INFORMATION AND COMMUNICATION TECHNOLOGIES FOR ENVIRONMENTAL SUSTAINABILITY

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Abstract.
The impact of human activities on the environment is issues of growing concern confronting life on Earth. At the same time, information and communication technologies (ICTs) are being rapidly developed around the world. Although ICTs require energy resources, they also offer a number of opportunities to advance global environmental research, planning and action. This includes monitoring and protecting the environment as well as mitigation of and adaptation to climate change.

Key words: ICT, technology, e-environment, environmental protection, environmental sustainability.

INTRODUCTION

e-environment
The use and promotion of ICTs as an instrument for environmental protection and the sustainable use of natural resources;
The initiation of actions and implementation of projects and programmes for sustainable production and consumption and the environmentally safe disposal and recycling of discarded hardware and components used in ICTs;
The establishment of monitoring systems, using ICTs, to forecast and monitor the impact of natural and man-made disasters, particularly in developing countries and small economies. [11]

A report from the Society of IT Management (Geneva Plan of Action (2011) from the World Summit on the Information Society (WSIS) Action Line C7: E-environment) describes ICT as having poor 'green' credentials. It currently accounts for some 2% of global CO2 emissions, which is the same amount as that of the airline industry. However, ICT also has significant potential to reduce its own environmental impact from equipment manufacture and use of electricity, as well as helping organizations become greener through adoption of practices like flexible working and increased efficiencies in business processes.
ICTs are essential to our understanding of the environment and to our ability to deal with environmental change. Newly developed high speed processors using energy efficient CPU designs along with the rapid diffusion of advanced broadband networks and deployment of web-based services are

transforming the way environmental research; learning and decision-making are taking place. Faster processors using ever larger, accurate and detailed data sets are increasingly linked together through GRID networks and this is permitting more accurate, predictive and complete modeling of environmental processes. This in turn is facilitating decision-making thanks to new technologies such as geographic information system (GIS) and a new generation of web-based services such as virtual globe browsers which may gradually replace stand-alone software platforms. Today, a broadband Internet connection is probably the most important tool to support environmental research, learning and decision-making [8].

MATERIAL AND METHODS

Information and Communication Technologies for Environmental Sustainability (**ICT Ensure**) is a general term referring to the application of Information and Communication Technologies (ICTs) within the field of environmental sustainability. [10]

Information and Communication Technologies (ICTs) are acting as integrating and enabling technologies for the economy and they have a profound impact on our society. Recent changes in ICT affect as well the environmental sustainability regarding the Millennium Development Goal (MDG) set up to ensure environmental sustainability in this century. With the usage of new technologies, the global community can be supported in their collaboration to preserve the environment in the long term. New technologies provide utilities for knowledge acquisition and awareness, early evaluation of new knowledge, reaching agreements and communication of progress in the interest of the human welfare. This includes ethical aspects of protecting human life as well as aspects of consumer safety and the preservation of our natural environment.

Green computing, green IT or **ICT Sustainability**, refers to environmentally sustainable computing or IT. In the article Harnessing Green IT: Principles and Practices, San Murugesan [7] defines the field of green computing as "the study and practice of designing, manufacturing, using, and disposing of computers, servers, and associated subsystems—such as monitors, printers, storage devices, and networking and communications systems — efficiently and effectively with minimal or no impact on the environment". The goals of green computing are similar to green chemistry; reduce the use of hazardous materials, maximize energy efficiency during the product's lifetime, and promote the recyclability or biodegradability of defunct products and factory waste. Many corporate IT departments have Green Computing initiatives to reduce the environmental

impacts of their IT operations [2]. Research continues into key areas such as making the use of computers as energy-efficient as possible, and designing algorithms and systems for efficiency-related computer technologies.

Sustainability is the capacity to endure through renewal, maintenance, and sustenance, or nourishment, in contrast to durability, the capacity to endure through unchanging resistance to change. In ecology, sustainability describes how biological systems remain diverse, robust, and productive over time, a necessary precondition for the well-being of humans and other organisms [9]. Long-lived and healthy wetlands and forests are examples of sustainable biological systems.

