115. Environmentally Sustainable ICT: A Critical Topic for IS Research?

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Abstract
This paper aims to increase awareness and understanding of the environmental sustainability of Information and Communication Technologies (ICT) and to highlight the opportunities for timely action by Information Systems (IS) researchers and practitioners in this field. Through examples from a diversity of literature sources this paper defines the problems and the scope of ICT environmental sustainability. The potential for inclusion of this topic in the mainstream of Information Systems (IS) research is evaluated by testing the definition, scope and examples against both Barki et al.'s (1993) Keyword Classification Scheme for IS Research Literature and a current test for classification as IS research. This paper concludes that: the issue of environmental sustainability of ICT is applicable to the mainstream of IS research; the research issue is sustainable; and warrants urgent action by IS researchers. Contributions include: review of multi-disciplinary literature to better inform the reader; proposal of a definition of the environmental sustainability of ICT derived from the literature; description of the scope; presentation of a rationale for IS researchers to contribute to resolution of the issue; and submission of a research taxonomy to facilitate IS research activity into aspects of the environmental sustainability of ICT.

Keywords: Environment, Sustainable, ICT, Research, Taxonomy

Introduction

Since the 1950s, ICT has become a major contributor to business innovation and wealth generation at both organisational and national levels. Unfortunately, it has also become a major contributor to environmental contamination. During that time, *"the average lifespan of computers in developed countries has dropped from six years in 1997 to just two years in 2005. Mobile phones have a lifecycle of less than two years in developed countries. Some 183 million computers were sold worldwide in 2004. About 674 million mobile phones were sold worldwide in 2004 - 30 percent more than in 2003. By 2010, there will be 716 million new computers in use"* (Greenpeace, 2006). ICT contributes to environmental contamination at all stages in its lifecycle: in its production, its use and in its disposal.

The United Nations Environment Programme (UNEP) reports that electronic waste (e-waste) from computers, televisions, telephones and other sources *"is currently one of the fastest growing segments of solid waste."* Disposal of this e-waste represents a major problem since it contains *"toxic substances such as mercury, cadmium and lead which contaminate the environment and pose a danger to human health. It is often buried in landfills, where pollutants can leach into soils and groundwater, or burned in incinerators forming dangerous compounds."* (UNEP, 2005).

The environmental impact of ICT is not limited to disposal of ICT products but includes the provision of services. Rapidly increasing levels of ICT energy consumption indirectly contribute to global warming as the additional demand for energy from ICT operations is predominantly produced by carbon-emitting coal-fired power stations (Colley 2006, Friedman 2007).

This paper aims to build awareness in IS researchers and practitioners of the global importance of ICT environmental sustainability and to promote this topic as being a challenge deserving their urgent action. An overview of the IS discipline follows this introduction, then a section explaining the research approach. Examples of ICT environmental sustainability are explored from a diverse range of literature and this paper then identifies and defines the problem and scopes the field; fundamental pre-requisites for undertaking significant research and determining successful solutions. To confirm the topic's relevance as part of the mainstream of the IS discipline, the definition, and scope are tested against both the Barki et al. (1993) scheme for classifying IS research literature and a current review of the IS discipline (Avison and Elliot, 2006). Following this evaluation, a research taxonomy is developed, conclusions are drawn and implications for IS research and practice discussed.

Definition and scope of Information Systems

Since this paper aims to develop awareness of ICT environmental sustainability as a critical topic for IS research it raises the question, what is IS? Since IS is a new and dynamically developing discipline, there can be a diversity of perspectives and a recent book by King and Lyytinen (2006) explores these views. While acknowledging different perspectives, this paper takes a broad and inclusive view of the IS discipline that is open to dynamic developments. Allen Lee distinguishes Information Systems from other disciplines. He argues that the IS discipline is distinct in that: *"it examines more than just the technological system, or just the social system, or even the two side by side; in addition it investigates the phenomena that emerge when the two interact."* (Lee, 2001, p iii).

A leading international IS journal Management Information Systems Quarterly (*MISQ)* published a classification scheme of IS keywords in 1988*, "To provide a description of the discipline, introduce a common language, and enable research of the field's development"*.

