A Green IS Taxonomy

Helen Hasan, Alemayehu Molla and Vanessa Cooper

Introduction

As a specialisation 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. Drawing on the emerging Green IS literature, we propose the following set of 11 categories as a taxonomy of Green IS in an endeavour to stimulate efforts to determine the scope and content of the field.

- Creating, Managing and Using Information;
- Supporting and Transforming Human Enterprises;
- Decision Support for Environmentally Sustainable Development;
- Green Information Systems Development (ISD);
- Changing Attitudes and Behaviours;
- 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.

With the full derivation of these categories available here, a summary of the 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 2011);
- Crowd sourcing of information and solutions on Environmental Change, e.g. Pitt et al. 2011;and,
- E-Research and big data support for Environmental Change, e.g. Buchhorn & McNamara 2006.

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 endeavours 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 sceptics. 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 sceptics 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 democratisation 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.

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); and,
- 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 organisational 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 organisations.

Other prominent Green IS research address 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 organisations 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 modelling of past, current and future scenarios (Tebaldi et al. 2006); and,
- Integrating knowledge across diverse Information Infrastructures for comprehensive planning for adaptation to environmental changes (Smith & Hasan 2012).

Modelling future scenarios: Modelling 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 modelling 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 Information Systems Development (ISD)

An information system will normally include an IT artefact, 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. 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 and
- 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, p. 545). 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 Baliga et al. 2011); and,
- 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.

5. Changing attitudes and behaviours

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 behaviours;
- Monitoring changes of attitudes and behaviours; and,
- Evaluating the consequences and impacts of changed attitudes and behaviours.

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 mobilised. An example of one online advocacy group is www.greenwashing.com.

Changing attitudes and behaviours 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 behaviour 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) proposed that 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 organisations 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 analysing, 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 Tenhunen & Penttinen 2010) with the increasing usability of e-readers and tablets.

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 endeavour to do so. This has led to embryonic research into topics such as:

- The viability, usability, effectiveness of online collaboration tools;
- Concerns of security, identity, acceptability of boundary crossing activities; and,
- 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 organise 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 centres and networks; and,
- Protocols to reduce the environmental impact over the Life-Cycle of ICT devices.

There are a great many articles in the literature that deal explicitly with topics related to the Greening of IT/Green IT (see Fujitsu 2011; Gartner 2007).

9. The connection of environmental responsibility to economic and social Imperatives

The 2012 UN commitment to Sustainable Development is expressed in the Rio+20 outcome document, 'The Future We Want' and emphasises the integration of its economic, 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 publicising occurrences of Green Washing (Delmas & Cuerel 2011); and,
- Finding green solutions to meet the disparate needs of developed and developing countries.

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 organisational 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 economic, social and environmental issues of SD.

10. Education: Including green IS in the curriculum

Not as glamorous as research, IS teaching is none-the-less as critical for the future of the discipline as IS research. We advocate the incorporation of Green IT and Green IS topics into

the IS curriculum and the incorporation of 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 described 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 recognise 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 specialised 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 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 Sustainable 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.

References and links

ACS2007,*The Australian Computer Society Policy for Green IT*,21 February 2012, <http://www.acs.org.au/acs_policies/docs/2007/greenictpolicy.pdf>.

Aoun, C, Vatanasakdakul, S& Cecez-Kecmanovic, D 2011, 'Can IS Save the World? Collaborative Technologies for Eco-Mobilisation', in Paper 143, *Proceedings of ACIS2011*, Sydney.

Avouris, N & Page, B 1995, *Environmental informatics: methodology and applications of environmental information processing*, Springer.

Baliga J, Ayre, R., Hinton, K& Tucker, R2011, 'Green Cloud Computing: Balancing Energy in Processing, Storage, and Transport', in *Proceedings of the IEEE vol.* 99 no.1, pp. 149-167.

Boudreau, MC, Chen, AJ& Huber, M2008, 'Green IS: Building Sustainable Business Practices' , in RT Watson (ed.), *Information systems,* Global Text Project, Athens, pp. 247-261.

Bray, R2007, 'Informative Smart Green Office Buildings', workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck.

Brundtland, G 1987,*Report of the Brundtland Commission of the United Nations: Our Common Future*, Oxford University Press.

Brush, AJB2007, 'Did You Leave the Calendar On? Exploring Trade-offs Between Availability and Consumption in the Home', workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck.

Buchhorn, M& McNamara, P2006, *Sustainability Issues for Australian Research Data: The report of the Australian eResearch Sustainability Survey Project,* DSpace, The Australian National University,Canberr <http://hdl.handle.net/1885/47620>.

