ICTs for e-Environment

Guidelines for Developing Countries, with a Focus on Climate Change

ICT Applications and Cybersecurity Division
Policies and Strategies Department
ITU Telecommunication Development Sector

Final report

International Telecommunication Union

Acknowledgements

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e-Environment

a) The use and promotion of ICTs as an instrument for environmental protection and the sustainable use of natural resources; b) 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, and; c) The establishment of monitoring systems, using ICTs, to forecast and monitor the impact of natural and man-made disasters, particularly in developing countries, LDCs and small economies[1].

Please consider the environment before printing this report.

[1] Derived from the text in the Geneva Plan of Action (2003) from the World Summit on the Information Society (WSIS) Action Line C7: E-environment (http://www.itu.int/wsis/docs/geneva/official/poa.html#c7-20)

TABLE OF CONTENTS

Table of figures

Tables

Text boxes

1. EXECUTIVE SUMMARY

The impact of human activities on the environment – and on climate change in particular – are issues of growing concern confronting life on Earth. At the same time, information and communication technologies (ICTs) are being rapidly deployed 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.

This report, *ICTs for e-Environment*, reviews key ICT trends and provides an overview of the impact that ICTs have on the environment and climate change as well as their role in helping mankind to mitigate and adapt to these changes. Intended as guidelines for developing countries, the report approaches the topic from a developmental perspective and is based on consultations with key actors and extensive online research. The *ICTs for e-Environment* report documents current activities and initiatives and makes a set of recommendations for strengthening the capacity of developing countries to make beneficial use of ICTs to mitigate and adapt to environmental change, including climate change.

The *ICTs for e-Environment* report presents the results of research that demonstrate that ICTs can help to significantly reduce greenhouse gas (GHG) emissions while increasing energy efficiency and reducing the use of natural resources. This is achieved through the use of ICTs for travel replacement, dematerialization and reduced energy consumption. The report indicates there is a need for more research to understand the long-term impacts of ICTs on human activities. For example, there is a need to undertake life cycle assessments (LCAs) of ICT impacts on the environment and especially on GHG emissions and energy consumption. The report also looks extensively at the use of ICTs in many different aspects of work on the environment, including environmental observation, analysis, planning, management and protection, mitigation and capacity building.

The report demonstrates that 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.

But not all countries have the capacity to take advantage of these technologies in order to use the full potential of ICTs for environmental action. There is a need to strengthen the capacity of developing countries to benefit from the use of ICTs for managing the environment to help countries mitigate the impact of and adapt to environmental and climate change – all while helping them to achieve the Millennium Development Goals (MDGs).

There is a clear need for a more comprehensive and integrated approach to global environmental action through access to ICTs and the use of information technologies and management practices to eliminate duplication of efforts. This can be done by consolidating action at national levels on the many and varied environmental conventions and initiatives that developing countries have already agreed to in principle. ICTs provide a unique opportunity to do so while assisting in building local capacity to use these tools and practices. There is also a need to assign the environment a more important profile in ICT strategic planning initiatives at the national level and, in particular, in e-Government initiatives so that the use of ICTs for the environment is integrated into planning processes from the beginning, along with other national priorities and initiatives.

Finally, the *ICTs for e-Environment* report proposes a methodology to undertake rapid national e-Environment assessments as well as to develop and implement national e-Environment strategies. Among other proposals, the report recommends the preparation of an e-Environment toolkit comprised of best practices as one practical method to assist developing countries to take advantage of ICTs for environmental research, planning and action. Strengthening ongoing research activities is another proposal as well as placing more focus on the environment sector in e-Government initiatives. Working on a regional basis may be the best approach for smaller, landlocked or island jurisdictions, such as small island developing states (SIDS).

Whatever approach is taken to support the use of ICTs for environmental action in sustainable development, it must be undertaken in close collaboration with key development partners at the national and international level and in consultation with actors in the public and private sectors as well as civil society.

This is a preliminary scoping study. The authors recognize the need for much more feedback from development practitioners and environmental actors – especially from collaborators and partners in the developing world. There is also a need for more input from stakeholders at local and community levels where there are undoubtedly many additional important examples that can be shared on how ICTs can be used for environmental action.

2. BACKGROUND INFORMATION ON THIS REPORT

2.1. Introduction

The objective of this report is to provide a high-level overview that documents the use of information and communication technologies (ICTs) in the area of the environment with a particular emphasis on the needs and perspectives of the developing world. This report looks at current use and trends in the use of ICTs for environmental applications around the world in an attempt to identify the key issues and applications and to draw conclusions on how to enhance their use by governments and other stakeholders.

2.2. A growing interest in climate change

During the preparation period of this report (2007/2008), the importance of climate change was the subject of much interest on the international stage. In fact, the urgency of acting on climate change was highlighted in 2007 as a result of following events:

- The publication of "Climate Change 2007", the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC)[2], a report that received wide media attention for the definitive evidence it presented underlining the need to act immediately to mitigate the impact of climate change on planet Earth;
- The IPCC and Mr. Albert (Al) Gore Jr. were awarded the Nobel Peace Prize for 2007[3] "for their efforts to build up and disseminate greater knowledge about man-made climate change, and to lay the foundations for the measures that are needed to counteract such change";
- The United Nations Climate Change Conference in Bali which adopted the Bali roadmap to finalize negotiation processes by 2009, which is intended to lead to a post-2012 international agreement on climate change[4]. This conference also received wide media attention as the follow-on to the IPCC Assessment Report.

The result of this growing interest is that much more information is now being published about the role, both proven and potential, of ICTs in mitigating greenhouse gas (GHG) emissions, and how they could contribute to help reduce and even reverse climate change.

Many efforts are underway to deal with the issue of climate change and adaptation to climate change but we are still at an early stage. It appears clear from the research undertaken in preparing this report that climate change has become a predominant issue that the international community needs to urgently address. The exact role that ICTs play in this domain is the subject of growing policy research, much enthusiasm and good intentions — but a shared understanding of the greatest opportunities that ICTs have with regard to environmental action remains elusive.

While this study considers environmental issues, it does so within a broader context of sustainable development — with a focus on human, social and economic development — and on achieving the Millennium Development Goals (MDGs). In this regard, the report adheres to the principles of sustainable development as outlined by the World Commission on Environment and Development (WCED) which was captured in *Our Common Future*,[5] the report the World Commission produced in 1987.

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[2] IPCC. See http://www.ipcc.ch/ipccreports/
[3] Nobel Foundation. 2007. *The Nobel Peace Prize 2007*. http://nobelprize.org/nobel_prizes/peace/laureates/2007/index.html
[4] UNFCCC. 2007. *Bali Action Plan*. Advanced unedited edition. http://unfccc.int/files/meetings/cop_13/application/pdf/cp_bali_action.pdf
[5] World Commission on Environment and Development. 1987. http://www.un-documents.net/wced-ocf.htm

2.3. Background on this report

This report was commissioned by the ICT Applications and Cybersecurity Division (CYB) of the International Telecommunication Union's (ITU) Telecommunication Development Sector (ITU-D). The CYB Division is the ITU-D's focal point for assisting developing countries in bridging the digital divide by advancing the use of internet protocol-based networks, services and applications, developing e-strategies and promoting cybersecurity[6]. One activity of the CYB Division is to develop guidelines on the technology and policy aspects of ICT applications such as e-Environment[7].

With regard to ITU's broader activities on climate change, see the ITU's dedicated website on *ITU and Climate Change* at http://www.itu.int/climate/.

ITU has also been identified as one of the co-moderators/co-facilitators for follow-up on the World Summit on the Information Society (WSIS) Action Line C7 on e-Environment — together with the United Nations Environment Programme (UNEP), the World Meteorological Organization (WMO), the World Health Organization (WHO), the International Civil Aviation Organization (ICAO), and UN-Habitat. Additional information on WSIS Action Line C7 on e-Environment can be found at http://www.itu.int/wsis/c7/e-environment/.

2.4. Investigators who contributed to the report

Richard Labelle

Mr. Labelle has a background in the biological sciences and over 26 years of experience in institutional strengthening and on issues related to sustainable development and the management of information and knowledge in countries around the world. He has undertaken missions to 58 countries to advise government and other development actors on the use of the Internet and of information and communication technologies (ICTs) and to present, discuss and negotiate projects to build capacity to make beneficial use of these tools. He has developed and implemented several ICT strategies, action plans and projects including projects in e-Government, e-Commerce, for local and community development. From 1981 to 1990, Richard Labelle was responsible for the knowledge management activities of the International Council for Research on Agroforestry (ICRAF) now the World Agroforestry Centre, a research centre of the Consultative Group on International Agricultural Research located in Nairobi, Kenya. Mr. Labelle can be contacted at rlab@sympatico.ca.

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Ralph Rodschat

Mr. Rodschat currently works for Nortel and has over 19 years of experience in telecommunications. Over the past 10 years, he has worked with telecom networks in over 25 developing countries throughout Asia and South America. He holds an MBA in international business and development and has remained involved in development through an innovative environmental education program in the Philippines in 1998, his involvement in the Telecommunications Executive Management Institute of

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[6] The CYB Division has coordination responsibility for Programme 3 of the Doha Action Plan adopted at the 2006 World Telecommunication Development Conference (WTDC-06). Priority activities of the Division include promoting cybersecurity, e-strategies, ICT applications, Internet and IP networks development, multilingualization, and community telecentres. See URL: http://www.itu.int/ITU-D/cyb/.

[7] See World Telecommunication Development Conference (Doha, 2006) Resolution 54: *Information and communication technology applications* instructing the ITU-D to undertake studies on ICT applications, including e-Environment, and to circulate the outputs to all Member States. See http://www.itu.int/ITU-D/cyb/app/docs/wtdc_resolution_54.pdf.

Canada (TEMIC) training program since 2002, and on-going support for NGOs in both Canada and the Philippines. Mr. Rodschat can be contacted at rodschat@sympatico.ca.

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2.5. Terms of reference

The terms of reference for this study can be found in Annex 5 to this report on page 169.

2.6. Definitions

Information and communication technology (ICT)

For the purposes of this report, the definition of information and communications technology is an umbrella term that include any communication device or system encompassing, *inter alia*, radio, television, mobile phones, computer and networking hardware and software, satellite systems, as well as the various services and applications associated with them.

e-Environment

For the purposes of this report, the definition of e-Environment[8] is: a) The use and promotion of ICTs as an instrument for environmental protection and the sustainable use of natural resources; b) 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, and; c) The establishment of monitoring systems, using ICTs, to forecast and monitor the impact of natural and man-made disasters, particularly in developing countries, LDCs and small economies.

2.7. Scope of study

In an attempt to better understand the contribution of ICTs and related management practices as tools for dealing with environmental issues, particularly from a developing country perspective, this report examines the following ICT application categories in the referenced chapters:

- **Environmental observation** (Chapter 7, page 29)
- **Environmental analysis** (Chapter 7, page 45)
- **Environmental planning** (Chapter 9, page 57)
- **Environmental management and protection** (Chapter 10, page 61)
- **Impact and mitigating effects of ICT utilization** (Chapter 11, page 67)
- **Environmental capacity building** (Chapter 12, page 85)

[8] Derived from the text in the Geneva Plan of Action (2003) from the World Summit on the Information Society (WSIS) Action Line C7: E-environment (http://www.itu.int/wsis/docs/geneva/official/poa.html#c7-20)

In addition, a list of specific ICT applications for each category has been prepared and can be found in Annex 2 of this report starting on page 122. A selected number of these are considered in more detail from the perspective of their adoptability and transferability to developing countries using a model assessment framework in Annex 1 of this report starting on page 106.

2.8. Methodology

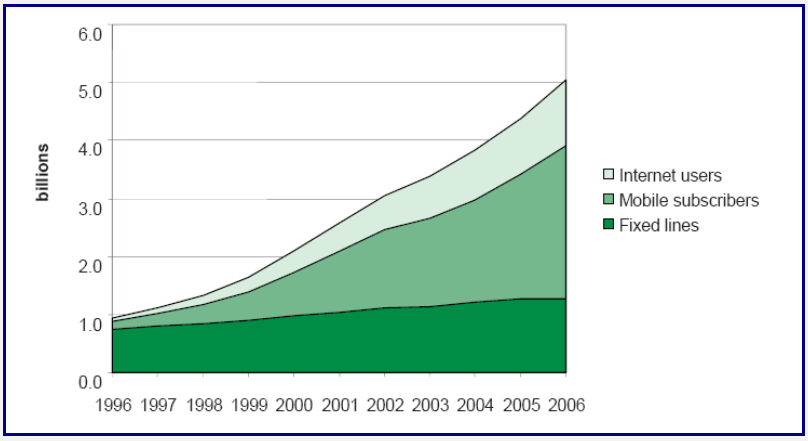
This report draws principally from online research but also included interviews with specialists and experts in the use of ICTs in the environmental field.

3. ICTs AND INTERNATIONAL DEVELOPMENT

3.1. Introduction

In the past 10 years or so, the availability and use of ICTs has grown dramatically around the world (see Figure 1 below). In the developing world especially, this growth has been largely due to the growth of mobile telephony. According to a recent ITU report[9] "…by the end of 2006, there were a total of nearly 4 billion mobile and fixed line subscribers and over 1 billion Internet users. This included 1.27 billion fixed telephone lines, 2.68 billion mobile subscribers (61 per cent of which were located in developing countries) and some 1.13 billion Internet users."

Figure 1. Growth in fixed lines, mobile subscribers and Internet users, in billions, World (1996-2006)[10]



Source: ITU[11]

3.2. ICT diffusion around the world

While the penetration of ICTs in the developed world has reached high levels, the penetration of ICTs in the developing world is still growing and there are marked differences between different categories of countries. ITU data[12] once again shows (see Figure 2 below):

- That countries of the Organisation for Economic Co-operation and Development (OECD) augmented by Taiwan, China; Hong Kong, China; Macao, China; and Singapore ("OECD +"), accounting for 18.7 per cent of the world's population, have demonstrated marked growth in ICT uptake with the exception of fixed line access.
- Whereas in the least developed countries (LDCs) which are made up of the "...50 least developed countries, recognized by the United Nations as requiring special attention in development assistance, accounting for 11.9 per cent of the world's population", growth rates are very low.
- In all other countries, which are termed developing and which account for 69.7 per cent of the world's population, rates are growing but albeit not at the same rapid pace as the developed countries in the "OECD +" categorization.

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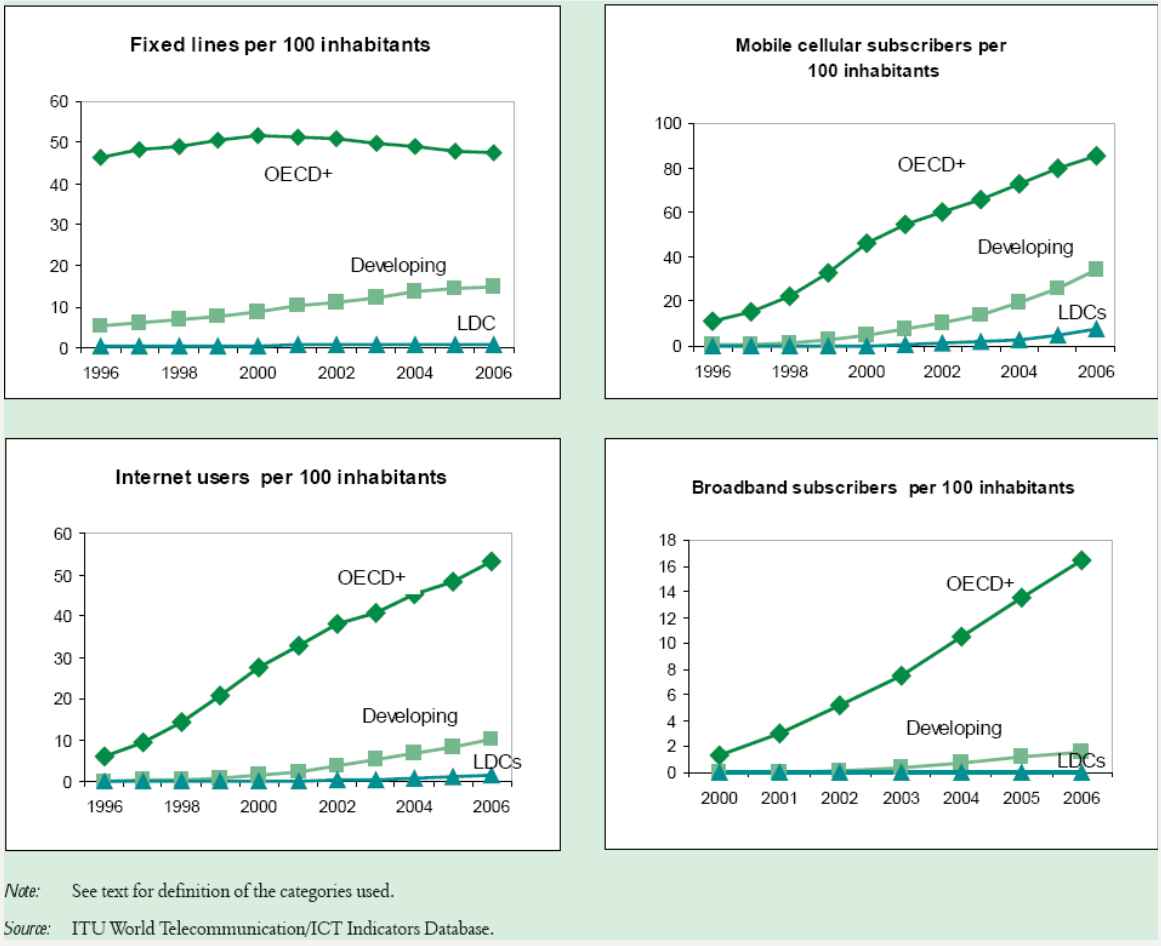
[9] ITU. 2007. *Trends in telecommunication reform 2007. The Road to Next Generation Networks (NGN).* Geneva. 238 pp.
[10] Idem.
[11] Idem.
[12] ITU. 2006. *World Telecommunication/ICT Development Report 2006. Measuring ICT for social and economic development*. ITU. Geneva. 206 pp.

3.3. The digital divide

While these data are important in determining access to ICTs and related applications, they do not tell the full story. ICT penetration rates are lower in developing countries than in the more industrialized countries. That said, nearly all capital cities in developing countries of the world have access to some form of broadband connectivity. While ICT penetration rates are lower in rural areas and higher in the urban areas around the world, both in developing as well as developed countries, rural areas of developing countries typically have much poorer connectivity and particularly poor broadband connectivity.

Figure 2. Penetration of selected ICTs, by category of economies, 1996-2006



Note: See text for definition of the categories used.

Source: ITU World Telecommunication/ICT Indicators Database.

International Internet capacity continues to increase steadily, growing at a compound annual rate of 45 per cent according to a recent study by Telegeography Research[13], as reported by Broadband Properties. According to this report, "…on average, peak international Internet backbone traffic grew 60 per cent between 2006 and 2007, while bandwidth grew 68 per cent."

[13] See www.telegeography.com and also "International Internet capacity growth accelerates" in http://www.broadbandproperties.com/2007issues/october07/FirstMile.pdf

According to Ovum Research[14], again as reported by Broadband Properties, after benchmarking countries from all regions of the world, the ten fastest growing broadband markets are: Greece, the Philippines, Indonesia, Ireland, India, Ukraine, Thailand, Vietnam, Russia and Turkey.

3.4. Access to PCs: an issue in developing countries

Generally, developing countries have less access to computers and this includes both high speed computing resources as well as personal computers. Notwithstanding the introduction of innovative solutions such as the One Laptop per Child (OLPC) PC and related initiatives, the cost of PCs still remains prohibitively high for the average citizen of a developing country. Users in these countries are more likely to log on at work or in community access facilities such as cybercafés or telecentres, which are very popular in many parts of the developing world. Fewer computers with less computing power and poor network access have serious implications for the use of ICTs in day-to-day life as well as in the broad use of ICTs for science and technology applications.

3.5. Broadband access to online data and knowledge resources

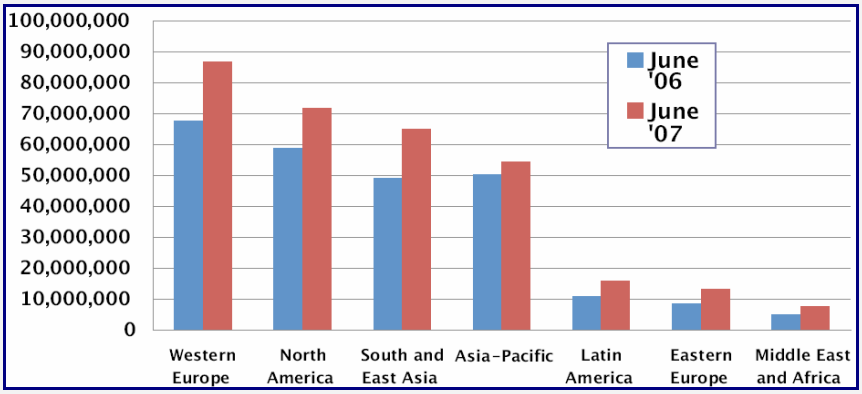
A major trend is the provision of public Internet access to a wide variety of data sources, including geospatial data including the use of "visual earth engines" such as Google Earth and Microsoft Virtual Earth. To take advantage of these online resources, countries that are not already directly connected to the global fiber backbone, such as many countries in Africa, need to gain access to submarine fiber networks that link them with other regions and continents.

Many landlocked countries of Africa that do not have full access to submarine fiber connections are at a definite disadvantage. The low household broadband growth rate in the Middle East and Africa reflects this current situation (see Figure 3 below).

As a measure of how far ahead some regions are, Hong Kong, a leader in the provision of broadband services to its population, has recently announced that it will be offering customers access to Gigabit broadband services for USD 215.40 / month with 100 Mbps for USD 48.50 / month[15].

[14] See www.ovum.com and also: "Top ten fastest-growing broadband markets" in http://www.broadbandproperties.com/2007issues/october07/FirstMile.pdf
[15] See Fiber Deployment Roundup Asia-Pacific. http://www.broadbandproperties.com/2007issues/october07/FiberDeployment.pdf

Figure 3. Growth in broadband use in households, 2006-2007[16]



Source: Broadband Properties.

3.6. The importance of being mobile

The data graphed in Figure 2 above shows the importance of mobile telephony as the telecommunications platform of prevalence around the world. In developing countries, where "…access to basic communications has basically been achieved through mobile communications"[17], wireless technologies have proven to be especially important.

In developing countries, mobile telephony remains generally more accessible than PCs and the Internet. In general, wireless technologies are likely to be more broadly used in developing countries for Internet access and increasing mobile broadband speeds will further facilitate access to the Internet for mobile subscribers. However, there remain a number of challenges ahead including broader adoption of broadband mobile technologies and availability of spectrum. For backbone or core networks, other transport technologies are likely to continue to dominate.

3.7. Saturating the Internet?

Concerns about the "exaflood"[18] or the exponential growth of data stored online as well as the increasing demand of bandwidth posed by the growing popularity of video and audio downloads and file exchanges as well as multimedia streaming of various sorts[19] raise the prospect that the current Internet infrastructure may not be sufficient to meet future demands. The situation will be exacerbated when high definition video becomes more prevalent. With this scenario in mind, it is clear that countries will need to move to fiber optics to meet their growing backbone communication requirements[20]. Other broadband transport or access technologies including fixed or mobile broadband technologies such as WiFi, WiMAX and 3G or 4G as well as cable or DSL will not be able to meet the demand, except perhaps as local area network or very last mile (or last few meters) access technologies that work at the periphery of the Internet.

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[16] Broadband Properties. 2007. *IPTV deployment almost triples in a year*. In First Mile, November 2007 issue, pp. 12-14. http://www.broadbandproperties.com/2007issues/november07/FirstMile.pdf

[17] ITU. 2007. *Trends in telecommunication reform 2007. The road to next generation networks (NGN).* Geneva. 238 pp.

[18] McClure, D. 2007. *The Exabyte Internet*. Broadband Properties. Vol. 27, No. 5. May 2007, pp 16-21. http://www.broadbandproperties.com/2007issues/may07issues/exabyte_may.pdf

[19] Internet Innovation Alliance. 2007. *What exactly is the exaflood?* http://www.internetinnovation.org/Editor/Videos/HPVideo/tabid/109/Default.aspx also: http://www.youtube.com/watch?v=yha25cphfF4

[20] Nemertes Research. 2007. *The Internet Singularity, Delayed: Why Limits in Internet Capacity Will Stifle Innovation on the Web*. Produced by Nemertes Research. Fall 2007, 62 pp. http://www.nemertes.com/

3.8. The importance of being fiber

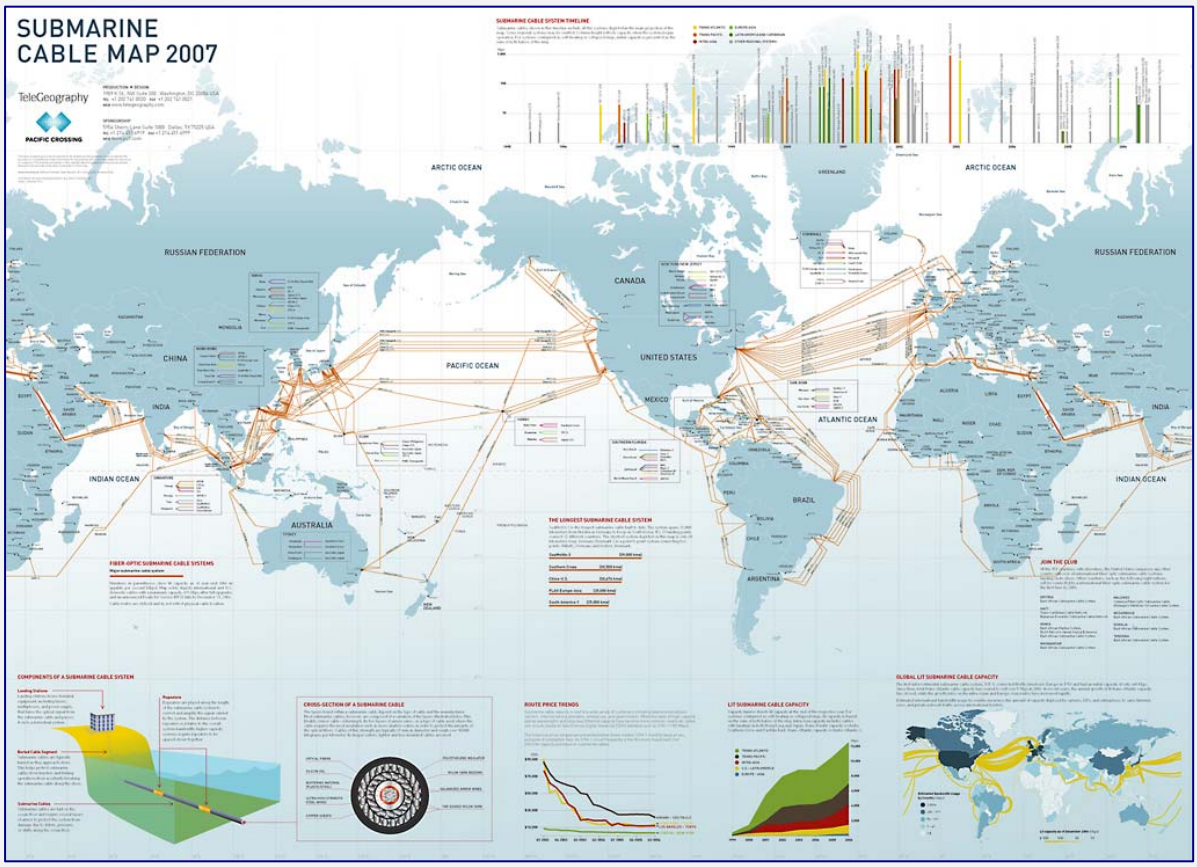
For scientific and other high bandwidth applications such as video transfers, fiber optic-based technologies are considered essential because of the increasing size of data resources and significant data transfer rates required for some ICT applications, including those used in the e-Environment field, such as those based on spatial data or manipulating large data sets.

For countries to participate fully in collaborative international research activities linked to the environment, and for these countries to take advantage of the opportunities for learning as well as for research, improved backbone network resources will have to be made available — most likely based on fiber optic solutions. Fiber optic core network infrastructures are likely able to provide as much bandwidth as necessary to meet the requirements of a number of different applications. An emerging paradigm of open access networks encourages service providers and application resellers to focus on shared infrastructures instead of building separate infrastructure for different or even unique applications. In any case, developing countries need to foresee the use of their national core networks for many purposes outside of research and development or education.

Limited access to fiber optic backbone networks is forcing many countries, particularly in Africa and small island states, to use satellite services to access the Internet. Technical limitations from the use of satellite broadband technologies limit the usefulness of certain kinds of applications that require rapid access rates and little network latency. At the time of preparing this report, for instance, the EASSy submarine link for East Africa appeared to be on the verge of beginning the installation phase of the project with the International Financial Corporation (IFC) announcing that it had closed on financing arrangements[21] and that "…the construction of the cable is now scheduled to commence on 14th March 2008"[22]. East Africa is one of the last regions not to be served extensively by submarine cables (see Figure 4 below) and the project will be ready for commercial service during the first half of 2010[23].

[21] See http://www.southafrica.info/doing_business/economy/infrastructure/eassy.htm
[22] See http://www.eassy.org/pressrelease.html
[23] See Ibid.

Figure 4. Submarine Cable Map 2007



Source: Telegeography

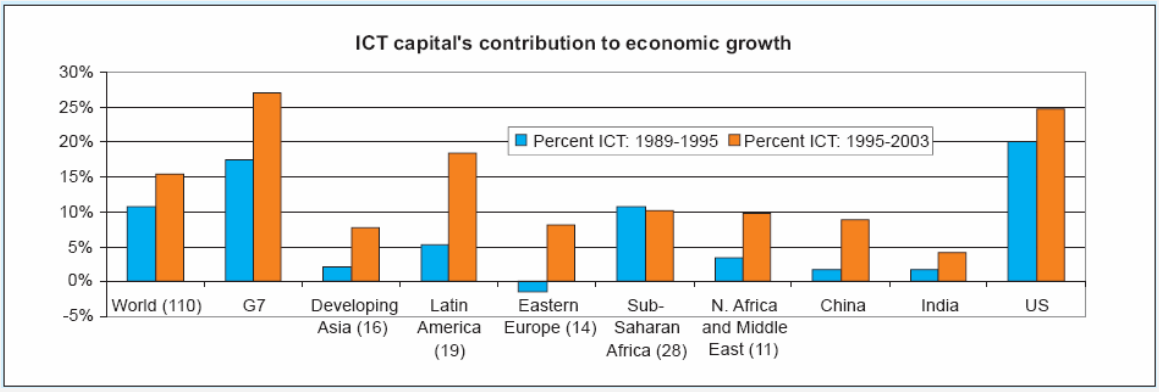
3.9. Impact of ICTs on productivity and national development

The increasingly ubiquitous use of ICTs in all aspects of human endeavor is transforming the way that people live and work. ICTs have been demonstrated to contribute to economic growth and development by stimulating the productivity of people, organizations and nations.

Figure 5 below from another recent ITU report[24] shows the impact ICTs have on economic growth in all regions of the world. This is in contrast with the situation in the mid-1990's where the impact of increased investments in ICT use was not apparently clearly related to increases in productivity and gross domestic product (GDP). According to the "Digital Economy 2000" report of the US Department of Commerce[25], only in the latter part of the 1990's was evidence produced demonstrating that the investment in ICTs had a positive contribution to gross domestic product. Previous to the 1990's, information technology (IT) and telecommunications were generally seen as separate and distinct sectors of the economy. While telecom had previously been linked with productivity increases, IT was typically not.

[24] ITU. 2006. *World telecommunication/ICT development report 2006. Measuring ICT for social and economic development*. ITU. Geneva. 206 pp.
[25] US Department of Commerce. 2000. Digital Economy 2000. Washington, D.C., 84 pp.

Figure 5. ICTs contribution to economic growth



Source: ITU

The broad availability of ICTs impacts society and the economy in different ways. Some of these are highlighted below.

Social impact

- Enhanced capacity and efficiency in accessing and delivering social and community services by transforming government and other social service providers (such as NGOs) as well as local and community groups into more client-focused providers of public services according to current models of e-Government;
- Greater and more varied communication between the public and the government and other providers of public services at the local, national and international levels, and the possibility of greater participation by or partnership with the public in government decision-making and public service delivery;
- Enhanced self sufficiency at the local and community level;
- Greater access to opportunities for the poor and disenfranchised.

Human impact

- Impacts that accrue as a result of ICTs providing more choices for people to work, learn, entertain themselves, trade, be productive and contribute to the mainstream of social, cultural and economic life of the community, region, country they live in and beyond;
- More opportunities for people to be and become self-sufficient, as well as local and community level empowerment and self-sufficiency;
- Some possible downsides of increased ICT use including addiction to online activities such as chat, surfing, shopping, gaming, gambling, pornography, trivial and other virtual activities that limit face-to-face interaction and socializing.

Economic impact

- Enhanced capacity and efficiency of the private sector to meet the needs of customers;
- Improved production efficiency;
- More consumer choice and greater competition in the market place;
- Enhanced access to markets and to buying and selling opportunities;

- New opportunities for service delivery (for examples: call centres, offshoring, etc.) and economic transactions at the local, national and international level;
- Enhanced efficiency in the operation of markets and in buying and selling.

Impact on research and development

- Enables and enhances research networking and exchanges;
- Allows recent graduates to remain connected and to continue learning and researching;
- Greater access to funding possibilities and to collaborative research ventures;
- Opportunity to gain access to otherwise unavailable computing resources including digital data warehouses via research grids and cloud computing;
- More opportunity to undertake research in the developing world in line with follow-up on WSIS Action Line C7 on e-environment;
- More opportunity for residents and especially students in the developing world to learn about science and technology;
- More opportunity to apply ICTs to problem-solving at the local and community level which can enhance local self-sufficiency in disaster early warning, mitigation and management;
- Makes it easier for countries to meet their reporting requirements under various environmental treaties.

Impact on the environment

These are discussed extensively in Chapter 11 of this report starting on page 67.

4. THE ENVIRONMENT AND INTERNATIONAL DEVELOPMENT

4.1. Introduction

This chapter situates the support for environmental action in ongoing international development activities and the evolution of mainstreaming environmental programming in global development initiatives.

4.2. The changing perceptions of the environment

Environment issues are increasingly at the fore of public concerns in the industrialized as well as in the developing world. According to a recent report published by the Pew Research Center (USA) which undertook a global opinion survey of 47 nations, there is a "…general increase in the percentage of people citing pollution and environmental problems as a top global threat. Worries have risen sharply in Latin America and Europe, as well as in Japan and India"[26].

Another poll commissioned by the BBC World Service shows that, "…large majorities around the world believe that human activity causes global warming and that strong action must be taken, sooner rather than later, in developing as well as developed countries, according to a BBC World Service poll of 22,000 people in 21 countries"[27].

The results of these surveys demonstrate a widespread consensus that developing countries should take action on climate change along with developed countries. In the BBC survey referenced above, seventy per cent of urban Chinese respondents believe major steps are needed quickly to address climate change. In all but one of the developing countries polled, the weight of opinion is towards agreeing to limit greenhouse gas emissions in the context of a deal that requires wealthy countries to provide aid and technology. All of the developed countries polled endorsed this idea by large margins.

According to the European Commission, concern about the environment in international development circles is a fairly recent phenomenon. This information which has been excerpted word for word from the European Commission website appears below[28].

- *Environmental concerns did not figure on the international agenda when the UN was created. This explains the absence of a UN role in environmental protection in the UN Charter. However, with increasing evidence of deterioration of the environment scale in the following decades, the UN became a leading advocate for environmental concerns and sustainable development.*
- *Following the United Nations Conference on the Human Environment, held in Stockholm in 1972, the United Nations Environment Programme (UNEP) was established as the main UN body in the field of environment. As a subsidiary of the General Assembly, the Governing Council of UNEP reports to the Assembly, which considers and decides on selected environmental and environment-related issues, including institutional arrangements and related international processes.*
- *In the post-Stockholm years, mounting concern over continuing environmental degradation led the UNGA to convene the World Commission on Environment and Development in 1983. The report of the Commission (the Brundtland Report) was a catalyst for the 1992 UN Conference on Environment and Development (UNCED), also known as the Earth Summit. Among other outcomes,*

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[26] Pew Research Center. 2007. *Global Unease With Major World Powers Rising Environmental Concern in 47-Nation Survey*. Released June 27, 2007. http://pewglobal.org/reports/display.php?ReportID=256

[27] BBC World Service. 2007. All Countries Need to Take Major Steps on Climate Change: Global Poll. 25 pp. September 2007.
http://www.worldpublicopinion.org/pipa/articles/btenvironmentra/412.php?lb=bte&pnt=412&nid=&id=

[28] European Commission. International issues – Multilateral relations – United Nations
http://ec.europa.eu/environment/international_issues/relations_un_en.htm

the Summit adopted Agenda 21[29]*, a comprehensive plan of action for addressing both environmental and development goals in the 21st century and the Rio Declaration*[30].

[29] See http://www.unep.org/governingbodies/agenda21.asp
[30] See http://www.unep.org/Documents/Default.asp?DocumentID=78&ArticleID=1163

4.3. International agreements

According to International Environmental Agreements (IEA) Database Project at the University of Oregon, USA[31], there are currently over 900 multilateral agreements and over 1500 bilateral agreements in the environmental area. Of these, according to a US State Department website, the major environmental agreements are the following[32]:

Table 1. Major international environmental agreements

- Kyoto Protocol to the United Nations Framework Convention on Climate Change[33]. The document consists of the final authentic text of the Kyoto Protocol to the United Nations Framework Convention on Climate Change[34].
- Basel Convention on Transboundary Movements of Hazardous Wastes[35]. The Basel Convention on the Control of Transboundary Movements of Hazardous Wastes and their Disposal was adopted in 1989 and entered into force in May 1992. This global environmental treaty strictly regulates the transboundary movements of hazardous wastes and obliges its Parties to ensure that such wastes are managed and disposed of in an environmentally sound manner.
- Convention on Biological Diversity[36]. The Convention on Biological Diversity was signed by over 150 governments at the Rio "Earth Summit" in 1992. It has become the centre-piece of international efforts to conserve the planet's biological diversity, ensure the sustainable use of its components, and promote the fair and equitable sharing of the benefits arising out of the utilization of genetic resources.
- Convention on Climate Change[37]. Over 150 States signed the United Nations Framework Convention on Climate Change in June 1992 at the Rio "Earth Summit", recognizing climate change as "a common concern of humankind". The Convention provides a "framework" within which governments can work together to carry out new policies and programmes that will have broad implications for the way people live and work.
- Convention to Combat Desertification[38]. The Convention to Combat Desertification. In those countries experiencing serious drought and/or desertification, particularly in Africa, the CCD promotes a new approach to managing both dry land ecosystems and the flow of aid for development. This website contains the text of the Convention itself, official documents for the Intergovernmental Negotiating Committee (INCD), and public information.
- Convention on International Trade in Endangered Species (CITES)[39]. CITES establishes world-wide controls on the international trade in threatened species. In the case of species threatened with extinction, CITES prohibits all commercial trade in wild specimens. The Convention was signed in 1975 and more than 125 countries are members.
- Convention on the Law of the Sea (LOS)[40]. The United Nations Convention on the Law of the Sea codifies the rules by which nations use the oceans of the world. The site linked to here, maintained by the independent Council on Ocean Law, offers and extensive collection of documents about the LOS, including links to the text of the Convention.
- Montreal Protocol on Substances that Deplete the Ozone Layer[41]. The Montreal Protocol is the primary international agreement providing for controls on the production and consumption of ozone-depleting substances such as CFCs, halons, and methyl bromide. As of June 1994, 136 states had become Parties to the Protocol, including virtually all major industrialized countries and most developing countries.

Source: US State Department

[31] See http://iea.uoregon.edu. Also see UN Economic Commission for Europe. 2007. *Main environmental conventions, their web sites and status of ratifications* at http://www.unece.org/env/environment-conventions.html.
[32] See http://www.state.gov/www/global/oes/envir_agreements.html. The table is copied verbatim from the site.
[33] See http://www.unfccc.de/resource/protintr.html
[34] See http://www.unfccc.de/
[35] See http://www.basel.int/
[36] See http://www.biodiv.org/
[37] See http://www.cop4.org/
[38] See http://www.unccd.int/main.php
[39] See http://www.wcmc.org.uk/CITES/eng/index.shtml
[40] See http://www.tufts.edu/departments/fletcher/multi/sea.html
[41] See http://www.unep.ch/ozone/montreal.htm

4.4. Environment issues and priorities

Disasters and Climate Change

Many disasters are environmental in nature and invariably associated with earth events and/or climate and weather-related events. Given the increasing rate at which natural disasters are appearing (see Text box 1 below), disaster early warning and mitigation is now considered a major issue of importance and recognized as such in national development planning. Many disasters are directly related to climate change according to various sources, including the UN Office for the Coordination of Humanitarian Affairs (OCHA) and the United Nations Development Programme in its Human Development Report for 2007/2008[42]. According to the most recent assessment reports[43] prepared by the Intergovernmental Panel on Climate Change (IPCC), climate change is a man-made disaster in the making.

Text box 1. Humanitarian costs of climate change[44]

Natural disasters on the rise

Emergency aid donors are currently grappling with one of the most expensive years for natural disasters on record. Some 200 million people — 96 percent of them living in Africa — are already affected by natural disasters every year according to the UN — more than seven times the number caught up in conflict. By mid-November 15 'flash appeals' for emergency funds had been launched by the UN's humanitarian agency (OCHA) — the most it has ever launched in one year — as floods hit four times as often in 2007 as in the year before.

All but one of the OCHA appeals was in response to climate-related disasters. Flash appeals for flood-hit Burkina Faso received 2.3 percent of what was requested, Dominican Republic 23 percent and for the West Africa region which experienced the worst floods in decades, 25 percent.

UNDP's most recent Human Development Report[45] states that the increased frequency of natural disasters seen in 2007 is likely to continue, with cyclones, typhoons, mudslides and floods happening more frequently in areas already experiencing them, and occurring in places that have not seen such phenomena before.

More frequency and intensity

"We're worried," said Jenty Kirsch-Wood, a climate change expert at OCHA in Geneva, speaking to journalists on 21 November about the expected humanitarian impact of climate change. Currently, 80 percent of the disasters that happen around the world are handled internally by national authorities and communities themselves without outside intervention but with the greater frequency and intensity of disasters predicted, that is going to change, OCHA's Kirsch-Wood warned.

"The frequency of climate-related hazards is going to increase and while we know a community might be good at coping with one or two cyclones in a season, it is too much to ask them to cope with three or four." Killer epidemics like malaria and dengue fever will start occurring in areas that were previously deemed immune as rainfall shifts. Shrinking water sources will mean more cholera and diarrhea, both common causes of death especially among children.

Preparedness a priority

With disasters increasing and funds likely to remain in short supply, disaster preparedness and prevention should be a priority for cost-conscious donors, according to OCHA. Former UN Emergency Relief Coordinator Jan Egeland calculated that $1 spent on preventing disasters from affecting people saves between $4 and $7 that would otherwise go to responding to a humanitarian emergency after a disaster.

"We know there is a need for greater preparedness but I cannot underline enough that in the current global humanitarian system there are no clear funds allocated necessarily for this," Kirsch-Wood said.

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[42] UNDP. 2007. Human Development Report 2007/2008. Fighting climate change: human solidarity in a divided world. New York. UNDP. 399 pp. http://hdr.undp.org/en/reports/global/hdr2007-2008/
[43] IPCC. 2007. IPCC *Fourth assessment report*. http://www.ipcc.ch/ipccreports/ar4-syr.htm
[44] IRIN News Network. 2007. *Humanitarian cost of climate change understated*. UN Office for the Coordination of Humanitarian Affairs. 27 November 2007. http://www.irinnews.org/Report.aspx?ReportId=75529
[45] See footnote 42.

Adaptation to climate change

The UNDP Human Development Report 2007/2008[46] on "Fighting climate change" identifies "…five key transmission mechanisms that could stall and then reverse human development":

- Agricultural production and food security;
- Water stress and water insecurity;
- Rising sea levels and exposure to climate disasters;
- Ecosystems and biodiversity;
- Human health.