Table 1 Major categories in IS research (Barki et al., 1993)

A	Reference disciplines, including behavioral science, computer science, decision theory, information theory, organizational theory, social science, management science, economic theory, ergonomics, political science and psychology.
B	External environment: economic, legal, political and social.
C	IT, computer systems and software.
D	Organizational environment, including characteristics, functions and tasks.
E	IS management, including hardware, software, personnel, projects, planning, evaluation, security and other management issues.
F	IS development and operations, life cycles, IS development, implementation and operations.
G	IS usage, by organizations and users, and their support, access and processing.
H	IS types, application areas, components and characteristics.
I	IS education and research.

In 1993, this scheme was updated *'to incorporate the new research topics and methods, hence reflecting better the evolution of the IS discipline'* (Barki et al., 1993). Table 1 shows the scheme with nine major categories.

In a dynamic environment, individual keywords may become out of date and emerging research areas may not receive specific mention. The categories of IS research do, however, help to identify the focus of research within the IS discipline. Even where a new phenomenon is not identified explicitly as a keyword, analysis of the categories can provide a framework for its research. There have been many developments since 1993 but the general categories of the Barki et al. scheme remain applicable to current work.

A recent review of the IS discipline presents a current test of whether or not a phenomenon of interest could be classified as IS research. *"The research would be classified as IS research not because it could be allocated totally to an IS category, but because the primary focus of the research was within the IS classification categories. If the primary focus of the research was, for example, within a reference discipline such as psychology or ergonomics, rather than in its application to the IS discipline, then the research may be more properly classified and conducted within the other discipline. The particular phenomenon being examined may change, but the underlying IS research issues remain."* (Avison and Elliot, 2006).

Table 2 Cross-analysis of sources determining mainstream of IS research (Avison and Elliot, 2006)

Research categories (Barki et al., 1993)	A: Reference Discipline	B: External environment	C: IT systems	D: Organizational environment	E: IS management	F: IS development and operations	G: IS usage	H: IS types	I: IS education and research
ACS submission, 1992	√	√	√	√	√	√	√	√	√
Benbasat and Zmud, 2003	-	-	√	*	√	√	√	√	*
Baskerville and Myers, 2002	√	√	√	√	√	√	√	√	√
Ives et al., 2002	-	√	√	√	√	√	√	√	√
Key IS management issues, CSC 2001	-	-	√	√	√	√	√	√	-
Key IS management issues, CSC 1988	-	√	√	√	√	√	√	√	-
Key technology issues, CSC 2000	-	√	√	√	√	√	√	√	-
Barki et al., 1993	√	√	√	√	√	√	√	√	√

Key: √ core focus, - not mentioned or excluded; * limited applicability

The Barki et al. research categories have also been compared with a series of significant IS publications from 1988-2003 and the level of alignment between the research categories and the papers over a period of nearly 20 years is striking. Table 2 summarizes the comparison and illustrates the continuing relevance of the Barki et al. research classification scheme.

Research Approach

Environmental sustainability of ICT appears to be a problem of considerable and growing significance to society. But is this an IS research problem? And is it sustainable? Could other disciplines be more appropriate for its examination, such as economics, engineering or environmental sciences? If it is accepted as being an IS problem, how could IS researchers be motivated to action? Consistent with this paper's aim the research questions are: is environmental sustainability of ICT an IS research issue; is it more appropriately addressed in other disciplines; is it a sustainable research problem; and could an IS research agenda be proposed to facilitate researcher activity?

The most appropriate research approach to address the research aims and questions is analysis of a diverse range of literature to develop a model of environmental sustainability of ICT and subsequent testing of this model against an accepted definition and scope and the research categories of the IS discipline. A broad range of the literature is analysed to determine definition and scope of environmental sustainability of ICT. Applicability to the discipline of IS is determined by comparison with the definition of IS, the Barki et al. (1993) classification of IS research scheme, and a current test for inclusion in the IS discipline. Subject to resolution of the initial research questions, an IS research taxonomy for the topic is proposed.

