice over Internet Protocols), quality at low cost is constantly improving. Skype© has been at the forefront of this trend in the public arena now allowing multi-way video interactions where the Internet connection is good enough but also providing just audio or even text chat if necessary. Numerous other meeting products such as GotoMeeting© and Elluminate© are useful for more structured interaction in corporate or educational contexts. We can now relatively easily and cheaply organize podcasts, webinars and avatar-based 3D interactions in virtual worlds such as Second Life© (Erickson *et al* 2011). This will spawn many topics of investigation for Green IS scholars as they determine the viability, effectiveness and environmental footprint of such activities, particularly in reducing the reliance on travel.

8. The Greening of IT

Most IS scholars see Green IT as part of Green IS and in particular, developing and using systems that help reduce the environmental impact of ICT. Some of the relevant topics are:

- Software that turn off ICT devices when not in use
- Design and use of low energy use devices
- More efficient data centers and networks
- Protocols to reduce the environmental impact over the Life-Cycle of ICT devices

There are a great many articles in the IT and IS literature that deal explicitly with topics related to the Greening of IT/Green IT and it is beyond the scope of the paper to cover these. However, it is interesting to compare a content analysis of a selective set of 15 key Green IT articles with the content of the first author's library of 37 Green IS articles. List of ranked concepts and concept maps created by Leximancer[4] have been placed in the Appendix. This shows the dominance of the themes of *Technology*, *Energy* and *Costs* in the Green IT literature with *data centers* and *efficiency* highly ranked concepts. In contrast, the Green IS literature has dominant themes of *Environment, System, Analysis* and *Research* with other highly ranked concepts including *sustainability*, *organization*, *information* and *business*.

9. *The Connection of Environmental Responsibility to Economic and Social Imperatives*

As mentioned previously, the 2012 UN commitment to Sustainable Development is expressed in the Rio+20 outcome document, "The Future We Want" and emphasizes the

[4] Using Leximancer software (www.leximancer.com)

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integration of its economical, social and environmental aspects. The implications to Green IS research include:

- Creating and demonstrating the business values of a Green reputation (e.g. Schmidt *et al* 2009; Tenhunen & Penttinen 2010)
- Detecting and Publicizing occurrences of Green Washing (Delmas & Cuerel 2011)
- Finding green solutions to meet the disparate needs of developed and developing countries (related to the work of SIGGlobDev of the AIS)

IS has prided itself as being a multi-disciplinary field of study with strong connections to research in other disciplines. It is no surprise therefore that there are disparate publications that could be considered Green IS topics outside of the IS discipline. Some of these include the positive impact of Green IT social, environmental and economic indicators in organizational systems (Caldille & Parmigiami, 2004), in e-business (Yi & Thomas, 2006) and across the supply chain (Rao & Holt, 2005). What is more, one of the main contributions of Green IS scholars could be in facilitating the integration of economical, social and environmental issues of SD.

10. Education: Including Green IS in the Curriculum

Not as glamorous as research, IS teaching is non-the-less as critical for the future of the discipline as IS research. Several of the papers presented at the first SIGGreen workshop[5] concerned with the incorporation of Green IT and Green IS topics into the IS curriculum. We suggest that we should go further and incorporate Green IS topics into environmental courses more generally. As environmental issues are multi-disciplinary we should also investigate ways to break down the traditional discipline boundaries in the way university courses are designed.

11. Research: Stimulating Innovative Green IS Research

Members of academic communities seek professional esteem from conducting research and publishing their findings and Green IS scholars are no different. Among the growing body of literature on Green IS, the most cited paper is that of Watson, Boudreau and Chen (2010) who describe research that aims to develop environmentally sustainable business practices through the use of "energy informatics". The authors also advocate the broader Green IS cause and "plead for our [IS] leaders to not only champion direct changes but also to provide guidance to IS scholars in their quest for environmental sustainability" (Watson *et al*, 2010 p 33). Two other prominent MISQ articles (Melville, 2010 and Elliot, 2011) include comprehensive reviews of the literature followed by proposals for frameworks that recognize the value of the holistic and trans-disciplinary nature of Green IS research. The number of submissions of Green IS papers to relevant special issues of IS journals and tracks at IS conferences, indicates that quality Green IS research will be published within the IS Discipline. This should continue to be encouraged maybe with a new specialized journal or at least with ongoing tracks at IS conferences.