Dealing with these constraints requires measures that allow countries to adapt to these changes over time. One measure invoked to adapt to climate change will require integrating climate change adaptation into all aspects of national development policy. The same report highlights some of the constraints that limit the ability of developing countries to adapt to climate change:

- Many developing countries lack the capacity and resources to assess climate risks. One imperative for adaptation in sub-Saharan Africa where farmers depend on rain-fed agriculture is access to meteorological information. According to the Human Development Report 2007/2008, "…the region has the lowest density of meteorological stations".
- The lack of infrastructure against flooding, or to improve water harvesting, place developing countries at risk. As an example, according to the Human Development Report 2007/2008, "…flood defence systems, water infrastructure and early warning systems all reduce vulnerability. Japan faces a higher exposure to risks associated with cyclones and flooding than the Philippines. Yet between 2000 and 2004, average fatalities amounted to 711 in the Philippines and only 66 in Japan."
- Adaptation requires trying new practices and technologies. For example, poor farmers and landowners are the least capable of experimenting with new technologies and approaches because the risk is too great for them that they will not get it right the first time.
- In many countries, the poor have moved to marginal agricultural land as a result of overpopulation. Eking a living from poor lands is difficult enough, but during periods of environmental risk or catastrophe, such as when the rains fail or come too late or are too strong and wash everything away, can result in malnutrition, famine and in some cases, death.
- Insurance for social protection: many developing countries have very limited means to deal with environmental disasters and invariably call upon international humanitarian aid to help them cope with disaster.
- Social insurance in richer countries also provides a buffer and some protection to people and households but these services are usually less capable of coping or in some cases may not be adequate for dealing with environmental and climate related losses.

4.5. Support for the environment in international development activities

In the 1980s, the World Bank, assisted by many other partners and by developing countries, supported the research and preparation of national environmental action plans (NEAP) as a way to raise awareness of the importance of environmental issues in national development planning and as a way of assisting countries to identify and to address these priorities and to mobilize for action. NEAPs would also assist in mapping out a way forward and to secure support for funding.

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[46] UNDP. 2007. Human Development Report 2007/2008. *Fighting climate change: human solidarity in a divided world.* New York. UNDP. 399 pp.

In dealing with development issues, the international community has adopted a livelihoods-based approach with a focus on poverty eradication plans that operate at the national level. This approach is often operationalized on the basis of the Poverty Reduction Strategy Paper (PRSP) process[47], developed by the World Bank and agreed to by national governments working with the World Bank and with other donors. The PRSP process considers the environment a cross-cutting issue and it is argued that the "…environment should be integrated into the PRSP because the quality of the environment is inextricably linked to the quality of life for poor people".

When using a livelihoods perspective in national development planning, environmental as well as other issues are considered primarily from the perspective of their impact on the poor and pro-poor growth (i.e., economic growth benefiting the poor) primarily and as a factor in promoting economic development generally. Issues related to humanitarian concerns and specifically disaster management and relief are also priorities because they are a direct threat to human well-being and livelihoods.

One of those issues, directly related to disaster management as well as to broader concerns related to sustainable development, is climate change. Climate change has now become an environmental issue of grave concern for every country and one that has a particularly strong effect on the poorer countries and on the poor in those countries.

Today, the international community and partners in the developing world address environmental issues typically within a national development planning framework. This planning framework is one where national development priorities are proposed in the context of the Millennium Development Goals (MDGs) which have been agreed by the international community through the UN General Assembly — with a particular focus on poverty reduction. There are 8 goals to achieve the MDGs, one of which deals specifically with environmental concerns[48]. MDG goal number 7 is for "ensuring environmental sustainability" where it is proposed to:

- Integrate the principles of sustainable development into country policies and programmes; reverse loss of environmental resources;
- Reduce by half the proportion of people without sustainable access to safe drinking water;
- Achieve significant improvement in lives of at least 100 million slum dwellers, by 2020.

Even though the MDGs include the environment as one of its key goals, the main priority in development from the perspective of the World Bank, UNDP and other development partners, as well as many bilateral agencies, is poverty eradication. Indicators of development used by national authorities and by international development partners focus primarily on reducing poverty either by promoting economic development, or more specifically, by focusing on pro-poor growth.

That said, with rising interest in environmental issues, efforts are ongoing to "green" the PRSP process according to the Organisation for Economic Co-operation and Development (OECD)[49]. According to this same OECD report, the international community also supports efforts to enhance the capacity of developing countries to implement adaptation measures to deal with climate change. ICTs can assist in this regard facilitating decision-making on issues related to environment and development.

[47] Klugman, J. 2002. *A sourcebook for poverty reduction strategies. Volume 2: Macroeconomic and sectoral approaches*. Washington, D.C. USA, World Bank. 656 pp. See section on the environment.
[48] See http://www.un.org/millenniumgoals/
[49] OECD. 2007. *Survey of agencies' country level activities on environment and development*. Development Assistance Committee. DAC Network on Environment and Development Co-operation (ENVIRONET). Paris. 37.

4.6. Priorities of International Development

The main priorities in international development[50] could be summarized as:

1) The fight against poverty and promoting social, human and economic development, including pro-poor growth;
2) Ensuring that people can meet their basic human needs as per the Millennium Development Goals (MDGs). This is directly related to the fight against poverty;
3) Preventing conflicts and promoting peace and dialogue between countries and people, promoting social inclusion and integration and undertaking post conflict reconstruction and development;
4) Preventing disasters;
5) Providing humanitarian assistance and relief when necessary.

A separate but essential complement to development is conflict resolution, including peacekeeping.

The hypothesis that underpins international development aid is that poverty restrains human potential and restricts human development. Priorities 3-5 are essential because they must be overcome before the underlying causes of poverty can be dealt with.

All of these priorities are directly dependent on a good understanding of the environment and on sound environmental management. They are based on working closely with people and their communities within the context of their natural environment. The principles of implementation of these priorities are that development:

- Be people focused. People are at the centre of development efforts and this is the basis of human development;
- Be based on fair and equitable access to the benefits of development efforts: everyone can benefit from development efforts immaterial of origin, gender, age, religion, political affiliation, nationality or ethnic group;
- Requires a participatory approach to development: this is essential to ensure buy-in and successful outcomes that benefit people and communities;
- Efforts must be sustainable over time and not only conserve environmental systems and resources but sustain and nurture these systems over time for present and future generations. Natural systems are essential for human well-being and development because they sustain human and other life forms.

4.7. Mainstreaming the environment in development concerns

Mainstreaming the environment means that environmental issues need to be taken into consideration in all national development actions and projects. Mainstreaming can take many forms:

- Requiring that an environmental impact assessment (EIA) be undertaken as part of the planning and assessment of development projects; and/or
- Requiring all development planning take into consideration National Environment Action Strategies, Policies and Plans or equivalent documents, pronouncements as well as international treaties, engagements and/or commitments a country may have; and/or
- Requiring all development projects include ways to address, or be consistent with and/or mitigate environmental issues and concerns that are identified as part of the project EIA or that may have

[50] See *Promoting Pro-Poor Growth: Policy Guidance for Donors*, OECD 2007, at http://www.oecd.org/document/29/0,3343,en_2649_34621_38206045_1_1_1_1,00.html and http://213.253.134.43/oecd/pdfs/browseit/4307081E.PDF

been identified as part of any other formal or documented knowledge gathering process pointing out environmental issues and concerns related to the project in question. Some of the documented issues and concerns may come out of National Environment Action Plans (NEAP) or equivalent documents and/or as a result of consultation with stakeholders.

Mainstreaming also means that environmental policies, plans, strategies and agreements including those resulting from international treaties and/or commitments are not taken into consideration but that the development project in question should assist the country to meet its stated and agreed upon environmental goals and obligations to the extent possible.

4.8. The Global Environment Facility

One of the major funding mechanisms to implement the various agreements, strategies and plans dealing with global environment issues is the Global Environment Facility (GEF)[51]:

> GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants. GEF is an independent financial organization that provides grants to developing countries for projects that benefit the global environment and promote sustainable livelihoods in local communities.

GEF works through three implementing agencies: UNDP[52], UNEP[53] and the World Bank[54] and seven other executing agencies[55]. The GEF does not focus its work *per se* on the use of ICTs for environmental management. However, GEF does recognize the importance of providing support to the countries to help them acquire technical means to achieve their environmental objectives.

4.9. Special Climate Change Adaptation Fund (SCCF)

According to the UNFCCC website[56] referencing the Special Climate Change Adaptation Fund (SCCF), "…the SCCF under the Convention was established in 2001 to finance projects relating to adaptation; technology transfer and capacity building; energy, transport, industry, agriculture, forestry and waste management; and economic diversification. This fund should complement other funding mechanisms for the implementation of the Convention."

At the Bali UNFCCC climate change conference that took place in December 2007, the humanitarian news and analysis service, IRIN, reported the approval of the SCCF and that the fund will become operational in early 2008[57]. According to IRIN, the fund will be controlled by GEF, and "…the Adaptation Fund is expected to raise money from a levy of about two percent on credits generated by the Clean Development Mechanism (CDM) set up under the Kyoto Protocol." Up until now, the fund which had been held by the UNFCCC, has collected USD 67 million by charging a 2 per cent assessment fee on carbon credit transactions under the Clean Development Mechanism of the Kyoto Protocol.

The Clean Development Mechanism is an arrangement under the Kyoto Protocol allowing industrialized countries with a commitment to reduce Greenhouse gases (GHGs) to invest in projects in developing countries that reduce emissions as an alternative to more expensive emission reductions in their own countries.

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[51] See http://www.gefweb.org
[52] See http://www.undp.org/gef/05/
[53] See http://dgef.unep.org/
[54] http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/ENVIRONMENT/EXTGLOBALENVIRONMENTFACILITYGEFOPERATIONS/0,,menuPK:286248~pagePK:149018~piPK:149093~theSitePK:286243,00.html
[55] See http://www.gefweb.org/interior.aspx?id=106
[56] See UNFCCC. *The Special Climate Change Adaptation Fund*. At http://unfccc.int/cooperation_and_support/financial_mechanism/special_climate_change_fund/items/3657.php
[57] IRIN news service. 2007. GLOBAL: *Poor countries fail in demand for control of new fund.* Bali, Dec. 11, 2007. http://www.irinnews.org

5. ICTs IN THE STUDY AND MANAGEMENT OF THE ENVIRONMENT

5.1. Introduction

ICTs provide us with an unprecedented ability to collect and process environmental information that far exceeds the capacity of any individual, may span time durations far beyond that of a human lifetime, and may encompass the entire terrestrial system from the depths of the ocean to upper reaches of the atmosphere. It is the complexity of the environment that ICTs can help us to simplify and understand the impact of humans on the environment. This is achieved with the help of increasingly powerful and interconnected computing platforms combined with extensive informational databases.

ICTs can be used in a number of ways in the study and management of the environment:

- To help observe, describe, record and understand the environment (for environmental research and for comparative analysis), including tools to manipulate and visualize environmental information;
- To share information and data as well as processing power: data warehouses, clearing houses and data/information servers; environmental networks and grids, etc.;
- To facilitate and help coordinate environmental decision-making and management, including environmental early warning, risk assessment, mitigation and management, etc.;
- To help reduce and/or mitigate the environmental impact of human activity;
- To facilitate learning about the environment.

Many ICT applications in the environment field are the result of the diffusion and increasing availability and power of computers and related devices as well as the availability of broadband Internet connections. The Internet is a public network and as such is particularly important as a common medium for joining and sharing data and resources and for encouraging collaboration and networking in many different forms. However, the Internet is not the only technology that has assisted in the use of ICTs for environmental study and management. Several ICT capabilities stand out as tools that are used to understand the global environment:

- Satellite and direct sensor technology that provide the ability to record and store massive amounts of geographical and historical information with increasing resolution and geographic coverage;
- Geographic information systems (GIS) that allow the visualization and interpretation of the datasets made available through these observation systems;
- Increasingly faster and available micro processors which have provided computational power as well as increasingly intelligent algorithms that have allowed modeling of environmental systems and thus a better understanding of the complexity of the physical and biological systems that are part of the environment;
- Increasing bandwidth and very rapid distributed communications, processing and storage capabilities that facilitate data sharing and undertaking computationally-intensive tasks through the use of Grid and Cloud computing.

As a result of the ever-increasing availability of environmental information and resources, some argue that the Internet is modifying scientific research itself. According to S. Parastatidis, a researcher at Microsoft, web-based services and some of the technologies mentioned here have transformed the study of science itself into what is sometimes called “e-Science”.

The University of Oxford e-Science Centre defines e-Science[58] as science that is

[58] Oxford e-Science Centre. 2003. *E-Science definitions*. http://e-science.ox.ac.uk/public/general/definitions.xml

> …increasingly performed through distributed global collaborations enabled by the Internet, using very large data collections, terascale computing resources and high performance visualizations. This essentially means that many areas of science currently using computing resources as part of their research will soon have the ability to utilize more powerful computing resources across a new infrastructure commonly described as the 'grid'. Scientists will have access to very large data sets and perform real time experiments on this data. This will ultimately lead to scientists tackling the 'big scientific questions' hitherto unexplorable.

E-Science[59] can be also summarized as the use of ICTs for facilitating scientific research and for transforming the research processes of observing, recording, gathering, analyzing, managing and using data and information, and transforming this into knowledge. E-Science is changing the nature of scientific research and countries that cannot take advantage of ICTs in research and development are at a competitive global disadvantage.

5.2. Overview of Technologies

There are a number of specific information and communication technologies that are worth highlighting from a generic perspective for their impact on environmental information and process management. Some of the technologies worth highlighting include:

- Software such as database management systems (DBMSs) that can manipulate digital data. This includes geographic information systems (GIS); specialized database management systems that use textual, numeric, alphanumeric and imagery data including especially maps. Of particular use are spatial imagery and data and the possibility of linking data sets and images to map coordinates.
- Fiber optic technologies and especially wavelength division multiplexing (WDM)-based technologies that permit increasing volumes of data to transit fiber optic systems. The pace of development of fiber optic technologies, in terms of transmission speed, cost and capacity is "fast and furious" according to Goleniewski[60] and exceeds the pace of microprocessor development to such an extent that "…optical technology far outpaces silicon chips and data storage…" to the extent that "…the cost of transmitting a bit of information optically drops by 50% every 9 months."
- An increasing number of intelligent physical and embedded devices that are connected through the Internet — sometimes known as the "Internet of Things"[61]. These devices will be "…integrated into larger systems, where they will perform control functions and communicate with one another over the Internet"[62]. These include:
  - Smart tags using radio frequency identification (RFID) technology;
  - Smart devices: including devices embedded in sensors for telemetric data collection and remote sensing, in appliances of all sorts, in testing and medical equipment, etc.;
  - Smart offices where "roomware in the workplace will ensure greater efficiency and better working conditions".
- Increasingly rapid and sophisticated chip sets and processors containing an increasing number and density of transistors operating at an increasingly rapid number of transactions per second using increasingly rapid data buses and working collaboratively and in parallel to manipulate the data in concurrent streams and power software.

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[59] The World Summit on the Information Society has identified e-Science as one of the ICT applications of the WSIS Action Line C7, see ITU, 2003, URL: http://www.itu.int/wsis/docs/geneva/official/poa.html#c7-22 .
[60] Goleniewski, L. 2006. *Telecommunications essentials. The complete global source. Second Edition*. Edited by. K.W. Jarrett. Addison Wesley. 865 pp. Chapter 11.
[61] See http://www.itu.int/osg/spu/publications/internetofthings/
[62] See footnote 60

- Rapid, inexpensive and increasingly high capacity storage devices networked directly to one another and to users who may want to exploit these data sets. Currently, "…storage density doubles every 12 months"[63].
- Wireless technologies that allow broadband rates of data exchange and the linking of devices to form networks or clouds of sensors for monitoring and recording environmental phenomena of various sorts.
- Web-based services: a new class of Internet-based services based on open standards and resource sharing which have a "service orientation". Web-based services make it easier for users to develop applications and services of their own design. These services include standards-based tools that provide web-based logic such as Java, BPEL, .NET, SOAP, WSDL, XML and its variants and other Web services protocols. These tools underpin what is referred to as a service-oriented architecture (SOA) resulting in a new generation of applications including blogging and social networking, data processing and transformation, content uploading, sharing and discovery, storage, computation and messaging, mashups, wikis, etc. The characteristics of some of the new generation of web-based services[64] include:

  Grid Connectivity

  - Building applications that span organizations;
  - Creating virtual organizations;
  - Seamless integration of datasets and processing capabilities;
  - Hiding (virtualising) or sharing use of resources, network, infrastructure.

  Web Services

  - Glue for heterogeneous platforms/applications/systems;
  - Cross- and intra-organization integration;
  - Standards-based distributed computing;
  - Interoperability;
  - Composability;
  - Based on the idea of Service Orientation.

  Web Applications

  - Blogging, social networking;
  - Data processing/transformation;
  - Content upload, sharing, discovery;
  - Storage, computation, messaging;
  - Identity and presence management;
  - Mashups for data sharing;
  - Wikis and innovative user-based data entry.

5.3. Research on ICTs for the environment

There is ongoing research on the use of ICTs for the environment. One example is the work being done inside the multi-annual Framework Programmes of the European Commission (EC), initiated since the 1980's by the EC for research and technological development.

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[63] Goleniewski, L. 2006. *Telecommunications essentials. The complete global source. Second Edition*. Edited by. K.W. Jarrett. Addison Wesley. 865 pp.
[64] Parastatidis, S. 2007. The Web as a platform for research. 47 PPT slides. Presentation given at SuperComputing 07 conference: http://sc07.supercomputing.org/. See http://savas.parastatidis.name/2007/11/12/919a1978-9c1f-4b7b-8824-009363863b8e.aspx

The fifth[65] (FP5) and sixth[66] (FP6) Framework Programmes of the European Communities for research, technological development and demonstration activities included specific activities on the application of ICTs for sustainable development[67]. FP5 included three broad work areas under this heading: environmental monitoring and management systems, risk and emergency management, and humanitarian de-mining. FP6 included the theme of sustainable development, global change and ecosystems intended to "…contribute to international efforts mitigating adverse trends in global change." To date 74 different projects have been funded in FP5 and FP6, and more projects will be announced in the seventh Framework Programme[68] with a focus on mobility, environmental sustainability and energy efficiency. Some of the Framework Programme projects are described in Annex 2 of this report.

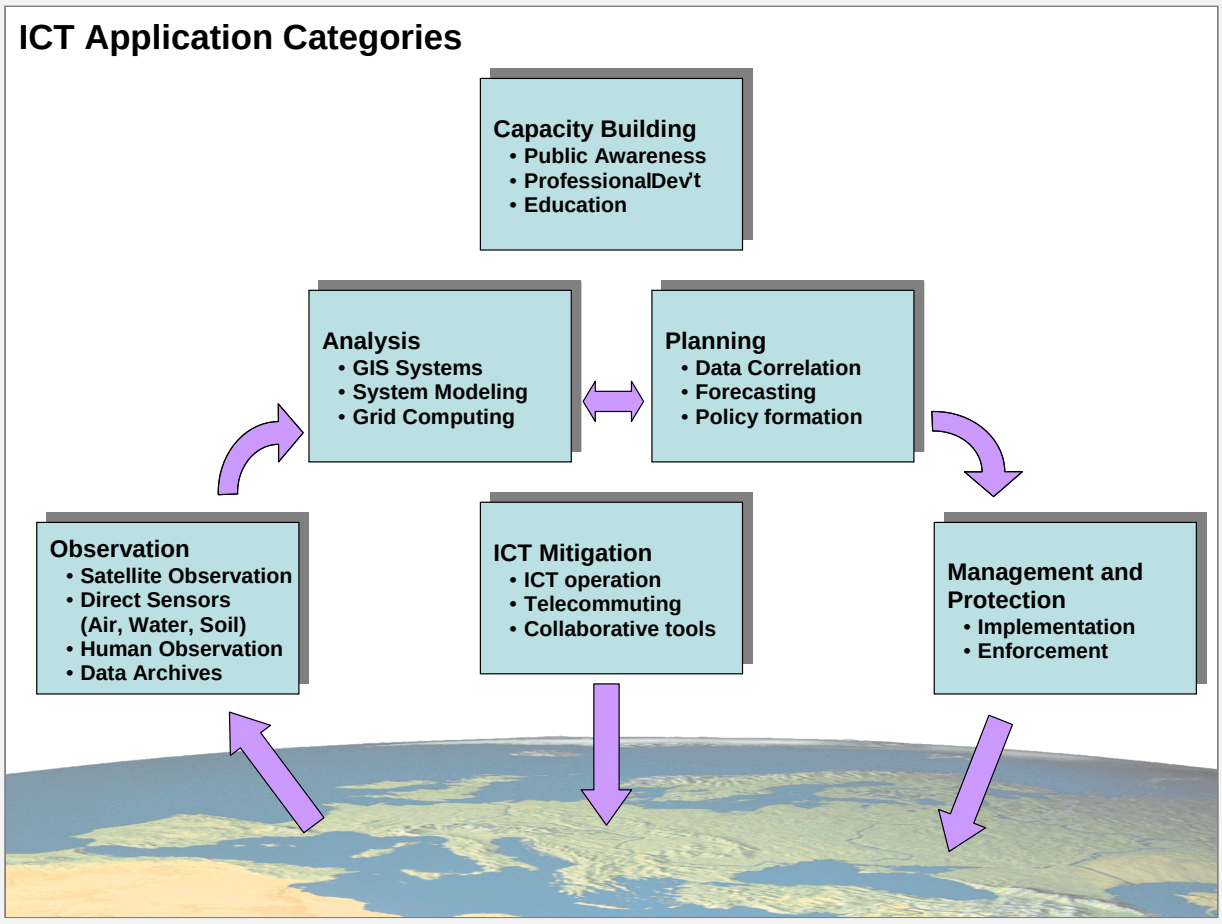
[65] European Union Framework Programme 5, About FP5. http://cordis.europa.eu/fp5/about.htm
[66] European Union Framework Programme 6, The Sixth framework Programme. http://ec.europa.eu/research/fp6/pdf/fp6-in-brief_en.pdf
[67] European Union Framework Programme 7, ICT Challenge 6: Mobility, environmental sustainability and energy efficiency. http://cordis.europa.eu/fp7/ict/programme/challenge6_en.html
[68] idem

6. ICT APPLICATION CATEGORIES

6.1. Overview

In an attempt to better understand the contribution of ICTs and related management practices as tools for dealing with environmental issues, particularly from a developing country perspective, this report considers the following six ICT application categories (see Figure 6 below).

Figure 6. ICT application categories



Source: ITU

The six categories are briefly reviewed below and discussed in detail in the referenced chapters.

1) **Environmental observation** (Chapter 7, page 29): terrestrial (earth, land, soil, water), ocean, climate and atmospheric monitoring and data recording technologies and systems (remote sensing, data collection and storage tools, telemetric systems, meteorological and climate related recording and monitoring system), as well as geographic information systems (GIS) as it applies to data recording and georeferenced data formats.

2) **Environmental analysis** (Chapter 8, page 45): once environmental data has been collected and stored, various computational and processing tools are required to perform the analysis and comparison of data available. This may include land, soil, water and atmospheric quality assessment tools, including technologies for analysis of atmospheric conditions including Greenhouse Gas (GHG) emissions and pollutants, and the tracking of both water quality and availability. The analysis of data may also include correlating raw observational data with second

order environmental measures such as biodiversity. Environmental analysis often draws on geographically distributed computational and data resources.

3) **Environmental planning** (Chapter 9, page 57): at the international, regional and national level, planning makes use of the output information available from environmental analysis as part of the decision-making process for the purpose of policy formulation and strategic planning. Planning proceeds from environmental analysis in order to forecast short-term and long-term environmental conditions and objectives. The planning activity may include classification of various environmental conditions for use in agriculture and forestry and other applied environmental sectors. Planning is often focused on specific issues such as protected areas, biodiversity, industrial pollution or GHG emissions. In addition to improving environmental conditions, planning may also include the anticipation of environmental conditions and emergency scenarios, such as climate change, man-made and natural disasters.

4) **Environmental management and protection** (Chapter 10, page 61): environmental policy and strategic direction set during planning must reach the implementation phase in order to have a direct impact on the environment. In the area of climate change, management and protection deals with issues related to mitigating the impacts of climate change as well as adaptation to climate change. ***Mitigation*** refers to efforts to reduce emissions (or capture carbon) so as to reduce the extent of climate change. ***Adaptation*** refers to actions designed to reduce the negative impacts of climate change. Mitigation would focus on technologies and practices that reduce emissions and adaptation would focus on technologies and practices that reduce the vulnerability of human populations to environmental change in general and to climate change in particular by the application of appropriate agricultural, land use, water conservation and/or watershed management practices among others and through increased disaster preparedness. Mitigation deals with prevention of a state that has not yet occurred and adaptation means taking steps to deal with an existing situation, i.e., climate change[69] [70].

   More generally, it can be said that environmental management and protection involves everything related to managing and mitigating the impact of man on the environment as well as helping man adapt to given environmental conditions. This includes resource and energy conservation and management systems, GHG emission management and reduction systems and controls, pollution control and management systems and related methodologies including mitigating the ill effects of pollutants and man-made environmental hazards on man.

5) **Impact and mitigating effects of ICT utilization** (Chapter 11, page 67): Producing, using and disposing of ICTs require materials and energy and generates waste, including some toxic waste in the form of heavy metals for example. ICT use can mitigate environmental impact directly by increasing process efficiency and as a result of dematerialization also and indirectly by virtue of the secondary and tertiary effects resulting from ICT use on human activities which in turn reduce the impact of humans on the environment.

6) **Environmental capacity building** (Chapter 12, page 85): the end results of any efforts to improve environmental conditions rely on the actions of individuals and organizations in order to be fully effective. Capacity building includes efforts to increase public awareness of environmental issues and priorities, the development of professionals involved either directly or indirectly in the environment, as well as integrating environmental content into formal education.

In addition, a list of specific ICT applications for each of categories has been prepared which can be found in Annex 2 to this report starting on page 122. A selected number of these are considered in

[69] Matheson, G. 2008. Personal communication. Marbek Resource Consultants, Ottawa, Canada http://marbek.ca/

[70] CIESIN. 2005. *Limiting future climate change: mitigation*. http://ccir.ciesin.columbia.edu/nyc/ccir-ny_q4.html and *Preparing for a different future: adaptation*. http://ccir.ciesin.columbia.edu/nyc/ccir-ny_q3.html

more detail from the perspective of their adoptability and transferability to developing countries using a model assessment framework in Annex 1 of this report starting on page 106.

The results provide a snapshot of available applications documented with web references and categorizations. Given the rate of application development, many of the applications and references listed will quickly be out-of-date. While some of the applications in Annex 1 are mentioned in this report, others mentioned may not be documented in the list.

Several of the sites referenced have catalogued information in a database in the form of application lists or member profiles. The most useful sites appear to be those who combine user generated content and active online participation that keeps their information up-to-date.

An example is the Earth Observation Portal (eoPortal)[71] which lists what appears to be current information for 1,486 member organizations. Information is submitted using a template and reviewed by an administrator before being posting to the portal. The template permits the categorization of members and the ability to search for organizations on the basis of criteria. A similar approach might also be useful to track e-Environment related organizations as well as the many applications that are being created on an ongoing basis by developers around the world.

The six categories referenced above are discussed in more detail in the following Chapters 7 - 12.

[71] eoPortal, Earth Observation Portal, http://www.eoportal.org/

7. USE OF ICTS FOR ENVIRONMENTAL OBSERVATION

7.1. Overview

Environmental observation: terrestrial (earth, land, soil, water), ocean, climate and atmospheric monitoring and data recording technologies and systems (remote sensing, data collection and storage tools, telemetric systems, meteorological and climate related recording and monitoring system), as well as geographic information systems (GIS) as it applies to data recording and georeferenced data formats.

This also includes tools for not only acquiring the information but also tools for recording and storing observations in a standardized format. This category is closely related to analysis and many actors in the field of environmental observation are also engaged in the analysis and presentation of data. However, analysis can be performed independently of the collection of the information.

This application is discussed in more detail in the following sections.

7.2. Remote sensing

A variety of remote sensing observation platforms are used to help researchers gather information about environmental processes and systems. Much of this information has been archived in large and increasingly accessible datasets or databases. ICTs play an important role in making these datasets/ databases available to researchers regardless of their location.

Sensors generate vast amounts of data. Analyzing this data challenges researchers and decision-makers alike. This is especially so in the developing world where the researchers and other specialized intermediaries who can help interpret environmental information for government decision-makers are few and far between.

7.3. Collection of primary scientific data about the environment

With the help of ICTs, a researcher on the ground can collect and georeference location-specific environmental data live for biodiversity research and conservation. One example is the Biotics and related applications developed by Natureserve (see description of the Biotics software package in Annex 1), "…a not for profit conservation organization whose mission is to provide the scientific basis for effective conservation action"[72]. This application strengthens the scientific basis of conservation research. Environmental data can be collected directly in the field using hand-held devices, a technology readily available with the spread of wireless networks and devices.

7.4. Accessing and evaluating environmental information

Information about the weather in particular and, increasingly, about natural disasters is of higher priority in national decision-making than information dealing with other environmental issues.

The impact and timeliness of weather and disaster information on human activities and human well-being explains this necessity. However, given the increasing availability of environmental data from a variety of sources and the development of tools to facilitate sharing and analysis, this may be changing. The ability to access a variety of different data sources related to a specific environmental condition is important in the analysis phase in order to correlate and validate environmental models (see Trotter[73] et al.).

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[72] Natureserve. 2007.

[73] Trotter, C.M.; Leathwick, J.R. and D. Pairman. 2001. Spatial information for ecosystem classification, analysis, and forecasting. p. 7-36 in Halls, P. 2001. Spatial information and the environment. Innovation in GIS 8. London and New York. Taylor and Francis. 284 pp.

Some of these data sharing tools include ubiquitous broadband connections, more user friendly and powerful and integrated technologies such as Web 2.0, service-oriented architecture (SOA) and mashups which together facilitate data collection, entry and sharing as well as the participation of a community of users — including members of the public and/or of interested groups that could also be sources of primary research data and research partners.

The Group on Earth Observations (GEO) has recognized this shift and the Global Earth Observation System of Systems (GEOSS) is an attempt to bridge the data gap to empower users at all levels to use data for their own decision-making while also encouraging these same users to share their data and knowledge.

7.5. The origins of remote sensing technologies

Advances in the use of remote sensing technologies have allowed much more detailed observation and analysis of the earth. Meteorological satellites were used in the 1960s as part of what is now the World Weather Watch[74] of the World Meteorological Organization. However, the launch of the LANDSAT 1 satellite in 1972 allowed the use of images in the public domain (spy satellites had been acquiring imagery for some time already).

LANDSAT allowed "…repetitive and systematic observations…" of the earth's surface to be acquired[75]. The use of satellite-based remote sensing platforms and the development of high spatial resolution sensors as well as sensors that allowed high spectral resolution in many bands and "multi-polarization radar systems" along with "interferometric systems" which provide global digital elevation data allow detailed spectrophysical measurements of almost any part of the earth's surface.

Earth observation satellites generate massive amounts of data, in digital form, that is used for a variety of applications related to the state of the environment and disaster early warning and more. Some of this data may be available in real time under some circumstances as well as in data archives dating back from the use of LANDSAT satellite systems back in the 1970s — using resources such as the EROS Data Centre in South Dakota in the USA[76].

World Weather Watch operated by the World Meteorological Organization (WMO) in collaboration with national meteorological organizations is one of the most valued applications using satellite-based technology and is used on a day-to-day basis throughout the world.

The Global Observing System of the WMO[77] is a satellite-based platform for observation and communication. For example, satellite-based sensors monitor and provide information on barometric pressure, water temperature and wave action to users of the system. Land-based sensors using radio telemetry relay data acquired from surface stations to supplement and validate the satellite data. Other platforms are also used including commercial aircraft, specialized weather observation aircraft, weather balloons and ships.

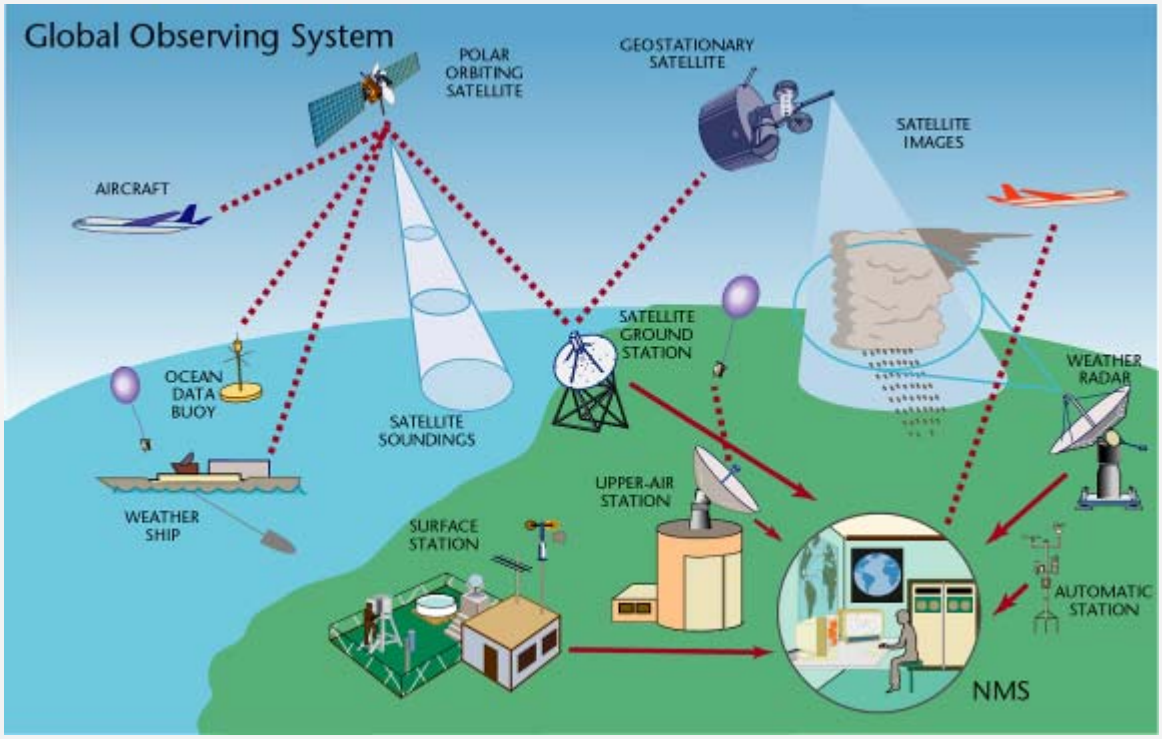
[74] WMO. World Weather Watch Programme. http://www.telecommagazine.com/newsglobe/article.asp?HH_ID=AR_3995

[75] Van der Meer, F., Schmidt, K.S., Bakker, W. and W. Bijker. 2002. *Chapter 3. New environmental remote sensing systems*. Pp. 26-51 in Skidmore, A. Environmental modeling with GIS and remote sensing. Taylor and Francis. 268 pp.

[76] About the Center for Earth Resources Observation and Science. http://eros.usgs.gov/about/background.html

[77] WMO. About the Global Observing System. http://www.wmo.ch/pages/prog/www/OSY/GOS-purpose.html

Figure 7. The Global Observing System of the World Weather Watch operated by the WMO



Note: In this figure, NMS means national meteorological service.

The several tsunami early warning systems currently in place or being developed are other examples of earth observing and data recording systems in use in many parts of the world. Various governments are cooperating with UNESCO[78] [79] in the creation of an International Tsunami Information Centre which at present is hosted in Hawaii by the National Oceanic and Atmospheric Administration of the USA. The tsunami warning systems draw on a number of sensor systems developed for the purposes of weather observation (ocean buoys) and earthquake detection (seismic sensors) to feed into real-time analysis and detection systems.

7.6. Some key ICTs

- ICTs used in remote sensing:
  - For digital sensors and for digital signal processing, especially satellite-based remote sensing systems;
- ICTs used in telemetric sensors and systems;
- Global telecommunication networks:
  - For maintaining communications with satellite-based sensors, as well as sensors that are connected to mobile and fixed telephony networks;
  - Probably the best example and one that has been operating for the longest period of time is the Global Telecommunication System (GTS) that is part of the Global Observing System of the World Weather Watch programme operated by the WMO in collaboration with national meteorological services;

[78] UNESCO, http://ioc3.unesco.org/itic/
[79] See US Indian Ocean Tsunami Warning System, http://www.iotws.org/

- Broadband networks and GRID networks for exchanging data acquired and for allowing access to clearing houses and data warehouses:
  - These networks underpin research activities including modelling of earth phenomena. They are further discussed in Chapter 8 starting on page 45 discussing the ICT application category Environmental Analysis;
  - Next generation networks (NGNs) are also important technologies for further broadband diffusion.
- Clearing houses and associated data warehouses: data storage and retrieval systems including hard disk arrays, server arrays, database management systems (DBMS), storage, back up and retrieval software, etc.;
- Data collection devices such as hand-held computers and devices for collecting data on physical and biological environmental phenomena and systems.

7.7. Some key organizations

There are many organizations to list under this heading, including:

- National Aeronautics and Space Administration (NASA), National Oceanic and Atmospheric Administration (NOAA) and the European Space Agency (ESA);
- The World Meteorological Organization (WMO);
- United Nations Environment Programme (UNEP): Global Environment Monitoring System (GEMS), Global Resource Information Database (GRID), UNEP-WCMC, Earthwatch, etc.;
- The Global Biodiversity Information Facility (GBIF);
- NatureServe[80];
- The Secretariats of various environmental conventions such as the United Nations Framework Convention on Climate Change (UNFCCC), the Convention on Biological Diversity and the Desertification Convention and others;
- Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS) project;
- Center for International Earth Science Information Network (CIESIN);
- Various national satellite operators and satellite data providers;
- Various commercial satellite operators and satellite data providers;
- Commercial GIS service providers such as ESRI Inc. and other companies;
- Google, Microsoft and many other companies that increasingly recognize the value of map-based information and visualization tools for decision-making and for buying and selling goods and services.

7.8. UNEP WCMC

A key institution which has been working for a long time on environmental observation and data recording and management, and which brings much expertise to the subject is the United Nations Environment Programme (UNEP) World Conservation Monitoring Centre (WCMC), originally established by the World Conservation Union (IUCN) in 1979.

[80] See the description of the NatureServe application in this report on page 114.

According to UNEP-WCMC, it supports "…the world's decision-makers with accurate and timely biodiversity knowledge"[81].

The Centre's six Strategic Objectives are:

1) Support Decisions;
2) Create Knowledge;
3) Share Information;
4) Manage Key Datasets;
5) Validate Data & Information;
6) Succeed through Partnership.

For these objectives, the WCMC not only relies on ICTs, but is a cutting-edge experimenter in testing and developing new ICTs, knowledge products and services for policy makers, researchers, students and other concerned stakeholders and, in particular, biodiversity decision-makers.

UNEP-WCMC's present focus is on going beyond the collection and integration of data and their analysis to creating information products. In the future, UNEP-WCMC will be working from a premise that instead of collecting all available information, the relevance of data should also be assessed.

Key issues regarding ICT use at UNEP-WCMC

In order to discover firsthand the issues and concerns related to environmental information and the use of ICTs, WCMC staff were contacted and interviewed by telephone[82]. Some of the points made during this conversation are presented below, enhanced with additional information on some of the organizations and information resources mentioned.

WCMC was one of the early users of GIS in the environment field and as a result, has acquired a strong reputation in that arena. Originally, it was an aggregator of environmental information which it used to build data sets and subjecting these to analysis for others to use.

One of the flagship products of WCMC is the "World Database for Protected Areas"[83] of the department responsible for early environmental warning and assessment. The WDPA is managed in partnership with IUCN and the World Commission on Protected Areas (WCPA)[84]. Data from protected areas from around the world is collated. WCMC is required to submit this information to UNEP in order to determine the extent of conservation activities globally. One key indicator is the percentage of the land surface of any country that is designated as protected land.

Most and nearly all countries submit this data to WCMC in varying formats and media. One way the data may be submitted is as GIS structured data submitted online. For countries and jurisdictions with more limited means, a hand drawn map may be prepared and sent by the post.

It is clear that the capacity of the countries participating in this exercise is integral to the success of this endeavor. Many countries have neither the capacity to use nor the resources to acquire the server technology required for the sophisticated analyses undertaken by the WCMC and by others. Other limiting factors include poor communications, along with availability of manpower and time that can be allocated to this work by decision-makers in the concerned countries. This situation is exacerbated particularly in less developed countries.

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[81] UNEP-WCMC. 2007. *Annual report 2006*. 20. Pp, Cambridge, UK.
[82] Telephone interview with Derek Gliddon, Programme Head, Spatial Unit and Jerry Harrison, Head of Development, UNEP-WCMC, Oct. 8, 2007.
[83] See http://sea.unep-wcmc.org/wdbpa/
[84] See http://www.iucn.org/themes/wcpa/

IT infrastructure at WCMC

Consistent with its strategy, UNEP-WCMC is experimenting with using web-based services as the basis of its future offerings. However, the biggest challenge facing the centre is not technological. A key concern is the lack of data sharing between departments and ministries within the same government.

Encouraging the sharing of environmental data and of biodiversity data in particular is crucial — examples include natural history collections in museums, existing library materials and databases. Apart from the problem of digitizing older materials, there a need to respect the intellectual property rights (IPR) of the data owners. The organizations that own the datasets have to be persuaded that these rights will be recognized and respected.

One solution may be offered by the example provided by the "Global Biodiversity Information Facility (GBIF)"[85]. The GBIF facilitates the "…digitization and global dissemination of primary biodiversity data, so that people from all countries can benefit from the use of the information." In this case, the data remains with the individual organizations that own the information. In the GBIF, a standard Web service has been developed and is used by each member organization. GBIF data portal allows querying of the data which remains resident in the host institution yet available all the time through this shared interface. IPR is recognized and respected yet access to and use of the data sets is permitted as long as it takes place via the GBIF common data portal. This occurs without compromising the ownership and integrity of the data.

UNEP-WCMC is also making available analytical services along with the data using Web-based services. As a result, it is hoped that organizations will be willing to discuss with UNEP-WCMC what their needs are and become less reluctant to share their datasets and knowledge as part of a large web-based orchestration of information and services. This is concept consistent with the work being done by organizations such as Group on Earth Observations (GEO) and the Global Earth Observation System of Systems (GEOSS) as well as the GBIF.

7.9. Key applications for observation

Data acquired from remote sensing platforms can be stored as raw data and/or treated quickly after acquisition and on a real-time basis in some cases, i.e. for meteorological applications and for disaster early warning.

For this to happen, systems such as the Global Observing System (GOS) and Global Telecommunication System (GTS) of the WMO World Weather Watch have to be in place and efforts such as the GEOSS have to be operational and useful in less developed countries.

Applications that facilitate the recording of environmental data in digital format and the storage, management and sharing of primary scientific data about biodiversity for example are also essential.

7.10. GIS databases and presentation tools

Geographic information systems (GIS) integrate database management systems (DBMS) with georeferenced data. Data are stored as georeferenced data sets for subsequent analysis using GIS software (see Chapter 8 on page 45 discussing the Use of ICTs for Environmental analysis). GIS tools are used for observation as well as for analysis, planning, management and mitigation activities.

In particular, GIS are increasingly used as a component of decision support systems. The ease of visualization and lack of technical training required to assess georeferenced data in support of decision-making has greatly generated interest in the use of GIS. A decision-maker can more readily relate mapped environmental and other data if that same data is graphed or described in narrative

[85] See http://www.gbif.org/

form. Furthermore, real time analysis and time series analysis allow the measurement of trends and the visualizations of cause and effect as well as the modeling of complex systems.

GIS systems are being promoted in many countries around the world. While commercially available GIS software can be prohibitively expensive for developing countries, some commercial suppliers (see Text box 2 below) recognize the potential market these countries represent and have undertaken efforts to enhance the capacity of developing countries to use these tools through direct support and training.

Text box 2. Cooperation between Rwanda and ESRI[86]

In Rwanda, a German GIS software supplier has partnered with the Geographic Information Systems and Remote Sensing Regional Outreach Center (CGIS) established at the National University of Rwanda (NUR) in Butare.[87] CGIS is an interfaculty unit at the NUR that exists to build capacity to use and apply GIS in Rwanda. In 2005, CGIS developed a partnership with its GIS supplier "*to support a long term vision for the emergence of private entrepreneurship in the field of Geo-ICT in Rwanda through capacity building*". *The supplier has expressed interest in Rwanda and has made a major investment to support a long term vision for the emergence of private entrepreneurship in the field of Geo-ICT in Rwanda through capacity building…[with a] 5 year agreement between the two institutions.*

The agreement is mainly implemented by the promising CGIS-NUR. It will allow professors, researchers and students of NUR to access GIS software using an unlimited campus license. It covers also an intensive professional training-of-the-trainers program, distance learning support through a virtual campus, software applications development, infrastructure enhancement and so on.

Through this partnership, the University will be able to progress in its goals to become a Competence Centre in Geographic Information Systems (GIS) and Remote Sensing (RS) with a national and regional visibility. This agreement recognizes that academic education in developing countries in general and in Rwanda in particular is of utmost importance.