Literature on ICT as a problem

The quantities involved in e-waste are astonishing. It is estimated that in the U.S, during the 10-year period 1997-2007, 500 million PCs will be discarded (Hasan, 2002). Four million personal computers are abandoned annually in China. In India e-waste worth US$1,500 million was generated in 2003 and today there are still no laws for its safe-handling (Bhalla 2007, UNEP 2004). Australia currently disposes of around 1.6 million computers in landfill each year, 1.8 million are put in storage (in addition to the 5.3 million already gathering dust in garages and other storage areas) and about 0.5 million are recycled [ABC, 2003]. Recycling may appear attractive but the valuable ICT components are useless for further manufacture until the product can be dismantled and the component materials separated – frequently a difficult and expensive process. Some of the components are dangerous. If disposed of into landfills, metals like lead, cadmium, mercury and arsenic can leach into the water table. *"Brominated-flame retardants used in computer equipment are both an occupational and environmental health threat. Printer inks and toners often contain toxic materials such as carbon black and cadmium. It is these environmental health implications that have put e-waste under the spotlight of international governments and environmentalists alike"* (ABC, 2003)

The cost and environmental impact of recovering components has resulted in export of hazardous wastes, particularly from the USA, to Asia.

> *"In towns like Guiyu in China it is not uncommon to see open burning of plastics and wires and smelting of circuit boards to reclaim metals. Riverbank acid baths are used to extract gold. Lead-containing cathode ray tubes from monitors and television sets don't render much of marketable value and so are dumped. Toner cartridges are pulled apart manually, sending clouds of toner dust into the air. The workers, some of whom are children, generally work without facemasks or protective clothing. Guiyu's ground water is now so polluted that drinking water has to be trucked in from 30km away." (ABC, 2003).*

A legally binding international agreement, the Basel Convention, was introduced in 1992 to curtail the transportation of hazardous wastes across international boundaries, particularly to developing nations. More than 150 countries have agreed to this Convention. Notable among the few countries not ratifying it is the USA (Basel, 2007a, 2007b).

While e-waste has been the ICT sector's most public environmental problem, it's not the only concern. Gartner estimates that the global ICT industry is responsible for about 2 per cent of global carbon dioxide (CO_2) emissions. The estimate includes emissions produced in the manufacture and use of personal computers, servers, mobile phones and telecommunications infrastructure (Woodhead, 2007). Growing social concern about global warming will lead organisations to conserve energy and thereby reduce their "carbon footprint" or level of CO_2 emissions from energy consumption (Friedman 2007, WMO 2007). Apart from CO_2 emissions, the amount of energy consumed by computer operations is becoming a problem. Sun Microsystems Australia-New Zealand chief technical officer Angus MacDonald believes, "There is a realisation that we cannot just continue to put additional servers in and expect the electricity grid is going to continue to provide us with an endless stream of power," (Colley, 2006).

Literature on Resolution of the Problems

Initiatives to address these problems commence operationally with cleanups and take-backs and then more tactically with recycling, redesign, government guidelines and public pressure. Ultimately, corporations will come to appreciate the strategic potential in addressing environmental sustainability and respond proactively.

Operational and tactical

Greenpeace suggest immediate action to resolve the e-waste problem: stop using hazardous materials, in many cases safer alternatives exist. Manufacturers of electronic goods, who reap the benefits from selling their products, need to accept responsibility for those products for the whole of their life. That is, the customer should not bear the cost of recycling e-waste. The e-waste environmental crisis could be avoided through design of cleaner products that are easier and safer to recycle or to dispose of at the end of their life (Greenpeace, 2006).

Some small ventures have commenced recycling activities. The Australian Mobile Telecommunications Association (AMTA) with environment group Planet Ark operates a mobile phone and battery recycling program that has processed "hundreds of thousands of mobile phones", recovering gold, nickel, copper and plastics for other manufacturing and extracting cadmium from the batteries for safe disposal. Close the Loop Ltd has developed toner cartridge processing technology that safely remanufactures or recycles all makes and models of printer cartridge, toner drums and fax cartridges. Green PC is a non-profit organisation restoring several thousand computers annually that have been donated by corporations and reselling them to low-income earners. It has a product stewardship scheme to ensure that no PC goes to landfill at their end of life (Colley, 2006).