Green IS research has particular challenges in the complexity, diversity and uncertainty of the causes and the future of environmental change together with the rapid and unpredictability of developments in ICT. For example, who would have thought 10 years ago that emergency services would be using social media to disseminate and collect information during major

[5] See http://sprouts.aisnet.org/view/organization/SIGGreen.html

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crises? Green IS research may need to look for new methods and approaches to produce results that are meaningful in such an uncertain context.

Green IS research is already producing new models, frameworks and theories which should be encouraged to grow and develop as the field matures. Published Green IS frameworks include ones on Energy Informatics (Watson et al 2010), Belief Action Outcome (Melville 2010), G-readiness (Molla *et al* 2009) and Environmental Compliance Management Systems (Butler & McGovern 2009).

In an area as globally important as Sustainably Development, more effort should be made for wider dissemination of Green IS research findings. In a panel at one IS conference, Desouza *et al*, (2006) declared that while IT-based information systems continue to lead transformational efforts in our societies, the MIS research community has yet to keep pace with or lead such efforts. Green IS should be one area where IS scholars could make a global impact guiding practice and influencing policy for sustainable development.

CONCLUSION AND NEXT STEPS

This paper has presented a first cut of a Taxonomy of Green IS using the following list of categories:

- Creating, Managing and Using Information
- Supporting and Transforming Human Enterprises
- Decision Support for Environmentally Sustainable Development
- Green ISD
- Changing Attitudes and Behaviors
- Resource Informatics
- Meeting and Collaborating Virtually: Reducing the need to Travel
- The Greening of IT
- The Connection of Environmental Responsibility to Economic and Social Imperatives
- Education: Including Green IS in the Curriculum
- Research: Stimulating Innovative Green IS Research

This set of categories, with their descriptions and examples, is intended to be a contribution to effort to scope the field of Green IS and to the Statement of basic principles put forward by SIGGreen. This paper is written as part of the 2012 program of SIGGreen activities to aid the development of a general understanding and context of what we, as IS scholars, mean by Green IS. Some of the next steps include:

- that the academic IS community continues this scoping exercise and further develops this taxonomy;
- that the SIGGreen Statement and an accompanying description of what Green IS is, or should be, reach a wider audience beyond academia;
- that, as a result, the IS community contributes its particular knowledge and skills to global and local sustainable development; and also
- improve its reputation as a field where its research is not only rigorous but highly relevant to critical economic, social and environmental challenges.

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APPENDIX

Two set of documents, one of 37 prominent Green 15 prominent Green IT articles and one of IS prominent articles, were analyzed using Leximancer (Version 4); a software application for performing conceptual analysis of text data where words are mapped onto a small set of derived concepts. Leximancer is superior to other text mining approaches in the way robust artificial intelligence algorithms develop and identify concepts and the relationships between them (Smith & Humphreys 2006; Martin & Rice 2007). The resulting concept tags provide a document exploration environment for the user (Smith 2003). Leximancer develops a co-occurrence matrix of concept frequency and the co-occurrence of data, and then applies a statistical algorithm to derive a two-dimensional concept map (see Figures 1 and 2). The labels and themes are developed solely from the text analyzed; thus avoiding researcher bias (Hewett *et al* 2009). Details of the scientific basis of Leximancer can be found from Smith (2003) and Martin and Rice (2007).

Due to the validity and quality of Leximancer's in-built analytics it has two distinct advantages: usability and objectivity. Large amounts of text can be processed quickly in a quantitative, unsupervised manner that may identify concepts that were not envisaged by the researchers. One run of the Leximancer procedure produced a list of ranked concepts and an initial concept map such as depicted below. After the first pass, users can inspect the source of the concepts in the text, and remove, merge or add concepts where appropriate. Another pass can then quickly regenerate the map. Text is quickly re-classified using machine learning that removes much of the need to revise thesauri as the domain vocabulary evolves.

The researcher can then drill down to the text where individual concept are found to get a deeper understanding of meaning in the text related to the ranked concepts.

For each set of documents (Green IS and Green IT) we present the list of ranked concepts and the Leximancer concept map with all identified concepts grouped into themes by the Leximancer algorithm.