ICT originally was another way to say IT. Now that definition has expanded to include unified communication technologies (UC) and more. ICT refers to the integration of telecommunications, computers, middleware and the data systems that support, store and transmit UC communications between systems. Information and communications technology is often used as an extended synonym for information technology (IT), but is a more specific term that stresses the role of unified communications and the integration of telecommunications (telephone lines and wireless signals), computers as well as necessary enterprise software, middleware, storage, and audio-visual systems, which enable users to access, store, transmit, and manipulate information. [1]

The term ICT is now also used to refer to the convergence of audio-visual and telephone networks with computer networks through a single cabling or link system. There are large economic incentives (huge cost savings due to elimination of the telephone network) to merge the audio-visual, building management and telephone network with the computer network system using a single unified system of cabling, signal distribution and management.

ICT is used as an overarching term in many schools, universities and colleges to encompass the spectrum from information systems/technology at the organizational end to software engineering and computer systems engineering.

RESULTS AND DISCUSSION

"Open your outlook and you could see your emails. That's not so unusual, but what if in your email was a message from your cell phone's voice mail? Instead of calling a number to hear your voice messages, you can now read a transcript or listen to a recording of your voice message within outlook. No need to check voice mail on your cell phone again." [6]

In the future, ICT will increasingly be present in our everyday lives, and as users we have more and more possibilities to customize products and services to reflect our individual needs. Simultaneously, background systems are globally interconnected and optimized, working faster, and collecting more and more small-scale information. And as the development of ICT integration continues, it might not be too bold to predict that e.g. tomorrow's car producer could be Intel or Microsoft instead of GM. Despite uncertainties in terms of predicting the future, one thing seems to be apparent: environmental sustainability is here to stay, since the challenges it involves are ongoing, and increasingly, it is also becoming a competitive factor [4]. More and more application areas are becoming relevant to sustainable development in industry, health care, agriculture and the information society. And they have an impact on the perspectives of ICT, the environment, policy and science. More and more interest has been emerged as well to risk and disaster management, adaptation to climate change and resource use.
ICT will increasingly be present in our everyday private and business life. It has contributed to decreasing the resource consumption and resource-intensive lifestyles in many ways. ICT offers achievable data and easy-to-use tools for the people to decrease their ecological footprint and to select more environmentally sustainable products and services. Smart production and recycling technologies have resulted in optimized products, processes and systems that consume as few resources as possible at every stage of their lifecycle. Smart metering and grid technologies have enabled flexible, accessible and economical energy generation (using renewable), distribution and consumption both in households and business/industry. Intelligent transportation systems and remote collaboration technologies have reduced unnecessary traffic and minimized the energy usage of transportation in general. ICT devices and networks themselves will naturally be highly optimized. Sustainable decisions are also supported by governmental regulation and other incentives [14].

Information Technology which in recent times has experienced a phenomenal growth both as an industry and in applications may be characterized by the use of computers, the Internet, cellular phones, e-business or commerce, video-conferencing, etc. Although, the global society is excited and basking in the euphoria of the various use of ICT, both as a private and corporate applications with all the obvious benefits. However, the question of how ICT revolution affects the environment vis-à-vis sustainable development, which is one of the major twenty-first century challenges, has received limited attention to date [12]. Underlying the

driving force of ICT is computer technology-hardware which consists of all physical devices including cell phones and other electronic devices and software which consists of programmed instructions including embedded systems on which many electronic devices run. It is not an understatement to conclude that advances and diffusion of ICT have drastically changed the economic and social system of today, but the reverse effects also exist. That is, construction and development of ICT infrastructures is both energy-intensive and resource-intensive and the environmental impacts of the production, use, and disposal of ICT resources/materials are of great concern and not trivial [3].

Information and Communication Technology is more than computers and by its performance and potentials has offered various options to help realize the Millennium Development Goals (MDGs). However, the development and usage of ICT is creating serious environmental concerns that need serious attention. The three categories of environmental challenges or risks identified with ICT products and infrastructure [13] can be as follows:

i) Global resource depletion
ii) Energy use
iii) The emission of toxic substances over the lifecycle (production, use, disposal).