The Australian Government recognises that the high level of ICT use across the country *"has prompted further consideration of how to better manage and reduce the environmental impacts, including energy consumption, from using ICT."* The government is *"working closely with the ICT industry and other stakeholders to develop strategies for appropriate packaging, and effective recycling, reuse and disposal of ICT products at the end of their life."* However, it is up to the ICT industry to *"address environmental considerations for manufacturing, product use, design and disposal."* Within government, voluntary guidelines have been proposed on environmental considerations of procurement and implementation of these guidelines is subject to audit by the National Audit Office. (AGIMO, 2005)

Small scale activities, regardless of how well they may be implemented, will not serve to address the enormity of an e-waste environmental problem where millions of computers are discarded each year. Public concerns for more active intervention are beginning to take effect. In November 2006, frustration over governments' lack of determination to address the problem resulted in hundreds of discarded computers being dumped at the door of the NSW Department of Environment and Conservation. The NSW Waste Avoidance and Recovery Act passed in 2001 can force industries dealing with large volumes of toxic waste to establish adequate voluntary schemes but, to date, no regulation has been passed to put the legislation into affect (Colley, 2006).

A different approach to public pressure came with release of the Green Electronics Guide that ranks leading ICT manufacturers on their environmental policies and practices. The criteria were how well companies clean up their products by eliminating hazardous substances, and if they were prepared to take back and recycle their products responsibly once obsolete. Based on publicly available information, Lenovo, Nokia and Dell were most highly ranked. At the other end of the scale, Apple was rated most poorly (Greenpeace, 2007).

Strategic

Organisations move through three stages in development of their environmental strategy (Hart, 1997). The first stage is to move from controlling pollution, i.e., cleaning up waste after it has been created, to preventing pollution, i.e., continuous improvement to reduce waste production and use of energy. Stage two is product stewardship, minimizing the environmental impact of products over their complete life cycle. This requires designing products for recovery, reuse and recycling of their components. Stage three is planning for, development and use of emerging clean technologies. At this stage companies need to develop a strategic vision of environmental sustainability showing what new products and services must be developed and what capabilities and competencies will be required to use them. In the automobile industry, development of clean technologies was driven by legislation requiring reduced levels of exhaust emission. In technology, a legislative imperative is less likely than companies seeing the market potential for innovative products that meet society's growing environmental concerns.

In the short term, publication of corporate rankings based on the environmental impact of their products, like Greenpeace's (2007) Green Electronics Guide, may encourage firms to prevent pollution. Corporations like Apple that position their products and marketing to attract consumers for their style and consumer-friendliness have a strong incentive to be, and be seen to be, environmentally sensitive. Xerox reconceptualised its business by redefining its leased copiers as part of the company's assets. In a good example of product stewardship, Xerox remanufactured components from the copiers at end of lease and reassembled them into new machines. Their estimated savings in raw materials, labour and waste disposal were in the range $300-$400 million, annually (Hart, 1997).

In the longer term, the business opportunities from development of clean technologies will attract more widespread corporate attention but an immediate requirement to support a strategic review of product design requirements is measurement and monitoring of whole of life product costs. Monsanto developed a methodology for whole of life costing, including the environmental costs associated with producing, using, recycling, and disposing of it. By capturing and analysing the full product costs, a clearer view of the issues emerge and improved decision-making can be made as the cost factors change in the future (Magretta, 1997).

An essential element of a strategic approach to environmental sustainability is determination of organisational performance metrics that incorporate a broader focus than short term financial returns. John Elkington's (1998) Triple Bottom Line integrates traditional financial goals with social and environmental concerns to create a new measure of corporate performance. However, a business strategy that focused solely on the bottom line – irrespective of what may be measured - can inhibit innovation and value creation. An approach to encourage sustainable design can refocus product development to creating environmentally safe, quality products right from inception (McDonough and Braungart, 2002). The emphasis is on a strategic approach to development of both ICT products and services as well as ICT-enabled business products and services that are conceived and constructed with regard to their whole of life not just a short term of its potential utility.

Irrespective of the type of environmentally responsible metrics, the critical issue is that these measures are capable of being used and are used. While the Australian national government policy encourages triple bottom line reporting one government agency expressed concern that *"effective triple bottom line reporting could not be undertaken until the ICT industry makes available better information to support government reporting requirements."* Triple bottom line reporting remains voluntary for Australian Government agencies. (AGIMO, 2005)

In summary, a situational analysis of ICT environmental sustainability shows:

- ICT hardware is an essential component of Information Systems;
- rapid development of ICT has resulted in increasingly short life cycles for these technologies – typically two years for computers and less than two years for mobile telephony;
- disposal of ICT hardware once it has reached the end of its operational life is creating major waste problems with millions of computers being dumped in landfills each year;
- toxic chemicals and metals are leaching from these landfills and contaminating water tables thereby threatening health;
- in developed countries, some small scale efforts have been made to introduce recycling and reuse;
- large scale recycling and component recovery is difficult and costly and is rarely undertaken in developed countries without a regulatory requirement;
- a very large amount of ICT materials intended for recycling is being exported from developed countries to developing countries which have few controls or provisions for safe handling and where recycling practices present real danger to the environment and to health;
- the current and growing levels of energy consumption in ICT operations make a significant contribution to global warming that is not sustainable in the future;
- a longer term, more strategic view of ICT sustainability can lead to business opportunities and improved attention to sustainable practices over the whole of a products life;
- society's, organisation's and individual's increasing reliance on ICT and Information Systems mean that ICT environmental sustainability is a real and present concern and will remain so in the foreseeable future;

- sustainable ICT represents factors in technology acquisition and adoption; whole of life costing; value determination of IT, e.g. triple bottom line; and the impact of ICT on society through business innovation.

Model of Environmentally Sustainable ICT

Following analysis of ICT as problem and solution for environmental sustainability, and in the absence of any previous definition, we now need to determine a definition of environmentally sustainable ICT. The term "sustainable development" was first used by the Brundtland Commission (1987) to mean *"development that meets the needs of the present without compromising the ability of future generations to meet their own needs"*. A sustainable organization *"is one whose characteristics and actions are designed to lead to a desirable future state for all stakeholders over the longer term"* (Funk, 2003). Sustainability requires *"both an efficient allocation of resources over time and a fair distribution of resources and opportunities between the current generation and between present and future generations, and a scale of economic activity relative to its ecological life support systems."* (Gray and Milne, 2002). A sustainable global economy is *"one that the planet is capable of supporting indefinitely"* (Hart, 1997).

With consideration to the different examples of the problem, associated challenges and usage identified above, in this paper environmentally sustainable ICT is defined as:

> *the design, production, operation and disposal of ICT and ICT-enabled products and services in a manner that is not harmful and may be positively beneficial to the environment during the course of its whole-of-life.*

Figure 1 shows stages in the process of developing a high level of environmental management (de Groot, 2000). This Figure encompasses the scope of the environmental sustainability of ICT, ranging in ten steps from non-compliance through product stewardship to sustainable business strategies.

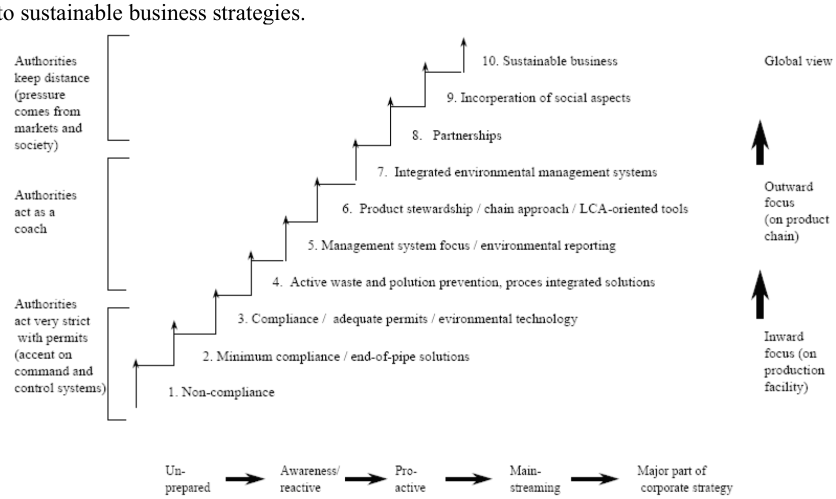

Figure 1: Scope - different stages in the process of growing to a high level of Environmental Management (source: de Groot, 2000).

Testing the Model

Applicability to the discipline of IS can be determined by comparison with: the definition of IS; the Barki et al. (1993) scheme for classifying IS research literature; and a current test for inclusion in the IS discipline. As seen in section 2. above, Allen Lee argues that the IS discipline: *" examines more than just the technological system, or just the social system, or even the two side by side; in addition it investigates the phenomena that emerge when the two interact."* (Lee, 2001, p iii). The definition of environmental sustainability of ICT as devised from the literature in section 6. above locates the environmental sustainability of ICT exactly at that point of interaction between the technology and society as it is the impact of ICT on society and the environment that creates the problem and presents the potential solution.