7.11. Visual earth browsers and mark-up tools

Google Earth and Microsoft Virtual Earth are two recent competing web-based applications that allow people to access earth observation information free of charge and to contribute information to their earth observation platforms. According to the website, Google Earth[88], "…combines the power of Google Search with satellite imagery, maps, terrain and 3D buildings to put the world's geographic information at your fingertips." According to the website[89], "…Google Earth is a geographic browser — a powerful tool for viewing, creating and sharing interactive files containing highly visual location-specific information. We call these files KMLs (for Keyhole Markup Language): what HTML is to regular Internet browsers, KML is to geographic browsers".

Google Earth and Microsoft Virtual Earth allow the ready visualization and annotation of planet Earth, and are now being used by a number of organizations. For example, ITU has partnered with Microsoft to use their Virtual Earth platform for applications such as mapping and visualization of country statistical and indicator data[90]. Likewise, UNEP GRID North America has an agreement with Google Earth that has allowed the publication online of the "Atlas of our changing environment", an online resource for viewing as well as adding and sharing information on earth-based features using Google Earth[91]. The American Library Association has recognized the "Atlas of our changing environment" application as one of the "Best Free Reference Web Sites 2007"[92].

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[86] CGIS. 2006. *Cooperation Agreement between NUR and ESRI Germany*. Modification Date: Tuesday, 21st March 2006 at 21:29:53. http://www.cgisnur.org/article.php3?id_article=150
[87] See http://www.cgisnur.org/_webpages/aboutus.htm
[88] See http://earth.google.com/
[89] See http://earth.google.com/gallery/index.html
[90] See ITU. ITU Global View. http://www.itu.int/ITU-D/connect/gblview/index.html
[91] See http://na.unep.net/unep-atlas.php
[92] See http://www.ala.org

Google Earth allows facilitated access to georeferenced data sets. Users of Google Earth and Microsoft Virtual Earth can view nearly any part of the planet with varying levels of resolution and contribute information in a variety of forms. Several commercial providers of georeferenced data are now also selling their data via Google Earth-based applications. Google Earth and Microsoft Virtual Earth are both now in the process of photographing cities in North America and at other locations and embedding the digitized images, which allows virtual fly-overs of cities. The digital photos taken at ground level allow the user to experience three-dimensional effects.

According to Ashbindhu Singh, Regional Coordinator of the UNEP Division of Early Warning & Assessment - North America, UNEP – GRID has a working relationship with Google Earth to provide increased access to satellite imagery of the earth and disseminating environmental information. According to Dr. Singh, greater access to broadband connections is required to allow developing countries to make greater use of these tools in support of sound environmental management and decision-making.

Text box 3. UNEP and Google Earth highlight environmental hot spots[93].

On January 31, 1998, then U.S. Vice President Al Gore gave a speech at the California Science Center in Los Angeles, California, on " **The Digital Earth: Understanding our planet in the 21st Century".** In this speech, Mr. Gore presented a visionary concept for the virtual and 3-D representation of the Earth. According to Mr. Gore, this representation conceived the Earth as geographically referenced and interconnected with digital knowledge archives from around the planet with vast amounts of scientific information to describe and understand the Earth, its systems, and human activities. A significant breakthrough to his vision was realized with the launch of Google Earth.

Google Earth is one of the most popular visualization tools on the Internet and has been downloaded by over 200 million users from around the world. Among other things, it provides a platform for dissemination "UNEP content" that can assist in 'keeping the state of environmental situation under review' and in raising public awareness about environmental change taking place around the world.

An extreme decentralization of information and data through the Internet makes it possible for millions of people worldwide to have easy, instantaneous access to a vast amount of diverse online information. Similarly, remote sensing satellites now provide a continuous stream of data. They are capable of rapid and effective detection of environmental phenomena and hazards such as transboundary air pollutants, wild fires, deforestation, changes in water levels, and natural hazards. With rapid advances in data collection, analysis, visualization and dissemination, including in the use of technologies such as remote sensing, Geographical Information Systems (GIS), web mapping, sensor webs, telecommunications and ever growing Internet connectivity, it is now feasible to deliver relevant environmental information on a regular basis to a worldwide audience relatively inexpensively. In recent years, companies including Google, Yahoo and Microsoft, have started incorporating maps and satellite imagery in their products and services, delivering compelling visualization and providing easy tools that everyone can use to add to their geographic knowledge.

UNEP has partnered with Google to publish via Google Earth one of UNEP's best-selling publications ever: "One Planet, Many People: Atlas of our Changing Environment". The UNEP GRID Sioux Falls team developed a digital version of the publication to showcase how a time series of satellite imagery can be integrated into the Google Earth software for visualization. Over the period of one year, the system was developed and content was collected for 100 environmental hotspots and were submitted to the Google Earth team. On September 13, 2006, Google Earth released "UNEP Atlas of our changing environment" as a part of "**Featured Content"**. This layer has now become one the most popular layers on Google Earth.

On April 10, 2007 Google Earth released content provided by UNEP describing **120 environmental hotspots** (the original Atlas has information on **79** environmental hotspots). Google Earth created a new folder, called "**Global Awareness**" to showcase featured layers of public interest**.**

The combination of this Atlas information with Google Earth software provides a 'Flying' experience around a virtual planet earth, zooming in on environmental hotspots and comparing today's crisis zones with yesterday's areas of natural beauty. The application show images of retreating glaciers and melting ice in polar and mountain areas, explosive growth of cities such as Las Vegas, forest loss in the Amazon, rapid oil and gas development in Wyoming and Canada, forest fires across sub-Saharan Africa and the decline of the Aral Sea in Central Asia and Lake Chad in Africa. This and much more is being presented in a series of before and after satellite images to over 200 million Google Earth users worldwide. By keeping pace with the changing world of technology and media, this effort helps the environmental community keep pace with the real changes in our real world. Much of this data was includes NASA imagery and was made available from the archives of the US Geological Survey Eros Data Center in South Dakota.

Source: Modified from Ashbindu Singh, UNEP GRID, North America, September 2007

7.12. Data Sharing Standards and Applications

A key application that allows the sharing of earth observation data is the Global Earth Observation System of Systems (GEOSS). GEOSS is an initiative of the Group on Earth Observations (GEO)[94] that arose after the 2002 World Summit on Sustainable Development "…highlighted the urgent need for coordinated observations relating to the state of the Earth." The G8 group of countries affirmed the importance of earth observation as a priority activity.

[93] Singh, A. 2007. *Mobilizing public support for the environment using the latest ICT tools*. Personal communication from Dr. A. Singh, UNEP. Sept. 2007.
[94] See http://earthobservations.org/

GEOSS is an intergovernmental initiative overseen by 66 nations and 45 international organizations through GEO. The members of GEO came together to participate in the "…development of a comprehensive, coordinated and sustained Earth Observation System to collect and disseminate improved data, information, and models to stakeholders and decision-makers"[95].

At the centre of GEOSS, is a clearinghouse that will "…help users discover, evaluate and use the broadest range of data and information".

GEOSS will allow "…interoperability between and among hundreds of interoperable catalogues and Web portals in use today". All of this is rendered possible by adopting existing international standards such as ISO 19128 Web Map Service; ISO 19115 Geographic Information Metadata; and ISO 23950 Information Search and Retrieval. These standards are already used.

For this project to bear fruition, partners have to agree to share spatial data. Standards provide the technical means but organizations have to agree to allow access to their data. For this purpose, the Global Spatial Data Infrastructure (GSDI)[96] Association was created. GDSI is a partnership among 60 countries and organizations dedicated to sharing geospatial data. GDSI has registered over 400 catalogue servers.

7.13. Clearinghouse mechanisms (CHMs)

There are many environmental conventions that have been agreed by the international community which UNEP is hosting[97]. The actual implementation of these conventions is the responsibility of the parties to the convention but a secretariat hosted by UNEP was established to assist with the convention process.

The convention process is a global consultative exercise, modeled on the successful Rio Earth Summit in 1992 also known as the "UNCED process". The Rio event was a major turning point in international conferences and specialized UN conferences in particular. Two groundbreaking initiatives are noteworthy. In the first instance, non-governmental organizations (NGOs) were involved for the first time, and, secondly the importance of ICTs for decision-making was recognized. Access to information was explicitly recognized as a tool for achieving sustainable development in particular in Chapter 40 of Agenda 21[98], a comprehensive plan of action for addressing both environmental and development goals in the 21st century. At UNCED, the global NGO movement rapidly created a global network of users linked via e-mail and newsgroups and other electronic discussion and information sharing tools.

The convention process involves research and much back and forth discussion between official national delegations and others, including invited parties, observers and a variety of stakeholder groups. Over the years, the convention process has benefited greatly from the use of ICTs. Since the use of email and Usenet and other news groups as well as bulletin board systems (BBSs), the convention process has moved to the World Wide Web and other technologies such as real time streaming video for broadcasting the processing of the convention deliberations. The proceedings of the Bali climate change conference in Indonesia included downloadable streaming video broadcasts as well as RSS feeds and podcasts[99].

For the purpose of this report, two of these conventions (United Nations Framework Convention on Climate Change[100] and the Convention on Biological Diversity[101]) are examined in greater detail in

[95] US EPA. 2007. *Global Earth Observation System of Systems (GEOSS) – Basic information*. http://www.epa.gov/geoss/basic.html
[96] See http://www.gsdi.org/
[97] UNEP. 2006. About UNEP. 44 pp. UNEP, Nairobi. http://www.unep.org/PDF/ABOUT_UNEP_ENGLISH.pdf
[98] See http://www.unep.org/governingbodies/agenda21.asp
[99] See http://unfccc.int/2860.php
[100] See http://www.unfccc.de/
[101] See http://www.biodiv.org/

order to develop a better understanding of the issues that developing countries who are parties to the conventions face in making beneficial use of ICTs to support the Convention goals and objectives.

These conventions deal with climate change directly (UNFCCC) and with broad environmental issues related to the management and conservation of all living things (Convention on Biological Diversity). They were chosen because of the perceived importance of climate change and biodiversity to the global environment.

For both of these conventions as well as for other conventions and other information sharing activities in the international development sphere, the idea of the clearinghouse mechanism (CHM) has been conceived and applied. CHMs are information sharing activities focused on assisting the agencies in question support their stakeholders and others in meeting their information sharing needs and obligations under the conventions or charters that these organizations operate.

7.14. CCINet operated by the United Nations Framework Convention on Climate Change

The Climate Change Information Network (CC:iNet)[102] is a Web portal with the objectives to serve "…as a clearinghouse for information sources on public information, education and training in the field of climate change. It is designed to help governments, organizations and individuals gain rapid and easy access to ideas, strategies, contacts, experts and materials that can be used to motivate and empower people to take effective action on climate change".

CC:iNet was established in 2005 and is still in an evaluation phase before full implementation will take place at the end of 2007.

7.15. TT:CLEAR

TT:CLEAR is a web-based technology information clearinghouse developed by the secretariat of the United Nations Framework Convention on Climate Change (UNFCCC), with support from Parties and the Expert Group on Technology Transfer (EGTT). It enables users to find information on:

- Technology transfer projects and programmes;
- Case studies of successful technology transfer;
- Environmentally sound technologies and know-how;
- Organizations and experts;
- Methods, models, and tools to assess mitigation and adaptation options and strategies;
- Relevant Internet sites for technology transfer;
- Ongoing work of the Parties and the EGTT such as issues under negotiation, documents and meetings, and implementation of the technology framework[103].

TT:CLEAR offers a web-based information sharing platform for access to a variety of sources of information including case studies. The objective is to provide useful information to stakeholders and decision-makers and others on all aspects of technology transfer for climate change mitigation and adaptation.

It aims to help countries take advantage of opportunities for technology transfer by helping them become more aware of the technologies available, of the funding and other forms of assistance that exists for them, and to show these users case studies that they can use when developing proposals or

[102] UNFCCC: See - http://unfccc.int/cc_inet/items/3514.php
[103] UNFCCC. Technology Information Clearing House – TT:CLEAR http://unfccc.int/home/items/3092.php

undertaking projects. It also provides for the exchange of views and experiences on the development and transfer of technologies.

7.16. UNFCCC staff comments on ICT use

In discussion with Mr. Kevin Grose[104], Coordinator of the Information Services programme at the UNFCCC as well as some of his staff, it was noted that there have been changes in the way delegates use ICTs at the annual convention of the parties meeting.

The UNFCCC Secretariat like any large international organization uses tools such as web-enabled enterprise content management systems for a variety of tasks including allowing partners located in their home countries and organizations to submit data files directly over the Internet as part of their reporting requirements under the Climate Change Convention. These web-enabled services have allowed the UNFCCC to facilitate information sharing which helps the parties to the Convention to meet their obligations.

For UNFCCC, the information requirements on climate change are twofold: there is a need to acquire and share information on climate change mitigation as well as on adaptation to climate change. The nature and structure of the information and knowledge on each of these important and related subjects is different.

UNFCCC uses databases for storing data and the information collected. Even though there is enhanced connectivity and greater access to and use of ICTs, only a few developing countries have the ability to use these tools to their full capacity and potential. However, there are other issues that limit the capacity to make beneficial use of these tools including lack of information and information only available in English.

UNFCCC has tried experimenting with machine-based language translation, but the technology is still immature. Open source software makes it easier for some countries to access applications that otherwise may not be available. Some firms recognize that developing countries cannot afford their products and may at times make these available under concessionary terms if not for free.

In addition to the formal Clearing House Mechanisms developed as part of specific conventions, other formal and informal information sharing tools have emerged. For example, Online Access to Research in the Environment (OARE)[105] is a "…public-private consortium coordinated by the United Nations Environment Programme (UNEP), Yale University, and leading science and technology publishers that enables developing countries to gain access to one of the world's largest collections of environmental science research".

With over 1,300 articles available at the time of the writing of this report, it represents both a means of distributing environmental research as well as creating an equitable exchange of information with developing countries. Less formal CHMs also exist in the form of professional associations and news and information web sites that provide articles and references to environmental information. For example, iConnect[106], sponsored by The International Institute for Communication and Development (IICD)[107] provides news articles, on-line information and links to other organizations related to ICT4D, including themes related to the environment.

7.17. The clearinghouse mechanism of the Convention on Biological Diversity

In order to learn more about the Convention on Biological Diversity Clearing House Mechanism (CHM), staff at the Secretariat of the Convention on Biological Diversity (CBD) in Montreal were asked for their input. Mr. Markus Lehmann, Economist, Social, Economic and Legal Affairs and his

[104] Grose, K. 2007. Record of telephone interview with R. Labelle, K. Grose and UNFCC staff 4 October 2007.
[105] See http://www.oaresciences.org/en/
[106] See http://www.iconnect-online.org/home
[107] See http://www.iicd.org/

colleague Mr. Olivier de Munck who is the Programme Officer responsible for the Clearing House Mechanism at the Secretariat of the Secretariat of the Convention on Biological Diversity in Montreal, gracefully made their time available. As a result in part of their input, the following points were made[108].

The objective of the CHM of the Convention on Biological Diversity (CBD) is "…to ensure that all governments have access to the information and technologies they need for their work on biodiversity"[109]. The protocol uses ICTs to facilitate the sharing of information and knowledge as well as networking with partners around the world. The CHM is also used to enhance the capacity of parties to the Convention to address their scientific and technical information needs. The CBD CHM includes the "…Central Portal of the Biosafety Clearinghouse to support the Cartagena Protocol. This on-line system facilitates the exchange of legal, scientific, environmental and other relevant information related to living modified organisms (LMOs)".

Each partner country is encouraged and sometimes provided assistance to develop a national CHM. As of 2006, "…151 Parties to the Convention as well as other governments have established national CHMs. Of these, only 76 have established websites in support of its work and to assist with information exchange".

For this purpose, the CBD Secretariat has developed a portal took-kit to help partners set-up a CHM website. The tool-kit includes a content management system (CMS). With the exception of training that takes place on the occasion of the regular meetings of the Conference of the Parties, the CBD Secretariat does not undertake CHM capacity-building activities in countries *per se*. Bilateral aid agencies and the GEF will sometimes fund the establishment of CHM Secretariats in developing countries. For example, Belgian Aid has helped many countries to establish national CHM Secretariats. The CHM website maintained by the Secretariat is the main international node. There are many searchable databases available through their website[110].

7.18. Using ICTs for biodiversity mapping

The CBD Secretariat uses ICTs extensively. ICTs are used for biodiversity monitoring and are also used as tools for sharing information through the CHM website and national sites and resources. One emerging trend of relevance to biodiversity monitoring is "geomapping". Data acquired by remote sensing is analyzed using GIS and mapped using tools such as Google Earth or Microsoft Virtual Earth or other tools (see Section 7.11). Georeferenced data can be tagged with relative ease using these tools instead of commercial GIS systems. Again, the use of these tools is preconditioned by availability of PCs and access to broadband Internet connections.

7.19. Institutional issues

Along with strengthening the capacity of countries to use ICTs for biodiversity conservation, there is also a need to recognize institutional issues that affect the capacity of countries to implement the Convention on Biological Diversity as well as make use of ICTs. In many countries, the national CBD Secretariats operate in relative isolation within the confines of national institutions. Many ministries and/or departments dealing with the environment are not well financed. CBD national focal points may not receive the national support required to ensure their survival and more importantly, their ability to undertake tasks without continued support from international partners.

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[108] The officers of the Secretariat of the Convention on Biological Diversity provided information and pointers. The opinions expressed here are not necessarily those of the Secretariat.
[109] Convention on Biological Diversity. 2007. *Clearing-House Mechanism. Introduction.* http://www.cbd.int/chm/introduction.shtml
[110] See http://www.cbd.int/chm/

7.20. Using ICTs in the environment sector is also an e-Government issue

ICTs are used to enhance service delivery to the public and to researchers and other target groups, and this remains a key objective. In many countries, e-Government applications are being introduced, but ICTs are typically still not used in an integrated fashion.

One of the key issues is how to share government services across ministries and organizations and more important, how to ensure that these services are focused on the ultimate beneficiary, the public. For example, specific initiatives such as the establishment of a government biodiversity focal point need to be firmly anchored in the institutional and ICT context of the country and contribute to realizing overall national e-Government as well as e-Governance ambitions.

Invariably, the first priority of governments in many developing countries is the executive and parliamentary affairs, finance and administration, planning, government operations and the provision of key public and social services. Unless the issue deals with events that have a direct impact on human health and safety such as the weather and/or disaster early warning, mitigation and management, usually biodiversity and other issues are of secondary concern. This may change given the recent findings on the impact of climate change and the stated commitment of donors to address this issue.

7.21. The need for a coordinated approach

In many developing countries, there is need to strengthen the capacity of the government to deal with issues related to the environment in a coordinated fashion. The competing interests of different ministries and the dispersion of responsibilities often leads to a lack of coordination and to duplication of efforts and resources. Environment is one of many cross-cutting national issues that could greatly benefit from the use of ICTs.

International organizations can also benefit, and in many countries, ICTs are now being used to help coordinate development aid activities[111]. The use of web-based coordination platforms allow both national and international partners to share documents, meeting calendars and notes, registers of various sorts including lists of partners, telephone numbers and email addresses. In general, the deployment of e-Government services facilitates overall coordination with governments.

7.22. Using Web services for a global biodiversity CHM

In 2006, the Executive Secretary of the Secretariat of the Convention on Biological Diversity recognized the importance of ICTs to the implementation of the Convention and to the operation of their CHM. The Executive Secretary made a proposal to strengthen the CHM by focusing its efforts on the use of web-based tools and technologies for sharing information. The Executive Secretary also proposed using the web for extending the reach of the CHM by involving a host of institutions with information and resources to share, both nationally and internationally.

This information gathering system would use all means at its disposal to gather information, including exploiting "…links to national, regional or international electronic databases as well as by personal communications/contacts. [The] Convention's clearing-house mechanism should act as a central gateway to the information on technology transfer available on national clearing-house mechanisms"[112].

To do this, the Secretariat proposed what amounts to web-based information sharing mechanisms and encouraged the adoption of interoperable web-based technologies for doing so. The Secretariat also

[111] See for example the "Rwanda Development Partners" website designed to maximize aid effectiveness: http://www.devpartners.gov.rw/

[112] Executive Secretary. Convention on Biological Diversity. 2006. Technology transfer and scientific and technical cooperation. *Addendum Proposals for the enhancement of the clearing-house mechanism as a key mechanism in technology transfer and cooperation. Note by the Executive Secretary* http://www.cbd.int/doc/meetings/cop/cop-08/official/cop-08-19-add1-en.pdf

proposed identifying existing sources of information and mining existing sources of information available on the Web. This idea is similar to the idea advanced by the UNEP-WCMC to identify primary sources of scientific data related to biodiversity for use by the scientific community through the web. This approach is also consistent with the ideas put forward by the Group on Earth Observations (GEO).

7.23. United Nations Convention to Combat Desertification

The United Nations Convention to Combat Desertification (UNCCD) does not have a CHM *per se*, but UNCCD collaborates with UNFCCC and with CBD. Both the UNCCD and the UNFCCC are located in Bonn.

In discussions and exchanges with Mr. Arnaud de Vanssay, a Programme Officer at the UNCCD, several sources of information were identified regarding the use of ICTs for desertification control and management. UNCCD works through national focal points and also works closely with scientific collaborators in the countries that are signatories of the Convention on Desertification. In many of these countries, ICTs are used for information and knowledge sharing on desertification and related issues.

Some of the most important examples of ICT web references with regard to desertification action are the following:

- http://www.scid.ma
- http://www.csf-desertification.org/
- http://www.desertknowledge.com.au
- http://panda.igeo.pt/pancd/
- http://www.unccd-deselac.org/
- http://www.unccd.int/actionprogrammes/asia/regional/tpn3/website/index.htm
- http://www.oact.dz

7.24. Issues and trends and relevance to developing countries

Some of the issues and trends that are of particular relevance to developing countries include:

- **The capacity to develop, acquire and/or launch satellite-based remote sensing systems**. Until recently, this has been usually limited to industrialized countries. However, according to the WMO, "…several countries, including Argentina, Canada, China, France, India, Indonesia, Mexico, Saudi Arabia, Thailand and the USA, have implemented satellite-based multi-point telecommunication systems for their national Meteorological Telecommunication Networks".
- Many private sector firms have launched **commercial for-profit satellite-based remote sensing systems**. However, it is important to note that the cost of acquiring commercially certain types of imagery may be beyond the financial means of many developing countries.
- The use of the Web and of new web-based technologies such as Web 2.0, service-oriented architecture and mashups, etc. allow **more ready access to global data sets**.
- The importance of **open standards to ensure interoperability** is essential so that data that has been organized and stored in servers around the world can not only be linked via the Internet, but so that the information contained in these databases can also be used without having to deal with software, coding and other format incompatibilities or restrictions that would limit the use of this data. The GEOSS concept as well as other clearinghouse projects are addressing these issues and rely on international standards to ensure interoperability.

- **High speed access to the Internet** will help countries access and GEOSS and similar clearing-houses, and also can help developing countries contribute information as well.
- **Battery operated data collection devices** that can transmit information using either wireless or satellite transmissions are becoming more widespread and economical. Under some conditions, these technologies may make possible local data collection independent of the availability of broadband connections or reliable power sources.
- There is a need to recognize the importance of **collecting existing primary scientific data** from biological collections from around the world. This issue is discussed later in this report.
- The GEOSS initiative allows the use of open source software and GEOSS servers can be run on inexpensive PCs. In this regard, GEOSS takes into consideration the information needs and circumstances and therefore challenges that many developing countries face in accessing data sets for sustainable development. Some of the most important challenges that these countries will have to overcome in order to take full advantage of GEOSS are the following:
    - Acquiring the human capacity to make beneficial use of the data stored in GEOSS and like clearinghouses and data centers;
    - Raising the awareness of key decision-makers in developing countries of the advantages of GEOSS;
    - Persuading decision-makers in developing countries to set aside resources to use these resources and make them available as part of e-Government initiatives in the developing world. This will help developing countries in making the information available through GEOSS and like initiatives and resources useful for decision-makers and for use in the development planning process;
    - Demonstrating to international organizations such as UNDP and the World Bank as well as international financial institutions the value of using GEOSS data sets for saving lives and more importantly, for contributing to poverty eradication and the attainment of the MDGs.

8. USE OF ICTS FOR ENVIRONMENTAL ANALYSIS

8.1. Overview

Environmental analysis: once environmental data has been collected and stored, various computational and processing tools are required to perform the analysis and comparison of data available. This may include land, soil, water and atmospheric quality assessment tools, including technologies for analysis of atmospheric conditions including Greenhouse Gas (GHG) emissions and pollutants, and the tracking of both water quality and availability. The data analysis may also include correlating raw observational data with second order environmental measures such as biodiversity. Environmental analysis often draws on geographically distributed computational and data resources. Analysis is closely related to observation and a feedback loop must exist between the various sources of data and the agencies and applications that make use of this data. This application is discussed in more detail in the following sections.

8.2. Grid computing

Grid computing depends on broadband infrastructure to connect physically distant arrays of computers. It enhances access to environmental data and encourages networking and virtual collaboration. Grid networks link thousands or hundreds of thousands of microprocessors, which can be put to task to undertake data analysis. In environmental observation, very fast supercomputers are used for computational analysis.

In principle, Grid computing would allow smaller and less well endowed institutions to address computing tasks by setting up Grid networks for computation analysis. Another variant on Grid computing is cloud computing that allows users to tap into existing computing and network resources for a fee. This is a business model used by Amazon to allow third parties access to the significant online computing resources at its disposal.

Analyzing these sometimes complex environmental systems and their components over time and space is facilitated through numerical analysis and the use of specialized applications such as geographic information systems (GIS) and various models used to better understand complex environmental phenomena. This is particularly so in the case of weather and climate phenomena but also applies to understanding ecological systems (see Text box 4 below for more information on Grid computing).

According to Guinness World Records, the Folding@Home Grid used to study protein folding is the largest Grid in the world, linking over 670,000 PS3 (Sony PlayStation 3 gaming computers) and PCs[113]. The Folding@Home project is the most powerful distributed computing network, which harnesses the spare processing power of Sony's PlayStation 3 (PS3) to examine protein folding and how it may be linked to diseases. Having signed up nearly 700,000 PS3s, the network has more than one petaflop of computing power – the equivalent of 1,000 trillion calculations per second. By comparison BlueGene L, which tops the list of most powerful supercomputers, has a top speed of just 280.6 teraflops[114].

Grid computing has also been used for environmental analysis and the largest Grid based climate research project is called ClimatePrediction.Net[115], which is described below. ClimatePrediction.Net, like other Grid computing projects, has also allowed the greater public to become involved in cutting-

[113] Endgadget. 2007. Folding@Home recognized by Guinness World Records. Oct. 31, 2007. http://www.engadget.com/2007/10/31/folding-home-recognized-by-guinness-world-records/
[114] BBC News Online | Technology | PS3 network enters record books, 02 Nov 07, http://news.bbc.co.uk/nolpda/ukfs_news/hi/newsid_7074000/7074547.stm (accessed 27 Jan 2008).
[115] See http://www.climateprediction.net/project.php

edge research and to learn in the process as well to become more aware of the issues related to climate change[116]. A world map showing the distribution of ClimatePrediction.Net Grid computers appears in

Figure 8 on page 48.

8.3. Environmental models

Environmental models are used to understand how ecological systems work. According to Seppelt[117], "…setting up an ecological model requires detailed systems analysis of the processes of interest. After this translation into mathematical equations is performed […] environmental processes are recognized as complex, highly interacting and spatially distributed. These properties make analyzing, describing, modeling and even simulating our environment a challenging task."

The use of computers and of modeling software has been helpful for developing and using models to understand complex environmental systems. However, according to Reed et al.[118], it is the increased availability of environmental datasets that is critical to allowing modelers "…to improve their simulation and forecasting models. […] Until recently, there were very few observations of global-scale environmental phenomena from which to construct consistent scientific databases of vegetation, soils and climate. A significant increase in activity to fill this void has resulted in improved databases of global topography, land cover, soils, and satellite imagery that improve information on vegetation dynamics."

[116] Stainforth, D. A. et al. 2004.*ClimatePrediction.Net: a global community for research in climate physics*. Chapter 12. p. 101-112 in Scharl, A. Editor. Environmental online communication – Advanced information and knowledge processing. London, Springer-Verlag. 298 pp.
[117] Seppelt, R. 2003. *Computer-based environmental management*. Weinheim. Wiley. 284 pp.
[118] Reed, B., Brown, J.F. and Loveland, T.R. 2002. *Chapter 4. Geographic data for environmental modeling and assessment*. Pp. 52-69. In Skidmore, A. Environmental modeling with GIS and remote sensing. Taylor and Francis. 268 pp.

Text box 4. What is Grid computing

Grid computing[119],[120],[121],[122] is a catch-all phrase that refers to several different types of distributed computing. Some commonly accepted definitions include:

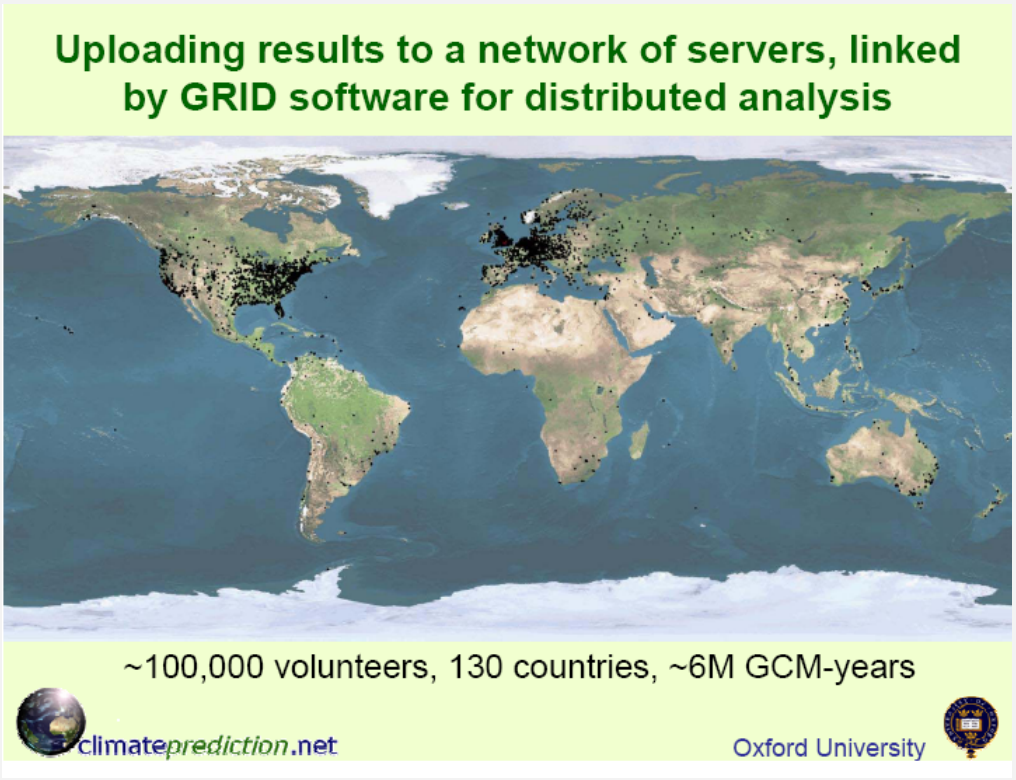
- Grids consist of geographically distributed and heterogeneous computational, network and storage resources that may belong to different administrative domains, but can be shared among users by establishing a global resource management architecture.
- The use of networked infrastructure software and capacity to provide resources to users in an on-demand environment. Sometimes known as utility computing, (or cloud computing), provides a set of typically virtualized computers which can provide users with the ability to start and stop servers or use compute cycles only when needed, often paying only for the use of those services.
- The creation of a "virtual supercomputer" by using spare computing resources within an organization.
- The creation of a "virtual supercomputer" by using a network of geographically dispersed computers generally focuses on scientific, mathematical, and academic problems.

Functionally, one can classify Grids into several types:

- Computational Grids (including CPU scavenging Grids), which focuses primarily on computationally-intensive operations.
- Data Grids or the controlled sharing and management of large amounts of distributed data.
- Equipment Grids which have a primary piece of equipment e.g. a telescope, and where the surrounding Grid is used to control the equipment remotely and to analyze the data produced.

[119] I. Foster and C. Kesselman. 2004. *The Grid: Blueprint for a New Computing Infrastructure*. 2nd Edition, Morgan Kaufman. 748 pp. Wiley., Chichester, UK.
[120] What is cloud or utility computing? Red Hat Europe Solutions. http://www.europe.redhat.com/solutions/enterprise/cloud/faq/#what_is_cloud (accessed 25 Jan 2008).
[121] Shangli Ou, *Introduction to Grid Computing*. Presentation at LONI High Performance Computing Workshop - La Tech Oct 11, 2007. http://www.hpc.lsu.edu/training/20071011/grid_computing.pdf (accessed 26 Jan 2008).
[122] Dissemination and Exploitation of GRids in Earth sciencE (DEGREE), "What is Grid?". http://www.eu-degree.eu/DEGREE/General%20questions/copy_of_what-is-grid. (accessed 26 Jan 2008).

Figure 8. World map showing distribution of ClimatePrediction.Net servers



8.4. Numerical analysis, simulation and modeling for understanding climate change

Numeric analysis is important and the advent of microprocessors has greatly facilitated our understanding of the environment for this reason. According to the Intergovernmental Panel on Climate Change (IPCC), the sensitivity of the analysis possible today is increasing in parallel with increases in the power and availability of ICTs. As a result of these increases in computing power, the resolution of climate models of various sorts has increased significantly and this has made an important contribution to our understanding on these phenomena. Without the advent of increasingly powerful microprocessors and related technologies such as high-speed IP networks and increasingly large and complete data sets, it would not have been possible to arrive at our present understanding of the climate and how it operates.

According to the IPCC 1.5.1 Model Evolution and Model Hierarchies,

> climate scenarios rely upon the use of numerical models. The continuous evolution of these models over recent decades has been enabled by a considerable increase in computational capacity, with supercomputer speeds increasing by roughly a factor of a million in the three decades from the 1970s to the present. This computational progress has permitted a corresponding increase in model complexity in the length of the simulations, and in spatial resolution[123]… [and, consequently,]… models are more realistic today than were those of a decade ago.

Earlier models "…included simple representations of the atmosphere. Rain was included but not clouds… Now, current state-of-the-art climate models include fully interactive clouds, oceans, land

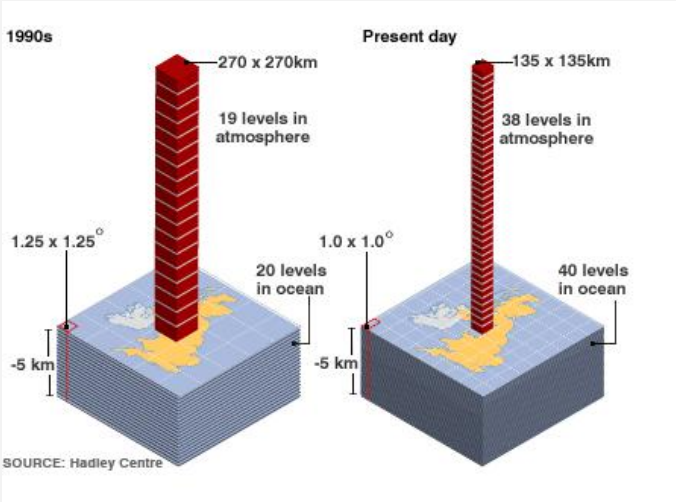
[123] IPCC, 2007: *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change* [Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor and H.L. Miller (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 996 pp.

surfaces and aerosols, etc. Some models are starting to include detailed chemistry and the carbon cycle"[124]. Today's models require 256 times more computing power that what was available in the 1970s.

As a result of this increase in computing power, climate change models are more accurate and allow for much higher resolutions as indicated in the figure below, along with the representations of all key processes, much longer time scales over which it is possible to predict climate change and different version of the models can be run allowing to "…quantify the uncertainty in our predictions"[125].

Efforts to facilitate access to data sets used in earth observation through collaborative efforts such as the Global Earth Observation System of Systems described previously are therefore particularly useful and important.

Figure 9. Progression of climate models[126]



For developing countries access to these systems will increasingly become important. In particular, for large and rapidly growing and energy consuming developing countries such as India, China, Brazil and others, these computational facilities will be helpful in advancing their understanding of environmental processes in general and climate processes in particular at a time when their contribution to GHG emissions is increasing along with their rapid pace of economic development.

Small island developing states (SIDS) will also need to remain aware and be directly involved with research on climate change and rising sea levels. Smaller and poorer developing countries will need to take advantage of resources available through clearinghouse mechanisms such as GEOSS. All countries will need to participate in research networks that allow them to evaluate for themselves the scientific facts and assist decision-makers to take facts-based appropriate measures. Access to reliable broadband networks is essential for these countries to take full advantage of these resources and knowledge.

[124] Pope, V. 2007. *Models 'key to climate forecasts'. The only way to predict the day-to-day weather and changes to the climate over longer timescales is to use computer models*. BBC News. http://news.bbc.co.uk/2/hi/science/nature/6320515.stm
[125] Idem.
[126] Idem.

8.5. Geographic information systems

One of the most important categories of software applications in the environment field – and indeed increasingly in many other fields – are geographic information systems (GIS).

GIS suppliers develop and support GIS software at all levels, from the desktop to the enterprise. In addition, they can provide educational services, user support, and consulting services ranging from needs assessments to system design and development. These tools are widely utilized in the fields of environmental management and sustainable development.

Geography is the key component for successful environmental management. The idea of using geography as the intellectual backbone to which all environmental data can be attached by location was the foundation that ultimately led to the development of GIS. Natural resources – whether terrestrial, marine, or atmospheric – are finite, and the measurement and management of these resources are gaining importance as increased demands are put upon them.

GIS software helps organizations, agencies, and governments work together to develop strategies for sustainable development. It provides the tools to access and process information from a variety of sources and displays it in a spatial and visual medium. This supports decision-making and promotes better organizational integration and knowledge management to improve the quality of life for future generations.

GIS technology has been developed and used for a variety of applications including weather, early warning, environmental management, conservation, forestry, and other international development/environment activities – such as economic development, humanitarian de-mining, carbon sequestration, etc. Some GIS software is being made compatible with Open Source Software (OSS) platforms, and has been adapted to accommodate earlier generation desktop equipment present in some developing countries, which lack interface options that are common in more industrialized countries (e.g., USB ports). GIS has had a tremendous impact on conservation as evidenced by the activities of organization such as the Society for Conservation GIS (SCGIS), which assists conservationists worldwide in using GIS through communication, networking, scholarships, and training.[127]

Developing countries could make significant gains in their ability to leverage GIS applications with improved access to the Internet. Given the proliferation of data portals including those containing georeferenced data such as the Conservation Geoportal[128] or applications such as Google Earth and Microsoft Virtual Earth, developing countries need facilitated access to broadband networks.

8.6. Energy efficient computer chips and chip arrays

The development of increasingly powerful microprocessors is still proceeding according to Moore's law[129]. However, not only are processors becoming more powerful, they are also becoming less power hungry.

Chips are now being marketed as dual or quad or octo core processor chips that share the same bus and contain 2 to 8 CPUs on the same chipset. This combination of chips sharing a common bus for processing and moving instructions more rapidly between processors allows processors to work together in parallel, thus greatly speeding up processing and throughput, and resulting in much improved energy efficiency.

[127] The Society for Conservation GIS (SCGIS), http://www.scgis.org (accessed Dec 1, 2007).
[128] Conservation Geoportal. See http://www.conservationmaps.org (accessed Dec 1, 2007).
[129] See http://www.intel.com/technology/mooreslaw/index.htm

8.7. Energy efficient programmes in CPU design

For CPU designers, environmental friendliness has become increasingly recognized as an issue for customers and an important differentiator between competing products in an increasingly energy consumption and GHG emission-aware world.

Particularly relevant to graphics intensive applications, GPUs or graphic processing units are microprocessors dedicated to processing images (particularly popular for computer gaming). GPUs include some of the most advanced and powerful microprocessors on the market today. Many contain the largest concentration of transistors in any chip. Increasingly, GPUs are not only used for gaming, but also for numerical analysis and to contribute cycles to the central processing unit on a computer motherboard.

More and more specialized processors are appearing on the market, largely in response to the ever-increasing demand for realism in computer gaming. These include "physics processors" designed to offload physical effects calculations or processing cycles from the main CPU[130]. These processors do not at this time appear to be used in environmental and other real world modeling or data processing, although this could change in the future.

These developments will eventually become standard in consumer level PCs. They are also contributing to more powerful servers and workstations that can be used for scientific analysis and for environmental modeling and computational analysis, for example.

8.8. Key ICTs

Key ICTs involved in environmental analysis include:

- Increasingly powerful and energy-efficient CPUs, that can be readily used for numerical analysis;
- Multithreading of CPUs organized in multicore units, that promise to bring significant gains in processing power to PCs;
- Database management systems (DBMS);
- Geographic information systems (GIS) which integrate DBMS' with georeferenced data;
- Algorithms for simulations and models;
- Inexpensive storage solutions and arrays: low cost hard disk drives and storage systems that have greatly contributed to acquiring, sharing and using environmental data sets;
- Applications to collect, analyze and transmit environmental data in situ and/or remotely. This would include telemetric applications such as water and airflow and quality meters and sensors of various sorts. These devices include data recording and display tools and technologies including dedicated sensors, display devices, as well as the communication technologies used to connect these sensors if they are used remotely for telemetry for example. These also include undersea and space based applications as well as sensor platforms;
- Broadband Internet to connect data sets with environmental modelers and other users and providers of environmental information; and
- Grid and cloud computing.

8.9. Key organizations

- Some of the key organizations involved in environmental analysis include:

[130] See Physics processing unit at: http://en.wikipedia.org/wiki/Physics_processing_unit, Dec. 7, 2007.

- Organizations responsible nationally and at the local level for environmental quality monitoring, assessment and reporting;
- NASA, NOAA, WMO, ISO;
- GEOSS;
- IPCC;
- A variety of private sector firms that supply the scientific community in ICTs for environmental analysis;
- Research and development institutions such as universities, government and private sector research centers;
- Networks of researchers and standards promoting associations of ICT and environmental experts, including the Group on Earth Observations (GEO) and the supporters of GEO;
- A wide range of ICT companies;
- CABI.

8.10. Key applications

- GIS for visualizing and analyzing data;
- Clearing houses and data warehouses;
- Environmental models capable of dealing with large data sets and complex environmental parameters and variables;
- Sensor specific applications used for chemical and physical analysis of environmental samples: soil, water, air quality sampling and measurements tools and technologies, etc.;
- Statistical analysis tools and technologies, usually statistical analysis programs;
- Grid computing clusters;
- Web services and related technologies that can help either offload computing requirements of and/or share advanced computing resources with countries and organizations that do not have the capacity to undertake environmental analysis and research. Here broadband Internet connections are key.

8.11. Issues and trends

- The use of **common and open standards to ensure interoperability** between various applications and technologies is key to ensuring access to data.
- There is a need to **raise awareness of importance of what is primary scientific data** and of the need to share this data and of the value of this data, especially of **historically significant data** locked in public and private stores, records and collections or museums such as samples of biota, including museum specimens, herbaria pressings and collections as well as related annotations and notes, textual data of various sorts including scientific reports and datasets from past times: tide tables, record data and observations, for example from the colonial era, etc. **Much of this data is or can be georeferenced** and could add significant value to the historical record of life, ecosystems and other natural systems, including past events of environmental significance and how these have changed over time.
- **More accessible data sets** and the use of these data sets for environmental analysis, but also for learning and education.

8.12. Relevance to developing countries

- **Primary scientific data related to biodiversity is located all over the planet**. Some is in the natural environment itself, and there are tools now available to allow the recording and entry of biodiversity data and information in real time as the NatureServe application attests. However, there is also **biodiversity information in the historical record** that has been maintained in the many museums, collections and research centers of the world. This includes valuable references from the collections of museums and their collections of samples of biota of all types from around the world. Invariably, these samples will include georeferenced data in the form of statements of provenance and origin as well as time and date stamps. Assembling and exploiting these valuable and unique collections, including digitizing them through the use of digital photography of all sorts, scanning and annotation as well as ground truthing will require significant resources, which may not presently be available in many of these countries, whether developed or not.
- **Developing countries may not be able to muster the means required to (re-) constitute the data sets** and develop the models used to analyze these data sets, but they can take advantage of the increased availability of online computing resources which may be available through research Grids and related technologies (e.g., cloud computing) as well as applications such as Google Earth and Microsoft Virtual Earth. **By encouraging international collaboration** on these issues through existing and newly developed mechanisms, these online resources can be used as **decision support systems and can also be used for education and training** purposes. Increased networking between researchers and planners in the developing world with those in other countries is required to help both take advantage of these knowledge resources. There may be a need to first raise awareness of the importance of this issue and of the advantages of research networking while at the same time strengthening capacity building efforts in this sense
- There is much data, including especially **georeferenced data in digital form about developing countries in data repositories around the world**. Access to some of these data sets and databases may be on a commercial basis or may be otherwise restricted. **Developing countries do not have the financial resources** to buy the datasets and many countries, if not most developing countries and especially the less developed countries do not have the ICT infrastructure and human skills to make beneficial use of these data sets even if they could gain access to them. A continuing role of the international community and of efforts such as the UNEP-WCMC and the Group on Earth Observations will be required in order **to enhance the capacity of these countries** to use these tools and technologies and to integrate the data sets and knowledge resources available into day-to-day as well as longer-term decision-making.
- There are also **significant resources available** in libraries and research centers as well as in some private collections. Many of these collections have already been microfiched and/or digitized as part of previous **efforts to help build the research knowledge base and research capacity of developing countries** and of developed countries. Some **key institutions** already exist that have been making this type of information available to researchers for many decades, such as the former Commonwealth Agricultural Bureaux now known as CABI (originally called Commonwealth Agricultural Bureaux International)[131]. Some of this data is available online in the form of searchable full text commercial databases, some of which may be available in developing countries and especially to CABI member states for a nominal fee if not free of charge.