This paper will consider these three categories and finally proffer a list of recommendations that we think are worthy of note.

i) Global Resource Depletion: In the pursuit of sustainable development, the plans or strategies must consider the use of natural resources with respect to the consequences for the future generation and without exploitation. ICT has grown to be part of our development. But the question is how sustainable is that development in the light of the various environmental threats (global warming, ozone layer depletion etc) facing the world today. In the production of the various microelectronics components that make up the ICT infrastructures, the level of natural resources used is significant due to highly organized structure of the components. [15].

ii) Energy Use: Considering the massive production of ICT facilities and components, the level of energy consumption has in turn increased over the years. With the extensive use and production of ICT infrastructures, the energy consumption is increasingly phenomenal. [15]

iii) Toxic Substances Emission (Production, Use and Disposal): The rapidly growing amount of ICT equipment is causing increasing problems in the disposal (end-of-life) phase of the electronic waste. [15]

Recycling or disposal of computers and telecommunication hardware is problematical, because electrical and electronic equipment includes a multitude of components causing human and ecological risks, such as heavy metals and halogenated organic compounds. In case of inadequate disposal or recycling, the emission of toxic substances from electronic waste can pollute water, soil, and air, and harm human health. The technically complex problem of electronic waste disposal is not taken care of equally well in all parts of the world. [5]

Electronic waste or E-waste is the most rapidly growing waste problem in the world. It is a crisis not only of quantity but also a crisis born from toxic ingredients – such as the lead, beryllium, mercury, cadmium, and brominated flame retardants that pose both an occupational and environmental health threat. But to date, industry, governments and consumers have only taken small steps to deal with this looming problem. Both the hazardous and non-hazardous waste at the end of a high tech product's use, often referred to as "e-waste", presents environmental concerns. In the U.S. only 14% of computers are recycled or remanufactured, with the remaining 86% going to hazardous waste landfills (46%), solid waste landfills (25%), and incineration facilities (15%). Only about 25% of Europe's medium sized household appliances and 40% of larger appliances are collected for salvage and recycling, leaving "substantial room for improvement," according to a study for the European Commission by a United Nations University-led consortium [11]. Small appliances, with a few exceptions, are close to zero percent collection.

CONCLUSIONS

Researchers. We see three different types of researchers related to ICT Ensure:

i. Researchers in environmental sciences: experts in the field of the environment (generally universities and research organizations) applying ICT to improve their capacity to monitor and predict; these actors generally assume an observational stance with respect to the environment.

ii. Researchers in ICT for the environment: experts in ICT research, development and application related to environmental topics (e.g. climate models, GIS) investigating open research questions (research organizations and universities, members of environmental protection agencies).

iii. Researchers in Socio-Economics: Experts (and policy consultants) in the area of the Information Society in its economic and societal aspects or in specific fields such as health, agriculture and economics, all approaching the

ICT-Ensure problem space as a question of sustainable development including both the environment and human communities within it.
Community Stakeholders. Associations, NGOs, Networks representing communities who have in common special emphasis on dissemination and awareness activities, e.g. who want to raise awareness about environmental change or want to promote the potential of ICT for sustainable development etc.
Industry. Organizations in the private sector developing products and/or services in the field of ICT applied to environmental protection, corporate social responsibility, sustainability reporting etc.
Policy Makers
Individuals in official bodies who have the authority to make decisions about which problems within a particular sector, i.e. ICT for sustainability, are to be addressed and how these problems are to be handled.
Interested Public. People who are interested in the environmental change and in potential solutions influencing this change.

This paper intends to proffer a 2-level recommendations namely, organizations/companies and non-governmental organizations (NGOs), and universities and research institutes. Some of the recommendations are as follows:
Private and non-governmental organizations

i. To support the implementation of integrated programmes for processing and safe disposal of ICT waste in their community, to establish the supporting institutional and legal frameworks for this purpose, and to consider the implementation of such programmes on a priority basis.
ii. To organize seminars and workshops to enlighten and educate people on the environmental impact of electronic wastes proffer possible solutions of management.
iii. To produce and disseminate scientific periodicals, in local languages focusing on health and environmental risks associated with ICT.
iv. To initiate programmes that ensure that safety and prevention measures are being applied to control exposure to occupational and environmental risks related to the work with ICT equipment are in place and implemented.

Universities and research institutes.

i. To give special attention to research on health and environmental impact of ICT, including the Internet and mobile telephony.
ii. To direct part of their research work to health and environmental impact of ICT on living organisms, including microorganisms, especially the effect of such impact on the ecological balance and human beings.

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