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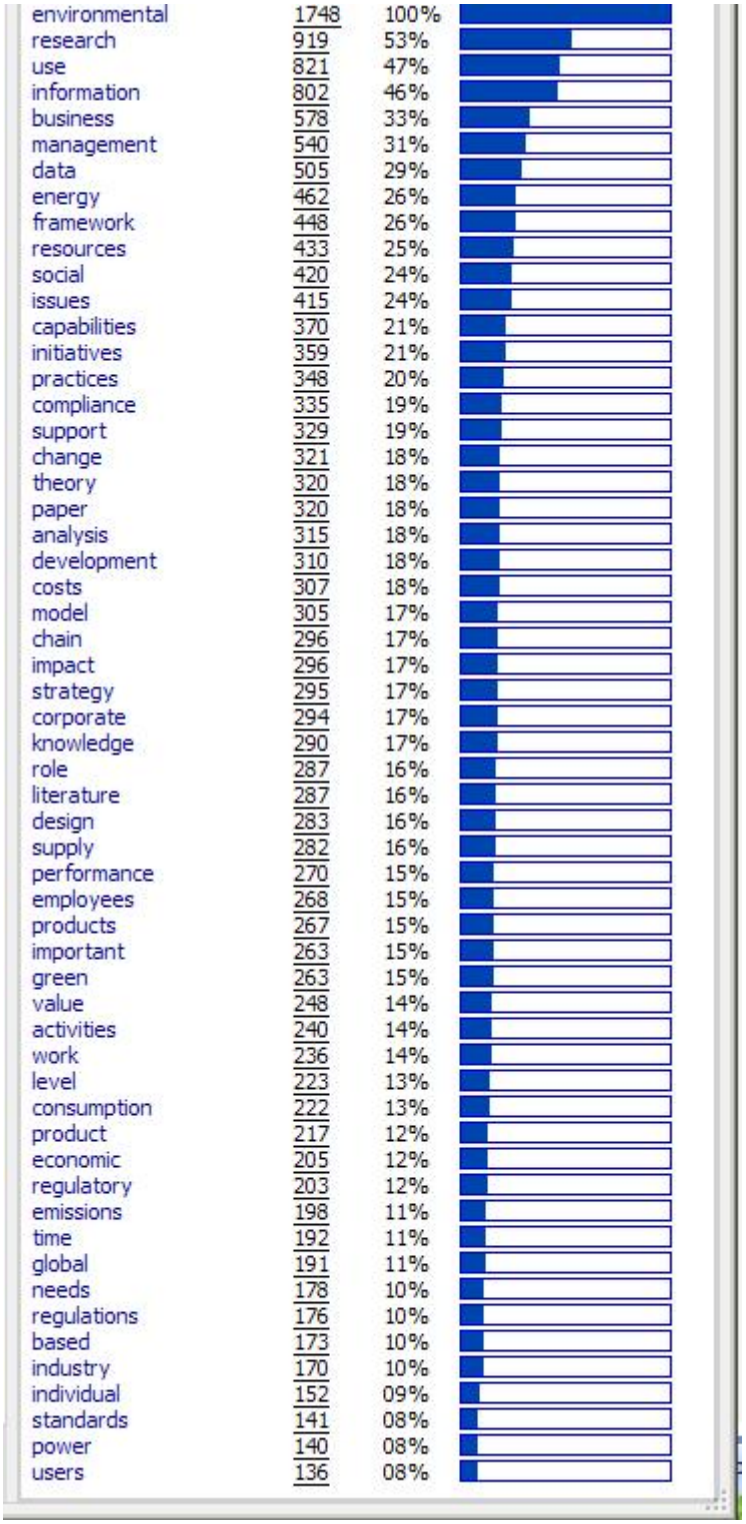
Ranked Concepts in the Green S Literature



environmental	1748	100%
research	919	53%
use	821	47%
information	802	46%
business	578	33%
management	540	31%
data	505	29%
energy	462	26%
framework	448	26%
resources	433	25%
social	420	24%
issues	415	24%
capabilities	370	21%
initiatives	359	21%
practices	348	20%
compliance	335	19%
support	329	19%
change	321	18%
theory	320	18%
paper	320	18%
analysis	315	18%
development	310	18%
costs	307	18%
model	305	17%
chain	296	17%
impact	296	17%
strategy	295	17%
corporate	294	17%
knowledge	290	17%
role	287	16%
literature	287	16%
design	283	16%
supply	282	16%
performance	270	15%
employees	268	15%
products	267	15%
important	263	15%
green	263	15%
value	248	14%
activities	240	14%
work	236	14%
level	223	13%
consumption	222	13%
product	217	12%
economic	205	12%
regulatory	203	12%
emissions	198	11%
time	192	11%
global	191	11%
needs	178	10%
regulations	176	10%
based	173	10%
industry	170	10%
individual	152	09%
standards	141	08%
power	140	08%
users	136	08%