[131] CABI. Our history. See http://www.cabi.org/datapage.asp?iDocID=235

- Some of the other significant resources include:
  - The Royal Tropical Institute and the Tropenmuseum in Amsterdam, the Netherlands,[132] with its online searchable database that includes much information from Indonesia and other countries and regions;
  - The Royal Museum for Central Africa at Tervuren[133] outside of Brussels, Belgium, which contains some of the most important collections of wood samples (xylotheque or xylarium) in the world and the most important in all of Europe. It contains wood samples from around the globe, which in itself may constitute a significant resource for scientific research and which has already begun to be exploited as such (see the article by H. Beeckman, 2007[134]).
  - The Centre de coopération internationale en recherche agronomique pour le développement (CIRAD)[135] in France is an institution that contains significant collections of research information and documentation from the various research centers;
  - Specialized research centers such as the Oxford Forestry Institute[136];
  - And many others in developing countries, such as the Forestry Research Institute in Dehra Dun in India, and the various research institutes as well as the botanical gardens in Bogor Indonesia; CATIE in Turrialba, Costa Rica, etc.
- **Research networking** may not be adequately recognized by aid organizations as a worthy endeavor, although experience from research networking in the field of applied agriculture as well as in the field of economics has shown significant results, even before the advent of the Internet. There is a significant body of knowledge on research networking in the agriculture field, especially in farming systems research, much of this related to research around green revolution technologies and sustainable agriculture. The FAO and the Consultative Group on International Agricultural Research (CGIAR) and many related organizations are the repositories of this information and knowledge, which has many lessons to share for the purposes of enhancing the capacity of countries to adopt and adapt modern ICT based management practices to environmental study and management[137].
  - Some of the institutions with the greatest experience of and support for research networking in the developing world include the Consultative Group on International Agricultural Research (CGIAR)[138]. The CGIAR deals with applied environment issues and is a vehicle for supporting environmental research and development while adopting a livelihoods and pro-poor approach to environmental analysis and management;
  - The FAO and its many activities and research endeavors are also worth mentioning, including the World Agricultural Information Centre (WAICENT)[139] as well as other programmes such as the Special Programme for Food Security, e.g. the Global Information and Early Warning System on Food and Agriculture (GIEWS).
- FAO is contributing to making information available as freely as possible over the Internet through initiatives such as "…opening the content of agricultural repositories using Open

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[132] See http://www.kit.nl/ and also http://www.tropenmuseum.nl/smartsite.shtml?id=16433
[133] See http://www.africamuseum.be/museum
[134] Beeckman, H. 2007 A xylarium for the sustainable management of biodiversity: the wood collection of the Royal Museum for Central Africa, Tervuren, Belgium, *Le bulletin de l'APAD*, n° 26, *Gestion des ressources naturelles. Participations et médiations* , Published online December 15 2007. http://apad.revues.org/document71.html.
[135] See *http://www.cirad.fr/fr/le_cirad/histoire/index.php*
[136] *See* http://www.plants.ox.ac.uk/ofi/
[137] One of the best sources of information comes from the Institute of Development Studies at the University of Sussex in the United Kingdom. See http://www.ids.ac.uk/
[138] See http://www.cgiar.org/
[139] See http://www.fao.org/waicent/

Archives Initiative (OAI) framework"[140]. FAO is the repository of the AGRIS database, one of the most extensive and useful agricultural information resources in the world, with significant documentary resources related to environmental research and development in the developing countries because the data was actually submitted by the developing countries themselves.

- One of the most significant issues that developing countries face is a lack of access to data as well as the ability to analyze this data. The ICTs discussed above will assist in providing improved access, but even computer-facilitated systems need human beings to make sense of the data and to use this data in support of sound environmental decision-making.

[140] See http://www.fao.org/waicent/portal/detail_event.asp?back=back&lang=en&event_id=37874

9. USE OF ICTS FOR ENVIRONMENTAL PLANNING

9.1. Overview

Environmental planning: at the international, regional, national and local level, planning starts with a study and assessment phase that is based on the output information available from environmental observation and analysis. This is then used to develop policies and strategies.

Environmental planning and decision-making uses many of the applications mentioned under environmental analysis. Decision support systems for environmental decision-makers are useful to assist the planning process and to help implement the activities stipulated under the plan of action.

This application is discussed in more detail in the following sections.

9.2. Background

One of the key tools used for environmental planning are environmental impact assessments (EIAs). The EIA process is an established management practice that is used in many industrialized countries and around the world. The World Bank, for instance, requires EIA statements as part of the project definition and approval process before it can approve loan and/or grant requests. In other words, environmental planning is becoming "mainstreamed" into all development projects, especially in industrialized countries and increasingly in developing countries as well.

Organizations and individuals responsible for undertaking EIAs must be able to quickly pull up information on the present and existing state of the environment. They need site specific and therefore georeferenced data and knowledge. ICTs facilitate the integration of environment data in the decision support systems of environmental planners and decision-makers.

An issue that applies in environmental planning in general and in applying EIAs has to do with stakeholder engagement and participation. ICTs can assist this process by facilitating communications and exchanges between different stakeholder groups.

9.3. Key ICTs and applications

- **Decision support systems** integrating environmental data and other factors are key resources. Decision support systems will likely be related to e-Business or e-Government systems where decision support functions already exist and can be more or less readily adapted to the specific requirements of environmental planners.
- Database management systems (DBMS) for storing and managing as well as visualizing and analyzing a host of site-specific variables allowing to assess environmental interactions.
- Geographic information systems (GIS) which integrate DBMS with georeferenced data and will likely be part of the solutions being used by groups such as GEO to facilitate the interpretation of environmental and related data for planning purposes.
- Increasingly powerful microprocessors to analyze the reams of data.
- Computer models to assist with EIAs and for decision support.
- Environmental management information systems to allow environmental organizations to manage their operations using e-Business and e-Government technologies and management practices.
- The Internet/web to share best practices and experiences in environmental planning as well as tools used in project planning, management, implementation and monitoring and evaluation, including office productivity and project planning software as well as software for measuring impacts, outputs and outcomes and for monitoring and evaluation.

9.4. Key organizations

- Key UN organizations:
  - UNEP, FAO, World Bank, UNDP;
- Key NGOs:
  - IUCN, WWF, Friends of the Earth, Greenpeace, the Sierra Club, GEO, GBIF, and many others, including international and national chapters of these organizations;
- Key private sector organizations:
  - Natural resource extractors including especially oil and mining and other companies in the extractive industry;
  - Various firms that specialize in EIA methodologies and practices;
- Key national organizations:
  - Ministries and departments of the environment and of natural resources;
  - Ministries and departments of agriculture, as well as urban and rural development and planning;
  - National parks and reserves as well as other protected areas;
  - Private sector firms that undertake EIAs and related activities;
- Key research organizations:
  - Universities and other research centers.

9.5. Key applications

- GIS image processing systems for time-based or geographical analysis;
- Land use and classification and vegetation mapping systems
  - Soil maps;
  - Biodiversity maps;
- Decision support systems;
- Facilities-siting tools;
- e-Government linkage to policy making;
- Environmental transaction systems such as carbon trading mechanisms like the International Transaction Log (ITL)[141].

9.6. Issues and trends

- Greater integration of ICTs in the planning process;
- Many of the issues and trends already recognized in previous sections also apply to environmental planning, in particular the ability to access information related to the environmental conditions.

[141] See Section 14.7 on page 120

9.7. Relevance to developing countries

- The use of ICTs for environment planning in many developing countries is subject to the same constraints related to ICT use in general in these countries.
- The level of priority assigned to environmental management by governments is of concern and will affect the deployment of ICTs for this purpose. In poorer countries, where the priority is poverty reduction, environmental management per se will be assigned a lower priority by national authorities as well as the international community. However, agencies such as the GEF exist specifically to address this situation.
- Many developing countries do not have the human and institutional capacity to undertake environmental planning activities on their own and rely on the assistance of the international development community through the aegis of institutions such as the GEF as well as other multilateral and bilateral agencies.
- Many developing countries and especially less developed countries do not have the e-Business or e-Government systems in place to take advantage of their own data sets if they exist and more important, do not have the tools required to assist with environmental planning in general and project planning in particular. While the ministries of finance and of planning, as well as the Office of the President and/or the Prime Minister's Office or equivalent in these countries may well have these tools and use them, most other line ministries and public service organizations in these countries, including the Ministry of the Environment and related ministries of agriculture, land use, local development and even education may not have these tools.
- Many developing countries will not be able to access commercially available data sets and databases to support environmental planning because of the cost involved.

10. USE OF ICTS FOR ENVIRONMENTAL MANAGEMENT AND PROTECTION

10.1. Overview

Environmental management and protection: environmental policy and strategic direction set during planning must reach the implementation phase in order to have a direct impact on the environment. Management and protection involves everything related to managing and mitigating the impact of man on the environment, including resource and energy conservation and management systems, GHG emission management and reduction systems and controls, pollution control and management systems and related methodologies including mitigating the ill effects of pollutants and manmade environmental hazards on man.

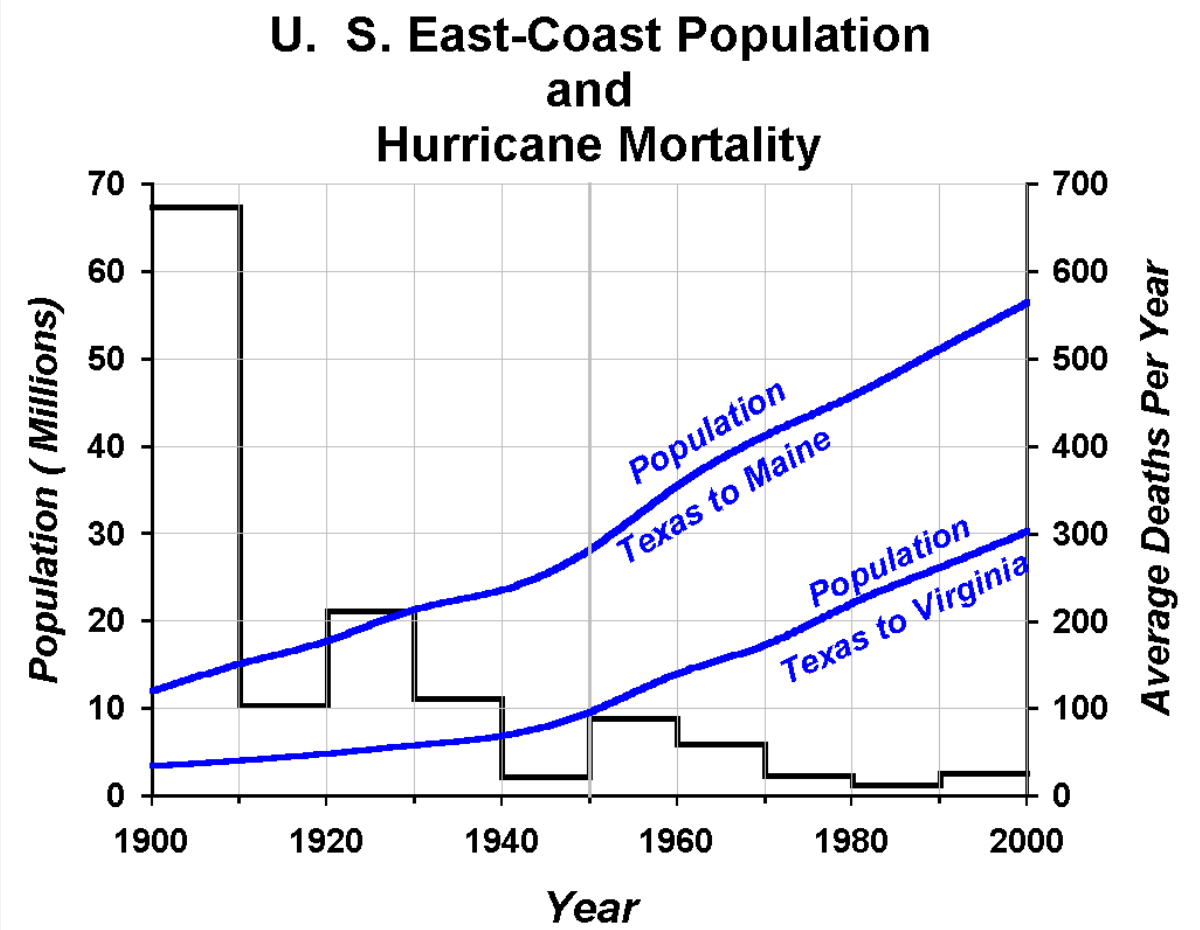
This application is discussed in more detail in the following sections.

10.2. Background

Many of the ICTs already mentioned under the headings of environmental observation and analysis planning are used as part of environmental management information systems. At the local level, natural resource management programs like Trees for Tomorrow and MIST (see Annex 1: Ranking e-Environment applications) show how the GIS tools built during the assessment phase become an integral part of on-going project management.

In the case of early warning systems, the management and protection aspects of these applications rely heavily on ICTs for both identifying events that trigger responses (based on policies set out during planning activities) and then ensuring that the responses are both timely and effective. In the case of Tsunami early warning systems, the use of SMS broadcasts over mobile telephone systems in coastal areas has become important. ICTs have been used to help identify areas at risk and to help mitigate the expected impacts in these areas. As Figure 10 shows, the death toll from hurricanes on the South Eastern coast of the USA has been dramatically reduced over the last century, most recently with the help of ICTs.

Figure 10. Impact of early warning systems on mortality - Coastal USA



This example demonstrates that although the population of the areas affected by hurricanes increased from 1900 to 2000, the death toll continued to drop due primarily as a result of improvements in early warning systems and response planning[142]. In the developing world, the example of the case of Cyclone Sidr is a good example of how a catastrophe similar to Cyclone Bhola which occurred in 1970, was averted as a result of using both formal and informal communications channels[143].

10.3. Intelligent building systems

Environmental control systems are emerging as tools that can allow remote management of human dwellings and facilities including buildings and construction sites. Intelligent building systems (IBS) integrate ICTs in their design and operation in order to manage comfort, security and costs. Using ICTs in the form of broadband cabling and wireless systems as well as networked devices and intelligent algorithms is the technological foundation for a "smart building".

This consists of a combination of networked devices such as intelligent thermostats, presence sensors, lighting sensors and controls, heating ventilating and air conditioning systems (HVAC), security, fire,

[142] NOAA, Hurricanes and Tropical Meteorology, http://www.aoml.noaa.gov/general/WWW000/nhurr00.html
[143] MeteoGroup, 22.11.07, Building a global earth observation system, http://www.meteogroup.co.uk/uk/home/weather/weather_news/news_archive/archive/2007/november/article/building_a_global_earth_observation_system.html

vibration, strain and moisture sensors, elevator and escalator control systems, and other building systems communicating over a "single broadband infrastructure"[144].

According to the US Climate Change Technology Program[145], these technologies could save more than 30 per cent of the energy costs of existing buildings and over 70 per cent for new buildings while allowing these new buildings to become net electric energy *suppliers* to the electric power grid.

10.4. Key ICTs

- The Internet and the World Wide Web;
- Broadband connectivity;
- PCs and peripherals;
- Storage devices networked and shared across organizational boundaries;
- Wireless technologies that are part of mobile communication systems to enable ubiquitous communications and tracking.

10.5. Key organizations

- Governments at all levels, including municipalities, public as well as private utility companies;
- The private sector in general and especially the transportation sector, the construction industry, the energy industry;
- People and households at the local and community level.

10.6. Key applications

ICTs for managing the natural environment

- Land, water and atmospheric use management systems. This will include systems for managing specific natural areas or ecosystems such as coasts, i.e. coastal zone management systems, mountains, etc.;
- Systems for managing natural areas: parks, reserves, etc.;
- Participatory management applications that make use of ICTs for collecting, visualizing and collective management of natural resources at the community level.

ICTs for managing the human environment

- Managing the environmental enterprise in the public and/or private sectors and beyond. This is related to e-Business and the automation of environmental business in the public and private sector, which is typically either an e-Business or e-Government issue.
- Pollution control and management systems;
- Adaptation to climate change: some of the major issues and concerns, proposed solutions, alternative scenarios and a discussion of some relevant tools and technologies including applications. This includes applications related to:
    - Zero carbon emissions based solutions;

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[144] National Research Council of Canada. 2002. *Technology roadmap for intelligent buildings*. Government of Canada. 66 pp. http://www.caba.org/trm/download.html#formtop and http://www.caba.org/trm/

[145] Government of the USA. 2003. *U.S. Climate Change Technology Program – Technology Options for the Near and Long Term* . pp. 25-27. http://www.climatetechnology.gov/library/2003/tech-options/tech-options-1-2-3.pdf

- Carbon market trading mechanisms and regimes (e.g., CDM Bazaar[146]).

- Energy and resource management systems in different sectors:
  - Enterprise and facilities management systems: building automation systems. This could be considered an aspect of adaptation to climate change;
  - Systems for managing and controlling manufacturing processes;
  - Energy generation, storage and transport;
  - Transport and warehouse management including port and airport management systems;
  - Water use and management (water utilities);
  - Land use and management (land use and registration agencies);
  - Customs management systems (a component of e-Government applications);
  - Agriculture and forestry management;
  - Reporting on compliance to conventions.
- Business process and workflow automation: e-Business, e-Commerce and e-Government solutions that reduce transaction costs and energy use and contribute to the automation and dematerialization of business processes;
- Decision support systems related to natural resource planning and management;
- Intelligent community applications
  - Smart community applications where ICTs are integrated into urban development policies, strategies and plans, which is rather related to policy than technology matters;
- A variety of sector specific applications
  - Facilities management systems including building management systems;
  - Transport management systems;
  - Energy management systems that match energy consumption with available capacity;
  - Agriculture and forestry management systems;
- Intelligent building control systems
  - Reducing energy and water consumption;
  - Utilization of environmentally friendly building materials.
- Monitoring electrical power use and matching and balancing energy utilization with power grid demand by monitoring electric use by customers in relation to power available over the electrical grid.
  - This allows for planned and controlled load shedding[147] when electric grids have to distribute load and cut power selectively to users during times of record or over peak demand;
  - Monitoring and controlling electric power grid use allowed by ICTs embedded in ambient sensors and power control devices and linked via broadband connections.

[146] See http://www.cdmbazaar.net/
[147] For definitions of load shedding, See WikiAnswers. 2008. *Q: What is load-shedding?* http://wiki.answers.com/Q/What_is_load-shedding as well as: http://www.gocolumbiamo.com/WaterandLight/Business/shedding.php and http://www.eskom.co.za/live/content.php?Item_ID=5608

- Environmental policy enforcement
  - Using environmental observation and analysis for monitoring and reporting;
  - Managing enforcement agency resources;
  - Tracking compliance with international conventions;
  - Providing reporting portals for violations (SMS, Web-based, telephone hot-line).
- Emergency response system
  - Contingency plan activation;
  - Notification of impending events;
  - Resource management during and after emergency events;
- Environmental condition reporting
  - Distributed information points (e.g., Smog Alert Panels).

10.7. Issues and trends

- The emergence of a global knowledge management practices based on extensive innovations in how ICTs and the Internet in particular are or can be used by people and organizations for all matters of human interaction. For example, an excellent introduction to the use of knowledge management tools in international development is the Knowledge for Development site with much information[148];
- ICTs imbedded in various appliances used for managing and controlling human environments and linked using wireless (RFID) and other technologies such metal cabling and fiber optic broadband: traffic control and management systems, building control systems, environmental quality monitoring and reporting systems, etc.;
- Greater use of ICT in policy formulation and for enforcement;
- More efficient resource planning for implementation and policy enforcement;
- Better reporting mechanisms for international conventions;
- Greater sensitivity and ability to predict and faster responses to environmental emergencies;
- Challenges related to adoption of technology
  - Resource training;
  - Lack of ubiquitous communication resources;
  - Cost;
  - Availability of trained personnel, including especially managers, planners and technicians.

10.8. Relevance to developing countries

- The use of ICTs for environment management and protection in many developing countries is subject to the same constraints mentioned under previous headings.
- The priority given by governments to environmental issues is a concern that affects the deployment of ICTs. In poorer countries, where the priority is poverty reduction and economic development through the promotion of pro-poor growth for example, environmental management

[148] Knowledge for Development. 2008. http://www.km4dev.org/ and related electronic distribution list: http://www.km4dev.org/wiki/index.php/Mailing_List_Environment

per se will be assigned a lower priority by national authorities as well as the international community unless it can be demonstrated to contribute directly to disaster mitigation and relief, humanitarian aid, economic development and/or pro-poor growth. However, agencies such as the GEF exist specifically to assist in this situation. Nevertheless, because the GEF relies on voluntary contributions from the international development community, funding for environmental priorities may not be as important as funding for other priority issues more directly related to poverty reduction unless the countries themselves have decided so.

- Participatory management techniques that are enhanced by the use of collaborative ICTs including the Web and increasingly web-based services have an important role to play as well. However poorer countries in particular and developing countries in general will by definition have less capacity to make beneficial use of these tools for environmental management and protection.

11. IMPACT AND MITIGATING EFFECTS OF ICTS

11.1. Overview

Life cycle assessments demonstrate that ICTs have an environmental cost and impact as a result of their manufacture, use and disposal. ICTs can also mitigate environmental impact either directly by substituting or replacing actions with digital processes that are more environmentally friendly and efficient and/or by modifying human behavior resulting in actions that reduce or eliminate environmental impact.

The potential mitigating benefits of ICT use arise primarily in transportation (both in management and reduction), energy management (in the case of server management, smart buildings, etc.), production chain efficiencies by decreasing warehousing costs, inventories, etc., and in waste reduction through dematerialization for example. However, there is a need for scientifically rigorous assessment of both the environmental impacts and benefits of using ICTs. This will include measuring the impact on and benefits to the environment of ICTs at all stages of their life cycle. This approach is based on the use of life cycle assessments (LCA) as well as the study of the secondary and tertiary or so-called rebound impacts of using ICTs.

This includes looking at the impacts of practices and technologies such as e-Business in general, including, for example, e-Commerce and e-Government in particular; telecommuting; the use of collaborative tools and technologies such as high definition videoconferencing; the impact of e-Commerce on production chain efficiencies and other transaction cost efficiencies due to the replacement of brick and mortar retail establishments with online stores, etc.

In reviewing the literature on the impact of ICTs on the environment, there are two trends that can be distinguished. On the one hand, there is an increasing amount of literature that reports on the benefits of ICTs from the perspective of ICT proponents. The results of these assessments, which are sometimes based on second hand research or on predictions, suggest that ICTs can mitigate environmental impacts, especially those related to energy consumption, GHG emissions and the use of natural resources. Some but not all of this research comes from what may be called the ICT industry as well as individuals and organizations that are very enthusiastic about the use of ICTs and that are proponents of the information society. One very prolific source of these positive assessments is the electronic mailing lists and blogs of an ICT professional and enthusiast, Bill St-Arnaud[149].

A second approach is based on primary research on the impact of ICTs on the environment. This approach is still in its infancy and results are not definitive as there has been relatively little research undertaken on this issue to date. However, this approach is not focused on demonstrating particular outcomes but at looking at the broader perspectives surrounding the use of ICTs. As such, this approach appears to be more objective and scientific. What research has been undertaken has been reviewed recently and reported on in the scientific literature as documented below.

11.2. Research on the impact of ICTs on the environment

One approach that is being used to assess the balance between positive and negative environmental impacts of ICTs involves looking at any given ICT through the lens of life cycle assessments (LCA). LCA's "…also known as life-cycle analysis, is a tool for estimating the total environmental impact of a given product or service throughout its lifespan, from cradle to grave[150]. LCA, or the extended economic or environmental input–output life cycle assessment, has been the most common method…"

[149] See http://lists.canarie.ca/mailman/listinfo/news ; http://green-broadband.blogspot.com/
[150] See also the concept of cradle to cradle, as mentioned by the Basel Convention at http://www.basel.int/meetings/cop/cop9/docs/i10e.doc

applied to the study of the impact of ICTs on the environment according to a recent review of research undertaken in this area[151].

This approach suggests that a review of the impact of ICTs on the environment is not complete without assessing and reporting on the environmental impact of ICTs throughout their life cycle, from the moment of the search for, extraction and refining of the materials used for the manufacture of ICTs, their creation on an assembly line, their marketing, inventorying and sale, to the point at which the device or technology in question is definitely removed from human use and all constituent components are safely disposed of so that they no longer represent any threat to the environment. As a result, this study will also consider in passing issues related to the environmental impact of ICT manufacturing.

According to the research review undertaken by Ly and Thomas, research on the effects of ICTs on the environment has led to the identification of "the three order effects of ICTs". These are captured in Text box 7 below.

Text box 5. The three order effects of ICTs[152]

1. First order (direct): the impacts and opportunities created by the physical existence of ICT and the processes involved;
2. Second order (indirect): the impacts and opportunities created by the ongoing use and application of ICT;
3. Third order: the impacts and opportunities created by the aggregated effects of large numbers of people using ICT over the medium to long term.

Most of the benefits of ICTs lie in the second order effects via increased efficiency, transparency, speed of transactions, rapid market-clearing, long-tail effects and so on. For instance, the average trans-Atlantic business flight uses 80,000 to 100,000 lb of fossil fuel (Cohen, 2000), which could easily be avoided by the use of teleconferencing. Most of the downsides are associated with first order: direct environmental impacts from ICT infrastructure such as resources consumption and carbon emission during manufacturing and disposal of hardware. For example, the annual material usage of a typical semiconductor (an electronic component that is essential in many electrical devices from computers to mobile phones) facility include: 832 million ft3 of bulk gases, 5.72 million ft3 of hazardous gases, 591 million gal of deionized water, 5.2 million lb of chemicals, and 8.8 million kWh of electrical power (SVTC, 2006).

The third level effects, such as increased consumption due to lower price online and taking a leisure drive after teleworking, await to be further explored due to many uncertainties involved.

This research raises several issues that were are not considered in the sometimes enthusiastic assessments of the benefits of ICT use, in the present and into the future. For example, it has been assumed that teleworking could only have a beneficial impact on the environment by alleviating congestion and reducing energy consumption associated with commuting. However, many of these studies and reports only look at one aspect of the problem. For example, as the research reviewed by Ly and Thomas suggests, there is more to teleworking than just savings gas commuting to and from work.

Other behavioral issues (sometimes called "rebound effects") also need to be taken into consideration such as alternative uses of vehicles what are not used for commuting but which may be used for other purposes that may not be accounted for in studies looking strictly at savings due to commuting to and from work. For example, teleworkers could use their vehicles for doing things such as running errands.

Another contribution of teleworkers is to the local economy. A more complete survey of teleworking and its impact has been published online as part of "An Initiative supported by the European Commission (DGXIII) as part of the Advanced Communications Technologies and Services (ACTS)

[151] Yi, L. & Thomas, H.R. 2007. *A review of research on the environmental impact of e-Business and ICT*. Environment International Volume 33, Issue 6, August 2007, Pages 841-849

[152] Yi, L. & Thomas, H.R. 2007. *A review of research on the environmental impact of e-Business and ICT*. Environment International Volume 33, Issue 6, August 2007, Pages 841-849

Programme"[153] that ran from 1996 to 2000. A report on benefits and related issues raises the point about the impact of teleworking on the local economy[154]. Flexibility Ltd., a company based in the United Kingdom, has published a briefing paper that is available online, called "ICT & Sustainability. Making work more environment-friendly and creating a better society" that looks at several issues including the impact of teleworking[155].

In 2001, the private sector and especially telecommunications service providers or operators recognized the importance promoting sustainable development in the ICT industry and together with the ITU and UNEP created the Global e-Sustainability Initiative (GeSI). Within GeSI[156], the "…Climate Change Group is working to identify the overall impact of ICT as well as initiate solutions through the development of measurement systems. Currently, the Group is developing a tool to quantify carbon credits for using Video\Teleconferencing as an alternative to business travel. Our goal is to provide an online emissions measurement tool that can be used by any individual or company to generate Offset Credits in accordance with the ISO-14064 Standard".

GeSI is also undertaking research using life cycle assessments (LCAs) to determine the environmental footprint and especially the contribution made on GHG emissions by ICTs with a focus on the members of GeSI. One of the major concerns is the actual extent of GHG emissions due to the ICT industry itself and how this can be reduced. According to Gartner, the ICT industry "…accounts for 2 % of global CO_2 emissions…", which is on par with the emissions of the aviation industry[157]. Also according to Gartner, 40 per cent of these emissions come from the operation of PCs and monitors, and 23 per cent from data centers[158]. However, emissions from data centers are rising much more rapidly[159] and represent an important challenge given rising electricity costs and concern about GHG emissions and climate change.

11.3. Main benefits of ICTs for environmental action

ICTs for mobilizing environmental action

- **Email newsgroups and the Internet are used for development networking** by concerned individuals, non-governmental organizations (NGOs) and others to participate in environmental decision-making and awareness promotion as well as environmental learning.
- Email and newsgroups were used by the international environmental movement for the first time on the occasion of the UN Conference for Environment and Development (UNCED) also known as the Earth Summit. This global conference took place in Rio de Janeiro in 1992. The Association for Progressive Communications (APC)[160], an NGO that promotes the use of ICTs for social and environmentally sound development was instrumental in mobilizing NGOs and other concerned individuals and organizations in support of sustainable development. APC used email and newsgroups to share information for this purpose. All discussions were documented and key documents shared in this way. The net result was not only more participation in this and subsequent UN conferences, but also the development of a global network of organizations that worked for sustainable development from that point onwards[161].

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[153] European Commission. European Telework Development (ETD).
[154] See http://www.eto.org.uk/faq/faq03.htm#social_bens
[155] Flexibility Ltd. 2000-2007. http://www.flexibility.co.uk/issues/sustainability/sustainability.htm
[156] GeSI. 2007. Climate change. See http://www.gesi.org/activities/introducing-the-climate-change-working-group-ccwg-.html
[157] Gartner Inc. 2007. *Gartner Estimates ICT Industry Accounts for 2 Percent of Global CO2 Emissions*
[158] HIS. 2007. *Gartner: Data Centres Account for 23% of Global ICT CO2 Emissions*. http://engineers.ihs.com/news/gartner-datacentre-co2.htm
[159] See http://www.nanog.org/mtg-0802/presentations/Snowhorn-Power.pdf
[160] See http://www.apc.org/
[161] See http://www.apc.org/english/about/history/english.shtml?cmd[384]=x-575-5320

- From 1992 to 2004, and even today in some countries such as Pakistan the UNDP Sustainable Development Networking Programme (SDNP) was instrumental in helping over 40 developing countries gain access to the Internet and to the advantages of ICTs. The SDNP was created as a support mechanism for the implementation of Agenda 21[162] and sought to facilitate access to information for decision-making and to encourage participation in the development process.
- Using ICTs for **research networking** on environmental issues.

Computational and environmental benefits of using ICTs

- **Digitization: facilitates the acquisition, storing, retrieval, manipulation, analysis and presentation** of complex environmental data and information and systems. Digitization also facilitates miniaturization of tools and technologies that sometimes would not have been possible with earlier technologies. Miniaturization reduces the need to produce and consume materials. Miniaturized components and devices are more likely to consume smaller amounts of energy by virtue of their smaller size. Miniaturized equipment, sensors and physical components may also mean that these materials also leave a smaller environmental footprint when produced and disposed of.

Text box 6. What is dematerialization?

Digitization permits what is called "dematerialization" or "e-materialization" whereby physical projects are replaced by electrons and savings in materials required for manufacturing products as well as savings in energy production and thus in the production of green house gases (GHGs). E-materialization has induced savings in paper used for letter mail and/or office correspondence, for newspapers and other print publications, and in plastic used in CDs and DVDs. In the USA, the impact of e-materialization on GHGs has been estimated (see Figure 11 below on page 73).

Source: ITU

- Digitization, miniaturization as well as increased sensitivity due to improved digital signal processing means the capacity to make use of more powerful data acquisition, broadcasting and telemetric technologies often under conditions of environmental extremes such as in depths of the oceans, in outer space or in other remote and/or extreme environments. This allows for greater coverage and accuracy in measuring a greater number and variety of environmental parameters and a faster response in disaster early warning applications.
- **Wireless technologies to connect remote users** and especially, for environmental applications, **for linking remote sensors of the environment**, for building automation, for monitoring soils and water, etc. According to Goleniewski[163], these sensors can be linked together in "wireless micromesh networks" which eliminate the need to wire all the devices and nodes and allow more flexibility in deployment of "sensor and control networks".
    - In the environmental area, "micromeshes" can be used for environmental sensing, sensing shock, vibration, thermal, optical, chemical, biological and other environmental factors"
- **Reduced energy consumption** of transistors, chips, microprocessors and LCDs (liquid crystal displays) as well as microcircuits as compared to cathode tubes and diodes and other older technologies. **Reduced use of heavy metals** such as lead used in cathode ray tubes.
- Teleworking as a way of reducing the impact of commuting and travel on energy demand and by extension on the environment.

[162] UNDP. 1999. *Sustainable Development Networking Programme. About SDNP*. http://www3.undp.org/about/
[163] Goleniewski, L. 2006. *Telecommunications essentials. The complete global source. Second Edition*. Edited by. K.W. Jarrett. Addison Wesley. 865 pp. See chapter 15.

- **Virtualization of operating systems and software applications** as a way of **reducing the demand for energy and materials** used for manufacturing computers and for increasing the efficiency of computing in general. A well-established example comes from virtualization as applied to server technology.
- Reducing energy consumption by using smart applications to control energy use over IP networks, for example intelligent building systems (IBS) as mentioned previously.

The benefits of e-Business, e-Government and e-Commerce

An integrated and functioning e-Business application or e-Government system can provide many environmental benefits to organizations whether in the public or private domain.

How do e-Business, e-Government and e-Commerce contribute to energy and natural resource conservation and energy efficiency?

- By helping to limit duplication of effort and resources;
- By sharing data and resources and by automating repetitive tasks and by centralizing tasks and services in central and/or distributed processors: data centers, common applications servers, etc.;
- By increasing the efficiency in the use of existing and/or common resources, with particular concern about computational and human resources;
- By decreasing the use of paper and contributing to dematerialization;
- By decreasing wait times and queuing;
- By limiting travel and cutting on GHG emissions;
- By reducing commuting and pollution in city centers;
- By concentrating computing resources in server or data centers.

11.4. The effect of broadband and related applications on the environment

A recent study in the USA[164] that "…investigated the use of advanced technologies, including broadband services and telecommunications technologies and their specific effects on energy use and the environment" is enthusiastic about the significant savings that broadband technologies can bring as measured in terms of reduced GHG emissions. In its summary, this report, which reviews the literature on the effects of ICTs on the environment and specifically on GHG emissions, concludes as follows:

> In summary, a review of existing literature shows that the potential impact of changes stemming from the delivery of broadband is estimated to be an incremental reduction of more than 1 billion tons of greenhouse gas emissions over 10 years. It is important to note that the promise of these advancements and their contribution to improving the environment can only be fully realized with the widespread use of broadband services by consumers and businesses. According to data for the Energy Information Administration of the Department of Energy of the US Government, carbon dioxide emissions for the year 2005 in the U.S. hover around 7.9 billion tons and are growing[165].

According to this study, the greatest potential for GHG reductions over the coming 10 years in the USA would come from the use of e-Commerce, followed by telecommuting, teleconferencing and paper reduction. "If the greenhouse reductions noted in this study were converted into energy saved, we forecast that IT applications could save 555 million barrels of oil by year, or roughly 11 per cent of

[164] Fuhr, J.P. and Pociask, S.B. 2007. *Broadband services: economic and environmental benefits*. The American Consumer Institute.
[165] Idem and US Department of Energy. http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/ghgeuse_table.pdf

the oil imported into the USA today". Figure 11 below shows the estimated reduction in GHG emissions as a result of broadband related technologies in the USA.

Similar conclusions were reached in another report on the role of ICTs and broadband on GHG emissions and climate change commissioned by Telstra, the incumbent Australian telecommunications operator[166]. The Telstra report states that according to a survey of Australian businesses, their ICT use amounts to 7.9 Megatons of CO_2 equivalent or roughly 1.4 % of national emissions.

ITU has also published a summary document on this topic entitled "ICTs and Climate Change"[167].

[166] See Climate Risk Pty. 2007. Towards a High-Bandwidth, Low-Carbon Future: Telecommunications-based Opportunities to Reduce Greenhouse Gas Emissions. Fairlight, Australia. 109 pp. http://www.climaterisk.com.au/wp-content/uploads/2007/CR_Telstra_ClimateReport.pdf

[167] ITU. 2007. *ICTs and Climate Change*. ITU-T Technology Watch Briefing Report No. 3 (Revised, December 2007). 10 pp. http://www.itu.int/ITU-T/techwatch/index.html and http://www.itu.int/oth/T2301000003/en

Figure 11. Estimated reduction in GHG emissions for given broadband applications in the USA

Study Summary

Reductions in Greenhouse Gases for Select Activities (Millions of Tons)

Area of Technology Replacement	Current Annual Savings	Forecast Incremental (10-year)
E-Commerce Green Effects		
• B2B and B2C	37.5	206.3
• C2C	N.A.	N.A.
Telecommuting Green Effects		
• Direct Effects from Driving	45.0	247.7
• Indirect Effects from Congestion	4.8	N.A.
• Office Space Not Built	28.1	28.1
• Saved Office Space Energy	56.8	312.4
Teleconferencing		
• Business Air Travel	36.3	199.8
E-Materialization		
• First-Class Mail	1.4	7.3
• Plastic CDs	0.5	2.5
• Newspapers	7.9	57.4
• Office Paper	2.9	N.A.
• Paper used in Households	0.7	N.A.
Tele-Medicine		
• Home Nurse Visits	1.6	N.A.

N.A. – Estimate not available

Source: Fuhr, J.P. and Pociask, S.B. 2007. *Broadband services: economic and environmental benefits*. The American Consumer Institute and and US Department of Energy at http://www.eia.doe.gov/oiaf/1605/ggrpt/pdf/ghgeuse_table.pdf

11.5. Using ICTs to reduce GHG emissions and contribute to sustainable development

One of the first and seminal publications to our knowledge that deals with the relationship between ICTs and the environment was published in 2002 by the Swedish office of the WWF, the global conservation organization. This publication is the result of an initiative known as "Sustainability at the speed of light"[168].

One of the key observations made in this publication was that as "…traditional manufacturing and commercial companies put their supply chain on the Internet, and reduce inventories, overproduction,

[168] Pamlin, D. ed. 2002. *Sustainability at the speed of light. Opportunities and challenges for tomorrow's society*. WWW Sweden. Solna, Sweden. 202 pp.

unnecessary capital purchases, paper transactions, mistaken orders, and the like, they achieve greater output with less energy consumption". This has resulted in reduced "energy intensity"[169],[170].

According to Romm, the author of the chapter on the energy economy and a specialist in energy efficiency, the Internet contributes to greater energy efficiency as measured in terms of electrical power consumption per unit of work performed and some of this efficiency means reduced environmental impacts and reduced green house gas emissions.

Romm states that the Internet contributes to efficiency as well as structural gains in the economy and that these gains can be broken own as follows:

- Efficiency gains come when a company uses ICTs to more effectively manage its supply chain;
- Structural gains come from companies that use the Internet to limit inventories and the use of warehouses or when companies place their stores on the Internet rather than constructing retail facilities.

Examples cited in the report include:

- Between 1990 and 1998, Dell computer moved many of its operations to the Internet and increased sales 36 fold while its physical assets rose by only a factor of four.
- IBM uses the Internet to link all of its production facilities to find out beforehand the availability of production facilities and to shift production accordingly. By mid-1998, the reduced investments and operating costs had saved the company USD 500 billion.
- Home Depot uses information technology and the Web throughout its supply chain to largely bypass the warehouse: 85% of its merchandise moves directly from the manufacturer to the storefront.
- A process called Collaborative Planning Forecasting Replenishment (CPFR) makes use of the Internet to improve forecasting and restocking. *Ernst & Young has estimated that CPFR could lead to an inventory reduction of $250 billion to $350 billion across the economy, roughly a 25% to 35% cut in finished goods inventory across the supply chain.*
- Many companies are reducing office space as more and more of their sales force becomes mobile and works from places others than the office, including their homes. The author estimates that this could avoid the need for up to 5 per cent of the total retail space in the USA as well as eliminating much commercial office space.

In summary, "…if U.S. manufacturers of durable goods today held inventories at the 1988 inventory to sales ratio, they would be holding an additional $115 billion in inventory. This represents $115 billion in durable goods that were not manufactured, even as output and GDP soared. This means saving the enormous energy required to make, move, and store $115 billion worth of goods. Clearly, if we continued to have significant GDP growth without significant inventory growth, that would suggest that our energy intensity gains will continue. If indeed the Ernst & Young estimate is correct, then we have not even achieved half of the inventory savings that the Internet economy will ultimately make possible".

The report adds weight to the observation that ICTs enhance business process efficiency to such an extent that the contributions to energy efficiency and sustainable development are highly significant.

A subsequent publication "Saving the climate @ the speed of light"[171] was the result of collaboration between the WWF, the global conservation organization and of the European Telecommunications Network Operators' Association (ETNO).

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[169] Energy intensity: The ratio of energy consumption to a measure of the demand for services (e.g., number of buildings, total floorspace, floorspace-hours, number of employees, or constant dollar value of Gross Domestic Product for services). http://www.eia.doe.gov/emeu/efficiency/ee_gloss.htm

[170] Romm, J. 2002. *The Internet and the new economy*. in *Saving the climate @ the speed of light.* p 30-52.

The European Union (EU) has a strong commitment to reducing GHG emissions and meeting the obligations of the signatory states under the Kyoto Protocol. According to this report, the EU "…has affirmed that at least a 15-30 % cut in green house gas emissions by 2020 will be needed to keep the temperature increase under 2 º C, and a deeper reduction of 60-80 % may be needed by 2050". In the EU, the ICT industry has paired up with WWF, an international NGO headquartered outside of Geneva with many national chapters around the world, to develop a strategy to reduce CO_2 emissions. The strategy sets ambitious targets over two time frames. The first steps are to be taken up to 2010 and aim for a reduction of 50 million tons of CO_2 per year through the use of ICTs to the year 2010. In phase 2 of the proposed strategy, a new target will be set that will "…include new services and system solutions, where a number of services are combined".

The report suggests that the ICT sector can provide leadership because it is used "…to rapid change and has many of the most innovative people in the business sector, and a unique service focus".

The report recognizes that ICTs impact the environment in three ways: direct, indirect and systemic.

Direct effects of ICT use:

- Direct effects are caused by ICT infrastructure and equipment, i.e. resource and energy consumption during the production or manufacture of ICT equipment;
- The energy consumption when using ICT;
- The effects of electronic waste that result from ICT production, use and disposal.

Indirect effects of ICT use

- Effects resulting from the use of ICTs can be both positive and negative. For example, the reduced need for transportation as a result of teleconferencing, or the increase transportation in just-in-time deliveries due to B2B applications, are examples of secondary effects.

Systemic effects of the use of ICT

- These are largely behavioral effects that humans develop as a result of ICT use. "They stem from new habits, social structures and consumption patterns that arise through the use of communication products, applications and services when they are used in society, such as the change in commuting distances and times due to potential mobile communication, access to information and the speed of technological development"[172].

Systemic effects are also called "rebound effects" by some analysts.

The strategy calls for using ICTs to contribute to reducing environmental impact by encouraging the following:

- Travel replacement using technologies such as videoconferencing and audio-conferencing, tele-education, tele-medicine, tele-care/remote assistance services, flexi-work, intelligent living: flexible car ownership, e-Commerce, e-Government and e-Business in general;
- Reducing energy and material consumption
  - Intelligent building design;
  - Intelligent building management including controlling the internal environment (heating and air or climate conditioning) of buildings through the use of intelligent building system (IBS);

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[171] Pamlin, D. Szomolanyl, K. 2006. *Saving the climate @ the speed of light. First roadmap for reduced CO2 emissions in the EU and beyond*. WWF. European Telecommunications Network Operators' Association (ETNO). 40 pp.
[172] Idem.