Butler, T& McGovern, D2009, 'A Conceptual Model and IS Framework for the Design and Adoption of Environmental Compliance Management Systems', *Information Systems Frontiers,* pp. 162-171.

Caldille, A & Parmigiami, M 2004, 'Management Information System - Tool for Corporate Sustainability', *Journal of Business Ethics,* vol. 55, no. 2, pp. 159-171.

Chen, AJW, Boudreau, MC& Watson, RT2008, 'Information systems and ecological sustainability' , *Journal of Systems and Information Technology*, vol. 10, no. 3, pp. 186-201.

Daly, M& Butler, T2009, 'Environmental Sustainability and Green IT: An Institutional Perspective' , in *Proceeding of ECIS2009*, Verona.

Delmas, MA& Cuerel B V2011, 'The Drivers of Greenwashing' ,*California Management Review*, <http://ssrn.com/abstract=1966721>.

Desouza, K, El Sawy, O, Galliers, R, Loebbecke ,C & Watson, R 2006, 'Beyond Rigor and Relevance Towards Responsibility and Reverberation: Information Systems Research That Really Matters', *Communications of the Association for Information Systems,* vol. 17, no. 1, article 16,.

Elliot, S2011, 'Transdisciplinary Perspectives on Environmental Sustainability: A Resource Base and Framework for IT-Enabled Business Transformation', *MIS Quarterly,* vol. 35, no. 1, pp. 197-236.

Fujitsu2011,*ICT Sustainability: The Global Benchmark 2011*, January 2012,<www.fijitsu.com/global>.(accessed January 2012).

Gartner 2007,*Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO2 Emissions*, Press Release, viewed 21 February 2012, <http://www.gartner.com/it/page.jsp?id=503867>.

GeSI 2008,*SMART 2020 Report by GeSI and The Climate Group*, viewed 21 February 2012,<http://www.gesi.org/>.

Ghose, A, Hasan, H & Spedding, T 2008, *Carbon-Centric Computing: IT Solutions for Climate Change,* CCCI Report, viewed 21 February 2012, <http://ro.uow.edu.au/infopapers/669/>.Ghose, A, Hoesch-Klohe, K, Hinsche, L& Le, L2010, 'Green Business Process Management: A Research Agenda' , *Australasian Journal of Information Systems*, vol. 16, no. 2.

Gore, A2006, 'An Inconvenient Truth' , DVD and companion book, *An Inconvenient Truth: The Planetary Emergency of Global Warming and What We Can Do About It.*

Hasan, H2012,'Information Systems as a Force for Climate Change Mitigation and Adaptation', *The International Journal of Climate Change: Impacts and Responses*, forthcoming.

Hasan H, Ghose A& Spedding, T2009, 'IS solutions for the Global Environmental Challenge: an Australian Initiative' , in *Proceedings of AMCIS2009*, San Francisco.

Hasan, H& Meloche, J2013, 'Innovative ICT-Mediated Activities for People, Profit and Planet' , *European Journal of Innovation Management,* vol. 16, forthcoming.

Hasbrouck, J, Igoe, T, Mankoff, J & Woodruff, A 2007, 'Ubiquitous Sustainability: technologies for Green Value' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck

Hooker, B, Gave, W Steed, A & Bowers, J2007, 'The Pollution e-Sign' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck.

Houy, C, Reiter, M, Fettke, P& Loos, P2010, 'Towards Green BPM - Sustainability and Resource Efficiency through Business Process Management' , in *Proceedings of the 1st International Workshop on BPM and Sustainability*, Hoboken, .

Huang, G & Chang, N 2003, 'The perspectives of environmental informatics and systems analysis', *Journal of Environmental Informatics*, vol. 1, no. 1, pp. 1-7.

IPCC 2012,*The Fifth Assessment Report* (AR5), viewed 21 February 2012,<http://ipcc.ch/>.LeBlanc, J2007, 'Device-level Power Consumption Monitoring' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck.

Liaqut A2011, 'How to Make Use of Knowledge Embedded in Development Practice by using ICT to Sustain Rural Development?' Case Gilgit-Baltistan Pakistan, Örebro University, <http://urn.kb.se/resolve?urn=urn:nbn:se:oru:diva-16387>.

Ljungblad S2007, 'Everyday Visualization to Support a sustainable Development' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing,* Innsbruck.

Melville, NP2010,'Information Systems Innovation for Environmental Sustainability' , *MIS Quarterly*, vol. 34, no. 1, pp. 1-21.

Millecevic, M2007, 'Imaginary To Dos: Three initiatives for personal environmental explorations' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck.