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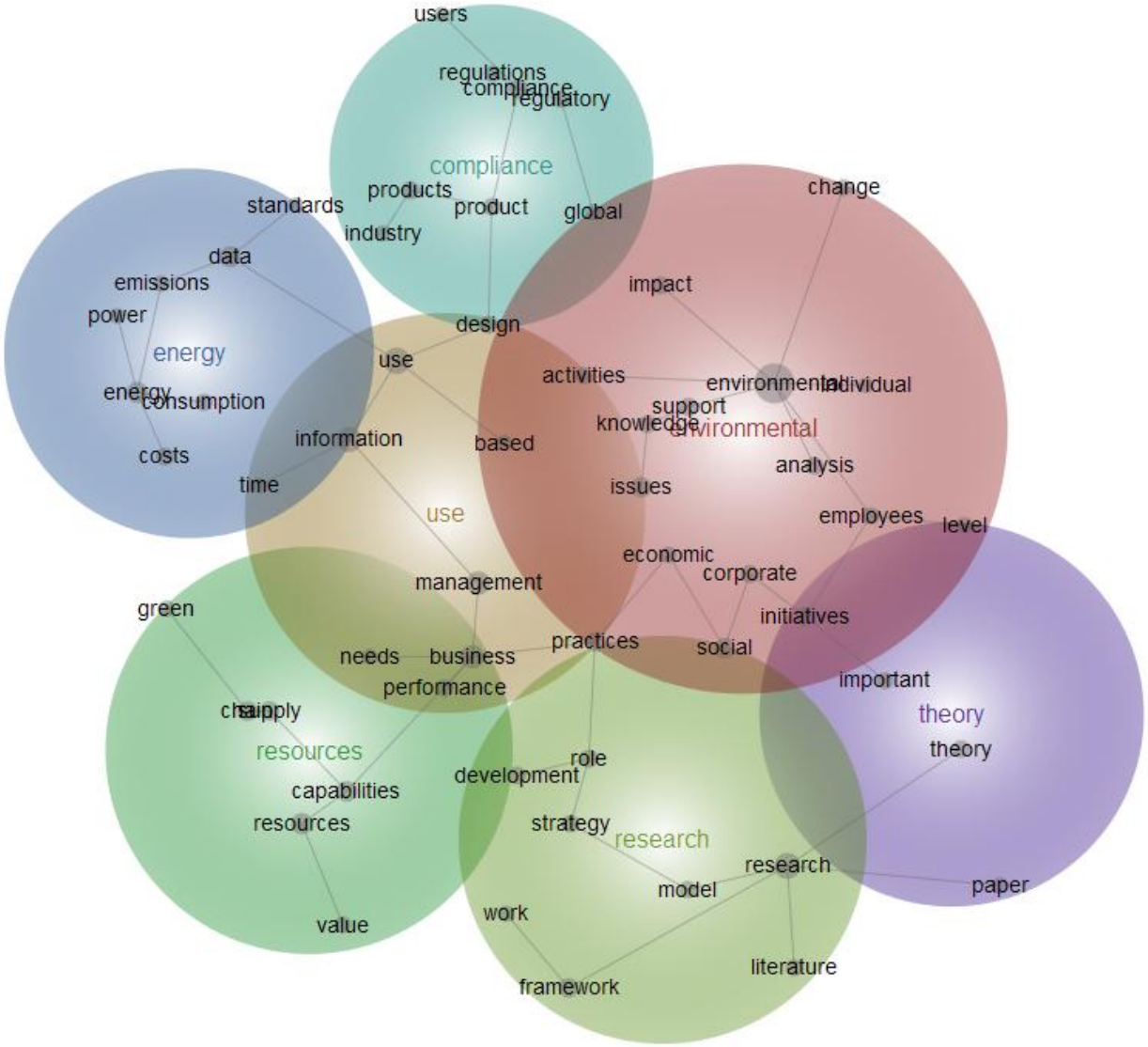