- e-Commerce, e-Government and e-Business in general which enhance process efficiency;

- De-materialization: virtual answering machines, online billing, web-taxation, video on demand, music on demand;

- Virtual meetings that could reduce CO_2 emissions by around 24 million tonnes / year. This would include audio and visual conferencing applications in lieu of travel.

The report acknowledges that taking these steps requires policies that are supportive. The report groups these interventions under various headings, including sustainable consumption, sustainable production and sustainable community / city planning including travel replacement. All of these recognize the need for concerted policy action. The concept of the "sustainable city" is mentioned as one where decision-makers agree on policies that would encourage behavior that is environmentally sustainable through the intelligent use of ICTs that reduce environmental impact.

While the ETNO report proposes in general terms actions that need to be taken, a further report is actually an outline proposal for a sustainable e-strategy that the government of Sweden may wish to take into consideration[173]. This outline strategic plan proposes an approach to ICT use that will result in measurable changes that are supportive of the principles of sustainable development.

The strategy proposes actual concrete steps that could be taken to reduce environmental impacts through the increased and intelligent use of ICTs. However, the report also looks at the downside of using ICTs and make recommendations accordingly. The report states rightly that using ICTs has several direct and indirect effects over different time horizons and suggests that these need to be better researched before coming to a decision or reaching a conclusion about the impact of ICT use in government or in organizations in general.

Of particular interest in this document is that it adopts a strategic planning approach and proposes principles of ICT use that will serve as an example and best practice that other jurisdictions may also want to consider when developing e-Environment strategies. Some of the practical steps that can be taken by all countries that are cited in this report are reproduced below (see Text box 7 below).

Some of these advantages have already been recognized. E-Government is considered to be successful inasmuch as it enhances service delivery to the end user or client, i.e. the public[174]. The important point to make here is that the advantages of e-Business in general and e-Commerce and e-Government in particular are not only due to the fact that they increase the efficiency of business processes *per se*, but that they transform the way people work and live.

Most e-Government strategies and action plans however don't measure their success in terms of environmental impact and sustainability. There are few if any environmental indicators of success in the log frame analyses undertaken when e-Government projects are planned and success factors taken into consideration or when results based management (RBM) exercises are applied. The same can probably be said for e-Business planning in the private sector. An exception occurs in the case of environment or sustainable development specific projects and activities. As mentioned previously, poverty is the focal point of development action and EIAs are undertaken at the planning stage, not after and not as part of the assessment phase or as part of monitoring and evaluation activities post facto. This has to change in order for environmental mainstreaming to be effective and a reality.

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[173] Pamlin, D. & Thorslund, E. 2004. *An outline for a sustainable e-strategy - Sweden and a central issue for the future. IT Forum Mislo*. 35 pp. (originally published in Swedish). http://www.pamlin.net/written/documents/An%20outline%20for%20a%20sustainable%20e-strategy%20for%20Sweden.pdf

[174] Accenture. 2007. *Leadership in customer service: delivering on the promise*. Government Executive Series. 128 pp. http://www.accenture.com/Global/Services/By_Industry/Government_and_Public_Service/R_and_I/DeliveringontheePromise.htm

This applies to organizations, companies and governments in developed as well as in developing countries, which have adopted e-Business or e-Government strategies and plans. What is clearly needed is for these strategies and action plans to consider environmental sustainability at all stages of the project life cycle.

Text box 7. Some practical components of an e-Sustainability or e-Environment strategy

1. Shift focus from products to services

IT generates new solutions that allow previous needs to be met in completely new ways, and the new environmentally friendly solutions should be encouraged. Laws and taxes should be reviewed…since this change in perspective will cause the focus to shift from physical space and products to services and the web. An area that should be prioritized is public procurement, since strategic assistance could be a key instrument, particularly for the procurement of services. For instance, meeting service could be purchased instead of travel. This could mean replacing leasing cars with integrated solutions for flexible work comprising cars, car pools, home workplaces, video conferencing systems, etc. Naturally, the same type of solutions can be introduced by individual big companies, where innovative purchasing choices could significantly boost leading-edge markets.

2. Highlight the environmental benefits of the use of all major IT investments

Today's major IT-related initiatives (e.g. the 24-hour Authority (24-timmarsmyndigheten) and various IT-related services) include little or no integration of environmental issues. Similarly, when telephone and videoconferences are used, the participants are rarely made aware of the enormous environmental gains this type of solution offers. Actors should be encouraged or obliged to report the environmental gains – or losses – generated by different IT solutions, as well as various types of related repercussions. A study of how environmental information can be gathered, analyzed and reported in various organisations should be prioritized as a preparatory step in implementing this measure.

3. Reduce rebound effects and calculate total gains

Finding completely new methods to meet needs often has both positive side effects and rebound effects (negative side effects). While it is crucial to seek new solutions that dramatically reduce environmental impact, the environmental benefits of isolated efforts are often cancelled out by various indirect rebound effects. For instance, a transition to ecommerce could significantly reduce resource consumption, but this requires changes in transport systems, partial decentralization of products, reduced consumption of physical products and increased use of experiential services. Without a comprehensive vision that coordinates various investments, control instruments and laws, the various improvements could lead to binding investments in sub-optimized systems that do not promote sustainability. Consequently, a comprehensive, coordinated strategy combined with long-term research should be prioritized.

4. Parallel time horizons

IT often contributes to increased efficiency, faster decisions and faster product turnover. This frequently prevents long-term considerations from being prioritized. Finding ways of integrating various time horizons into decision-making at all levels will therefore be a central concern for both politicians and business owners. For instance, the issue of long-term reductions in carbon dioxide emissions should be taken into account when deciding on measures to strengthen export. Similarly, the issue of long-term resource consumption and emissions should be integrated into infrastructure planning. The political considerations when dealing with conflicting objectives should be clearly explained.

Source: Pamlin, D. & Thorslund, E. 2004. *An outline for a sustainable e-strategy - Sweden and a central issue for the future. IT Forum Mislo*. 35 pp.

11.6. Deleterious impacts of increased use of ICTs on the environment

Heavy metal pollution

In the manufacturing of ICT equipment, there is reliance on the use of heavy metals (Cd, Cr, Ag, Pb, Hg, Ga, Ge, Sn, Hf and Au) for their conductive, metallurgical and other properties consistent with ICT component design. Many of these metals, which are usually sequestered in mineral deposits and not naturally present in the environment, are highly toxic (Cd, Pb, Ag, Hg) and present a grave threat to human health and to ecological and living systems in particular when released into the environment in the form of biologically active chemical compounds as a result of unsafe extraction, use and/or disposal.

The ICT sector is responding to the concerns of the public and of regulators, and green computing is increasingly catching on.

Energy cost of using ICTs

The Internet can have a beneficiary effect on energy consumption and can also help reduce the overall impact of human activity on the environment as indicated above. But the Internet also requires energy for its operation.

A study of the energy consumption of the Internet in the USA and worldwide has been attempted using available data[175]. According to D. Sarokin who undertook the research, the Internet is estimated to make up 9.4 % of total US electricity consumption and 5.3 % of global electricity consumption. Table 2 on page 78 shows the figures.

Reducing the overall use of the Internet and related technologies, for example server farms, by turning them off when not in use and/or by using virtualization technologies when appropriate (to replace servers with virtual machines) will reduce the demand for electricity associated with the use of these technologies.

One other source of energy wastage comes from PC power supplies that have traditionally operated at between 65 to 75% efficiency. The idea is to replace these with more efficient power supply units that operate at over 80 % efficiency with the objective of achieving 90% operating efficiencies at different load levels. The 80 PLUS programme has been put in place in the USA by electric utilities and appears to be a voluntary programme to reduce the energy consumption of PC power supplies[176].

Table 2. Annual electricity use of the Internet: US and World

	US Consumption (Billion kWh)	World Consumption (Billion kWh)
Data Centers (includes cooling)	45	112.5
PCs & Monitors	235	588
Modems/routers/etc.	67	167
Phone network	0.4	1.0
TOTAL ELECTRICITY DEMAND OF THE INTERNET	~350 billion kWh	~868 billion kWh

11.7. The trend toward increasing ICT energy savings and e-Waste reduction

Similar to other industries, the manufacturers and operators of ICTs are looking at opportunities to reduce their direct environmental impact and specifically the energy cost of using and operating ICTs. According to Business Week[177], Google's "…energy bill for servers now exceeds the cost of the equipment. With 100,000 servers, Google's electricity bill probably tops $50 million a year".

[175] Sarokin, D. et al. 2007. *Energy use of the Internet*. An online presentation of research results and ensuing discussion on the assumptions behind and validity of such a study and the figures presented by Sarokin. See http://uclue.com/index.php?xq=724

[176] 80 Plus. 2008. *Energy-Efficient Computers Run with 80 PLUS® Certified Power Supplies*. http://www.80plus.org/index.htm

[177] Business Week. 2006. *Inside Intel*. Cover story. January 9, 2006. http://www.businessweek.com/magazine/content/06_02/b3966001.htm

There are two trends in the ICT industry over the last few years that merit examination:

- Trends to shortened life cycles that result in more toxic waste created in both network and user terminal equipment;
- The increasing energy demands of ever growing data centers in terms of consumption by hardware itself and the costs to cool the equipment.

According to the US EPA, more than 4.6 million tons of e-waste ended up in US landfills in 2000. The trend to shortened life cycles is not unique to ICTs and applies to all electronics equipment. However, as devices and services blend into an interconnected network, traditional devices such as cameras and music players have become ICT devices.

For developing countries such as China and India, the hazards associated with e-waste have become even more critical as they become the dumping grounds used for sorting and extracting raw materials. In the core of networks, the trend to shorter life cycle has been observed with life cycles of 25 years common in equipment prior to the 1970s, but with life cycles in the 3-10 year range today.

There have been efforts to reduce toxic waste created by electronics goods, and the European Union Environmental Directive (EUED) initiative for the Restriction of Hazardous Substances (RoHS) has had a global impact on the use of toxic materials such as cadmium and mercury in the manufacture of goods. Many manufacturers in the ICT industry have discontinued the use of these materials rather than support separate product lines for European customers.

Similarly, the electronics manufacturers that were responsible the production of a large portion of the chlorinated fluorocarbons (CFCs) effectively eliminated these products when the impact on the ozone layer became apparent in the 1980s.

In step with the increased ubiquity of ICTs, component power consumption has rapidly risen from the days when a fixed line phone was a passive device powered remotely during use only. In the central part of the network, although the absolute power consumption has increased, many metrics for power efficiency have shifted to relative power consumption (Watts per Gbps for example).

Particular concern relates to computer data & search centers, which have very demanding requirements for air-conditioning, electricity supply and back up. It is estimated that the five leading search companies use some two million servers[178]. The total power required to run and cool these data and search centers amounts to around 5 GW and represents some 30 per cent of their total costs. It is no surprise that search service companies have a vested interest in energy efficiency and consumption are branching out with investments in renewable energy.

For developing countries with irregular power supplies, the requirements for fully independent power systems and the associated maintenance and capital costs must be factored in also. For example, on the occasion of a meeting of the parties of one of the major environmental conventions in the very recent past, establishing what amounted to a large data centre for participants at a developing country venue resulted in local blackouts and called for the help of the national power utility to guarantee sufficient electrical power would be available to allow the conference to take place.

[178] See footnote 159

Text box 8: Next Generation Networks

There are some signs that controlling energy consumption may be possible in the future and the telecommunications industry is currently undergoing a major revolution as it migrates from today's separate networks (for voice, mobile, data etc) to a single, unified IP-based next-generation network (NGN). It is estimated that the energy consumption of an NGN will be 40 per cent lower than today's PSTN (Dittberner Associates) and this could be further reduced. The savings will be achieved in a number of ways:

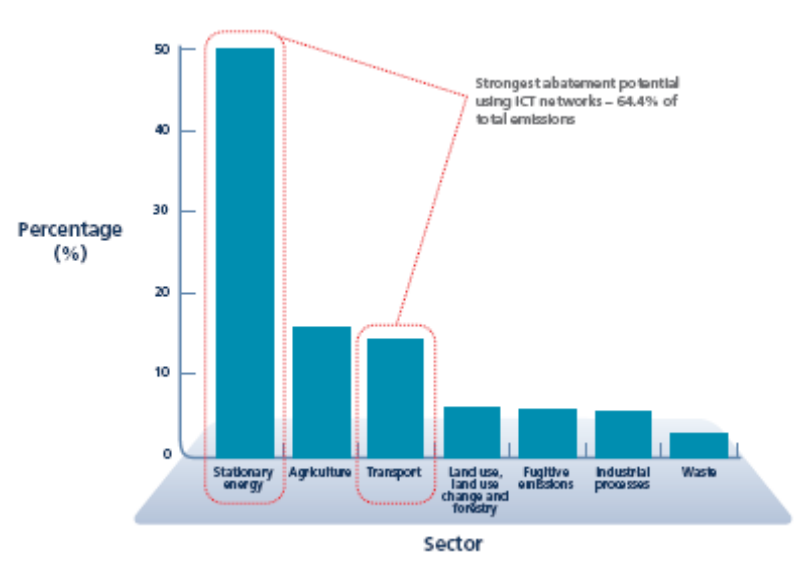
- A significant decrease in the number of switching centres. For instance, BT's 21st Century Network (21CN) will require only 100-120 metropolitan nodes compared with its current 3,000 locations;
- More tolerant climatic range specifications for NGN switching locations, which are raised from 35 degrees (between 5 and 40°C) to 50 degrees (between -5 and 45°C). As a result, the switching sites can be fresh-air cooled in most countries rather than requiring special air conditioning.
- NGNs may make use of more recent standards, such as VDSL2 (ITU-T G.993.2), which specifies three power modes (full, low-power and sleep), whereas VDSL has only a single power mode (full power).

Sources: Adapted from various sources including Young (2007)[179], Schiwy (2005)[180] and AMD[181].

According to a recent and independent report[182] commissioned by Telstra, the incumbent telecommunications operators in Australia, the greatest "…carbon opportunities for telecommunications networks…" or potential for reducing GHG emissions from the use of ICTs comes from stationary energy, agriculture, transport and other activities as shown in Figure 12.

[179] See Young, S. 2007. *Climate Change and ICT*, presentation made at "Effective IT Summit", Cardiff, United Kingdom, 24 January 2007, available at: http://www.effectiveit.com/__data/assets/pdf_file/0015/171402/Stephen_Young.pdf.
[180] SwissCom and T-Com. 2005. *Energy optimization in the anticipated NGN switching*. available at: http://re.jrc.cec.eu.int/energyefficiency/pdf/Workshop_May.2005/Broadband%20comunication/Schiwy.pdf
[181] For more information on the Green Grid consortium, See http://www.thegreengrid.org/
[182] Climate Risk Pty. 2007. Towards a High-Bandwidth, Low-Carbon Future: Telecommunications-based Opportunities to Reduce Greenhouse Gas Emissions. Fairlight, Australia. 109 pp. http://www.climaterisk.com.au/wp-content/uploads/2007/CR_Telstra_ClimateReport.pdf

Figure 12. Breakdown of Australian energy emissions by sector



Source: Climate Risk Pty. 2007. Towards a High-Bandwidth, Low-Carbon Future: Telecommunications-based Opportunities to Reduce Greenhouse Gas Emissions. Fairlight, Australia. 109 pp. http://www.climaterisk.com.au/wp-content/uploads/2007/CR_Telstra_ClimateReport.pdf

In a recent article, PC World Canada summarized the trend in using green components in PCs and what the consumer should look for in a "green PC" (the following excerpted from the PC World article[183]):

- The biggest environmental offender in a PC system is the CRT monitor - those old heavy cathode ray tube monitors. Most are full of deadly lead, mercury, barium, cadmium and phosphorous. Similar sized flat LCD screens burn half as much energy and are free of the exotic toxins.
- PC power supplies used to run full tilt whether or not they needed to. A new initiative called the 80 Plus Program certifies lead-free power supplies designed to deliver only the power called for at the moment.
- High performance graphics cards can actually draw more than three times the power of a CRT monitor. Gaming may be fun, but it's an environment killer.
- CPUs are traditional power-drainers. Still, new processors use much less energy yet run faster than earlier chips.
- New variable speed CPU fans are available that work only as hard as necessary to keep CPUs cool. Additional heat sink features increase efficiency.
- SATA hard drives being used now are lead-free and energy efficient, with single instead of multiple platters to decrease the eventual discarded hazardous waste.
- Motherboards are also being developed that are lead-free, consume less power and eliminate the need for graphics and sound expansion cards because they're already integrated into the board.
- Today there are also lead-free DVD/CD drives available.

[183] Agerbo, M. 2008. Saving your business money...and the environment with Green PCs. http://www.pcworld.ca/news/column/239128d10a01040801c09d0275db0bed/pg0.htm

- Avoid getting too much RAM – even of the lead-free variety. Users may never need the extra module, and avoiding it keeps energy waste down.

11.8. Greening ICTs

A recent report suggests that there is still some way to go before the ICT industry fully integrates the concept of environmental friendly decision making. According to a recent survey of 337 IT professionals undertaken for eWeek magazine[184], only 34 per cent of respondents reported that their company has a green initiative. However, immaterial of whether companies have a green imitative or not, 70 per cent of respondents reported that they were either replacing or planning to replace equipment with newer energy efficient equipment. The most prevalent technologies are server consolidation and server virtualization with 70 per cent of respondents saying they have implemented virtualization or plan to.

In one company, the intention is to "…shrink the server population from 40 to perhaps a dozen. The main business benefit of concentrating servers is scalability, green IT is a byproduct". "Most business aren't about to spend more money for eco-friendly IT measures. They will do so only if the payback is there." However, for companies such as Google that have an active green initiative in the form of a "…major solar power initiative to run its myriad servers…", only 30 per cent of Google's power demands will be met in this way and the payback period is expected to be 7.5 years.

11.9. Sea water, virtualization and solar power?

Still, data centers are making such demands on energy that some companies including one California based "…company is retrofitting cargo ships docked at major urban facilities to act as data centers…" and using sea water to cool the server rooms[185]. Another solution has been adopted by a company that has built a made-to-measure energy efficient building to house its data center and that also makes use of server virtualization and uses solar energy to power all operations. Virtualization is run on a 30/1 ratio of virtual servers to physical servers[186].

Solar energy may be an important alternate source of energy for ICTs, and solar energy conversion or efficiency rates are now approaching 10% using an industrial production processes that can mass produce the solar modules in thin films.

Recent development in solar voltaic technology in the form of increasing efficiencies of conversion and falling production costs suggest that there may a future in solar as an alternate source of power for the ICT industry and ICT users and indeed and eventually, for consumers. This is especially so in jurisdictions where government subsidies exist for alternate source of energy, as is the case in the European Union and Germany, in particular, where renewable energy generated 14 % of the country's electricity in 2007.

Germany is expending significant efforts and lots of taxpayer money to attract investment in renewable energy[187]. Already, renewable energy technologies make up 4-5 % of Germany's gross domestic product with figures expected to rise to 16 % by 2025. Germany has created 240,000 jobs in the renewable energy industry. Germany is now turning to photovoltaic (PV) industry and is offering big incentives in the form of co-financing and loans as well as grants to attract companies in this sector. Turnover in the solar technology sector has risen from 450 million to about 4.9 billion € over

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[184] Gibson, S. 2008. *How green is your IT valley?* eWeek. Vol. 25, No. 3, 46-53. http://www.eweek.com/c/a/Infrastructure/How-Green-Is-Your-IT-Valley/

[185] Lundquist, E. 2008. *Working in the cloud. Remote access helps employees weather the storm*. Idem. p. 55. http://www.eweek-digital.com/eweek/20080121_stnd/?pg=56&u1=texterity&cookies=1

[186] Preimesberger, C. 2008. Solar power brings green payoff. Idem. p. 53. http://www.eweek-digital.com/eweek/20080121_stnd/?pg=56&u1=texterity&cookies=1

[187] Reguly, E. 2008. *Lessons from Germany's energy renaissance*. March 22, 2008. The Globe and Mail. Report on Business Weekend. P. B4. See http://www.theglobeandmail.com/servlet/story/LAC.20080322.RCOVER22/TPStory/?query=eric+reguly

the past 6 years and around 50,000 people were employed in the sector in 2006[188]. First Solar has taken advantage of this policy to establish plants in Germany.

Reports about the potential that solar represents are worth paying attention to. In order to reduce costs and offset GHG emissions, one solution being considered by some companies[189], is locating data centers in Iceland in order to take advantage of plentiful, inexpensive and green renewable energy in the form of geothermal power. The government of Iceland has recognized this opportunity[190] and is undertaking a feasibility study[191] to assess this possibility.

The government of Iceland is taking this opportunity seriously. It has commissioned a major submarine fiber upgrade to deal with a perceived lack of backbone capacity to make the idea of locating data centers in Iceland more attractive[192]. If Iceland can do it, then so can other jurisdictions and this may be of relevance to other countries such as those in the Rift Valley of Africa where the proximity to geothermal supplies could encourage similar ventures.

11.10. Key ICTs

- More efficient transistors and microprocessors;
- Energy-efficient electronic components that function at higher temperatures;
- Next generation networks (NGNs).

11.11. Key organizations

- Environmental Agencies such as the European Union Environmental Directive (EUED) as well as countries of the European Union including especially Germany;
- Local ICT organizations and institutions (PTTs and ISPs);
- Equipment manufacturing associations;
- International standards organizations such as the ITU;
- Local as well as international building associations and associations of architects: the International Chamber of Commerce[193].

11.12. Key applications

- Manufacturing techniques that reduce and/or eliminate hazardous substances;
- VoIP and video-conferencing tools;
- Virtual presence tools;
- Telecommuting and teleconferencing capabilities;
- Telepresence technologies;

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[188] Germany. Federal Ministry of Economics and Technology. *Solar power*. See http://www.german-renewable-energy.com/Renewables/Navigation/Englisch/solar-power,did=109916.html
[189] Libbenga, J. 2007. *Microsoft and Cisco eye Iceland for green server farms*. The Register. April 10, 2007. http://www.theregister.co.uk/2007/04/10/iceland_to_power_server_farms/
[190] Invest In Iceland Agency. 2007. *Iceland ideal for data storage centres*. July 3, 2007. http://www.prlog.org/10022675-iceland-ideal-for-data-storage-centres.html
[191] Invest in Iceland. 2007. *Benchmarking study on Iceland as a location for data centre activity. A green window on the world*. 10 pp. http://www.invest.is/resources/Files/invest.is/Extract%20DCR.pdf
[192] Hibernia Atlantic. 2007. *Hibernia Atlantic will construct a new submarine cable connecting Iceland directly to North America and Europe*. Aug. 9, 2007. Press release. 2pp. http://www.hiberniaatlantic.com/documents/8607-IcelandPR-JSAFinal.pdf
[193] See http://www.iccwbo.org/

- Building management technology as applied to data centers;
- More efficient power supplies in PCs and peripherals.

11.13. Issues and trends

- Conflicting analysis on the benefits of ICTs versus the impact;
- Shortened product lifecycles leading to greater e-waste;
- Awareness of the impact of ICTs on the environment is emerging within the industry;
- Zero carbon footprint activities;
- Relocation of data centers and energy intensive ICT industries to cheap, green and fiber connected energy sources located close to key markets.

11.14. Relevance to developing countries

- Rapidly developing countries such as China and India are becoming both the manufacturing and recycling centers for electronic goods. The impact of manufacturing processes and e-waste are being concentrated in these countries.
- The later adoption of technology presents both challenge and opportunity in maximizing the lifecycle of technology.

For another less scientific but very public opinion on the impact of various consumer goods on the environment, the following video clip http://www.storyofstuff.com/ has been produced with the support of the Tides Foundation of the USA and the Funders Workgroup for Sustainable Production and Consumption. Tides was instrumental in the creation of the Association for Progressive Communications (APC), a global initiative for using the power of the network for social and community development (www.apc.org) that operates with success in many developing countries and has done so since the 1980s.

12. ICTs FOR ENVIRONMENTAL MANAGEMENT CAPACITY BUILDING

Environmental capacity building: the end results of any efforts to improve environmental conditions rely on the actions of individuals and organizations in order to be fully effective. Capacity building includes efforts to increase public awareness of environmental issues and priorities, the development of professionals involved either directly or indirectly in the environment, as well as integrating environmental content into formal education.

12.1. Overview

In many developing countries, environmental management is tied to livelihoods. In rural areas, people live off the land and/or the water in coastal areas. Agriculture in many of these countries or regions is or has been in the past the mainstay of the economy and the most important means of production.

Many people and communities that rely on subsistence livelihoods live in areas of great environmental risk. The land may be marginal and/or the weather patterns may be unpredictable and/or severe weather and/or seismic events may continuously threaten their existence.

ICTs can be used to help people cope with the environmental challenges. Help can take the form of agricultural extension programmes, disaster early warning systems assisted by national and community radios, mobile phone networks and appropriate programming and services as well as other ICTs. These programmes provide access to information about disaster avoidance and mitigation as well as appropriate environmental management practices in general. This can include information about the weather, about sustainable forms of land use management such as agroforestry and other forms of sustainable agriculture and natural resource management as well as information about market and agricultural commodity prices.

Access to the right information is a means of local and community empowerment and helps people enhance their capacity to sustain themselves. Information becomes a factor of production. ICTs have an important role to play here. But ICTs can only be used for beneficial effect if people know about them and how to use them.

Some of the ICTs mentioned above are vehicles to help raise environmental awareness and mobilize action. Similarly, ICTs are used for more formal education and learning activities in the form of SchoolNet, computers in schools and related programmes and activities.

12.2. ICTs in education about the environment

ICTs have been and continue to be used to an ever increasing extent in education and learning. **Computer aided learning** focuses on the use of ICTs for enhancing the learning experience. **Distance learning** has also been enhanced as a result of ICTs. The educational and learning sector in many countries uses ICTs as a basis for marketing a plethora of learning and educational products and services to users around the world. These include distance based degree programmes of various sorts.

Many universities have distance learning programmes, activities and courseware that are marketed and sold or otherwise made available using the Internet. Learning is in some cases enhanced through the use of ICTs and especially the Internet or offered completely online using multimedia tools and technologies for learning and interaction with teachers and classmates. One of the best known learning offerings with a focus on the developing world is the “Cisco Academies” that promote learning about networking tools and technologies. Cisco Academies use computer enhanced teaching for course offerings and the Internet and appropriate software for examinations[194]. There are Cisco Academies

[194] Cisco. 2007. *Training resources. Academy connection*. 1999-2007. http://www.cisco.com/web/learning/netacad/index.html

around the world including especially in many countries of the developing world. 33 less developing countries participate in the Academy as of early 2008, according to Cisco[195].

For a useful source of information in French (mostly) and English (translated from the French but still an excellent source of information about online training as well as online courseware and offerings), visit the site maintained by Thot Cursus Inc. : http://thot.cursus.edu/infos/contact/. For courses and other online offerings and educational resources, search for "environment" using the search engine of the Thot/Cursus site.

In the area of environmental distance learning and courseware, there are undoubtedly offerings. The relevance of these tools for users in developing countries may be limited to those who can afford to pay the sometimes significant fees for online registration and online participation and attendance. The cost of accessing the Internet is another factor. However, there are online learning providers that are freely available for users in the developing world. Some of these are described below.

12.3. Online and digital learning about the environment

The United Nations University, in collaboration with UNEP and the "…UNU-GVU Consortium in Education for Sustainable Development partners cooperate in the development and implementation of online study programmes, short courses and modules that are designed to serve the needs and enhance the capacities of academic institutions in developing countries in the field of education for sustainable development. Partners are expected to share expertise on pedagogical approaches, content and instructional design methodologies, course implementation, quality assurance, and course evaluation. The partners currently are Agder University College (Norway), Kwame Nkrumah University of Science and Technology (Ghana), Makerere University (Uganda), and the University of Pretoria (South Africa)"[196].

The sharing of courseware and other online learning materials has been enhanced by the creation of the "OpenCourseWare Consortium" which promotes OpenCourseWare, which is "…a free and open digital publication of high quality educational materials, organized as courses. The OpenCourseWare Consortium is a collaboration of more than 100 higher education institutions and associated organizations[197]".

The UNU offers several courses on the environment as OpenCourseWare[198]. There are several virtual universities that have come together to provide learning via the Internet, e.g. a Canadian Virtual University that is a partnership of universities across Canada. Similar models exist elsewhere including in Hong Kong. A Syrian Virtual University and a Virtual University of Pakistan exist with the assistance of the government.

The Agence Universitaire de la Francophonie (AUF) supports online learning about the environment[199] in francophone Africa as well as the use of ICTs in support of higher education and research[200]. Several francophone universities benefit from these services.

The African Virtual University (AVU)[201] "…is a Pan African Intergovernmental Organization whose aim is to significantly increase access to quality higher education and training through the innovative use of information communication technologies. As an African organization, the AVU has a mandate to increase access for tertiary education and training using Open Distance and e-Learning (ODeL) methodologies".

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[195] Cisco. 2007. http://www.cisco.com/web/learning/netacad/digital_divide/ldc/participating_countries/index.html
[196] See http://gvu.unu.edu/about.cfm?pageid=1007 and http://gvu.unu.edu/partners.cfm?pageid=1015
[197] See http://www.ocwconsortium.org/
[198] See the courses listed under the appropriate headings: http://ocw.unu.edu/ocw/Courses_listing (Feb. 10, 2008)
[199] See http://www.cm.refer.org/hm/index.htm
[200] AUF. 2008. Soutien des TICs au développement de l'enseignement supérieur et de la recherche http://www.auf.org/rubrique21.html
[201] See http://www.avu.org/home.asp

The UN United Nations Asian and Pacific Training Centre for Information and Communication Technology for Development (APCICT) located in Inchon, South Korea, is a relatively new agency working with the United Nations Economic and Social Commission for Asia and the Pacific (UNESCAP). With the recent closing of the UNDP sponsored Asia-Pacific Development Information Programme (APDIP) in Bangkok, APCICT is now the only UN agency in Asia that focuses specifically on ICT for development. The Republic of Korea has made ICT a trademark of its development efforts and is supportive of efforts to enhance the capacity of countries to use ICTs for development.

Created with the support of UNESCAP and of the Government of the Republic of Korea which has made significant strides in the use of ICTs for national development, the APCICT is developing a series of 8 training modules under a flagship initiative known as the "UN-APCICT Academy of ICT Essentials for Government Leaders"[202]. The Academy exists to strengthen the capacity of policy makers to make use of ICTs for national development. Several of the themes covered in these modules deal with e-Environment and related issues, among others.

12.4. Public communication media

Radio in general and local and **community radio** in particular are useful communication vehicles for reaching people at that level. This applies in developed as well as developing countries. Radio is one of the most useful and largely diffused technologies for reaching the masses and especially the poor, in urban and rural areas of the developing world as well as in remote and sparsely populated areas of industrialized countries. Canada has used satellite technology to bring all forms of communications to its most Northern reaches[203].

In some parts of the world, the Internet and ICTs have been used by local radios to enhance programming to rural communities. UNESCO, which has long been a leader in matters related to the use of ICTs for communication and education has experimented with such a programme in Sri Lanka. The Kothmale **Internet radio** project in Sri Lanka is a classic example of the application of satellite communications along with Internet use for local learning and decision-making[204].

The use of **digital satellite radio** is also having a major impact in many parts of the world. This technology allows broadcasting of digital information using satellite technologies paired with portable digital radio receivers as well as digital capture devices hooked up to tape recorders and/or PCs to allow downloading of programming and of files made available through a central server in the offices of the satellite provider.

Digital satellite radio now operates in the developing world, with broadcasts across the world. Remote locations across Africa, for example, which are far removed from an Internet connection, can now connect using digital satellite radio receivers, some of which can be powered using small detachable solar panels. Content providers and others can also use this service for uploading content to users in remote locations.

Many community-based radios use this service to provide content for their radio programming, especially music but also educational programming which content providers can make available via the digital satellite downlink connection. Download speeds of up to 128 Kbps are possible. In Africa, digital satellite radio has been used in many of the poorest countries to provide connectivity and

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[202] See Academy Objective. http://www.unapcict.org/learning/Objective.asp
[203] See http://www.museum.tv/archives/etv/T/htmlT/televisionno/televisionno.htm; http://www.canadaconnects.ca/healthcare/main/1108/; and http://www.ic.gc.ca/cmb/welcomeic.nsf/261ce500dfcd7259852564820068dc6d/85256a5d006b972085256db8004f7cb2!OpenDocument
[204] UNESCO. 1999. Kothmale. Internet radio is Sri Lanka. *The right to information in rural areas through Internet radio*. http://www.unesco.org/webworld/netaid/com/sri_lanka.html

programming that is then used at the local and community level. Many community radio stations capture programming content from WorldSpace channels.

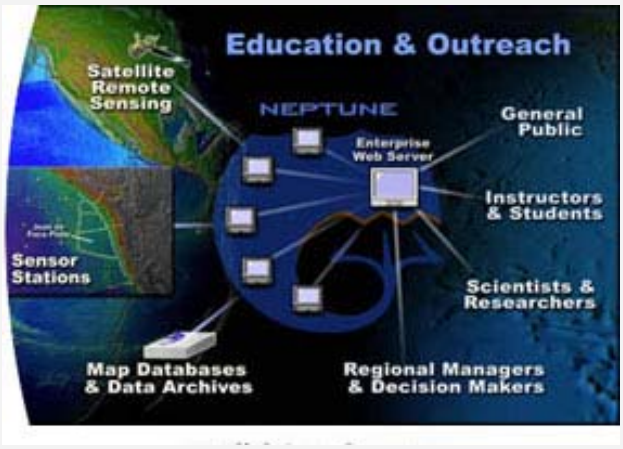
12.5. Environmental awareness kits

ICTs have been used to help get the message of sound environmental management across to a variety of audiences. The Mekong River Awareness Kit[205] along with the Nile River Awareness Kit[206] developed by a Vancouver consulting firm is an example of the use of ICTs for promoting public awareness of environmental issues. These kits combine both online vehicles and CD-ROM, a well-proven and often used tool for presenting digital information where connectivity is absent.

12.6. Education

In developed countries, there are learning projects designed to enhance the involvement of students in environmental observation and research. One example of this is the NEPTUNE[207] project. The North-East Pacific time-series Undersea Networked Experiments or NEPTUNE Canada "…will be the world's largest cable-linked seafloor observatory. It will expand the boundaries of ocean exploration and give us a new way of studying and understanding our planet. NEPTUNE brings power and the Internet to the ocean environment through novel technologies". The project provides real-time data and images from very dynamic earth-ocean systems, by bringing high-speed Internet connectivity to large areas of the oceans. NEPTUNE products will be useful and accessible to classrooms, laboratories, and even the homes of interested learners. Programs will include K-12 curricula and activities, exhibits for science museums, undergraduate and graduate research, and a real-time web interface for all users.

Figure 13. The Neptune ocean environmental observatory online



The challenge in developing countries lies in the requirements for high bandwidth connections and computer equipment to be able to participate in programmes like NEPTUNE. SchoolNet and "computers in schools" projects such as ITU's "Internet for Schools" implemented in Mali[208] will be essential to bring the required connectivity to schools and institutions of learning in developing countries before they can take advantage of these opportunities for learning about the global environment.

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[205] See http://www.mrcmekong.org/RAK/html/rak_frameset.html and a review at: http://www.adbi.org/cdrom-review/2003/08/27/31.mekong.river.awareness.kit..rak./
[206] See http://www.nileteap.org/nrak/ and http://www.nilerak.hatfieldgroup.com/
[207] See http://www.neptunecanada.ca/education/index.html and also http://www.ooi.washington.edu/
[208] See ITU, http://www.itu.int/ITU-D/cyb/app/e-educ.html and Swisscom, http://www.swisscom.ch/SCMCMS/GB/GBericht04/gb04_en/pdf/SC_GB04_Gesellschaft_e.pdf

The New Partnership for Africa's Development (NEPAD) supports e-school initiatives in several countries and has been experimenting with the One Laptop per Child among other tools and approaches[209]. HP participates in the NEPAD e-schools project by providing hardware and "…will also address issues around health and empowering the community through information"[210].

SchoolNetAfrica[211] is another project that operates in several countries with the assistance of national and international partners.

Novel projects such as the **I**nformation **L**iteracy in **R**ural **A**reas project (Ilira[212]) supported by the GTZ in the Philippines will help. In this case, computer education facilities were installed in schools using solar power to generate the electricity required to operate the systems. In addition, in order to provide for maintenance and upgrade costs, the centers were organized with a dual function as Internet cafes in the evenings to generate revenue.

12.7. Solomon Islands trials for the distribution of the OLPC

In the Solomon Islands, ICTs are being experimented in order to assist rural and sometimes remote communities manage local biodiversity using traditional means. The project makes use of the One Laptop per Child (OLPC) which it is also testing and takes advantage of a European Union funded project that brings very small aperture terminal (VSAT) earth stations for satellite-based broadband Internet connectivity to the communities in the outlying areas of the Solomons. International partners are involved along with local and regional institutions in order to help make the project sustainable over time. The following description comes from information provided by PFNet in Horiana in the Solomon Islands[213].

The PFNet[214] project has successfully deployed ICTs in the region and along with the Distance Learning Centre Project[215] funded by the European Union. The **People First Network** (PFnet) was started in 2001 through a UNDP programme as a community networking service to reach (some of) the 85% of people living in rural areas. PFnet uses ultra low cost HF radio email and solar power. In 2002, PFnet was involved in distance learning trials with the University of the South Pacific (USP). The village of Batuna was chosen for a pilot initiative as it is part of the larger Marovo Lagoon Learning Net project. 25 OLPC laptops were donated. Marovo Lagoon is a unique environment recognized as a potential World Heritage site. The project aims to foster a better understanding of Marovo in order to help the local community better manage and conserve its biodiversity base. As a result of this project, it is hoped that a network of community conservation agreements will be fostered.

The Schools also benefit from this project and use the network to raise awareness locally of the unique biodiversity in the lagoon. International institutions working in the lagoon have expressed interest in collaborating. These include the University of Queensland (UQ) Conserving Marine Biodiversity in Marovo Lagoon project, Conservation International (CI) and the American Museum of Natural History (AMNH).

This model can be and has probably already been adapted to rural areas in many different countries around the world where fixed broadband infrastructure is not available. What sets this project apart is

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[209] NEPAD News. 2005. *NEPAD e-schools initiative scoops global award*. http://www.nepad.org/2005/news/wmview.php?ArtID=36
[210] HP. 2007. *NEPAD e-school*. http://h41147.www4.hp.com/emea_africa/en/partners/nepad/index.html#1
[211] SchoolNetAfrica: http://www.schoolnetafrica.org/
[212] See http://www.ilira.org/
[213] Leeming, D. et al. 2007. *Trials for the distribution of One Laptop Per Child (OLPC) Laptops*. Solomon Islands Ministry of Education. 41 pp.
[214] People First Network. Rural Development Volunteers Association of the Pacific Islands. 2008. http://www.peoplefirst.net.sb/
[215] Distance Learning Centres Project. Ministry of Education and Human Resource Development. Solomon Islands. 2007. http://www.peoplefirst.net.sb/DLCP/

the use of the innovative OLPC and the desire to use ICTs as a way to encourage education about biodiversity at the local and community level as well as enhance the capacity of managers at the local level and otherwise to undertake research on and to conserve biological diversity.

12.8. Key ICTs

- Community radio with locally relevant programming along with low power, solar power and/or wind up radio receivers and antennae. A key component of this will include solar power equipment;
- Digital satellite radio along with locally relevant programming along with low power, solar power and/or wind up radio receivers and antennae;
- Small, low energy requiring, highly portable, rugged, well designed and dust proof PCs such as the One Laptop per Child (OLPC) and many other like devices that are now appearing on the marketplace;
- Mobile telephony, applications and services, including SMS broadcasts, voice broadcasts, EVDO and other high speed wireless broadband technologies and related services providing access to micro browsers including icon based micro browser applications for the illiterate and semi-literate;
- PCs and Internet connections networked together for local and community access and sharing;
- Hand held devices linked to wireless networks for collecting, analyzing and diffusing market and other agricultural information related to commodity prices: including farm gate prices of agricultural commodities, local market prices, prices charged by middle men buying and selling agricultural commodities directly from farmers, information about veterinary diseases such as avian flu and other diseases of epidemic dimensions, etc.;
- GIS tools for presentation purposes;
- Mash-ups as part of education and research;
- SOA applications;
- Broadband connectivity for distant learning.

12.9. Key organizations

- Development agencies focused on digital divide issues;
- National and local government;
- Local and community groups;
- Educational institutions;
- Ministries dealing with the environment and natural resources;
- Internet service providers (ISPs);
- Mobile telephony service providers;
- National regulatory agencies responsible regulating ICT policy.

12.10. Key applications

- E-Learning tools;
- Web-base presentation capabilities such as Google Earth and Microsoft Virtual Earth and various mapping software packages, especially open source mapping packages;

- Community access facilities of various sorts, including telecentres and multipurpose community telecentres (MPCTs);
- Online learning applications for developing countries, including those that may be made available through novel technologies such as the One Laptop per Child (OLPC) and many other like devices that are now appearing on the marketplace;
- Applications that provide access to locally relevant knowledge and appropriate technologies and agricultural and other management practices;
- Various research applications to help researchers collect information first hand as part of larger research activities, including various research and academic networking activities that have been enhanced by the use of ICTs and including GRID networks and other applications that are part of the Global Earth Observation System of Systems (GEOSS).

12.11. Issues and trends

- Greater access to broadband as well as greater availability of environmental data in digital form, along with more access to web-based services and also to web-based digital learning resources will encourage greater use of environmental data for learning and research;
- Greater access to mapping software and GIS;
- Increased popularity of ICTs and of educational applications relevant to ICTs;
- The perceived high rate of return of investing development aid in human capacity building and the apparent advantages of online learning including distance learning as well as computer based learning and training as tools to facilitate this;
- More online training and greater and more immersive learning environment and experiences will encourage the development of e-learning about the environment.

12.12. Relevance to developing countries

- Highly relevant to developing countries for the reasons mentioned above.

13. FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

13.1. Summary of findings

Current status and trends in ICT use for environmental management in developing countries

From a historically perspective:

- ICTs have mostly been used for weather information, for example, as part of World Weather Watch;
- World Weather Watch has demonstrated an evolutionary use of technology, using what is available and modernising as new technological developments have appeared;
- Other early applications have included disaster early warning as a result of droughts in Africa in the 1970s and 1980s, FEWS, and digitization of national maps with data layers entered into GIS;
- ICTs have also been used as part of usual office productivity applications in environmental departments and services, and for relational database management systems, etc.

Today, the following activities and/or trends contribute to an increased use of ICTs for the study of the environment:

- Increased concern about the environment has lead to the growth of environmental monitoring, which now includes climate long range forecasting:
- This has resulted in a larger number and sensitivity of sensors and observation platforms, and the production of masses of environmental data and information in digital form;
- Another feature is the availability of more powerful processors that are distributed over the Internet (GRID processing) resulting in more accurate modeling;
- Facilities have also increased to share environmental data globally via the Internet (GRID);
- More powerful processors are being developed, leading to more accurate and predictive environmental models;
- Faster processors and parallel / GRID computing means better models and a better understanding of climate and environmental systems and phenomena;
- This makes it easier to reduce complexity and achieve more accurate weather and disaster prediction;
- Applications have moved to real time environmental observation and computation;
- A key focus of applications is now environmental planning and management: more powerful, intelligent and user-friendly applications are available for manipulating environmental data and facilitating decision-making including:
    - Georeferenced databases such as GIS;
    - Mapping software: geographic information systems;
- Other reasons for this evolution are at play as well, such as:
    - The global increase in human population, particularly in more environmentally sensitive areas with lower carrying capacities and/or in areas that are more disaster prone;
    - Increased industrial activity and more pollution, resulting in ever increasing GHG emissions and CO2 levels in the atmosphere;

- Disaster early warning are becoming more important as weather phenomena become more disruptive;
- An example is FEWSNet, which has been available since the 1980s providing famine early warning based on remote sensing and archival imagery and data and other systems in use;
- Following are key areas where applications are on the rise:
  - Monitoring seismic activity, earthquakes and landslides;
  - Volcano and tsunami early warning systems;
  - Flood warnings;
  - Avalanche warnings (sometimes related to seismic activities but more likely related to weather for winter snow avalanches);
  - Telemetric systems for environmental monitoring: water and air quality, soil erosion and quality, etc., linked via satellite to centres on the IP backbone;
- There is also an important need for country reporting on their obligations under various environmental conventions which they are signatory to, e.g.: Climate change, Biodiversity, Desertification, Wetlands (RAMSAR), CITES, Convention on Migratory Species, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), etc.
- Environmental observation, data collection and research is a key focus of ICT applications in this area, including the following:
  - Earth surface observations and data recording and sharing facilitated through the use of ICTs;
  - NatureServe, a collection of biodiversity and related data using normalized data structures to ensure interoperability – with some use in Latin America, but with potential everywhere;
  - Georeferencing, making possible better information and planning, adding as many layers as possible and encouraging individual and local contributions;
  - Higher resolution and multispectral and 3-dimensional rendering of remote sensing photos / imagery and objects on earth's surface;
  - Innovative free of charge services such as Google Earth and Microsoft Virtual Earth;
  - The ability to use primary scientific information stored in collections such as museums, herbaria, xylotheques (xylaria), biological specimen collections, etc. to better understand the environmental record over time;
  - Telemetric systems, involving remote data collection and data transmission and data sharing using wireless and satellite platforms;

The key players involved in the development of ICT applications for environmental management include the following:

- Governments, responsible for ICT policies and for e-Government policies, who can make a big difference by implementing shared services
- Corporations, who can also save resources by using shared services and Web services
- Chief information officers (CIOs) or ICT Directors at all organizations
- Government institutions and agencies with particular relevance to the environment area, such as:
  - Executive agencies of national governments: Offices of the President, Prime Minister's Offices, Ministries of Finance, of Planning, etc.