Avison and Elliot (2006) analysed seven sources contributing to IS research focus and theory using the research categories proposed by Barki et al. (1993) and concluded that there was *"remarkable uniformity in breadth and depth of focus by industry and education over the past 20 years"* with *"a high degree of alignment on core issues."*

Table 3 compares the Barki et al. IS research categories with the major environmental sustainability of ICT problems; generation of e-Waste and high levels of consumption of CO_2 emitting energy, as discussed in this paper. Elements of both major problems are present in each of the Barki et al. categories: A: Computer Science and Electronic Engineering for the design and manufacture of new technologies (e.g., to avoid contamination, enable recycling or reduce energy consumption); B: legal and regulatory imperatives regarding e-waste disposal or energy reduction; C: hardware operations or disposal; D: strategies for extending whole of product life or reducing carbon footprints; E: hardware resource management in support of organizational strategies; F: requirements specification for purchase of 'green' ICT and reducing carbon footprints; G: disposal of ICT at end of useful life and operations; H: IS types include environmental management systems and control systems to reduce energy consumption; I: researchers developing theoretical models informed by industry best practice.

Table 3: Cross-analysis of major problem areas and categories of IS research

Major problems in Environmental Sustainability of ICT / **IS research categories** (Barki et al., 1993)	A: Reference Discipline	B: External environment	C: IT systems	D: Organizational environment	E: IS management	F: IS development and operations	G: IS usage	H: IS types	I: IS education and research
e-Waste	√	√	√	√	√	√	√	√	√
CO_2-emitting energy	√	√	√	√	√	√	√	√	√

Conclusions and Discussion

The aims of this paper are to promote researcher and practitioner awareness of challenges relating to the environmental sustainability of ICT and to encourage both groups to respond proactively. The research questions examined are: is the environmental sustainability of ICT an IS research issue; is IS the most appropriate discipline for its investigation; is this topic of sustainable research interest; and can a IS research framework be proposed to facilitate awareness, understanding and action? A diverse range of literature has been analysed to determine the definition and describe the scope of ICT environmental sustainability. These were tested against the Barki et al. (1993) scheme for classifying IS research literature, as well as a recent test for classification of research in the IS discipline (Avison and Elliot, 2006).

The paper finds support for each of the initial research questions and concludes that the environmental sustainability of ICT should be seen as a sustainable topic in the mainstream of IS research. As shown on Table 3, major problems are consistent with all of the IS research categories proposed by Barki et al. (1993) and meet the test proposed in a current review of the IS Discipline for inclusion as IS research (Avison and Elliot, 2006) that the *"primary focus of the research was within the IS classification categories."* It is sustainable in that the environmental problems created by ICT appear continuing, at least for the medium term, while the environmental solutions that may be enabled by ICT appear unbounded. Examples of issues for IS research attention include: factors in technology acquisition and adoption; whole of life costing for ICT products and services; value determination of IT, e.g. triple bottom line; and ICT's impact on society. While all of these issues can be incorporated in Barki et al.'s categories, the research issues underlined on Table 4 represent extension of topics in those categories to incorporate ICT sustainability.

Table 4 An IS Research Taxonomy for Environmental Sustainability of ICT
(developed from Barki et al. 1993, de Groot, 2000, Colley, 2006)