Figure 1 Output of the Leximancer content analysis of a library of 37 prominent Green IS articles grouped into coherent themes. The themes and concepts within them support the following categories of the Taxonomy as follows:

Taxonomy Category	Theme and Concepts
Supporting &Transforming Human Enterprises	Resources Themes
Creating, Managing and Using Information	Use Theme
Decision Support for Environmentally Sustainable Development	Environmental Theme with concepts of Knowledge and Analysis
Green ISD	Not yet prominent in this literature
Changing attitudes and behaviors	Compliance Themes
Resource Informatics	Energy Theme
Meeting and collaborating virtually: reducing the need to travel	Not yet prominent in this literature
The connection of environmental responsibility to economic and social imperatives	Not yet prominent in this literature
Research: Stimulating Innovative Green IS Research	Research and Theory Themes

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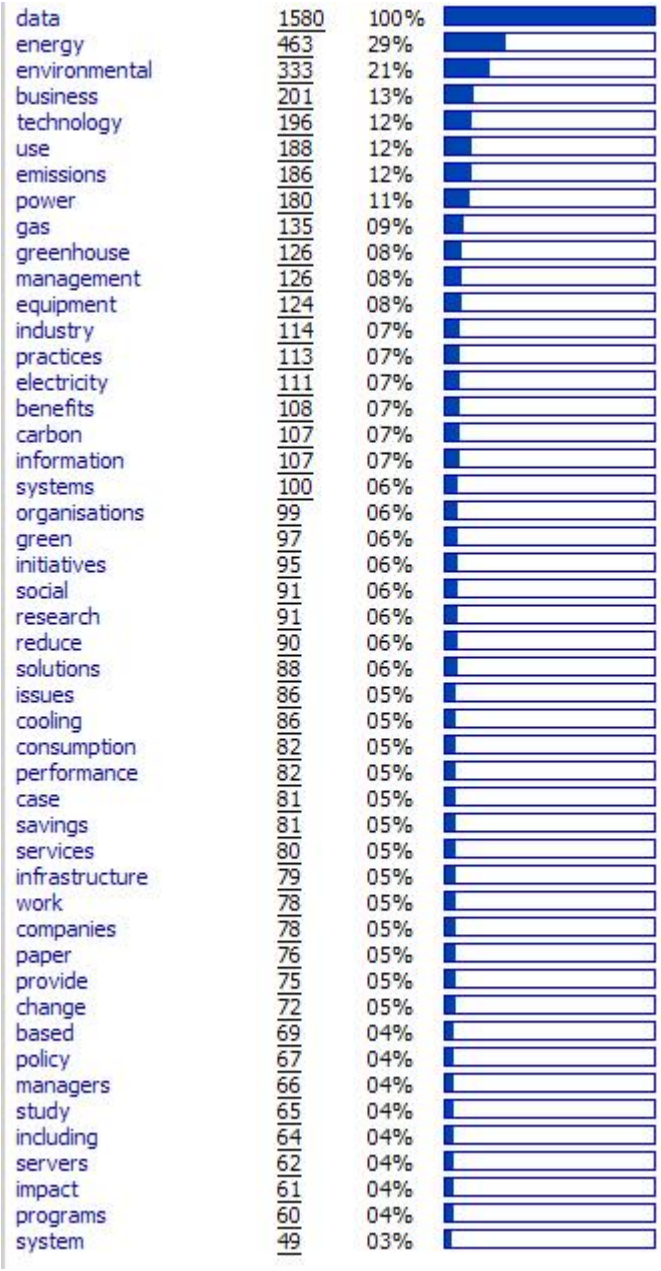
Ranked Concepts in the Green IT literature



data	1580	100%
energy	463	29%
environmental	333	21%
business	201	13%
technology	196	12%
use	188	12%
emissions	186	12%
power	180	11%
gas	135	09%
greenhouse	126	08%
management	126	08%
equipment	124	08%
industry	114	07%
practices	113	07%
electricity	111	07%
benefits	108	07%
carbon	107	07%
information	107	07%
systems	100	06%
organisations	99	06%
green	97	06%
initiatives	95	06%
social	91	06%
research	91	06%
reduce	90	06%
solutions	88	06%
issues	86	05%
cooling	86	05%
consumption	82	05%
performance	82	05%
case	81	05%
savings	81	05%
services	80	05%
infrastructure	79	05%
work	78	05%
companies	78	05%
paper	76	05%
provide	75	05%
change	72	05%
based	69	04%
policy	67	04%
managers	66	04%
study	65	04%
including	64	04%
servers	62	04%
impact	61	04%
programs	60	04%
system	49	03%