- Ministries of agriculture and forestry, natural resources and tourism, fisheries and aquaculture or equivalents;
- Ministries of the environment;
- Departments responsible for national parks and reserves.

Impact of ICTs on the environment

There are various orders of impact of ICTs, including:

1. First order (direct): the impacts and opportunities created by the physical existence of ICT and the processes involved;
2. Second order (indirect): the impacts and opportunities created by the ongoing use and application of ICT;
3. Third order: the impacts and opportunities created by the aggregated effects of large numbers of people using ICT over the medium to long term.

ICTs facilitate environmental research and management

ICTs have facilitated environmental research and management everywhere. In this regard, it is important to note that:

- Moore's Law still applies: faster and more powerful processors allow for more accurate modelling of complex environmental phenomena and a better understanding of environmental systems;
- Connectivity has facilitated research collaboration.

What are the benefits of the information economy?

The benefits of the information economy are found in all walks of life, in all sectors of the economy and at all levels of society in many countries and regions of the world. Some of these developments are illustrated in the following:

- Countries are modernizing their administrations and societies through the use of ICTs;
- Broadband is facilitating increased connectivity and automation, leading to more applications in e-Business, e-Government, e-Commerce & to embedded devices everywhere. Ubiquitous high speed network connections allow meshing for collaboration across barriers of all kinds.
- All this is leading to:
  - More access to data, processing power, applications, people and resources (including GRID computing);
  - Resources are being shared over the Internet and this is made easier the more broadband there is to allow sharing.

Why are benefits of ICTs not diffusing equitably around the world?

The benefits of ICTs are not diffusing equitably around the world – except for local wireless (mobile) connections. This situation results from several factors:

- The regulatory environment in many countries and jurisdictions is still evolving and may not always permit the operation of a level playing field in the ICT and telecommunications sector of the economy;

- Developing countries have less high speed IP connectivity, especially the poorer countries of Africa (see Figure 2. Penetration of selected ICTs, by category of economies, 1996-2006);
- Rural areas are less connected;
- They have a more limited telecommunications infrastructure;
- The lack of infrastructure constitutes a major impediment in Africa and in other parts of the world;
- Nevertheless, poorer markets remain appealing as long as there is a large population base for mobile services, for instance in Africa and particularly in Asia;
- Some parts of the developing world have very expensive broadband connectivity;
- West Africa has underused its submarine fibre connectivity because access to the SAT-3 submarine fibre continues to be very expensive. Countries on the West African coast thus rely on satellite connectivity;
- Eastern and Central Africa as well as landlocked countries of the Sahel are without submarine cable access at this time and must also rely on satellite connectivity.

13.2. Conclusions

Can ICTs help reduce GHG emissions and environmental impact generally?

An important opportunity presents itself: ICTs can, in fact, help reduce GHG emissions and environmental impact in general. Here are some of the ways that this can happen:

- The general benefits of using ICTs in the workplace lead to enhanced information and work flows and business process efficiency in general, and this also benefits the environment;
- Synergy through greater networking reduces duplication and increases the efficient use of resources;
- Pooling data and resources leads to greater sharing and collaboration and thus to better decision making;
- ICTs provide more complete data and a better picture of natural phenomena;
- They allow for a systematic approach locally, regionally and internationally to dealing with complex, large scale, multidisciplinary and cross-cutting issues such as the environment;
- ICTs facilitate a more strategic approach to environmental planning and management;
- Web services can themselves save energy and reduce GHG emissions;
- Shared (resource-saving) services are a usual feature of e-Government;
- The creation of green data centers is a step in the right direction that can help developing countries;
- Free and low-cost web-based applications such as Google Apps can be especially useful in saving resources and money for some developing countries with smaller and more concentrated government offices;
- More energy efficient devices and power supplies on desktop PCs and in servers also lead to lower GHG emissions;
- Virtualization helps to reduce the number of servers required and the amount of energy consumed;

Following is a list of measures that can be taken to improve energy usage and reduce environmental impact:

- Using laptops and other smaller form factor PCs;
- Using slim servers;
- Using energy efficient PCs: one step up from the One Laptop per Child (OLPC) which is not a business PC;
- Using more energy efficient chip sets and processors and other devices (compliant with Energy Star or equivalent);
- Focusing on shared services and use of data centres to cut costs and reduce environmental footprint;
- Developing green data centres;
- Organising travel replacement through technologies such as:
    - Virtual meetings & consultations, based on videoconferencing and audio-conferencing;
    - Tele-education;

- E-Health, including telemedicine, tele-care and remote assistance services;
- Flexi-work;

- Developing “intelligent living” practices such as:
  - Flexible car ownership;
  - Reduced energy consumption;
  - Intelligent building design;
  - Intelligent heating of buildings;
- Developing e-Commerce as a basis for business transactions;
- Promoting de-materialization through use of:
  - Virtual answering machines;
  - Online billing;
  - Web-taxation;
  - Video and music on demand;

However, the tertiary effects of these approaches are not all well understood, and need more research.

Understanding & acting on the environment depends on ICTs

Understanding the environment depends on ICTs for the following reasons:

- Without ICTs, the interrelationships within and amongst complex environmental systems are very difficult to comprehend;
- Complex data can readily be compartmentalized and studied using tools such as GIS and high speed processors and highly sensitive earth observation sensors;
- Complex interactions can be simplified and scaled up, avoiding getting lost in details;
- Without ICTs, the impacts of environmental change and of climate change in particular would have taken much longer to understand;
- Improved processing power and access to more and better environmental data allows for better understanding as a result of more realistic modelling of environmental events and systems;
- GIS and various analytical tools allow easy visualization of complex phenomena;
- GIS can be integrated into decision making, but the capacity to do so is limited – particularly in developing countries;
- ICTs are starting to permit real or near real time environmental analysis and prediction (e.g. weather systems, disaster early warning, famine early warning, more rapid prediction of change in environmental systems and in their components);

Emergency / disaster early warning & response systems are increasingly dependent on – and supported by – ICTs. Some illustrations of this include the following:

- Alerts using high speed networks to reach decision-makers and the media to warn people;
- IP networks and the airwaves becoming increasingly useful for conveying messages;
- There is growing recourse to new dissemination mechanisms, including SMS alerts, radio and television coverage, email storms, Web alerts, etc.

ICTs can also reduce the primary, secondary and tertiary environmental effects of human activities

There is a need to act

Consensus has recently been achieved worldwide and in development circles particularly about the urgency of dealing with changing environmental – and especially climatic and meteorological – conditions. The following events or issues have contributed to this realization:

- The 4th IPCC assessment report provided compelling evidence of the threat presented by climate change and increasing GHG emissions;
- The Bali Conference on climate change emphasized this problem;
- The public have shown their concern around the world, in developed as well as in developing countries;
- Many governments have taken these issues seriously by signing on to the Kyoto Convention and/or taking other steps to mitigate GHG emissions in particular and to deal with environmental change in general;
- Others with influence and media recognition have added their weight, including former US Vice President Al Gore and the Nobel Foundation.

There is a critical need to assist countries mitigate and adapt to environmental change in general and climate change in particular. Some of the key areas of concern are the following:

- Weather watching;
- Enhancing sustainable use of natural resources and of the natural environment;
- Disaster early warning, mitigation and management;
- Pollution abatement and mitigation;
- Climate change adaptation.

There are other areas of concern. Government agencies need to have access to the information and data necessary to understand the issues as well as act on these. The promotion of e-government is helping administrations modernize and make better use of ICTs. Efforts to strengthen the capacity of countries to deal with the key areas of concern mentioned above will also have to address broader issues related to institutional capacity. A broad based approach to ICT use across the environment sector is essential for success.

13.3. Recommendations

Awareness promotion

Before any action can be taken to strengthen the capacity of countries to use ICTs for environmental management and to help mitigate and adapt to climate change, there is a need to get the message across to decision makers in developing countries and in donor organizations about the role that ICTs can play. If key decision makers and the public do not see the advantages of promoting the use of ICTs to help reduce GHG emissions for example, then nothing will happen.

Awareness of the importance of acting on the environment is not universal, but this is rapidly changing for some of the reasons mentioned in this report and as a result of the recent increases in the price of energy. Research undertaken in preparing this report has shown that unless there is a clear benefit associated with green action, the private sector for example will not invest in it. That clear benefit is now becoming more apparent, once again thanks to increases in the cost of energy to operate servers and data centers.

Similarly, the concerns of the public about the importance of living in a safe and sound environment are growing around the world, as this report has demonstrated. The need to promote clean development is a recognized priority and here the private sector has demonstrated innovative technologies and management practices in dealing with some of these issues. Not all private sector operators are sceptics. Many private sector firms have staked their business on the move towards greater energy efficiency in everything that humans do, and this now clearly involves computing and using ICTs in general.

Still, developing countries need to be made more aware of the importance of acting on the environment and of seeking financial and technical support to do so. The international development community also needs to understand the role ICTs can play in helping to manage the environment for sound and sustainable development and to mitigate and adapt to the effects of climate change.

There is a need for more awareness among decision-makers of the benefits of using ICTs to deal with environmental issues.

Develop and implement an e-Environment communication plan

To do this, there is a need to work closely with the media to get the message out. It is proposed that countries and development actors prepare an e-Environment communication plan. This can be done by assembling a support group or advisory committee to publicize and raise awareness for e-Environment. This could also involve working with key journalists and associations of journalists as well as environmental communications organizations and agencies. Part of this effort could involve preparing stories on e-Environment in developing countries that could be published in newspapers and other popular media. For international agencies, the communications plan may also consider if and how celebrities could contribute to getting the message out.

Demonstrate success and feasibility

It may also be useful to demonstrate what can and has worked in different countries and jurisdictions and organizations around the world through the use of case studies. Along with case studies, best practice analyses can also be carried out and the results of all of these case studies and lessons learned can be assessed and shared with the public and especially among key decision makers.

Engage the private sector

The private sector has a major stake in the greening of the environment in making good use of ICTs for sound environmental management and in the fight against climate change. While it is a major contributor to environmental degradation as well as GHG emissions, yet, along with government, the private sector is also the main solution provider and implementer behind most of the actions that will be undertaken to green the planet and to develop appropriate ICT based solutions for mitigating and adapting to the effects of climate change.

Some members of the private sector are already participating in efforts to promote sustainable development around the world through the aegis of organizations such as the World Business Council for Sustainable Development (WBCSD). It may be useful to both the private sector as well as public service organizations, including some development or aid organizations, to partner for sustainable development.

Most of the innovations that will be required and that are indeed being developed to green the planet and to use ICTs in the fight against climate change are or will eventually come from the private sector. It may be useful to develop partnerships with lead ICT companies and to work with them to get the message across to the private sector in general and to the ICT industry in particular about the benefits of using ICTs for greening the environment specifically and in the promotion of sustainable development in general. Already there is considerable media attention given to this issue, including the ICT business media.

Working with the private sector is a logical step in jurisdictions that have established a carbon trading system and market. In these cases, the engagement of the private sector is even more evident.

Strengthen capacity of developing countries

The main recommendation of this report is to strengthen the capacity of developing countries to use ICTs for environmental action. Most developing countries do not have the capacity to undertake environmental research and/or to act on the environmental data, information and knowledge that is available online and/or in country. Many do not know what the risks to their countries are and how they could be mitigated or adapted to. This information is generally not available for decision-making. Similarly, not all countries are making full use of ICTs for e-Environment.

As part of this effort, there is a need to identify what resources and support are available to developing countries to help them address environmental issues in general and climate change and related issues in particular, especially issues related to climate change mitigation and adaptation. This would involve identifying financial and other resources that may be available to developing countries to pursue sound environmental management. There is agreement internationally to transfer technology to developing countries to help them mitigate and adapt to climate change. Some developed countries have agreed to participate in technology transfer or agree that the idea is worth pursuing.

There is also assistance available to developing countries to address environmental issues and climate change in particular. This is an opportunity to strengthen the capacity of developing countries to deal with environmental issues while at the same time tackling national development priorities given the strong link between the state of the environment and national development. Carbon trading and offsetting schemes are also directly relevant to developing countries as they can be the recipients of the resources and financial transfers that can accompany these international trading regimes and obligations.

There is a need to strengthen the capacity of developing countries to use and contribute to the generation, digitization and exchange of information, data and e-resources online and otherwise. There is a need to help countries make better use of ICTs for environmental management and for helping these countries to develop a better understanding of their natural environments and of their specificities. One way of doing this is to enhance support for initiatives such as the UNEP-WCMC, GEO and other like environmental information and resource sharing activities.

Computerize and modernize environmental departments and ministries

There is a need to modernize ministries and departments in developing countries that deal with the environment by helping them to make better use of ICTs in research and development, but more important, to help ministries and departments of the environment to use ICTs routinely, on a day to day basis and as a matter of course. This is part of national e-government efforts. The objective here is to enhance service delivery to the public as well as process efficiency in ministries and departments of the environment.

More funds for environmental research

There is also a need to direct more funds in support of environmental research and to enhance the use of ICTs for such purposes in developing countries. Some private sector firms such ESRI encourage the development of GIS capacity in developing countries. There are many others.

Given that many of the larger ICT manufacturers and/or software producers such as Cisco, Microsoft and others have already supported efforts to build capacity to use ICTs, and given the near universal concern that exists about climate change and environmental degradation, there is an opportunity to seek research partnerships and exchanges not only with the transnational corporations (TNCs) working in the ICT industry, but with other organizations and agencies as well.

Countries and jurisdictions should assess their needs and develop proposals for the consideration of donors that have an interest in enhancing the capacity of countries to use ICTs for sustainable development. Some of these donors are ITU, WMO, UNEP, UNDP, the World Bank, GEF and other international financial institutions as well as bilateral agencies.

13.4. Strategic planning framework

An e-Environment plan of action

Given the pace of change in general and of environmental and climate change in particular, the international community including developing countries needs to act now to address some of the issues raised in this report. The international community and especially individual countries and communities would benefit from a planning framework that can help them assess the situation and make the right decisions on how to strengthen their capacity to take advantage of ICTs for environmental action and how to act now to avoid difficulties in the future.

The international community has mobilized around the issue of environmental change in general and climate change in particular. Concerns about climate change and the Kyoto Protocol and the successor to the Kyoto Protocol have made the headlines. Governments around the world and in developing countries as well need help in understanding how ICTs and access to information can help them in dealing with environmental action.

They also need to know if these reasons are sufficient to allow them to redirect limited resources from existing priorities and especially from directly tackling poverty reduction. They need to know the cost-benefits, if any, of e-Environment and what this will give them and their people when compared to other basic development needs they have to address. A strategic planning approach is a methodology

that can be used to help countries assess the situation and come to the right decision based on local or country specificities, needs and circumstances.

A strategic planning framework

It is proposed that the first objective be to develop a strategic planning framework along with an action plan for enhancing the capacity of countries to use ICTs for environmental management.

The strategic plan should begin with a broad or national-level e-readiness assessment as well as a demand study – and a needs assessment, if necessary. A more detailed e-readiness assessment specific to the environmental sector should also be undertaken, including applying business process analysis (BPA) at the country's ministry concerned with the environment / sustainable development in conjunction with the administration concerned with information and communication technologies as well as all related organizations and departments. This will help map out information and workflows and will help inform recommendations about how ICTs can enhance process efficiency and work at the ministries as well as at related organizations. The framework requires ongoing consultations with key stakeholders at all levels and across all sectors of society, nationally, regionally and internationally.

The basic idea is to use appropriate information and communication technologies and management practices to help countries modernize all of their environmental activities as well as focus on mitigating environmental impact and adapting to environmental change.

This framework would operate at two levels. It would start at the international level in order to assess support and mobilize resources and make suggestions on the way forward and perhaps provide funding or encouragement to fund.

It would also operate at the national level and/or at the level of individual jurisdictions to help identify and understand needs, circumstances and demand, if any, and then identify priorities and develop a strategic planning framework along with a list of practical and doable projects and activities to deal with key environmental concerns and needs.

The strategic planning framework should clearly explain the issues and concerns related to the environment and climate change and make recommendations on how to deal with these.

An action plan is then needed to take this strategic plan and turn it into action, identifying projects, institutional and governance arrangements, funding arrangements and sources, budgets, timeframes, priorities and responsibilities for implementation.

At the international level

It is proposed to work with international partners to strengthen the capacity of developing countries to use and apply ICTs for dealing with environmental issues. Organizations able to support this effort include the OECD, the international financial institutions, various international associations involved in this area, GEO and the UNEP-WCMC, among others. Using existing environmental strategies, it will be useful to understand the existing situation and priorities. Already the OECD, UNDP and the World Bank have recognized the importance of dealing with the environment in general and with climate change in particular, but it is still necessary to know how that will translate at the country level and what activities or support programmes will be put into place to assist this.

At the national level

For countries – whether developed or developing – the first step is to understand the importance attached to the environment and to climate change by national authorities as well as by the public and the country's development actors. It is also important to understand the specific country risks associated with environmental and climate change. Countries that are particularly susceptible to the

risks associated with environmental and climate change – such as the small island developing states – have acquired a high level of awareness. But they still need help, and this has been recognized in the Barbados Plan of Action.

Similar approaches are required to help understand the risks and opportunities associated with the greater use of ICTs in general and for managing the environment in particular – within the context of limiting the overall risks associated with climate change.

The proposed e-Environment strategies and action plans would enhance the capacities of countries and jurisdictions to use ICTs in support of the environment, i.e. in support of environmental awareness raising, environmental research and management, etc.

The strategy should address the question at a national scale, but similar strategies and plans can be drawn up by local authorities at the country, district, province, municipality and community levels as well as at the individual organization level.

The strategic plan – the assessment phase

The strategy should include an assessment phase that includes the following steps or components:

- An e-readiness assessment to help understand ICT use at the national level and in the environment sector;
- A situation analysis assessing the use of ICTs for environmental research, management and planning;
- Identifying key players and stakeholders;
- Looking at some key issues, such as how countries are meeting their obligations under the various international and regional conventions and agreements;
- A SWOT[216] analysis of the present situation regarding the use of ICTs in dealing with the environment;
- A benchmark study comparing and contrasting the situation nationally with that in other countries or jurisdictions, i.e. where the country stands at present compared with other countries and jurisdictions;
- Case studies and best practice analyses;
- Feasibility report.

Depending on the resources and information available, an audit of existing energy demand and use as well as GHG emissions under the present scenario can be contrasted with future scenarios where ICTs have an ever increasing role to play in mitigating and helping people and organizations adapt to climate change. Some of the technologies and management practices mentioned in this report would feature in this audit. Alternative scenarios could include ones where smart transport or building management systems are used to reduce energy consumption and GHG emissions in specific locations and the results are extrapolated to a municipality, a district or even a country.

Whatever action is proposed, the strategy needs to deal with it within the context of the national development strategy and action plan and of the Millennium Development Goals (MDGs). The e-Environment strategy has to be seen as a component of the national development strategy or equivalent and has to contribute directly to the realization of national development goals and objectives.

[216] SWOT analysis is a strategic planning technique used to evaluate the strengths, weaknesses, opportunities and threats involved in a project.

The vision for the environmental strategy and action plan should answer the following questions: what do we as a country, jurisdiction, organization, community, etc. want to do in regard to environmental management and to use ICTs to achieve our vision and goals? How can ICTs be used to mitigate and adapt to climate change? To what extent do we want to act (i.e. what level of reduction in GHG emissions do we wish to reach by a given time)? To get a better idea of the way forward, it will be helpful to consider what other jurisdictions have done to promote sound environmental management.

The strategy and action plan for using ICTs in support of sound environmental management and decision making should touch on all sectors of the economy at all levels of society across the country or jurisdiction in question.

The strategy would include development objectives and immediate objectives to achieve the vision and goals. It would include a resource mobilization plan along with the communications plan outlined above to raise awareness and promote support from the public and key decision makers.

The action plan component of the e-Environment strategy would include sections detailing the main thrusts of the actions proposed, the justification for acting (based on the results of the assessment) and the projects and activities that would be undertaken to reach the goals and objectives outlined. The action plan would consider options and priorities and explain these.

A section on resource requirements would outline budgets and timelines. A work plan would include a listing of responsibilities, timelines and estimated costs and budgets along with suggestions for sources of funding.

Results based management (RBM) would be used along with indicators of performance, objectively verifiable indicators and means of verification. Performance indicators (results based management using logical frame analysis) would be detailed for each project and each activity associated with each project. Outputs and outcomes or impacts would be described. A monitoring and evaluation plan would also be put into place to track progress and to make changes as the project evolves and conditions change.

Rapid e-Environment assessments and audits

This more limited approach would involve quickly assessing the use of ICTs in the environment sector only and the impacts of greater use of ICTs on the environment. A quick assessment followed by recommendations may be a more realistic alternative to a full-fledged e-Environment action plan that may not have the support and financing required to move forward.

For a rapid e-Environment assessment, the steps outlined under the assessment phase of the e-Environment action plan would suffice, followed by a list of recommendations and of priorities for action with their expected benefits and costs.

The assessment phase is the most important step in preparing the e-Environment strategy along with defining any project or activity to be undertaken. The strategy is based on the results of the assessment phase along with inputs from different stakeholders and the will of the government that policy is made. The results of the assessment dictate the priorities and actions to be undertaken.

An e-Environment toolkit

An e-Environment toolkit is proposed to help countries assess their present situation regarding e-Environment, identify key issues and trends, identify and rate priorities and opportunities, and understand what steps to take to secure available financial and other support from the international community, including the private sector and other international partners.

The toolkit may be a first step that can be used in the assessment phase, prior to deciding whether or not a more determined assessment and strategic planning effort is required and the benefits of such an effort. The toolkit would include e-Environment auditing and assessment tools and techniques.

Proposals for future action regarding this report

The initial draft of this report proposed that it should be circulated before publication in order to gather the required feedback. This has been done over the period April – to August 2008).

Develop the Toolkit: September – November, 2008.

It is next proposed that the e-Environment toolkit be developed over the period indicated above.

Country assessments using the Toolkit – as from December 2008

Once the Toolkit has been published and circulated, it is proposed to undertake assessments using the Toolkit on a pilot basis in a few selected countries, starting in December 2008.

This would call for at least one country to be chosen from each of the following groupings: Africa, Latin America, the Middle East, Central Asia, Asia, Europe and North America; these should include at least one small island developing state and one country from each of the following: lower, middle and upper income countries or territories.

The assessments would involve about one to two months work in each country, depending on the country and on the availability of support and resources.

Undertake e-Environment strategies in selected countries

Depending on the feedback obtained from undertaking the in-country assessments using the e-Environment Assessment Toolkit, it would be useful to then develop some selected e-Environment strategies. This would require developing a resource mobilization strategy and a list of countries that would be interested in participating in developing e-Environment strategies and action plans.

The e-Environment strategies and action plans would take from 1 to 3 months to complete depending on the country or jurisdiction in question, and perhaps longer if an in-depth audit is undertaken with projections into the future about the estimated savings in GHG emissions and energy consumption. It may be useful to set up a consultative group to discuss these ideas further.

14. ANNEX 1: RANKING E-ENVIRONMENT APPLICATIONS

14.1. Implementing e-Environment at the national level

This Annex presents a methodology and ranking system for assessing the adoptability of selected ICT applications by developing countries in general.

The ranking criteria are based on four parameters: Environmental Scope, Technology, Transferability and Impact (ETTI). A ranking from 1-5 is proposed with 5 representing best in class performance. The objective of this exercise is to propose a framework for comparative analysis that may be of use in planning and preparing for the introduction of e-Environment applications and which may help flag issues that may affect the adoption of ICTs for environmental management in developing countries.

Environmental Scope: at the start the assessment of e-Environment applications it is crucial to carefully identify the intended environmental scope of the application. Scope, on the one hand, can be geographic in terms of the land area or geographic area covered or it can refer to the extent and variety of environmental issues to be addressed. For example, an e-Environment application that is focused on groundwater, forest, and biodiversity preservation at a local level would score higher in this ranking scale than applications dealing only with one of these issues. Conversely, applications that target issues that are global in scope such as climate change or persistent organic pollutants would also score high. Scoring would also increase in the event that the application links across several areas of concern such as forestry, agriculture, livelihood generation and other economic activities associated with natural resources.

Applications that score high on this count either will demonstrate a combination of the following characteristics, or will have a particularly strong thematic approach in only one:

- Geographic scope;
- Range of environmental sectors addressed;
- Linkage to related disciplines associated with natural resources and/or livelihoods.

Technology: this parameter recognizes the value of a particular application from the point of view of innovation, usability and ICT industry acceptance. Applications score high in this area by demonstrating all of the following characteristics:

- Innovation that creates new functionality;
- Innovation that combines existing technology in new configurations;
- Usability that simplifies implementation and on-going effectiveness, as well as training and propagation of the tools;
- Acceptance and utilization of concepts or tools by applications outside of the intended scope (industry standardization or widespread deployment);
- Efficient use of infrastructure (bandwidth, database resources, human skill sets);
- Professional development environment that ensures product maturity upon deployment and minimal software defects, as well as proven hardware reliability.

Transferability: this parameter identifies is an estimate of the extent to which an existing application can be transported to a new environment, i.e. its adaptability and adoptability, or can be expanded in scope or is interoperable with existing and/or other applications and technologies. Transferability should be ranked from the perspective of the intended end-customer and the ICT environment in which it will be deployed. For developing countries, it is important to take into consideration the requirements for bandwidth and telecom infrastructure as well as the ability to integrate into existing

or planned decision support systems. Applications score high in for this parameter by demonstrating at least three of the following characteristics:

- Makes use of commonly deployed technology and therefore allows interoperability;
- Follows a standards based approach and uses open standards as opposed to proprietary solutions, which also encourages interoperability;
- Fully functional within the constraints of ICT environment of the intended location;
- Easily expanded in geographical scope;
- Adaptable to local cultural conditions (language, societal organization);
- Integrates quickly into the existing or planned decision support systems;
- Able to provide references to previous transfers or user feedback from similar target locations.

Impact: In the definition phase of the e-Environment applications, it is usual to set objectives and outcomes and indicators of performance that will be associated with the outcomes and used to measure performance. Although programmes often undergo changes both prior to and after implementation, the expected outcome both related to the initial objectives as well as the overall effectiveness of the application should be ranked. This characteristic also takes into account the cost efficiency of a particular programme. This is the most challenging parameter in the rankings since it relies heavily on documentation from the implementation team and the impact may lag the project, particularly in the case of research projects. The following items should be pursued individually as part of the assessment of the impact of a particular application:

- Project documentation detailing the original objectives;
- Cost and resource reports that provide quantifiable measures;
- Degree of referencing and appearance in related reports;
- Current status of funding or application acceptance
- Degree to which the application implements a feedback loop to provide both continuous improvement as well as direct impact tracking.

In summary, evaluating an application using the above parameters should result in the ability to both rank similar applications as well as to provide cross-references to e-Environment applications with limited commonality. Ranking are not global and should be performed with the target location in mind, but for the purpose of this study, any rankings provided are completed from the perspective of a small developing country.

14.2. Analyzing the e-Environment Organizational Domain

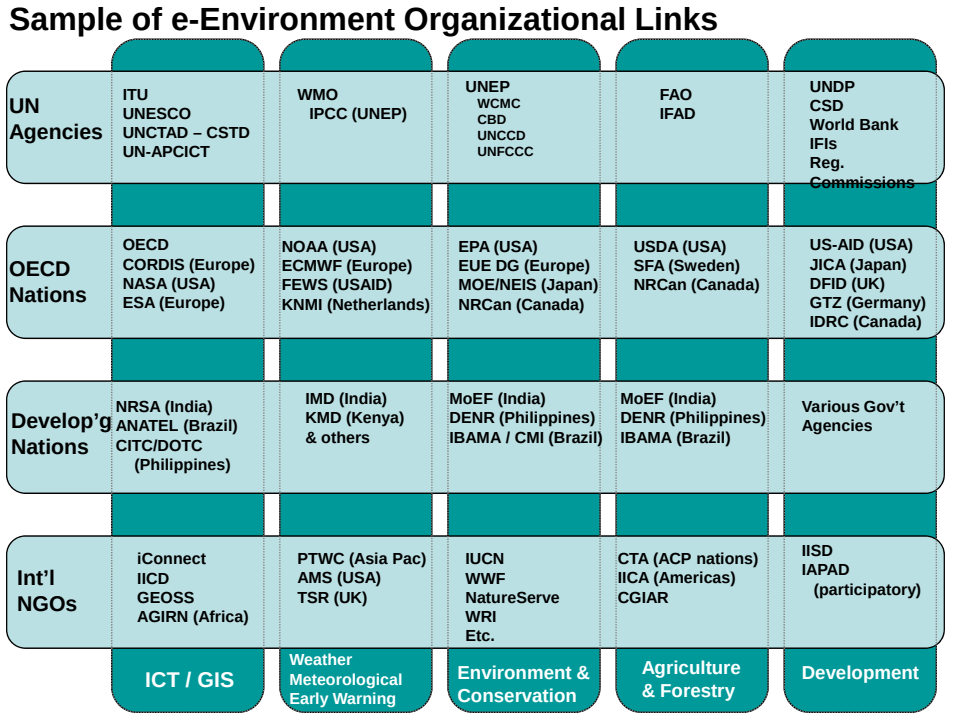
Just as previously described in the six categories for e-Environment applications discussed (see Chapter 6 on page on page 25) and the ETTI ranking approach identified for potential applications for ICT in the environment, there are also numerous agencies that are either directly or in-directly involved in the development and implantation of e-Environment applications. As part of the analysis of a particular e-Environment application it is often useful to map out the agencies that may play a role in the implementation and on-going function of a particular application. Figure 14 below shows a sample of the various levels of agencies and disciplines that either interact through the development of ICT applications or through their active engagement in fields directly related to the environment.

This diagram shows examples in each category of agency according to the sector of government or organization that is involved. The samples above represent only a small portion of the potential agencies that may be involved in an e-Environment application, but it provides a resource reference

framework that can be adapted in individual cases to determine what relevant agencies can be engaged when pursuing the implementation of e-Environment programs for developing countries.

The left side of the chart divides the agencies into domains based on their relationship to both local and international governments as well as NGOs and the UN organization. The headings of OECD and Developing Countries represent a very small sample of the potential government bodies specific to individual countries, so when adapting this framework for local use, these headings should be used as follows:

Figure 14. Some organizations involved in e-Environment and possible linkages



Source: ITU

OECD Nations: Agencies targeted under this heading should be selected based on existing strategic and development alliances that may already exist. They may be selected on the basis of geography (e.g. the Americas), or a combination of other cultural alignments.

Developing Nations: When used as a descriptive framework, this heading should be adapted to context of the country where the focus of the e-Environment applications is intended. It may also include neighboring countries that share environmental concerns.

The bottom headings on the chart provide a guideline for the general type of agencies that should be engaged when developing e-Environment applications. These are not mutually exclusive and many agencies may be involved in several of the disciplines listed on the chart. For example, many developing countries have a single agency that is responsible for all aspects of the environment and natural resources, including forestry, agriculture and mining. Similarly, many NGOs will have several of the disciplines combined in their core mission, such as in the case of ICT4D agencies. Conversely, there may be several relevant agencies under each heading with further specialization. For example, OECD countries may have several agencies responsible for the management and regulation of specific areas, such as forestry, pollution control or even hazardous substance control. In addition, depending on government divisions, both OECD and developing countries may have independent organizations for a specific field divided according to state or provincial jurisdiction. See the analysis below of the FEWS NET application for an example of how this mapping can be used.

The following five examples show how the application categories, organizational map and ranking methodology can be used to perform an assessment of an e-Environment application. Note that these analyses are performed from the perspective of the developing country either attempting to integrate into an existing system, or to adopt and/or modify a platform for localized use.

The examples have been chosen to address Global and Local applications of e-Environment, as well as to demonstrate different aspects ranging from observation to implementation of planning goals. The selection of these applications is based on availability of information and the fact that they are referenced more than once and as such appear as examples of best-in-class practices.

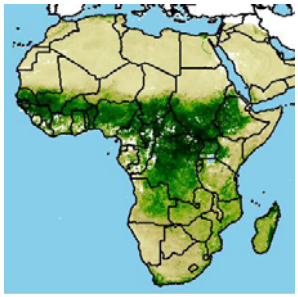
14.3. Example 1: Famine Early Warning System FEWS

Application Description:

The Goal of the Famine Early Warning Systems Network (FEWS NET) is to strengthen the abilities of African countries and regional organizations to manage risk of food insecurity through the provision of timely and analytical early warning and vulnerability information. FEWS NET is a USAID-funded activity that collaborates with international, national, and regional partners to provide timely and rigorous early warning and vulnerability information on emerging or evolving food security issues.

FEWS NET professionals in the US and Africa monitor various data and information — including remotely sensed data and ground-based meteorological, crop and rangeland conditions — as early indications of potential threats to food security.

FEWS NET also focuses its efforts on strengthening African early warning and response networks. Activities to do this include capacity development, network building and strengthening, developing policy useful information, and forming consensus about food security problems and solutions.



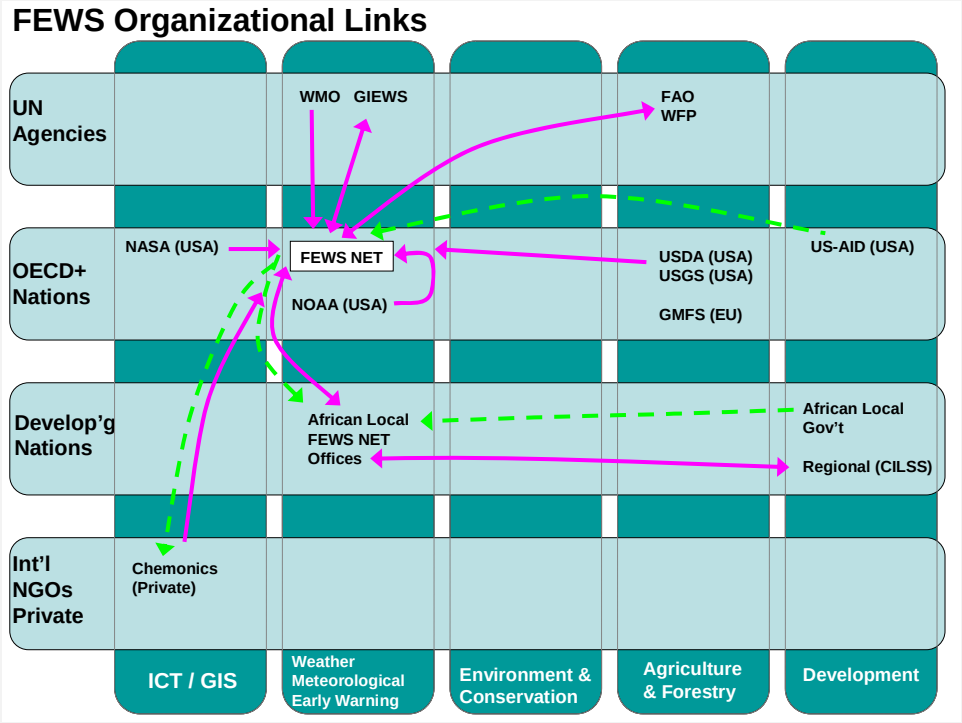
Example of NDVI Map

Categories covered:

Observation	Analysis	Planning	Management	Mitigation	Capacity Building
X	X	X	X		X

Support Partners: USAID (primary), Chemonics, NASA, NOAA, USDA, USGS

Figure 15. FEWS Organizational Links



Source: ITU

Ranking

Environmental Scope:

The FEWS program has a wide-ranging geographical scope as well as linkages with various other disciplines, including weather organizations and agriculture and food programs. Although the primary focus of the programme is at a human development and humanitarian aid level, it scores high in the environmental scope because it addresses both a large geographical area as well as a number of different environmental factors, including water utilization, vegetation coverage with linkage into agriculture and soil erosion.

Technology:

The FEWS system uses world-class GIS systems and ground linkage networks with support from NASA. It provides a number of analysis tools that include graphical presentation of:

Normalized Difference Vegetation Index (NDVI): a measure of the amount and vigour of vegetation at the land surface.

Meteosat Rainfall Estimation (RFE): imagery which uses Meteosat infrared data, rain gauge reports from the global telecommunications system, and microwave satellite observations within an algorithm to provide RFE in mm at an approximate horizontal resolution of 10 km.

Water Requirements Satisfaction Index imagery: map portrays WRSI values for a particular crop from the start of the growing season until this time period.

ITCZ Position: shows the 10-day average latitudinal position of the Africa Inter-Tropical Convergence Zone (ITCZ).

These tools have been proven to be robust, and in the case of the RFE, have been migrated to a unified support platform managed by NOAA. As it stands, the FEWS programme is actually a collection of ICT applications and a supporting organizational structure, which meets the full range of technology characteristics including innovation, usability, standardization and product quality.

Transferability:

The intent of the FEWS system is to provide centralized analysis of the conditions that can result in famine, and then to provide warnings. It scores high on the Transferability parameter because it has been expanded from initial deployment primarily focused on Africa to include countries in the Middle East, and Central America including Afghanistan, Nicaragua and Honduras. Any country seeking to be included in the FEWS network would receive high recommendations of the system from the different partner agencies, and the FEWS program incorporates some customization to the specific country management structure. The FEWS programme, although based from the US, seeks to involve local partners in the private sector, civil society and NGOs in the countries under the scope of the programme.

Impact:

From the outset, the FEWS program had a clear mandate and experienced an increasing level of success over the course of its 20 years of existence in helping countries monitor and predict famine. FEWS has been widely recognized as a key tool in planning the responses and building the knowledge base necessary for helping to pre-empt famine into the future. Project documentation and the process of expansion to other countries are well understood and the economies of scale provided by covering multiple countries from a single infrastructure provide for cost efficiency. The funding to establish a similar programme from scratch would be very large. The programme provides for a feedback loop and for continuous improvement of the accuracy of the system and its output.

In summary, The FEWS programme provides an example of well-established ICT programme that has direct environmental implications, innovative and reliable technology implementation, an expandable scope that allows the inclusion of additional countries and regions and a track record over 20 years. FEWS scores high in all dimensions related to ICT and the environment. Note also that several other food security early warning systems exist.

14.4. Example 2: Trees for Tomorrow Forestry Management in Jamaica

Application Description:

The goal of the project is to improve the management and conservation of the forests and tree crops for the benefit of the people of Jamaica. Project activities help to strengthen institutional capabilities within the forestry sector to plan and implement sustainable forest management and to improve land use in Jamaica's watersheds. The project focuses on human resource development, biophysical inventories, the establishment of a forestry sector database, watershed and forest management planning, and a public awareness program.

This program was developed over a period of 15 years from 1992 to 2007, with funding of $12M CAD provided by CIDA[217].

[217] See http://www.cida.gc.ca/CIDAWEB/cpo.nsf/vWebProjBySectorEn/1B2B19A616A0D522852572F700370438

Categories covered:

Observation	Analysis	Planning	Management	Mitigation	Capacity Building
X	X	X	X		X

Support Partners: CIDA (primary), Jamaican Ministry of Agriculture and Land

Ranking

Environmental Scope:

The Trees for Tomorrow program was initiated with the dual purpose of creating a strong and economically sustainable forestry infrastructure, as well as to provide the tools to protect the environment in Jamaica. This application had a sharp focus on managing all aspects of the forest resources, and was also ranked high in this category because the capacity building was extended to farmers and local schools. In addition, the watershed management improvements that emerged were also important.

Technology:

Since this project was carried out over an extended period of time, numerous ICT tools became much more readily available to record, analyze and present information as the project progressed. The project took an innovative approach in adopting technology as it became available (GPS, GIS, Satellite imagery), and was reported to have intuitive interfaces and smooth transition to local ownership of the tools. In addition, the project was adapted to include these tools as they became available.

Transferability:

The transferability of this application scores slightly lower because although the project was successfully handed over to the local agencies at the project completion, the duration for implementation suggests that multiple generations of technology were incorporated. The time-based deployment of the system would make it difficult to take the existing system and transfer it to another location as is, but the general approach for completing a similar project remains valid. Also favourable in the project was the early adoption of technologies that are now widely deployed such as GPS and ESRI software for visualization.

Impact:

It is clear from the reports that the program was successfully transferred to local management with numerous direct results in both resource management and capacity building (for example, 2 local team members completed their masters and 10 completed technical degrees) as well as numerous other accomplishments and clearly tracked budget for the project.

In summary, The Trees for Tomorrow project shows a clear example of a local implementation of e-Environment applications within a structured project to jointly improve forest and watershed management and enforcement as well as capacity building.

14.5. Example 3: NatureServe – Biotics-4

Application Description:

NatureServe[218] is a non-profit conservation organization whose mission is to provide the scientific basis for effective conservation action. NatureServe and its network of natural heritage programs are the leading source for information about rare and endangered species and threatened ecosystems.

NatureServe represents an international network of biological inventories—known as natural heritage programs or conservation data centers—operating in all 50 U.S. states, Canada, Latin America and the Caribbean. Together they not only collect and manage detailed local information on plants, animals, and ecosystems, but develop information products, data management tools, and conservation services to help meet local, national, and global conservation needs. The objective scientific information about species and ecosystems developed by NatureServe is used by all sectors of society—conservation groups, government agencies, corporations, academia, and the public—to make informed decisions about managing our natural resources.

Although NatureServe is actually an organization that manages a set of ICT tools for conservation, this particular ranking example applies to the Biotics-4 application. Biotics 4 is an advanced geographic information systems-based software tool for managing biodiversity information. The use of software such as Biotics 4 promotes interoperability throughout the NatureServe network, ensuring that data collected in each state and province can be compared, exchanged, and combined. NatureServe has extensive experience in the use of geographic information systems (GIS) to analyze and present our data, and has developed a close partnership with ESRI to develop additional GIS-based data management and decision-support tools for conservation.

Categories covered:

Observation	Analysis	Planning	Management	Mitigation	Capacity Building
X	X	X			

Support Partners: The Nature Conservancy, NBII, USGS, Convention on Biological Diversity Clearing house Mechanism, Global Biodiversity Information Facility (GBIF), Inter-American Biodiversity Information Network (IABIN), Integrated Taxonomic Information System (ITIS), IUCN Species Survival Commission Red List Programme, North American Biodiversity Information Network (NABIN)

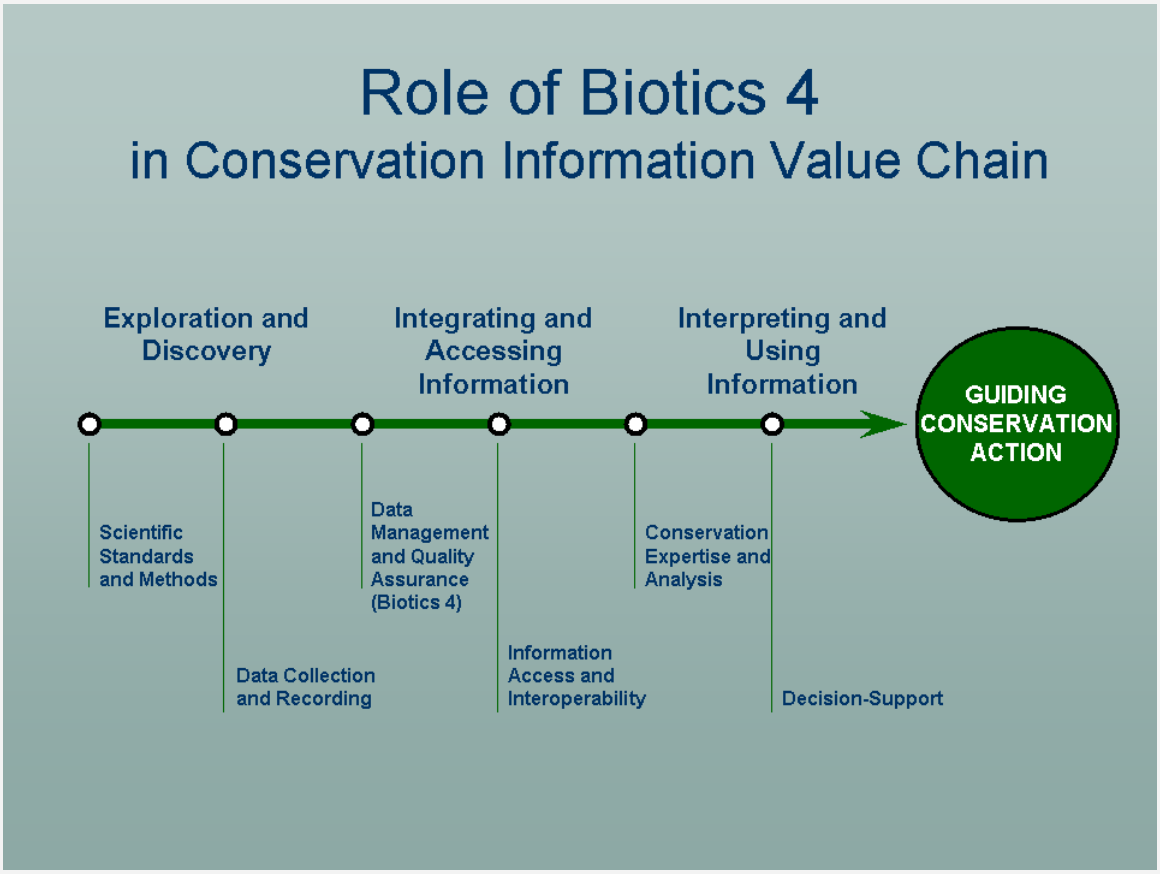
Ranking

Environmental Scope:

All of the NatureServe applications score high in environmental scope because of the organizations expertise and focus on conservation, and due to the geographical scope (across the Americas). In the areas of conservation, Biotics-4 has a clearly defined role in the collection, analysis and decision support within the well-established NatureServe network.