1. External environment: economic, legal, political and social. Research issues include: economic impact; impact in specific industries; <u>impact of legal imperatives (e.g., local ratification of the Basel Convention)</u>; government policy, e.g., on environmentally sustainable practices; impact of computers on society and the impact of changing social values.
2. IT hardware and software. Research issues include: focus on specific technologies, e.g., PCs, <u>over their whole of life through sustainable design, re-cycling and safe disposal.</u>
3. Organizational environment, including characteristics, functions and tasks. Research issues include: strategies; value chain; corporate computing facilities (<u>power consumption</u>); innovation; and change. <u>Environmental scanning and monitoring of activities in sustainable ICT leading to dialogue / partnerships with action groups and corporate strategy development. Determination of new strategies, products & services as well as the competencies and capabilities to use them.</u>
4. IS management, including hardware, software, personnel, projects, planning, evaluation, security and other management issues. Research issues include: hardware resource management; systems life cycle management, strategic planning; technology investment and evaluation. <u>Development of sustainable ICT practices, e.g., compliance, stewardship, innovation.</u>
5. IS development and operations, life cycles, IS development, implementation and operations. Research issues include: systems life cycle; requirements specification; systems design and implementation, e.g., <u>whole of system life cycle.</u>
6. IS usage, by organizations and users, and their support, access and processing. Research issues include: systems operation and <u>disposal</u>.
7. IS types, application areas, components and characteristics. Research issues include: impact on specific types of IS and across systems. <u>Development of ICT Environmental Management Systems.</u>
8. IS education and research. Research issues include: research frameworks; issues, trends and agendas. <u>Promoting awareness of the magnitude of the problem. Provide guidance on effective practice for corporate executives and policy developers.</u>

Extension of the existing category topics is necessary since, for example, Barki et al.'s legal issues from the early 1990s focused on protection of software Intellectual Property rights; criminal issues like fraud; and enablement for Electronic Funds Transfer. At that time there was no thought that the ICT legal environment might extend beyond enablement and support to require appropriate practices for disposal of ICT waste arising from the 1992 Basel Convention. There was also no thought by Barki et al. of global warming resulting from greenhouse gas emissions. While several other organizing schemes may have been potentially useful to classify the environmental sustainability of ICT (e.g., Ulrich's Critical Systems Heuristics (1987) concerned with setting social system boundaries or Van de Ven and Poole's (2005) four conceptions for analyzing organizational change) the Barki et al (1993) IS research classification scheme provides a benchmark for evaluation of the area as an IS research topic.

The major implication for IS researchers is that ICT sustainability research topics can be mapped across the Barki et al. classification scheme of IS research to develop a research taxonomy for IS investigations into environmental sustainability of ICT. As shown in Table 4, with the exception of the Barki et al.'s category A, all categories of IS research incorporate environmental sustainability of ICT. Barki et al.'s category A, reference disciplines, has been set aside as a specific focus of research since application of theory from a reference discipline to a particular issue such as product design would be more appropriately located in the research categories of IT hardware or IS management. This Taxonomy is significant as researchers have a critical role in raising awareness of the problem and providing exemplars for its resolution, as called for by the Basel Convention *"Sharing of best practices in a region would also help to improve the capacity of countries to deal with this problem"* (Basel, 2006b).

While the environmental sustainability of ICT has been found to be in the mainstream of IS research, it does not meant that this topic can be researched *only* from an IS perspective. Several of the research examples shown on Table 4, e.g., impact of legal imperatives, corporate strategy development, whole of system life cycles and development of ICT environmental management systems could be of interest to other disciplines, including legal, management, auditing and software engineering. A strong argument could be made for multi-disciplinary research in these areas to build a richer picture of the phenomenon of interest. Development of IS theory in this topic area may also be of use to other disciplines with an interest in related topics which ma create the opportunity for IS to serve as a reference discipline.

Implications for practitioners are considerable, but the organizational focus should not be seen as exclusively environmental. Forest Reinhardt argues that *"environmental problems are best analysed as business problems ... the basic tasks do not change when the word 'environmental' is included in the proposition."* (quoted in Funk, 2003). Funk expands on this point, *"In the computer industry, a better strategy might be to minimize the risk of obsolescence by extending product life - designing parts for ease of upgrade rather than disposal. The bottom-tine benefits could include customer loyalty or even customer lock-in with a service relationship over a longer product lifetime and lower disposal costs."* Analysis of business problems, computer industry product life cycles and technology-enabled business strategy are all fundamental to IS research and practice, whether associated with the environment, or not.

This paper demonstrates that problems relating to ICT environmental sustainability cut across all aspects of IS research and most business practice, as organizations rely increasingly on technology in their core business activities. IS researchers have examined the application of ICT by organizations and societies in considerable depth for more than 30 years. Unfortunately, that ICT utilization has come at a substantial and growing cost to the environment and to society. The United Nations Environmental Program and the Basel Convention have highlighted the necessity for concerted action to address these problems and the IS research community is well placed to make a significant contribution. What can be more important as a focus for IS research?

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