Molla, A, Cooper, VA& Pittayachawan, S2009, 'IT and Eco-Sustainability: Developing and Validating a Green IT Readiness Model', *International Conference of Information Systems*,, Phoenix, 15-18 December 2009

Oehlberg, L, Aipperspach, R & Jeffery, S 2007, 'Sustainability through Meaning; providing information to promote meaningful products' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing*, Innsbruck.

Petrini, M& Pozzebon,M2009, 'Managing Sustainability with the Support of Business Intelligence: Integrating Socio-environmental Indicators and Organisational Context', *TheJournal of Strategic Information Systems*, vol. 18, no. 4, pp. 178-191.

Pitt, LF, Parent, M, Jungles, I, Chan, A & Spyropoulou, S 2011, 'Integrating the Smartphone into a Sound Environmental Information Systems Strategy: Principles, Practices and a Research Agenda' , *Journal of Strategic Information Systems*, vol. 20, pp. 27-37.

Rao, O& Holt, D2005, 'So Green Supply Chains Lead to Competitiveness and Economic Performance' , *International Journal of Operations and Production Management,* vol. 14, no. 9, pp. 898-916.

Sayeed, L& Gill, S2008, 'An Exploratory Study on Environmental Sustainability and IT Use', *Fourteenth Americas Conference on Information Systems*, Toronto, 14-17 July 2008.

Schmidt, NH, Erek, K, Kolbe, LM& Zarnekow, R2009, 'Towards a Procedural Model for Sustainable Information Systems Management' , in RH Sprague, (ed.), *Proceedings of HICSS-42,* Big Island, Hawaii.

Smith, S & Hasan, H 2012, 'Increasing Demands on Information Systems and Infrastructures for Complex Decision-Making' , *Proceedings of PACIS2012*, Ho Chi Min City.

Smith S, Winchester, D, Hasan, H& Finnegan, P2011, 'IS for Government Climate Change Adaptation Activities: An Exploratory Case Study' , *Proceedings of ACIS2011*, Sydney.

Stair, R& Reynolds, G2010,Principles of Information Systems: A Managerial Approach, Course Technology CENGAGE Learning, Boston.

Stern Review 2006, *The Economics of Climate Change*, viewed 20 February 2012, <http://siteresources.worldbank.org/INTINDONESIA/Resources/226271-1170911056314/3428109-1174614780539/SternReviewEng.pdf>.

Stringer, M, Fitzpatrick, G, Chalmers, D, Harris, E, Krishna, R& Haarlander, M 2007, 'Kuckuck: Exploring Ways of Sensing and Displaying Energy Consumption Levels in the Home' , workshop in conjunction with the *Ninth International Conference on Ubiquitous Computing* Innsbruck.

Tebaldi C, Hayhoe, K, Arblaster, JM & Meehl, GA 2006, 'Going to the Extremes: An Inter-comparison of Model-simulated Historical and Future Changes in Extreme Events' , *Climatic Change,* vol. 79, no. 3-4, pp. 185-211.

Tenhunen M& Penttinen, E2010,'Assessing the Carbon Footprint of Paper vs. Electronic Invoicing' ,*Proceedings of ACIS 2010.*

The Climate Group 2008, 'SMART 2020: Enabling the low carbon economy in the information age ', <http://www.smart2020.org/_assets/files/02_Smart2020Report.pdf>.

UN 2007, 'Information Technology can be Harnessed Against Climate Change' , <http://www.un.org/apps/news/printnewsAr.asp?nid=24815>.

Velte, T, Velte, A & Elsenpeter, R 2008, *Green IT: reduce your information system's environmental impact while adding to the bottom line,* McGraw Hill, New York.

Vom Brocke, J, Seidal, S, Recher, J(eds)*Green Business Process Management: towards the Sustainable Enterprise,* Springer-Verlag, Berlinpp. 39-58.

Watson, RT, Boudreau, MC& Chen, AJ2010, 'Information Systems and Environmentally Sustainable Development: Energy Informatics and New Directions for the IS Community' , *MIS Quarterly,* vol. 34,no. 1, pp. 23-38.

Watson, RT, Boudreau, MC, Chen, AJ & Sepúlveda HH2011, 'Green projects: An Information Drives Analysis of Four Cases' ,*Journal of Strategic Information Systems,* vol. 20, pp. 55-62.

Watson, RT, Boudreau, MC, York, PT, Greiner, ME& Wynn, D2008, "The Business of Open Source" , *Communication ACM*, vol. 51, pp. 41-6.

Yi, L& Thomas, H2006, 'E-business and Sustainable Development' , *International Journal of Environment and Sustainable Development,* vol. 5,no. 3, pp. 262-74.