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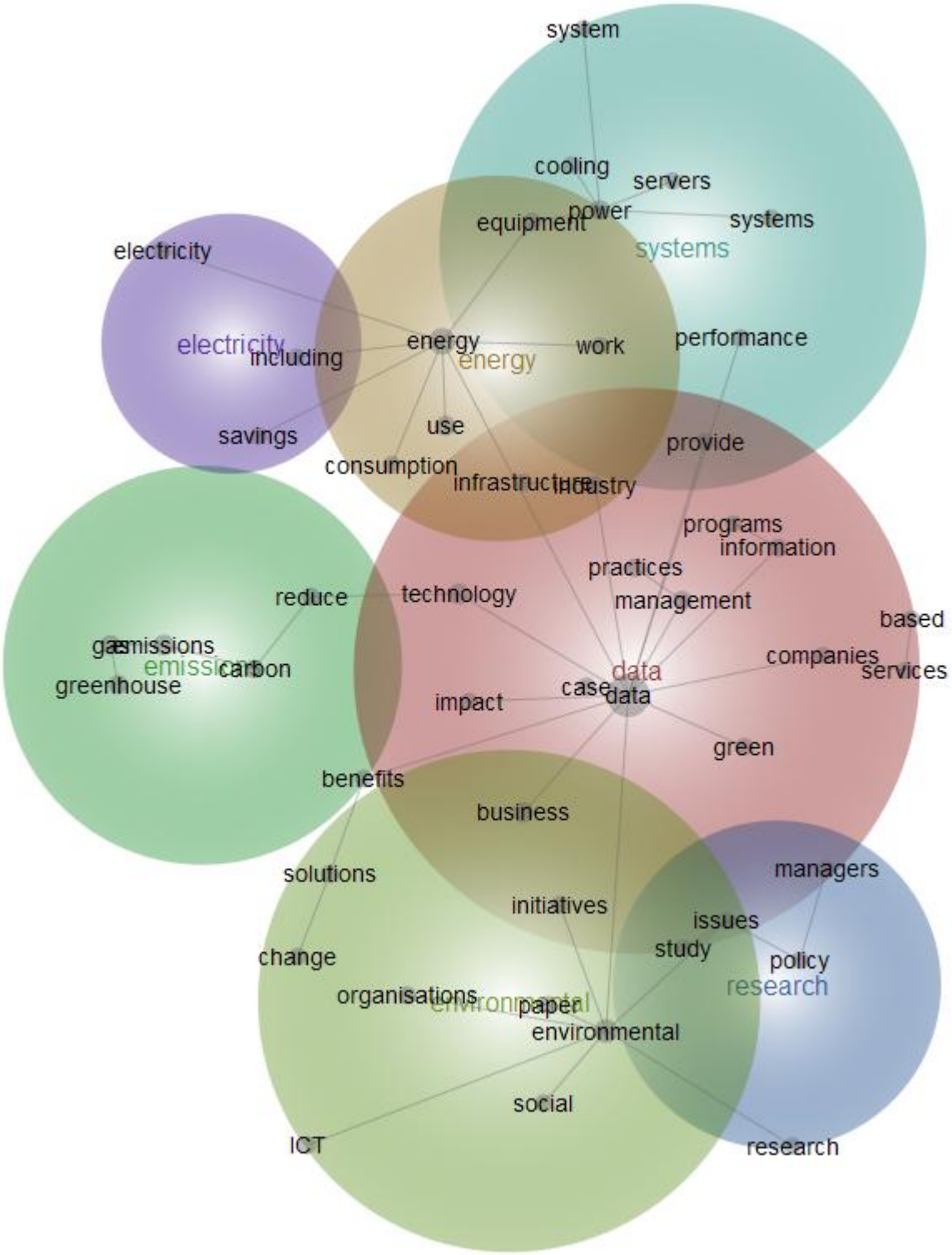

Figure 2 The Leximancer Concept Map of a library of 15 Green IT articles scoping the 'Greening of IT 'Category in the Taxonomy

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