[218] See http://www.natureserve.org/prodServices/biotics.jsp

Figure 16. Role of Biotics 4 in conservation information value chain



Source: NatureServe

Technology: 1 5

The Biotics-4 program scores high on the technology score for its professional development environment, its user-friendly functionality and richness of features. It also scores high as part of the NatureServe network because of the innovative use of participative data entry approach that allows the entire network to act as a data-collection tool. Within the application suite at NatureServe there is a strategic plan to increase the capabilities for data presentation and capture via Web interfaces.

Transferability: 1 5

The transferability of this application ranks med-to-high because of the track record of the organization of expanding into developing countries in Latin America. However, there is still a bias to the US and Canada with data transfers scheduled only for those countries in 2007.

Figure 17. Biotics Rollout LAC

Source: NatureServe

Impact:

NatureServe has been active for the past 30 years and has established itself as a recognized leader in the collection, categorization and analysis of conservation data. It has a partner network that spans both local and international organizations and has a well-developed set of services as well as numerous specific cases in which its tools have been used effectively in decision-making.

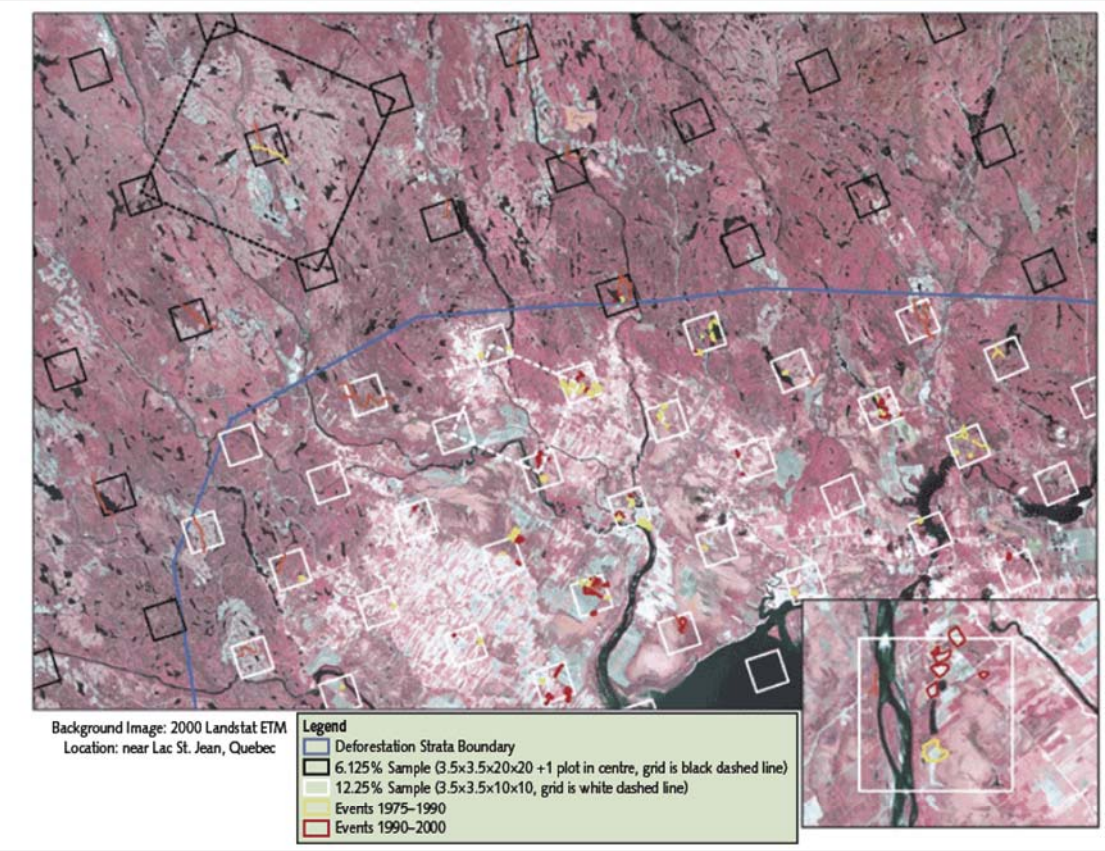
In summary, the Biotics-4 application was built on the data collection expertise at NatureServe combined with commercial tools such as ESRI ArcView to provide a comprehensive tool for collection and analysis of conservation data. When used within the context of the NatureServe organization, it is a leader in both technical innovation as well as environmental scope.

14.6. Example 4: Greenhouse Gas (GHG) Monitoring, Accounting and Reporting – Environment Canada

Application Description:

The Greenhouse Gas Division of the government agency Environment Canada has developed a National System for monitoring, analyzing, and reporting on emissions and removals of greenhouse gases (GHGs) in accordance with the requirements of the Canadian Environmental Protection Act, the United Nations Framework Convention on Climate Change (UNFCCC), and the Kyoto Protocol. The Division works closely with its partner government agencies; Agriculture Canada, Natural Resources Canada, and Statistics Canada, to collect data on the basis of distinct spatial units called reporting zones. The Division uses a geo-database based on ESRI's Advanced Spatial Data Server solution known as ArcSDE and Microsoft SQL server to manage both the spatial and non-spatial components of the gathered information.

Figure 18: Sampling Grids over Imagery for Forest Conversion Mapping and Delineated Forest Conversion Events[219]



Source: A3.5.2 Forest Land And Forest-Related Land-Use Change, National Inventory Report, 1990-2004 - Greenhouse Gas Sources and Sinks in Canada, http://www.ec.gc.ca/pdb/ghg/inventory_report/2004_report/ann3_5_2_e.cfm

Estimates of carbon stock changes, emissions, and removals for reporting zones are based on modelling of processes and events monitored by partner government agencies. For example, the Canadian Forest Sector reports on growth, litterfall, natural tree mortality, decomposition, management activities (thinning and cutting), natural disturbances (wildfires, defoliators, and wood borers), and forest conversion. Sampling approaches range from complete mapping to systematic sampling over the entire spatial unit of interest (see Figure 18)[220].

The use of GIS technology not only allows the Greenhouse Gas Division to report on changes that occur in GHG emissions and removals over time but also spatially. This analysis is captured in comprehensive National Inventory Reports from which estimates are provided to the UNFCCC annually. The Division's GIS expertise contributes to continuous improvements in the quality and certainty of these estimates. These ongoing efforts in turn support the development of new tools and models to estimate and track emissions and removals trends, support experts on UN Review Teams,

[219] A3.5.2 Forest Land And Forest-Related Land-Use Change, National Inventory Report, 1990-2004 - Greenhouse Gas Sources and Sinks in Canada, http://www.ec.gc.ca/pdb/ghg/inventory_report/2004_report/ann3_5_2_e.cfm (accessed Nov 30, 2007).
[220] Ibid. In populated areas of southern Ontario and Quebec and in the northern prairie fringe, a 12.3% sampling rate was generally achieved, with 3.5 × 3.5 km sample cells on a 10-km grid as shown.

support international negotiations, the undertaking of research on sources and sinks, education, and contribute to the development of applied solutions[221].

Categories covered:

Observation	Analysis	Planning	Management	Mitigation	Capacity Building
X	X	X			X

Support Partners: Agriculture Canada, Natural Resources Canada, and Statistics Canada,

Ranking

Environmental Scope:

The Greenhouse Gas Division's application of GIS to Environment Canada's monitoring, accounting and reporting of GHGs scores high in environmental scope because of its contribution through the growing scientific and engineering expertise in modeling estimates of carbon stock changes, emissions, and removals by reporting zones to the global issue of climate change. In terms of conservation, the linkage of this application to the monitoring and management of agriculture, forestry and other resources clearly has an influence on how data collection, analysis and corresponding decision making is made in these areas.

Technology:

The Greenhouse Gas Division's application of GIS scores high on the technology score for its use of the GIS technology to improve on their delivery of GHG inventory information and their confidence in the information they deliver. It also scores high for its contribution to developing new tools and models to estimate and track emissions and removals trends, and in supporting research on carbon sources and sinks.

Transferability:

The transferability of this application ranks med-to-high acknowledging that developing countries have no greenhouse gas emission reduction obligations at this time. However, given that carbon emissions from deforestation represent 18-25% of all emissions[222] there have been growing calls for the inclusion of forests in Clean Development Mechanism (CDM) schemes for the second commitment period from a variety of sectors[223]. Even though many developing countries lack a data gathering capacity comparable to Environment Canada and its partner agencies, capacity in developing countries for deforestation monitoring is well advanced in a few countries and is a feasible goal in most others[224]. International commitments of resources to increase capacity, coordination of

[221] About the GHG Division, Greenhouse Gas (GHG) Information, http://www.ec.gc.ca/pdb/ghg/about_e.cfm (accessed Nov 30, 2007).
[222] Annex 7.f Emissions from the land use sector, Stern Review on the economics of climate change, http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm (accessed Dec 1, 2007).
[223] The Forests Now Declaration, http://www.forestsnow.org/ (accessed Dec 1, 2007).
[224] DeFries R, F Achard, S Brown, M Herold, D Murdiyarso, B Schlamadinger, and C de Souza Jr. (2007) Earth observations for estimating greenhouse gas emissions from deforestation in developing countries. *Environmental*

observations, access to free or low-cost data, and standard and consensual protocols for data interpretation and analysis will be important for overcoming limitations effecting transferability.

Impact:

The Greenhouse Gas Division's efforts in using GIS for monitoring, accounting and reporting of GHGs rank high on the impact scale. These efforts have made significant contributions to the work of UN Review Teams, support of international negotiations, and to research on sources and sinks, including that of the Intergovernmental Panel on Climate Change (IPCC).

In summary, the Greenhouse Gas Division's GIS application for monitoring, accounting and reporting of GHGs leveraged the data gathering ability of its partner government agencies to create an impressive capacity for tracking estimates of carbon stock changes, emissions, and removals both over time and spatially for Canada. In the context of the United Nations Framework Convention on Climate Change (UNFCCC), and the Kyoto Protocol, these efforts have made important contributions to international reviews, negotiations and research on climate change.

14.7. Example 5: International Transaction Log (of the Kyoto Protocol Registries System)

Application Description:

Emission targets for industrialized country Parties to the Kyoto Protocol are expressed as levels of allowed emissions, or "assigned amounts", over the 2008-2012 commitment period. Such assigned amounts are denominated in tonnes (of CO2 equivalent emissions) known informally as "Kyoto units".

The ability of Parties to add to their holdings of Kyoto units (e.g. through credits for CDM or LULUCF activities) or move units from one country to another (e.g. through emissions trading or JI projects) requires registry systems that can track the location of Kyoto units at all times[225].

As part of the system of registries, the International Transaction Log acts as a centralize system to verify transactions proposed by registries to ensure they are consistent with rules agreed under the Kyoto Protocol. Each registry sends transaction proposals to the ITL, which checks each proposal and returns to the registry its approval or rejection. Once approved, registries complete the transaction. In the event that a transaction is rejected, the ITL sends a code indicating which ITL check has been failed and the registry terminates the transaction.

Data Exchange Standards coordinate the functions of systems when processing transactions. They define technical requirements for the communication between the ITL and registries. They also define the checks performed by the ITL, embodying the policy rules agreed by Parties for the accounting of their assigned amounts and their use of the Kyoto mechanisms.

Each registry is to be connected to the ITL through secure communication channels established across the Internet. These connections will allow a registry to receive an immediate response from the ITL, typically within a matter seconds after sending the transaction information.

The administrator of the ITL is the UNFCCC secretariat, which has awarded a contract for the development and operation of the ITL to leading companies in the field of IT services. The ITL is hosted at two commercially operated data centers, one for primary operations and the other as a

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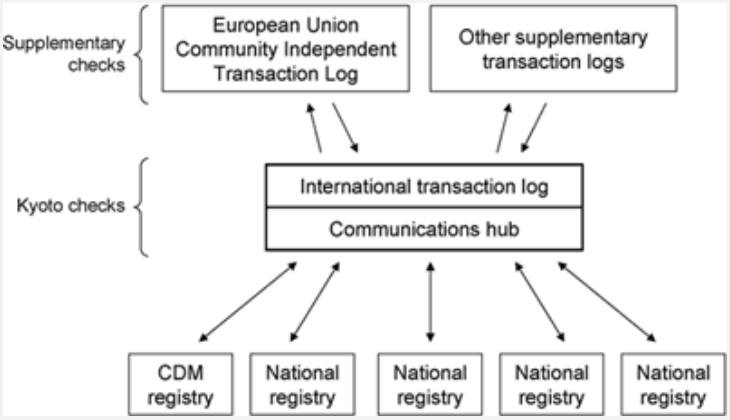
Science & Policy 10(4): 385-394, http://www.gofc-gold.uni-jena.de/documents/other/EO_for_GHG_emissions.pdf (accessed Dec 1, 2007).

[225] Registry Systems under the Kyoto Protocol, http://unfccc.int/kyoto_protocol/registry_systems/items/2723.php (accessed Dec. 11, 2007).

backup site, both located in the United Kingdom. A service desk, also based in the United Kingdom, has been put in place to support the administrators of the ITL, registries and the CITL [226].

Figure 19: Registry Systems under the Kyoto Protocol[227]



Source: UNFCCC

Categories covered:

Observation	Analysis	Planning	Management	Mitigation	Capacity Building
			X		

Support Partners: UNFCCC, parties to the Kyoto Protocol

Ranking

Environmental Scope: 1 — 5

The ITL is focused specifically on the serious issue of climate change through tracking of international emissions. It is part of a global effort within the Kyoto protocol to both track emissions as well as enforce limits that have been agreed upon. In this respect, the ITL scores high on environmental scope because it provides global coverage of a specific issue focused directly on the environment.

Technology: 1 — 5

The ITL was put into place as part of a larger system and therefore was constrained to the interactions of a specifically designed task. Within this context the focus of the implementation is on functionality, with innovation representing a minor component of the objectives. However, the application still scores med-high because it implemented new standards for use as a common mechanism for the transfer of data between the parties. Since the scale of the project was global, with many parties

[226] International Transaction Log , http://unfccc.int/kyoto_protocol/registry_systems/itl/items/4065.php (accessed Dec. 11, 2007).
[227] Registry Systems under the Kyoto Protocol, http://unfccc.int/kyoto_protocol/registry_systems/items/2723.php (accessed Dec. 11, 2007).

depending on a reliable, consistent application, a professional development and testing cycle was required.

Transferability: 

ITL inherently was intended to support all global parties to the Kyoto, and its successful implementation required the support of all parties. However, this built-in transferability should be considered part of the technology ranking of the application and transferability should apply to the use of the application outside of the scope of the initial intended users or environmental focus. Since this application is so specifically focused on the ITL function, it would be difficult to transfer this technology to another environmental focus, and since the original end users include most global players, there are no additional regions to which to extend the application. As a result, it scores medium on the scale of transferability.

Impact: 

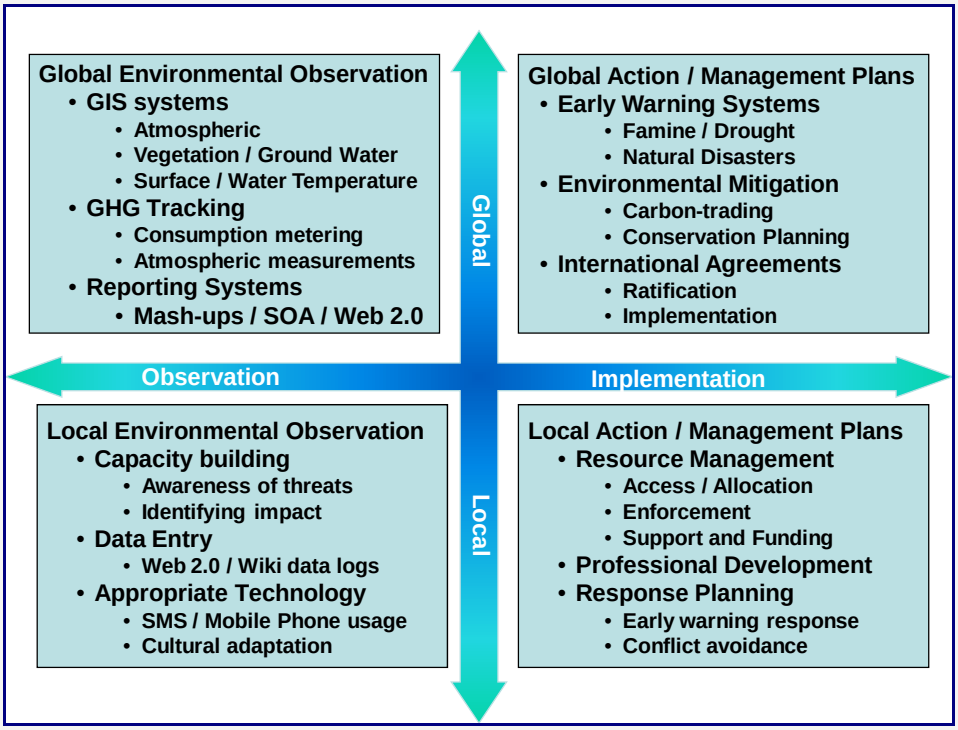
Although no information could be found regarding the funding resources required for this application, it could be seen that the adoption of this application by the end users demonstrates that the application has been effective in achieving its goals. In addition, the global scope of the project indicates that economies of scale could be achieved, and the ability of the ITL to define a global standard for the tracking of emissions, and interwork with the national registries and the ETS system show that it has been effective.

In summary, the ITL system is an example of an e-Environment application that came into existence as a result of the concerted efforts of the UNFCCC to address a specific requirement within the Kyoto protocol. The environmental scope of this project is clear, and the end results align with the original objectives. The design approach may be valid for other applications that seek to address similar global scale tracking mechanisms, but the application has been designed to a specific requirement which would make its transfer or redeployment difficult.

15. ANNEX 2: ICT APPLICATIONS LIST INCLUDING DESCRIPTION AND LINKS

Over 150 applications have been considered in preparing this report. A categorization of the applications is presented below.

Figure 20. e-Environment ICT application map



The survey of applications in the attached list was completed through a combination of Web-based research, telephone interviews and through secondary contacts. The initial phase involved creating a template for the classification and data collection, with a broad-reaching search initiated in parallel to identify and assess as many relevant links as possible. The template is based on the six environmental application categories described above as well as the perceived relevance and usefulness of the applications themselves.

As the number of applications recorded in this survey increased, a re-occurrence of previously identified applications within new references was noted. In addition, the agencies related to the applications that were identified were also tracked, and any source of information that contained multiple references was listed under the heading of Clearing House Mechanisms.

The applications highlighted in yellow are described in more detail in Annex 1 starting on page 107.

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
Jal-Chitra	Jal-Chitra was a PC-based tool for helping rural communities manage their water resources. It created an interactive water-map of the village in order to enable the community to keep records of the amount of water available from each water source and could record water quality testing, lists of maintenance work done and required, estimates of water demand, and could generate future monthly water budgets (based on past records). The interface was available in Hindi and the project was promoted in Rajastan in 2000.			X	X			Ajit Foundation Mr. Vikram Vyas Tilonia Barefoot College	India	2000-2004	http://www.irc.nl/page/13322	http://www.indiatogether.org/2004/jun/wom-onevill.htm http://www.gisdevelopment.net/application/nrm/water/ground/mi03240.htm http://www.gisdevelopment.net/application/environment/overview/envo0003pf.htm http://www.ciol.com/cchange/2007/article12.asp
WATEX	WATEX is a proprietary groundwater exploration process used to locate renewable groundwater reserves in arid and semi-arid environments. Application in Darfur to assess water supply risks and mitigation methods in response to refugee migration.	X	X			X		Radar Technologies France (RTF) Alain Gachet Firoz Verjee SEAS Doctoral Fellow & Research Associate Institute for Crisis, Disaster & Risk Management The George Washington University	Africa Darfur	2004-Active	http://www.radar-technologies.com/	http://www.gisdevelopment.net/application/nrm/water/surface/me05_100a.htm
DEWS	Distant Early Warning System for Tsunamis scheduled for completion in 2010.	X						SAAB Jan Larsson Funded by EC	Asia Pac	2006 - 2010	https://projectplace.com/pub/english.cgi/0/174344712?op=pm&o=PublicwebExternal_overview&tab=PublicwebExternal_overview&m=pubweb	
SHARE	S H A R E is one of the European Space Agency's DUE Tiger projects. SHARE aims at enabling an operational soil moisture monitoring service for the region of the Southern African Development Community (SADC). With this service	X	X		X			European Space Agency	Africa	?	http://www.ukzn.ac.za/sahg/share/	http://dup.esrin.esa.it/projects/summaryp77.asp

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	SHARE will address one of today's most severe obstacles in water resource management which is the lack of availability of reliable soil moisture information on a dynamic basis at a frequency of a week and less.											
ESA Tiger	Following the 2002 Johannesburg World Summit on Sustainable Development, the European Space Agency has launched the TIGER Initiative - focusing on the use of space technology for water resource management in Africa and providing concrete actions to match the Resolutions. There are currently 64 separate projects listed under the ESA tiger initiative (See "Other Web References" for complete listing)	X	X	X	X		X	ESA	Africa	2002-Active	http://www.tiger.esa.int/	http://www.tiger.esa.int/projectlist.asp?by=all
NatureServe	Conservation and biodiversity web site bringing together a wide variety of data in the US, Canada and Latin America.		X	X				The Nature Conservancy	North and Latin America		http://www.natureserve.org	
Dyvine	The DYVINE project focuses on integration of thousands of mobile and fixed video sensors to support the Risk Management Cycle and development of the associated communications network.	X	X					Philippe CHROBOCINSKI, EADS DS SAS EC Funding	Europe	2006 -	ftp://ftp.cordis.europa.eu/pub/fp7/ict/docs/sustainable-growth/fp6-fact-sheet-dyvine_en.pdf http://www.dyvine.eu/	
APNEE-TU	Air pollution monitoring system that reports air pollution conditions to users according to technology preferences in specific countries. For example in France the system used a voice retrieval (pull) system, whereas in Norway the system was an SMS based (push) system. Users paid for these services as part of either one-time charges or premium service bundles					X		EC FP5	Europe	2002 - 2004		

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
ADA	Advanced Distributed Architecture for telemonitoring services Air pollution and noise	X						EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
APNEE	Air Pollution Network for Early warning and on-line information exchange in Europe Air pollution and noise	X				X		EC FP5	Europe	2000-2001	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
BLUE WATER	Computerized video camera image analysis for monitoring water pollution	X						EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
COASTBASE	The Virtual European Coastal and Marine Data Warehouse - CoastBase- An open system architecture for integrated, distributed coastal and marine information search and access Marine and coastal zone, oil spills, algal blooms	X	X					EC FP5	Europe	2000-2001	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
DESTINY	Decision support system for local sustainable development based on eco-budget methodology DSS sustainable development			X				EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
DISMAR	Data Integration System for MARine pollution and water quality Marine and coastal zone, oil spills, algal blooms		X					EC FP5	Europe	2002-2005	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
EDEN IW	Environmental Data Exchange for Inland Water Flood and inland water pollution		X					EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
EGSO	European Grid of Solar Observations Solar Observation	X						EC FP5	Europe	2002-2005	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
EUROCLIM	European Climate Change Monitoring and Prediction System Climate change prediction	X	X					EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
FOREMMS	Forest environmental monitoring and management system Disaster prevention and emergency management	X	X		X			EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
GIMMI	Geographic Information and Mathematical Models Interoperability Flood and inland water pollution		X					EC FP5	Europe	2002-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
HARMONOISE	HARMOnised, accurate and reliable prediction methods for the EU directive on the assessment and management of environmental NOISE Air pollution and noise		X					EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
HEAVEN	Healthier Environment through Abatement of Vehicle Emission and Noise Air pollution and noise					X		EC FP5	Europe	2000-2003	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
ICAROS	NET Integrated Computational Assessment of urban air quality via Remote Observation Systems NETwork Air pollution and noise	X	X					EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
I-MARQ	Information system for Marine Aquatic Resource Quality Marine and coastal zone, oil spills, algal bloom	X	X					EC FP5	Europe	2002-2005	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
IMPACT	Estimation of human IMPACT in the presence of natural fluctuations Environmental management	X	X					EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
INTAIRNET	Intelligent Air Monitoring Network Air pollution and noise	X	X					EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
ISIS	Intelligent Systems for humanitarian Geo-InfraStructure Humanitarian intervention	X	X	X				EC FP5	Europe	2002-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
IWICOS	Integrated Weather, Sea Ice and Ocean service system Marine information system						X	EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
MERMAID	Marine Environmental Response Data Management and Acquisition using Internet data brokerage Marine and coastal zone, oil spills, algal blooms	X	X		X			EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
MINEO	Assessing and Monitoring the environmental Impact of mining activities in Europe using advanced Earth Observation techniques Mining impact	X	X					EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
ODIN	Geographic Distributed Information Tools and Services for the Mobile Information	X						EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/prev	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	Society										ious-fp5_en.html	
OSIRIS	Operational Solutions For The Management Of Inundation Risks In The Information Society Flood and inland water pollution			X	X			EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
RAMFLOOD	Decision support system for Risk Assessment and Management of FLOODs Flood and inland water pollution			X	X			EC FP5	Europe	2003-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
RAPSODI	Remote sensing Anti-Pollution System for geographical Data Integration Marine and coastal zone, oil spills, algal blooms	X						EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
SEWING	System for European Water monitorING Flood and inland water pollution	X						EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
SISCAL	Satellite-based Information System on Coastal Areas and Lakes Marine and coastal zone, oil spills, algal blooms	X	X					EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
SODA	Integration and exploitation of networked solar radiation Databases for environment monitoring Environmental monitoring of solar radiation	X	X					EC FP5	Europe	2000-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
SUMARE	Survey of Marine Resources Marine and coastal zone, oil spills, algal blooms	X						EC FP5	Europe	2000-2003	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
TEASE	Telematics Architecture Study for Environment and security Disaster prevention and emergency management	X		X	X			EC FP5	Europe	2001-2002	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
TELEMAC	TELEMonitoring and Advanced teleControl of high yield wastewater treatment plants Waste water treatment	X			X			EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
VIRTU@LIS	Social Learning on Environmental issues with the Interactive Information and Communication Technologies Learning tools						X	EC FP5	Europe	2001-2004	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp5_en.html	
DEWS	Distant Early Warning System Tsunami Early Warning and Alert	X						EC FP6	Europe	2007-2010	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
EU-FIRE	Innovative optoelectronic and acoustic sensing technologies for large scale forest fire long term monitoring Environmental Monitoring and Sensor Web	X	X		X			EC FP6	Europe	2006-2009	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
ERMA	Electronic Risk Management Architecture For Small And Medium Size Communities Shared Information Space and Services		X	X	X			EC FP6	Europe	2006-2008	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
INTAMAP I	NTeroperability and Automated MAPping Shared Information Space and Services		X					EC FP6	Europe	2006-2009	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
S@NY	The SANY integrated project focuses on interoperability of in-situ sensors and sensor networks Environmental Monitoring and Sensor Web	X						EC FP6	Europe	2006-2009	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
SCIER	Sensor & Computing Infrastructure for Environmental Risks Environmental Monitoring and Sensor Web	X	X					EC FP6	Europe	2006-2008	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
STREAM	Technology to Support Sustainable Humanitarian Crisis Management Humanitarian Intervention and Demining			X	X			EC FP6	Europe	2004-2008	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
WARMER	Water Risk Management In Europe Environmental Monitoring and Sensor Web	X	X					EC FP6	Europe	2006-2009	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
WIN	Wide Information Network Shared Information Space and Services		X					EC FP6	Europe	2004-2007	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
WINSOC	Wireless Sensor Networks with Self-Organization Capabilities for Critical and Emergency Applications Environmental Monitoring and Sensor Web	X				X		EC FP6	Europe	2006-2009	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
WISECOM	Wireless Infrastructure Over Satellite For Emergency Communications Public Safety Communication	X				X		EC FP6	Europe	2006-2008	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html	
GMFS	GLOBAL MONITORING FOR FOOD SECURITY provides early warning, agricultural mapping and crop yield	X	X				X	ESA	Global	2004-Current	http://www.gmfs.info/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	assessment services in support of food security monitoring activities in Africa. GMFS partners with key actors in the sector at the international (EC and UN), regional (Regional Economic Communities or key institutes) and national level (Ministries of Agriculture or national Food Security Monitoring groupings). At national level GMFS Activities focus on .Ethiopia, Sudan, Senegal, Zimbabwe, Mozambique and Malawi.											
SAHIMS	Interactive Atlas for tracking Human Development. Limited environmental factor consideration		X				X	SAHIMS NGO	Southern Africa	2003-	http://www.sahims.net/gis/Gis%20Input/MAP_library_Regional.asp	
Bantay Usok	website for reporting "smoke belcher" cars in the Philippines.	X				X	X	Philippines Government and ABS-CBN	Philippines	2000-2002	http://www.lto.gov.ph/news082302.html	
Kiunga Marine Protected Area	Project to monitor mangroves in Kiunga MPA in Kenya using GIS systems	X	X	X	X			KWS	Kenya	2003	http://www.yale.edu/tri/pdfs/bulletin2005/073Bull05-Soud.pdf	
Awhere-ACT	Awhere-ACT, a user-friendly geographical information systems (GIS) tool, is helping farmers and scientists in Africa to combat pests such as stem borers and the cassava green mite.	X	X		X			Mud Springs Geographers, Inc. International Maize and Wheat Improvement Centre (CIMMYT)	Africa	2003	http://ictupdate.cta.int/en/feature_articles/awhere_act_predicting_pest_outbreaks_in_africa	
TADInfo	Tool for tracking and monitoring animal disease outbreaks.	X	X	X	X			FAO	Africa	2004	http://ictupdate.cta.int/en/feature_articles/tadinfo_an_information_system_for_animal_health	
PIER	Pacific Islands Ecosystems at Risk listings and descriptions of plant species that threaten ecosystems of the Pacific islands. Also listed are many other invasive and potentially invasive plant species present in and around the Pacific region.	X					X	US Department of Agriculture - Forest services.	Pacific Islands	2005	http://www.hear.org/pier/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
Trees For Tomorrow	The goal of the project is to improve the management and conservation of the forests and tree crops for the benefit of the people of Jamaica. Project activities help to strengthen institutional capabilities within the forestry sector to plan and implement sustainable forest management and to improve land use in Jamaica's watersheds.	X	X	X	X		X	CIDA Govt. of Jamaica	Jamaica	2001-2007	http://www.cida.gc.ca/CIDAWEB/cpo.nsf/vWebProjBySectorEn/1B2B19A616A0D522852572F700370438	http://www.jis.gov.jm/agriculture/html/20070125T110000-0500_11093_JIS_12_YEAR_TREES_FOR_TOMORROW_PROJECT_COMES_TO_A_CLOSE.asp
CARPE	A consortium of government and NGO partners, CARPE aims to ensure that African decision-makers have access to, and the capacity to use, information critical to natural resources management (NRM). To a large extent, this information comes in the form of Landsat satellite-derived maps that can be continuously updated using geospatial databases.	X	X				X	USAID University of Maryland	Africa - Congo	Active	http://carpe.umd.edu/	http://ictupdate.cta.int/en/feature_articles/carpe_mapping_central_african_forest_resources_by_satellite
GemStat	GEMStat is designed to share surface and ground water quality data sets collected from the GEMS/Water Global Network, including over 2,700 stations, two million records, and over 100 parameters.	X	X				X	UN GEMS	Global	Active	http://www.unep-wcmc.org/posters/ESRI_Conference/mangrove_v91.pdf	
SMS Communities	It uses an internet-based SMS platform (SMS Malls) to send messages to community members inviting them to attend meetings with park staff, or special events. This builds on existing methods of communication (including expensive landline telephone and face-to-face meetings) and has been well received by the local people.					X	X	t4cd Kruger National Park	South Africa	Active	http://www.t4cd.org/Projects/Current%20Projects/Pages/SMSCommunities.aspx/	
World Weather Watch	To predict the weather, modern meteorology depends upon near instantaneous exchange of weather	X	X	X				WMO	Global	Active since 1963	http://www.wmo.int/pages/prog/www/index_en.html	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	information across the entire globe. Established in 1963, the World Weather Watch -the core of the WMO Programmes- combines observing systems, telecommunication facilities, and data-processing and forecasting centres - operated by Members - to make available meteorological and related environmental information needed to provide efficient services in all countries.											
Geo Data Portal	The GEO reporting process is based on sound empirical analysis and the contributions of a global network of partners. It thus requires having readily at hand - meaning, via the Internet and off-line - a wide range of statistical and geo-spatial data sets that meet as much as possible the following requirements: - offering world-wide coverage, but with data at the national level; - characterised by harmonised data values, collection units and definitions; - available for every year since 1970 to coincide with the GEO “retrospective” period; - freely and easily accessible to GEO contributors and broader user community; and - offering aggregated values for the sub-regional, regional and global levels.	X	X					UNEP	Global	2001 - Active	http://earthwatch.unep.net/data/geodata/index.php/	
Global Runoff Data Centre (GRDC)	The WMO digital world-wide repository of discharge data and associated metadata focusing the multifaceted world of global river discharge data for the sake of key research linking local and global change issues.	X	X					WMO	Global	1995-present	http://grdc.bafg.de/servlet/is/Entry.987.Display/	
SERVIR	A regional visualization and monitoring system for Mesoamerica that integrates	X	X	X	X			NASA, CATHALAC, USAID, the Central	Latin America	Active	http://servir.nsstc.nasa.gov/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	satellite and other geospatial data for improved scientific knowledge and decision making by managers, researchers, students, and the general public. SERVIR addresses the nine societal benefit areas of the Global Earth Observation System of Systems (GEOSS): disasters, ecosystems, biodiversity, weather, water, climate, oceans, health, agriculture, and energy. For example, SERVIR can be used to monitor and forecast ecological changes and severe events such as forest fires, red tides, and tropical storms.							American Commission for Environment and Development (CCAD), the World Bank, the Nature Conservancy, and the United Nations Environmental Programme (UNEP-ROLAC) and IAGT.				
P3DM for "Collaborative Protected Area Management"	The combination of GIS with 3D modeling to map out protected areas in the Philippines. Use of Participatory 3D Modeling	X	X		X			IAPAD	Philippines	1998-2007	http://www.iapad.org/applications/application_01.htm/ http://www.iapad.org/applications/protected_areas/nnnp.htm/	
Catalogue of Life	The Species 2000 & ITIS Catalogue of Life currently have cross-references to half the documented global species from 47 taxonomic databases from around the world. Species 2000 and ITIS teams peer review databases, select appropriate sectors and integrate the sectors into a single coherent catalogue with a single hierarchical classification. It is planned to introduce alternative taxonomic treatments and alternative classifications, but an important feature is that for those users who wish to use it, a single preferred catalogue, based on peer reviews, will continue to be provided.	X					X	ITIS	Global	2000-2011	http://www.catalogueoflife.org/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
VASAT Research Project	Use of remote sensing and GIS tools for village-level drought vulnerability assessment in Addakkal Region, AndhraPradesh	X	X	X				VASAT	India		http://www.icrisat.org/vasat/research/gis.htm/	
Dry-Net site	Due to current climatic changes and destructive land use, land is degrading faster than ever, increasing the surface area of drylands and deserts around the globe. Fourteen civil society organisations from all over the world have started working together to combat land degradation in an EU-funded project called Drynet.	X	X				X	EU	Global		http://www.dry-net.org/index.php?page=3/	
European Flood Alert System	An organization with modeling and reporting tools for flood warning in Europe	X	X	X				EU	Europe	1998-Active	http://efas.jrc.it/	
Desurvey	Understanding of desertification in a systemic and dynamic way. Assessing desertification and land degradation status, including diagnosis of driving forces, discrimination between current and inherited desertification, and identification of desertification hot spots. Forecasting of desertification under selected climatic and socio-economic scenarios. Monitoring of desertification and land degradation status over large areas using objective and reproducible methods. Bridging the gap between the knowledge generated by the project on the processes underlying desertification and the practice of formulating policy to detect, prevent and resolve desertification risks. The system is intended to be used at several temporal and spatial resolutions by national and regional environmental and agricultural authorities,	X	X	X			X	EU FP7	Global	2006 - Active	http://www.desurvey.net/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	such as the European Union (EU), the United Nations Convention to Combat Desertification (UNCCD) and local consortia of stakeholders in risk-affected districts.											
Famine Early Warning System (USAID)	The Goal of the Famine Early Warning Systems Network (FEWS NET) is to strengthen the abilities of African countries and regional organizations to manage risk of food insecurity through the provision of timely and analytical early warning and vulnerability information. FEWS NET is a USAID-funded activity that collaborates with international, national, and regional partners to provide timely and rigorous early warning and vulnerability information on emerging or evolving food security issues. FEWS NET professionals in the US and Africa monitor various data and information—including remotely sensed data and ground-based meteorological, crop and rangeland conditions—as early indications of potential threats to food security. FEWS NET also focuses its efforts on strengthening African early warning and response networks. Activities to do this include capacity development, network building and strengthening, developing policy useful information, and forming consensus about food security problems and solutions.	X	X	X	X	X	X	USAID	Africa	On-going	http://www.fews.net/imagery/?pageID=imageryAbout/	
GEOSS	The intergovernmental Group on Earth Observations (GEO) is leading a	X	X					GEO	Global	2005-2010	http://www.earthobservations.org/index.html/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	worldwide effort to build a Global Earth Observation System of Systems (GEOSS) over the next 10 years. GEOSS will work with and build upon existing national, regional, and international systems to provide comprehensive, coordinated Earth observations from thousands of instruments worldwide, transforming the data they collect into vital information for society.											
Conservation GeoPortal	The Conservation Geoportal is a collaborative effort by and for the conservation community to facilitate the discovery and publishing of geographic information systems (GIS) data and maps, to support conservation decision-making and education. It is primarily a data catalog, intended to provide a comprehensive listing of GIS data sets and map services relevant to biodiversity conservation. The Conservation Geoportal does not actually store maps and data, but rather the descriptions and links to those resources, known as "metadata."						X	NGO with partners:	Global	Active	http://www.conservationmaps.org/index.jsp	
Elevation maps - CGIAR-CSI SRTM 90m DEM Database	The CSI is a loosely structured consortium comprised of members which include all of the sixteen CGIAR Centers, plus several Associate Members. A coordinating center (currently IWMI) and a steering committee elected by all the members, direct activities on a 2-year rotating basis. The participating centers have identified six areas of high priority and common interest to the CGIAR/GIS community.						X	Consortium	Global	Active	http://srtm.csi.cgiar.org/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
Forestry Audit - TracElite	Forestry GIS (fGIS™) is a compact but robust shapefile editing program, digitizer and GIS data query tool for Windows®. fGIS was designed for natural resource managers who are not GIS specialists. It's easy-to-use and simple to install. Many power users also like fGIS because they can run it on laptops or home computers without copyright issues, it produces data compatible with commercial GIS programs, and fGIS is free.		X	X	X		X			2003-2005	http://www.forestpal.com/fgis.html	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS - Quantum	Quantum GIS (QGIS) is a user friendly Open Source Geographic Information System (GIS) that runs on Linux, Unix, Mac OSX, and Windows. QGIS supports vector, raster, and database formats. QGIS is licensed under the GNU General Public License. QGIS lets you browse and create map data on your computer. It supports many common spatial data formats (e.g. ESRI ShapeFile, geotiff). QGIS supports plugins to do things like display tracks from your GPS. QGIS is Open Source software and it's free of cost (download here). We welcome contributions from our user community in the form of code contributions, bug fixes, bug reports, contributed documentation, advocacy and supporting other users on our mailing lists and forums. Financial contributions are also welcome.		X				X	Private	Global	Active	http://www.qgis.org/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS base maps - Global Land Cover Facility	The Global Land Cover Facility (GLCF) provides earth science data and products to help everyone to better understand global environmental systems. In particular, the GLCF develops and		X				X	University of Maryland			http://glcf.umiacs.umd.edu/index.shtml	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	distributes remotely sensed satellite data and products that explain land cover from the local to global scales.											
GIS Databases and Software - Open Source Geospatial Foundation Website	The Open Source Geospatial Foundation has been created to support and build the highest-quality open source geospatial software. The foundation's goal is to encourage the use and collaborative development of community-led projects. This website serves as a portal for users and developers to share their ideas and contribute to project development. As the Open Source Geospatial Foundation grows and changes, so will this website.		X				X	Private Foundation	Global	Unknown	http://www.osgeo.org/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Dataset, Climate - WorldClim	WorldClim is a set of global climate layers (climate grids) with a spatial resolution of a square kilometer. They can be used for mapping and spatial modeling in a GIS or other computer program. The data are described in: Hijmans, R.J., S.E. Cameron, J.L. Parra, P.G. Jones and A. Jarvis, 2005. Very high resolution interpolated climate surfaces for global land areas.		X				X	Private	Global	2006	http://www.worldclim.org/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Datasets - U.S. Geological Survey	A variety of printed maps and geographical datasets		X				X	USGS	Global	Active	http://eros.usgs.gov/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Datasets - UNEP/GRID Sioux Falls	African and Latin America population databases now have multiple base layers such as rivers, lakes, and parks to overlay the population database.							UNEP	Global	Active	www.na.unep.net	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - 3D Visualisation and Fly By - 3DEM	Provides 3D views using many elevation model sources. Create animated flights through virtual terrains. Connect with Garmin or Magellan GPS receivers to display waypoints, routes, and tracks in 3D or generate elevation profiles of GPS		X								www.visualizationsoftware.com/3dem.html	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	tracks.											
GIS Software - Biomapper	Biomapper is centred on the Ecological Niche Factor Analysis (ENFA) that allows to compute HS models without the need of absence data.		X								http://www2.unil.ch/biomapper/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - DesktopGarp	GARP is a genetic algorithm that creates ecological niche models for species. The models describe environmental conditions under which the species should be able to maintain populations. For input, GARP uses a set of point localities where the species is known to occur and a set of geographic layers representing the environmental parameters that might limit the species' capabilities to survive.		X	X	X						http://nhm.ku.edu/desktopgarp/index.html	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - DIVA-GIS	DIVA-GIS is particularly useful for mapping and analyzing biodiversity data, such as the distribution of species, or other 'point-distributions'. The software was developed for use with species occurrence data such as available from natural history museums and genebanks. But the program can be used for other purposes.		X	X							http://www.diva-gis.org/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - DNR Garmin Tool	This extension was built to provide users the ability to directly transfer data between Garmin GPS handheld receivers and various GIS software packages. Using this program a user can use point features (graphics or shapefile) and upload them to the GPS as Waypoints. Line and Polygon Graphics or shapes can be uploaded to the GPS as Track Logs or Routes. Conversely, Waypoints, Track Logs, and Routes collected using the GPS can be transferred directly to	X									http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	ArcView/ArcMap/Google Earth/Landview and saved as Graphics or Shapefiles.											
GIS Software - ESRI	At the desktop GIS level, ArcGIS can include: ArcReader, which allows one to view and query maps created with the other Arc products; ArcView, which allows one to view spatial data, create maps, and perform basic spatial analysis; ArcEditor which includes all the functionality of ArcView, includes more advanced tools for manipulation of shapefiles and geodatabases; or ArcInfo the most advanced version of ArcGIS, which includes added capabilities for data manipulation, editing, and analysis. There are also server-based ArcGIS products, as well as ArcGIS products for PDAs. Extensions can be purchased separately to increase the functionality of ArcGIS. May extensions are also available as freeware.		X	X							http://www.esri.com/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - Forestry GIS (fGIS)	Forestry GIS (fGIS™) is a compact GIS data viewer, digitiser and shapefile editing program for Windows® from the University of Wisconsin and Wisconsin DNR - Division of Forestry. Designed for operational field managers like foresters and wildlife biologists, fGIS has essential tools tailored for precision mapping on a desktop computer. Use fGIS to customise layered views (including aerial photos and other imagery), draw map objects, query and search spatial data, annotate maps for printing, and much more. This standalone program is compatible with commercial GIS software.		X	X	X						http://www.forestpal.com/fgis.html	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - Geospatial	Automatically links digital photographic images to GPS location data in the GIS		X	X							http://www.geospatialexperts.com/	http://www.t4cd.org/Resources/ICT_Resources/Techno

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Experts	environment. Creates web pages in which the watermarked photographs are intergrated with satellite imagery, street maps or other GIS based mapping layer.											logies/Pages/ICTTechnologyList.aspx
GIS Software - GPS Visualiser	This software enables users to overlay your GPS positional data onto a map or aerial image without installing any new mapping software or large image databases on your PC. After logging on to the GPS Visualiser web site, just fill in a form for the type of map you'd like to create. The background image can be aerial photos, Landsat imagery, political maps or a variety of other choices depending where in the world your GPS data is. You browse to GPS data files on your hard drive, which will be uploaded to the GPS Visualiser server where the computing is done. Your GPS track and waypoint files can be of many common formats supported by the application. After a few seconds, GPS Visualiser will return a map. You designate the size of the image and other display parameters, which can be saved as an interactive scalable vector graphic (SVG) or conventional graphic. The utility will also generate an optional elevation profile of a GPS track. The only GPS Visualiser prerequisite is that you install the free Adobe SVG Viewer plug-in for it to work.	X	X	X							http://www.gpsvisualizer.com/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - GRASS	GRASS (Geographic Resources Analysis Support System) is a raster/vector GIS, image processing system, and graphics production system. GRASS contains over 350 programs and tools to render maps and images on monitor and paper;	X	X	X							http://www.grass.itc.it/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	manipulate raster, vector, and sites data; process multi spectral image data; and create, manage, and store spatial data. GRASS uses both an intuitive windows interface as well as command line syntax for ease of operations. GRASS can interface with commercial printers, plotters, digitizers, and databases to develop new data as well as manage existing data.											
GIS Software - LandSerf	Applications include visualisation of landscapes; geomorphological analysis; gaming development; GIS file conversion; map output; archaeological mapping and analysis; surface modeling and many others. It runs on any platform that supports the Java Runtime Environment (Windows, MacOSX, Unix, Linux etc.)	X	X	X							http://www.soi.city.ac.uk/~jwo/landserf/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - Map Maker	The foundation of the system is the free GIS, Map Maker Gratis. If your mapping needs are basic simply use the free Map Maker Gratis. Can be used to draw, edit and print basic maps, and link them to databases. Many users have taught themselves. Advanced features include manipulating vector, raster, 3D, and GPS data.	X	X	X							http://www.mapmaker.com/index.htm	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
GIS Software - MARXAN	MARXAN is software that gives support in designing biodiversity reserves. MARXAN finds reasonably efficient solutions to the problem of selecting a system of spatially cohesive sites that meet a suite of biodiversity targets. Given reasonably uniform data on species, habitats and/or other relevant biodiversity features and surrogates for a number of planning units (as many as 20,000) MARXAN minimises the cost (a weighted sum of area and		X	X	X						http://www.ecology.uq.edu.au/index.html?page=27710&pid=20497	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	boundary length) while meeting user-defined biodiversity targets.											
GIS Software - World Map	The WORLDMAP project was begun in 1988 in response to the need for a platform on which to research and develop new analytical tools for biologists. It is based on the same database - analytical tools - map graphics model as many commercial geographic information systems (GIS). Yet unlike commercial GIS, rather than concentrating on database and graphics flexibility, WORLDMAP is designed to perform specialist biological analyses for unlimited numbers of species (or other area attributes) at maximum speed, in order to support inter-active exploration of biodiversity data for research. Many of the biological tools are not yet available from commercial GIS. WORLDMAP is software for exploring geographical patterns in diversity, rarity and conservation priorities from large biological datasets. Because diversity is related in part to area extent, WORLDMAP was designed originally to use equal-area grid cells for more robust analyses, although in principle it can be applied to areas of any shape and size, at any spatial scale. Features: Explore geographical patterns in quantitative measures of diversity, rarity and conservation priorities, at any spatial scale (with tailored software), for large biological datasets, at high speed, inter-actively, through an easy-to-learn, graphical interface and with point-and-			X	X						http://www.nhm.ac.uk/research-curation//projects/worldmap/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	press data entry via maps in the data editor.											
GPS and GSM Mobile Phone - Garmin	GPS receiver units combined with mobile phone Two-way mobile phone communication between users with hand-held units. Ability to send GPS locations as SMS messages. PDA functions and compatible with most common email- and groupware programs (ACT!, Lotus Notes, Microsoft Outlook, Palm Desktop)										http://www.garmin.com/garmin/cms/site/us	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
Mapping - Flora Map	A software tool for predicting the distribution of plants and other organism in the wild. With software linked to agroclimatic and other databases, biodiversity specialists can create maps showing the most likely distribution of wild species in nature		X							2001-2003	http://www.floramap-ciat.org/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
Mapping, Satellite Images - OASIS	OASIS aims at enlarging the scope and activities of the ISIS programme (Incentive for the Scientific use of Images from the Spot system) implemented in 1994 by the French Space Agency (CNES) to a wider European dimension in order to reach new users.		X	X				EU	Europe	Active	http://medias.obs-mip.fr/oasis/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
Navigation - Earthcomber	Free Navigation system for Palm OS, Windows-powered PDAs and smartphones.	X						Private	Global		http://www.earthcomber.com/splash/index.html	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx
Tracking, Footprint Identification Technique - Wildtrack	Our mission is to develop and apply non-invasive and objective censusing and monitoring techniques as a fundamental resource for wildlife conservation. Our footprint identification technique (FIT) and others based on biometrics, can provide accurate and	X	X					Range of conservation sponsors, closely related to Rhino preservation.			http://www.wildtrack.org/	http://www.t4cd.org/Resources/ICT_Resources/Technologies/Pages/ICTTechnologyList.aspx

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	objective data to monitor endangered species, such as the black rhino.											
MeREM Mekong River Ecosystem Monitoring project	MeREM (Mekong River Ecosystem Monitoring) project began in April 2004 under the financial support of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) in Japan. The objective of the project is to establish an international research collaboration system for in-depth understanding of the many changes and challenges which affect the ecosystem of the Mekong River, and to predict long-term ecological changes. The research collaboration resumes the GEMS/Water programme in the Mekong River Basin.							Japan MEXT GEMS Water Kasesart University		2004 - ?	http://merem.kasetsart.org/	
NEIS Atmospheric Observation	A project consisting of 4 main themes related to Atmospheric observation, GHG tracking and analysis.	X	X				X	Japan NEIS			http://www-cger.nies.go.jp/climate/e_plan3.html	
GECEnvis	Gujurat Environmental Commission - ENVIS Page	X	X	X			X	Gujurat Environment Commission			http://www.gec.gov.in/envis/	
UNEP - INFOTERRA	INFOTERRA is the global environmental information exchange network of the United Nations Environment Programme. The network operates through a system of government-designated national focal points which at present number 177. An INFOTERRA national focal point is essentially a national environmental information centre usually located in the ministry or agency responsible for environmental protection. The primary function of each centre is to provide a national environmental information service.						X	UNEP		1997-2002	http://www.unep.org/infoterra/nfpspec.htm	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
TEMIS	TEMIS, which stands for Tropospheric Emission Monitoring Internet Service, displays data for tropospheric ozone (O3), nitrogen dioxide (NO2), and sulfur dioxide (SO2), among other pollutants. Most data goes back as far as 2002.	X	X								http://www.temis.nl/	
WGMS	Today, the World Glacier Monitoring Service (WGMS) collects standardised observations on changes in mass, volume, area and length of glaciers with time (glacier fluctuations), as well as statistical information on the distribution of perennial surface ice in space (glacier inventories). Such glacier fluctuation and inventory data are high priority key variables in climate system monitoring; they form a basis for hydrological modeling with respect to possible effects of atmospheric warming, and provide fundamental information in glaciology, glacial geomorphology and quaternary geology. The highest information density is found for the Alps and Scandinavia, where long and uninterrupted records are available.	X	X					NOAA	Global	1894-current	http://www.geo.unizh.ch/wgms/index.html	
GOS	The Global Observing System (GOS) provides from the Earth and from outer space observations of the state of the atmosphere and ocean surface for the preparation of weather analyses, forecasts, advisories and warnings, for climate monitoring and environmental activities carried out under programmes of WMO and of other relevant international organizations. It is operated by National Meteorological Services, national or international satellite agencies, and involves several consortia	X	X	X				WMO	Global	2004-current	http://www.wmo.int/pages/prog/www/OSY/GOS.html	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	dealing with specific observing systems or specific geographic regions.											
RETScreen	The RETScreen International Clean Energy Project Analysis Software is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The software, provided free-of-charge, can be used worldwide to evaluate the energy production and savings, life-cycle costs, emission reductions, financial viability and risk for various types of energy efficient and renewable energy technologies (RETs). The software also includes product, cost and climate databases, and a detailed online user manual.			X	X	X		Natural Resources Canada	Global	Active	http://www.retscreen.net/ang/d_o_view.php	
Online Atlas of the Millenium Development Goals	WorldBank tracking and reporting for different nations in their MDGs.						X	World Bank	Global	Current	http://devdata.worldbank.org/atlas-mdg/	
Common Phone Charger	An initiative to create a common phone charger in Inida to reduce waste created by multiple chargers for different telephones.					X					http://shopping.rediff.com/shop/storeproductdisplay.jsp?prrfnbr=1072292&strfnbr=2559&frompg=	
Phone Number for Life in India	Policy Initiative to make mobile telephones available to everyone in India.										http://www.voanews.com/english/2007-10-28-voa9.cfm	
e-Choupal: ICT for Rural Agriculture	ITC's International Business Division, one of India's largest exporters of agricultural commodities, has conceived e-Choupal as a more efficient supply chain aimed at delivering value to its customers around the world on a sustainable basis. The e-Choupal model has been specifically designed to tackle the				X			ITC Limited	India		http://www.itcportal.com/sets/echoupal_frameset.htm	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	challenges posed by the unique features of Indian agriculture, characterised by fragmented farms, weak infrastructure and the involvement of numerous intermediaries, among others.											
eoPortal	The eoPortal aims to open the door to the world of Earth Observation resources. By giving access to a large variety of information and services, eoPortal aims to provide a single access point for Earth Observation information and services including satellite imagery, a directory to locate data and resources, direct access to earth-observing satellite data as well as map servers and cartographic resources.		X	X	X						http://www.eoportal.org/	
CARMA	At its core, Carbon Monitoring for Action (CARMA) is a massive database containing information on the carbon emissions of over 50,000 power plants and 4,000 power companies worldwide. Power generation accounts for 40% of all carbon emissions in the United States and about one-quarter of global emissions. CARMA is the first global inventory of a major, emissions-producing sector of the economy.		X	X			X	Center for Global Development	Global	2007-Active	www.carma.org	
South Sumatra Forest Fire Management Project	In Indonesia – particularly in Borneo and Sumatra - the risk of forest fire is very pronounced. Around 15 million hectares of tropical rain forest and cropping areas were destroyed by fire in the El Niño years of 1982/83 and 1997/98. Thus, in South Sumatra, GTZ International Services (GTZ IS) is implementing a project geared to the prevention and control of forest fires on behalf of the European Commission.	X	X	X			X	GTZ	Indonesia	2003-2007	http://www.gtz.de/en/themen/uebergreifende-themen/15319.htm	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
IPACC 3D Mapping for Mukogodo	The Indigenous Peoples of Africa Co-ordinating Committee (IPACC) and SHALIN, a Finnish based networking NGO are supporting the Yiakku community in its effort to document the natural and cultural landscape of the Mukongodo Forest. The modeling exercise is a methodology introduced to Africa by the Technical Centre for Agricultural Rural Cooperation (CTA) in 2006. Yiakku elders and youth will create a three dimensional model of part of their ancestral lands, showing the Yiaku conception of natural systems of water, forestry, forest products and wildlife. The map helps to create an inventory of indigenous knowledge, natural resources and the intangible heritage of the region.	X	X	X			X	SHALIN	Africa	2007 -	http://udongo.org/2007/10/28/participatory-3-d-mapping-in-the-mukogodo-forest-communities/	
GMES	Global Monitoring of Environment and Security. GMFS is an activity started by the European Space Agency (ESA) under the joint ESA and European Commission (EC) Global Monitoring for Environment and Security (GMES) initiative. Through GMES, ESA and the EC have combined forces to unite the research, development and operational user communities across Europe in a coordinated effort to establish, by 2008, a European capacity for Global Monitoring for Environment and Security.	X	X	X	X		X	EC / ESA	Global	2004-2008	http://www.gmes.info/	
GIEWS	For countries facing a serious food emergency, FAO/GIEWS and the World Food Programme also carry out joint Crop and Food Supply Assessment Missions (CFSAMs). Their purpose is to	X	X	X	X			UN FAO	Global	Active	http://www.fao.org/giews/english/index.htm	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	provide timely and reliable information so that appropriate actions can be taken by the governments, the international community, and other parties. GIEWS undertakes up to 15 such CFSAMs every year											
OISAT	To eliminate the use of hazardous pesticides, and to promote community-based control over sustainably produced food and fibres, OISAT Info offers concrete alternatives with its Online Information Service on Non-chemical Pest Management in the Tropics. OISAT Info is thus a practical guide for trainers, extension workers and farmers on how to minimize pest damage in a safe, effective, and ecologically sound way.				X		X	GTZ	Global	2002-2003	http://www.oisat.org/concept_of_oisat.html	
GLOBWINET	Global Water Information Network (GLOBWINET) is a forum in the field of integrated water resources management and is based on IKON software. The software was developed by GTZ as part of an EU project. With the aid of this software users of GLOBWINET can analyse and compare information and find business partners in the water resources management sector.	X	X	X	X		X	GTZ	Germany / South Africa	2000-2005	http://www.gwpforum.org/servlet/PSP?iNodeID=1410&iFromNodeID=100	
Mekonginfo	: “Mekonginfo” is an internet-based information system which aims at exchanging data on participatory resource management in the area of the lower Mekong basin. “Mekonginfo” has more than 900 registered users. The online library gives access to more than 2000 documents on the subjects of forests, natural resource management and land management. Furthermore a		X	X	X		X	GTZ	Cambodia, Thailand, Laos and Viet Nam	1992-2005	http://www.mekonginfo.org/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	watershed information system is used, maps of forest inventories are generated and the maintenance and supervision of the GIS-database is supported.											
LandNet Africa	LandNet Africa is a network on land tenure and land policy issues in Africa. It was established in a regional workshop held in Addis Ababa in January 2000. The workshop was hosted by OSSREA and sponsored by DFID. The workshop was attended by participants from eighteen African countries; namely, Burkina Faso, Cameroon, Ethiopia, Ghana, Kenya, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Sudan, Swaziland, Tanzania, Uganda, Zambia, and Zimbabwe. The following donor and international support organizations: DFID, GTZ, French Cooperation, SIDA, UN-FAO, IUCN, World Bank, the IFAD Popular Coalition to Eradicate Hunger and Poverty, NRI, OXFAM, UN-ECA, CILSS and IIED also participated.			X	X		X	GTZ, DFID	Africa	2002-2006	http://www.ossrea.net/projects/landnet.htm	
MIST	The GTZ project 'Advisory Services to Uganda Wildlife Authority (UWA)' has been supporting UWA with the development of a spatial Management Information System (MIST) to provide managers and planners with up-to-date information for their planning, decision-making and evaluation. Important aspects taken into consideration during the development of the system were the organisational set-up of UWA, behavioural principles and technical factors.	X	X	X	X		X	GTZ / UWA	Uganda	2001-active	http://www.uwa.or.ug/IS.htm	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
ENO	ENO-Environment Online is a global virtual school and network for sustainable development and environmental awareness. Four environmental themes are studied within a school year on a weekly basis. About 400 schools from 104 countries take part.						X	NBE Finland, UNEP UNESCO	Global	2000-Active	http://eno.joensuu.fi/basics/briefly.htm	http://www.itu.int/osg/spu/wsis-themes/ict_stories/themes/e-Environment.html
GLIN	Great Lakes Information Network (GLIN) has become a reliable tool for information relating to the environment, economy, education and tourism for the Great Lakes region in the United States. Realizing that traditional forms of communication and information sharing were not sufficient to address the multitude of issues associated with environmental conservation in the region, the Great Lakes Commission, the non-partisan body that manages GLIN, turned to the internet in 1994.By providing an online resource for environmental, economic and cultural research and analysis, GLIN has helped professionals from a variety of disciplines and government agencies improve their understanding of the Great Lakes ecosystem. To the surprise of the GLIN managers, the number of domestic and international visitors to the site grew from 68,000 in 1995 to over 931,000 by 2000.The site continues to grow in popularity.						X	NGO	North America	1993	http://www.great-lakes.net	http://www.itu.int/osg/spu/wsis-themes/ict_stories/themes/e-Environment.html
EcoSandals	Ecosandals is a non-profit importer and reseller of sandals produced by Akala Designs Limited, a cooperative business based in Nairobi, Kenya. Fair Trade with e-Business for sustainability.					X		Private	Kenya	Unknown	http://www.ecosandals.com/	http://www.itu.int/osg/spu/wsis-themes/ict_stories/themes/e-Environment.html
Village	Designed by M.S. Swaminathan				X	X	X	MSSRF, IDRC	India	1999-	http://www.isoc.org/oti/artic	http://www.itu.int/osg/spu/w

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
Knowledge Centers	Research Foundation (MSSRF) and funded by the Canada-based International Development Research Centre (IDRC), the Village Knowledge Centres have been an important source of information for many rural villages throughout India. From healthcare to farming and transportation information, these “information shops” are both sustainable and empowering. For instance, a cadre of women volunteers between the ages of 21-27 run the shop in the village of Embalam, and women are given preference at each of the other sites in operation.									2000	les/0401/balaji.html	sis-themes/ict_stories/themes/e-Environment.html
RANET	RANET is an international collaboration to make weather, climate, and related information more accessible to remote and resource poor populations. RANET undertakes this mission in order to aid day-to-day resource decisions and prepare against natural hazards. The program combines innovative technologies with appropriate applications and partnerships at the community level in order to ensure that the networks it creates serve the entirety of community information needs. Community ownership and partnership is the core principle of RANET’s sustainability strategy.	X	X	X				USAID, NOAA	Africa, Asia, Pacific	Unknown	http://www.ranetproject.net/about.html	http://www.itu.int/osg/spu/wsis-themes/ict_stories/themes/e-Environment.html
Globe	The Global Learning and Observation to Benefit the Environment (GLOBE) project is an online learning tool targeted mainly at primary and secondary schools throughout the world. While global in scope, the project is sponsored by a consortium of federal United States						X	US EPA	Global	1994-Active	http://www.globe.gov/r/homepage	http://www.itu.int/osg/spu/wsis-themes/ict_stories/themes/e-Environment.html

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	agencies ranging from the National Oceanic and Atmospheric Agency (NOAA) to the Environmental Protection Agency (EPA).											
Oszone Online	The University of Cambridge, UK launched a project in 1997 to help educate students and concerned citizens about the effects of releasing chlorofloro carbons (CFCs) into the atmosphere. The Ozone Hole Tour site provides visitors with a comprehensive overview of the make-up of the earth's atmosphere, offers scientific insights into what is being done to address the manmade problem, and provides links to a variety of information resources about the issue.						X	University of Cambridge	Global	1998-?	http://www.atm.ch.cam.ac.uk/tour/index.html	http://www.itu.int/osg/spu/wsis-themes/ict_stories/themes/e-Environment.html
InfoAgro	Online system with agricultural information for Bolivia.			X	X		X	GTZ	Bolivia	2005	http://www.infoagro.gov.bo/	
Ilira	The project ILIRA (Information Literacy in Rural Areas) has the objective to connect remote and deprived schools and communities to the internet and support the school in installing or running a computer laboratory, train the staff and teachers in basic IT skills. Uses Solar-powered class-rooms with economic model of ICT dual use for training and internet cafe. Now expanding to new schools.					X	X	GTZ	Philippines	2005	http://www.ilira.org/	
IndoTsunami	This site, launched on Tuesday 10 February 2005, is intended to keep you informed about the progress in developing a Regional Tsunami Warning and Mitigation System for the Indian Ocean. Through the time line, displayed above, you will be able to obtain information on the many international events, organized by individual countries	X	X	X	X		X	WMO	Indonesia	2005-Active	http://ioc3.unesco.org/indotsunami/	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	as well as by UN agencies, related to follow-up actions to the 26 December 2004 tsunami.											
Neptune	NEPTUNE offers rich educational possibilities for students at all levels around the world. Because its Internet connections will provide real-time data and images from very dynamic earth-ocean systems, NEPTUNE products will be useful and accessible to classrooms, laboratories, and even the homes of interested learners. Programs will include K-12 curricula and activities, exhibits for science museums, undergraduate and graduate research, and a real-time web interface for all users.	X					X	University of Victoria	Pacific Ocean	2005-Active	http://www.neptunecanada.ca/education/index.html	
SAFORAH	The System of Agents for Forest Observation Research with Advanced Hierarchies (SAFORAH) was created in March 2002 to coordinate and streamline the archiving and sharing of numerous distributed large remote sensing data sets between various research groups with Canadian Forest Service (CFS), UVic and other academic and government partners to facilitate research in support of our national forest monitoring activities. SAFORAH was developed through a collaboration of government, university and industry.	X	X	X	X		X	Consortium	Canada	2002-Active	http://www.saforah.org/	
Euro GRID	The Bio GRID work package developed interfaces that enabled chemists and biologists to submit their work to HPC facilities via a uniform interface from their workstations, without having to worry about the details of how to run particular packages on different architectures.		X	X	X		X	EU			http://www.eurogrid.org/workplan.html	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
	The Meteo GRID work package developed adaptations to an existing weather–prediction code for on–demand localised weather prediction and made the first step towards a weather prediction portal. For the CAE GRID track, two CAE (Computer-aided Engineering) applications were adapted to EUROGRID: coupled CAE applications from the aircraft industry, and the provision of ASP services for a set of leading CAE application codes.											
OLCP Trials in Solomon Islands	These trials will be conducted under the OLPC Oceania initiative to deploy OLPC Laptops throughout the region and is part of that group's Pilot strategy. The Solomon Islands was chosen for the first OPLC trials in the Oceania region due to its experience in successfully deploying ICT projects in rural and remote areas, notable PF Net and the Distance Learning Centre Project. Batuna was chosen as the pilot village as it is part of the larger Marovo Lagoon Learning Net project. The trials are to be recognised by the global OLPC organisation as an official trial site. The trials will use 25 OLPC laptops and associated equipment provided by the global OLPC organisation and will be conducted under the 5 OLPC Principles.					X	X	OLCP	Oceania	2007	http://www.peoplefirst.net.sb/DLCP/downloads/OLPC_Solomons_Trials_v5_19-9-07.pdf	

ICT Application Name	Description	Observation	Analysis	Planning	Management	Mitigation	Capacity Building	Sponsor / Owner	Region	Active Dates	Primary Web Reference	Other Web References
GOF ISS	GOF Climate Change and Energy Programme: ISS (Information Sharing System) to enhance coping capacities of farming communities in dealing with climate variability and climate change					X	X	Swiss Agency for Development and Cooperation UNEP British High Commission	Pakistan / India	2005	http://www.teriin.org/project_inside.php?id=15561&area=&proj_type=ongoing	http://www.iied.org/CC/documents/ISS_Presentation_Suruchi.pdf
UNFCC CDM Registry	The UN Climate Change Secretariat on Wednesday announced that the International Transaction Log (ITL) became operational, thereby putting in place the cornerstone of the Kyoto Protocol's emissions trading system. The ITL is a sophisticated computerized system that ensures that emissions trading among Kyoto countries is fully consistent with the rules established under the UN Treaty.		X	X	X			UNFCC	Global	Active	http://unfccc.int/files/press/news_room/press_releases_and_advisories/application/pdf/pressrelease_itl_go-live_english.pdf	

16. ANNEX 3: REFERENCES/BIBLIOGRAPHY

The reference materials include a bibliography of seminal and key readings along with list of websites and other web-based resources, including a list of research and development networks working in this area around the world and in the developing world especially. The bibliographic units as well as the websites references are mentioned in the footnotes and in the relevant annexes.

17. ANNEX 4: ORGANIZATIONS AND EXPERTS

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
International Institute for Sustainable Development (IISD)	IISD is in the business of promoting change towards sustainable development. As a policy research institute dedicated to effective communication of our findings, we engage decision-makers in government, business, NGOs and other sectors in the development and implementation of policies that are simultaneously beneficial to the global economy, the global environment and to social well-being.	NGO	X	X	/			http://www.iisd.org/
Aijit Foundation	Indian community organization that sponsored Jal Chitra	NGO					X	http://www.ajitfoundation.org/
GIS Development	Geospatial Communication Network promoting the use of GIS in development, focusing on Asia.	Commercial	X	X	/	X	X	http://www.gisdevelopment.net/
U.S. Geological Survey	The USGS mission is to provide water information that benefits the Nation's citizens: Publications, data, maps, and applications software. USGS Water-Resources offices are located in every State.	OECD+	X		X	/		http://water.usgs.gov/software/
IT for Change (ITFC)	ITfC (IT for Change) is a non-profit organisation located in India. ITfC envisions a society capable of, and comfortable with, innovative and effective use of information and communication technologies (ICT) as a tool, to further goals of progressive social change.	NGO	X		/		X	http://www.itforchange.net/
The Centre for Communication and Development Studies (CCDS)	A social change resource centre focusing on the research and communication of information for change. CCDS uses communication tools and processes to inform, initiate and inspire change in societal attitudes and public policy. Our activities are designed to strengthen civil society by promoting a deeper understanding of issues related to sustainable development, justice, equity and rights	NGO			/		X	http://www.ccds.in/
Information Societies Technology - European Commission (CORDIS)	Website for coordinating EC Framework Programmes, with a specific section dedicated to ICT for Sustainable Growth. website is listing of the GIS / ICT / SD related projects from the FP6. Includes references to Tsunami early warning systems and other projects.	OECD+	X	X	X	/	/	http://cordis.europa.eu/fp7/ict/sustainable-growth/previous-fp6_en.html

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
African Geo Information Research Network (AGIRN)	A geo-information research portal that intends to ensure the establishment of a forum for a vigorous engagement by African researchers. The development of AGIRN intends to provide the geo-information research community a mechanism to publish and access high quality work, to share in geo-information knowledge and to engage in discussion through a widely accessible web based medium.	NGO	X	X	X	X	X	http://www.agirn.org/
The Food and Agriculture Organization of the United Nations (FAO)	Leads international efforts to defeat hunger. Serving both developed and developing countries, FAO acts as a neutral forum where all nations meet as equals to negotiate agreements and debate policy. - Putting information within reach. - Sharing policy expertise. - Providing a meeting place for nations. - Bringing knowledge to the field	UN	/	X	/	X	X	http://www.fao.org/
CTA	CTA is an ACP-EU institution working in the field of information for development that operates under the ACP-EU Cotonou Agreement with headquarters in The Netherlands. They provide training and information resources for capacity building in agriculture, including the disbursement of awards in African-Caribbean-Pacific countries.	OECD+	X		/	X	X	http://www.cta.int/
Iconnect	iConnect promotes the effective exchange of experiences and knowledge on the use of Information and Communication Technologies for Development (ICT4D).	NGO	X				X	http://www.iconnect-online.org/home
The Department for International Development (DFID)	Part of the UK Government that manages Britain's aid to poor countries and works to get rid of extreme poverty.	OECD+		X		X	X	http://www.dfid.gov.uk/
Convention on Biological Diversity (CBD)	Signed by 150 government leaders at the 1992 Rio Earth Summit, the Convention on Biological Diversity is dedicated to promoting sustainable development.	UN	X		X			http://www.cbd.int/
Online access to Research in the Environment (OARE)	OARE is a partnership project with Yale University, the World Health Organization (WHO), the Food and Agriculture Organization (FAO) and more than 35 publishers aiming to provide the developing world access to one of the world's biggest collection of environmental information at little or no cost	NGO	X		X		X	http://www.oaresciences.org/en/

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
American Society for Photogrammetry and Remote Sensing	The mission of the ASPRS is to advance knowledge and improve understanding of mapping sciences and to promote the responsible applications of photogrammetry, remote sensing, geographic information systems (GIS), and supporting technologies. Provides reviews of the available software for imaging and geospatial processing. (Somewhat dated).	Commercial	X		/	/		http://www.asprs.org/resources/software/index.html
The International Institute for Communication and Development (IICD)	A non-profit foundation that specialises in information and communication. IICD creates practical and sustainable solutions using both modern media (such as computers, Internet, email and multimedia) and traditional media (such as radio and television) to connect people and enable them to benefit from ICT, thereby contributing to the Millenium Development Goals.	NGO	X				X	http://www.iicd.org/
United Nations Environment Programme (UNEP)	To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.	UN	X		X	/	/	http://www.unep.org/
Consultative Group on International Agricultural Research (CGIAR)	Mission to achieve sustainable food security and reduce poverty in developing countries through scientific research and research-related activities in the fields of agriculture, forestry, fisheries, policy, and environment.	NGO			/	X	X	http://www.cgiar.org/w
The International Water Management Institute (IWMI)	A nonprofit scientific research organization focusing on the sustainable use of water and land resources in agriculture and on the water needs of developing countries. IWMI works with partners in the South to develop tools and methods to help these countries eradicate poverty through more effective management of their water and land resources.	NGO	/		/	X	X	http://www.iwmi.cgiar.org/
The International Development Research Centre (IDRC)	Canadian gov't agency to help developing countries use science and technology to find practical, long-term solutions to the social, economic, and environmental problems they face. Support is directed toward developing an indigenous research capacity to sustain policies and technologies that developing countries need to build healthier, more equitable, and more prosperous societies.	OECD+	X		/	/	X	http://www.idrc.ca/
The Center for International Earth Science Information	A center within the Earth Institute at Columbia University. CIESIN works at the intersection of the social, natural, and information sciences, and specializes in on-line data and	OECD+	X		X		/	http://www.ciesin.columbia.edu/

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
Network (CIESIN)	information management, spatial data integration and training, and interdisciplinary research related to human interactions in the environment.							
GRID-Arendal	The mission of GRID-Arendal is to provide environmental information, communications and capacity building services for information management and assessment. Established to strengthen the United Nations through its Environment Programme (UNEP), our focus is to make credible, science-based knowledge understandable to the public and to decision-making for sustainable development.	UN Agency	X		X			
GeSI, the Global e-Sustainability Initiative	Organized to further sustainable development in the ICT sector. GeSI fosters global and open cooperation, informs the public of its members' voluntary actions to improve their sustainability performance, and promotes technologies that foster sustainable development.	UN Agency	X		X			http://www.gesi.org/
World Meteorological Organization	The World Meteorological Organization (WMO) is a specialized agency of the United Nations. It is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.	UN Agency	X	X	X			http://www.wmo.ch/
Technologies for Conservation and Development	The Technologies for Conservation & Development project (t4cd) is a joint initiative of the international conservation organisation Fauna & Flora International (FFI) and the South Africa based development NGO ResourceAfrica (RA).	NGO	X		X			http://www.t4cd.org/Pages/HomePage.aspx/
United Nations Environment Programme - World Conservation Monitoring Centre	Mission to evaluate and highlight the many values of biodiversity and put authoritative biodiversity knowledge at the centre of decision-making	UN Agency	/		X			http://www.unep-wcmc.org/
World Resources Institute (WRI)	The World Resources Institute (WRI) is an environmental think tank that goes beyond research to find practical ways to protect the earth and improve people's lives.	NGO			X		X	http://www.wri.org/
Integrated Approaches to Participatory Development (IAPAD)	Uses GIS and 3D modeling for CBRM and conflict resolution.	NGO	X		X	/	X	www.iapad.org
European Commission's Environment Directorate-General (DG)	EU's agency for environmental issues	OECD+	/		X			http://ec.europa.eu/dgs/environment/index_en.htm/

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
GLOBAL SPATIAL DATA INFRASTRUCTURE ASSOCIATION (GSDI)	The GSDI Association is an inclusive organization of organizations, agencies, firms, and individuals from around the world. The purpose of the organization is to promote international cooperation and collaboration in support of local, national and international spatial data infrastructure developments that will allow nations to better address social, economic, and environmental issues of pressing importance.	NGO	X	X	/		/	http://www.gsdi.org/
ICT Netherlands	By means of education, research and project services, they contribute to capacity building in countries that are economically and/or technologically less advanced. In doing so, considerable attention is paid to the development and application of geographical information systems (GIS) for solving problems. Such problems can range from determining the risks of landslides, mapping forest fires, planning urban infrastructure, and implementing land administration systems, to designing a good wildlife management system or detecting environmental pollution.	NGO	X	/	/	/	/	http://www.itc.nl/about_itc/default.asp/
United Nations Convention to Combat Desertification (UNCCD) Committee on Science and Technology (CST)	The UN Convention to Combat Desertification has established a Committee on Science and Technology (CST). The CST was established under Article 24 of the Convention as a subsidiary body of the COP, and its mandate and terms of reference were defined and adopted during the first session of the Conference of the Parties in 1997. It is composed of government representatives competent in the fields of expertise relevant to combating desertification and mitigating the effects of drought. The committee identifies priorities for research, and recommends ways of strengthening cooperation among researchers. It is multi-disciplinary and open to the participation of all Parties. It meets in conjunction with the ordinary sessions of the COP.	UN			X	/		http://www.unccd.int/
European DesertNet	A network to provide a platform for scientific discussions and exchange of ideas, foster cutting edge science, identify topics and research areas, identify and document scientific state of the art of the main topics in desertification assessment, risk		/	X	X			http://www.european-desertnet.eu/wgroups_eu.php?wg_nr=2/

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
	evaluation, mitigation and restoration, identify and articulate the economic drivers and the socio-economic consequences of desertification, integrate scientific findings across disciplines, translate into common language and communicate scientific findings, and work in and on affected areas inside and outside Europe.							
CGIAR	The Consultative Group on International Agricultural Research (CGIAR), established in 1971, is a strategic partnership of countries, international and regional organizations and private foundations supporting the work of 15 international Centers. In collaboration with national agricultural research systems, civil society and the private sector, the CGIAR fosters sustainable agricultural growth through high-quality science aimed at benefiting the poor through stronger food security, better human nutrition and health, higher incomes and improved management of natural resources.	UN (Chair is nominated by World Bank)	/		/	X	X	
National Oceanic and Atmospheric Administration (US)	From daily weather forecasts, severe storm warnings and climate monitoring to fisheries management, coastal restoration and supporting marine commerce, NOAA's products and services support economic vitality and affect more than one-third of America's gross domestic product. NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers and other decision-makers with reliable information they need when they need it	OECD+	X	X	/			http://www.noaa.gov/
GEO	The Group on Earth Observations is coordinating efforts to build a Global Earth Observation System of Systems, or GEOSS. GEO was launched in response to calls for action by the 2002 World Summit on Sustainable Development and the G8 (Group of Eight) leading industrialized countries. These high-level meetings recognized that international collaboration is essential for exploiting the growing potential of Earth observations to support decision making in an increasingly complex and environmentally stressed world.	UN						http://www.earthobservations.org/
NBII	The National Biological Information Infrastructure (NBII) is a broad, collaborative program to provide increased access to	OECD+	X		X			http://www.nbii.org/portal/server.pt

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
	data and information on the nation's biological resources.							
Japan NIES	National Institute for Environmental Studies (NIES) has integrative expertise to tackle environmental issues through the collaboration of our researchers and staffs with diversified specialties such as physics, chemistry, engineering, agriculture, fisheries, medicine, pharmacology, law/politics and economics.	OECD+	/		X	/		http://www.nies.go.jp/index.html
GTZ	German development agency The GTZ is an international cooperation enterprise for sustainable development with worldwide operations. GTZ promotes complex reforms and change processes, often working under difficult conditions. Its corporate objective is to improve people's living conditions on a sustainable basis.	OECD+	/		/		X	http://www.gtz.de
ECMWF	European Centre for Medium-Range Weather Forecasts	OECD+		X				http://www.ecmwf.int/
Tropical Storm Risd	The TSR consortium comprises experts on insurance, risk management and seasonal climate forecasting. The TSR industry expertise is drawn from Benfield, the leading independent reinsurance intermediary, Royal & SunAlliance, the global insurance group, and from Crawford & Company, a global claims management solutions company. The TSR scientific grouping brings together climate physicists, meteorologists and statisticians from the UCL, Benfield UCL Hazard Research Centre and the Met Office.	NGO		X				http://tsr.mssl.ucl.ac.uk/
Web2fordev	Networking, collaborating and exchanging knowledge in agriculture, rural development and natural resources management	NGO	X		/		X	http://www.web2fordev.ne
PTWS	Intergovernmental Coordination Group for the Pacific Tsunami Warning System (ICG/PTWS) Under the auspices of the Intergovernmental Oceanographic Commission (IOC), the Intergovernmental Coordination Group for the Pacific Tsunami Warning and Mitigation System first convened in 1968 (ICG/PTWS, formerly known as ICG/ITSU for International Tsunami).		/	X	/			http://ioc3.unesco.org/itic/categories.php?category_no=172
CEOS	The Committee on Earth Observation Satellites (CEOS) is an international coordinating mechanism charged with coordinating international civil spaceborne missions designed to observe and		X	X				http://www.ceos.org/

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
	study planet Earth. Comprising 26 Members (most of which are space agencies) and 20 Associates (associated national and international organizations), CEOS is recognized as the major international forum for the coordination of Earth observation satellite programs and for interaction of these programs with users of satellite data worldwide.							
IRC	Since its foundation in 1968, the IRC International Water and Sanitation Centre (IRC) has facilitated the sharing, promotion and use of knowledge so that governments, professionals and organisations can better support poor men, women and children in developing countries to obtain water and sanitation services they will use and maintain.		X		X	/	/	http://www.irc.nl/page/103
IGES	The Institute for Global Environmental Strategies (IGES), established by an initiative of the Japanese Government in 1998, is a research institute that conducts pragmatic and innovative strategic policy research to support sustainable development in the Asia-Pacific region-a region experiencing rapid population growth and expanding economic activity.	OECD+	/		X		X	http://www.iges.or.jp/en/outline/index.html
RTF	Radar Technologies France or RTF is a France-based company with international activities. RTF specializes in Remote Sensing technologies, specifically radar/optic imagery interpretations monitoring the global environment with particular expertise in Oil & Gas, base metals and ground water exploration all over the world.	Private	X		X		/	http://www.radar-technologies.com/
CILSS	Le Comité Permanent Inter Etats de lutte contre la Sécheresse dans le Sahel(CILSS) a été créé le 12 septembre 1973 à la suite des grandes sécheresses qui ont frappé le Sahel dans les années 70. Le CILSS regroupe aujourd'hui neuf Etats dont 4 Etats côtiers: (Gambie, Guinée-Bissau, Mauritanie, Sénégal); 4 Etats enclavés : (Burkina Faso ; Mali ; Niger ; Tchad) ; 1 Etat insulaire: (Cap Vert).	Developing Nations	/	/	X	/	X	http://www.cilss.bf/htm/mandat.htm
National Remote Sensing Agency (Department of Space for India)	Agency with Mandate to provide remote sensing and processing services for India. Well-developed set of tools that include basic image rendering and geo-tagging to value-added processing	Developing Nations	X	X			/	http://www.nrsa.gov.in/products/level_processing.html#01/

Agency Name	Description	Category	ICT / GIS	Weather / EWS	Env. / Conservation	Agr. / Forestry	Development	Web Site
	(e.g. vegetation cover analysis).							
Center for Global Development	CGD is an independent, not-for-profit think tank that works to reduce global poverty and inequality by encouraging policy change in the U.S. and other rich countries through rigorous research and active engagement with the policy community.	OECD+	/		X		X	http://www.cgdev.org/
CIAT	To reduce hunger and poverty in the tropics through collaborative research that improves agricultural productivity and natural resource management	NGO			/	X	X	http://www.ciat.cgiar.org/about_ciat/mission.htm
GEF	The Global Environment Facility (GEF), established in 1991, helps developing countries fund projects and programs that protect the global environment. GEF grants support projects related to biodiversity, climate change, international waters, land degradation, the ozone layer, and persistent organic pollutants.	NGO	/		X	X	X	http://www.gefweb.org/
It is	The ITIS is the result of a partnership of federal agencies formed to satisfy their mutual needs for scientifically credible taxonomic information. Since its inception, ITIS has gained valuable new partners and undergone a name change; ITIS now stands for the Integrated Taxonomic Information System.	OECD+	/		X			http://www.itis.gov/
IABIN	The Inter-American Biodiversity Information Network (IABIN) is a forum to foster technical collaboration and coordination among countries of the Americas in collection, sharing, and use of biodiversity information relevant to decision-making on natural resources management and conservation, and education to promote sustainable development in the region.	OECD+	/		/	X		http://www.iabin.net/
GBIF	GBIF, the Global Biodiversity Information Facility, was established in 2001 to take on a special set of tasks that will make it possible for policy- and decision-makers, research scientists and the general public all around the world to electronically access the world's supply of primary scientific data on biodiversity. Hosted at the University of Copenhagen	OECD+	X		X			http://www.gbif.org/

18. ANNEX 5. TERMS OF REFERENCE

Background information on the role of International Telecommunication Union (ITU) in the World Summit on the Information Society (WSIS) process and otherwise

ITU has been identified as one of the co-moderators / co-facilitators, with the World Meteorological Organization (WMO) as lead facilitator/moderator, on issues related to the WSIS Action Line C7 dealing with ICT applications, *inter alia*, e-Environment.

Although all activities at ITU's Telecommunication Development Bureau are related to the WSIS action plan, it would be important to point out that the ITU mandate in e-Environment relates to ICT applications, telecommunications and related e-strategies. Environmental contents and other aspects relate to the responsibility of other agencies and specialized Programmes of the United Nations.

The ITU, on the occasion of the 4th World Telecommunication Development Conference that took place in Doha in Qatar in March 2006, was given the mandate under Programme 3 of the Doha Action Plan (DAP), and as per Resolution 54 on ICT applications to assist developing countries in the implementation of relevant ICT applications for environment and sustainable development. One task under DAP Programme 3, among others, is to develop guidelines on the technology and policy aspects of ICT applications, which also includes e-Environment.

Objective of this assignment

The objective of this assignment is to produce guidelines to help developing countries take full advantage of e-Environment applications and practices in national development planning. This will cover all aspects of the development planning cycle starting with creating an enabling environment for this to happen and then dealing with practical issues required to take full advantage of appropriate ICT applications for environmental management and sustainable development.

The guidelines are intended to help address challenges in formulating e-Environment policies in developing countries and to assist stakeholders, particularly from country partner institutions and from the donor community, to better understand the options for making strategic investments in e-Environment that achieve tangible results.

The guidelines will cover, inter alia, the following elements:

a) A review of current status and future trends in the use of ICTs for environmental management and related areas especially as these may apply to developing countries.
b) A listing and overview of existing ICT applications and information management practices in the environmental field.
c) This will include a description of examples and best practices when available and/or suitable. Key technologies standard off-the-shelf, customized and de novo ICT applications and management practices will also be described.
d) A strategic planning framework for implementing e-Environment in developing countries.
e) References to the main online links and publications dealing with e-Environment including short assessments of the contents of each (see Annex 1 on page 106).
f) A contact list of the main international, regional and national organizations, non-governmental organizations, research institutions, civil society organizations, business associations and recognized experts in this area - particularly those focusing on developing countries — including short description of resources available (see Annex 1 on page 106).
g) Submit a report to ITU on the work accomplished and proposals for future actions.
h) Perform any duties in his/her specialty as may be assigned to him/her by the ITU in relation to this activity.

The guidelines, with a length of 35-60 pages, should be suitable for ITU to publish and distribute through print and electronic media, including the ITU website. The work involved in preparing these guidelines will include:

a) a review of the relevant literature and of existing support institutions, experts and ICT applications in this area, particularly in the context of developing country requirements;

b) interviews of identified experts (mostly by telephone and through email exchanges) to review and assess relevant e-Environment experiences;

c) preparation and submission to ITU of a first draft of the guidelines; and

d) finalization of the guidelines based on feedback received from ITU and other sources.