

# Eye on Earth Summit

Working Group 3 – Technical Infrastructure  
White Paper 4:

## Information and Telecommunication Technologies for Environmental Challenges

Draft  
20 September 2011

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Document Revision Log			
Revision No	Date	Author	Reason for Change
1	11 August 2011	Aditya Agrawal	Development of original template
2	16 September	Hossam Allam, Chukwudozie Ezigbalike , Maria Cristina Bueti, Harlan Onsrud	Preparation of paper.
3	20 September	Bruce Bargmeyer	Title page and speakers for FC final version
4	20 September	Bruce Bargmeyer	Edit headers and format

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## **1.0 Introduction**

### **1.1 Background and Purpose**

The Eye On Earth Summit - Abu Dhabi 2011 (“The Summit”) is a global intergovernmental and multi-stakeholder event and exhibition to convene the thought and action leaders in the worldwide environmental and societal information networking movement, to converge consensus on key areas of mutual importance, and to collaborate towards strengthening existing initiatives and filling gaps towards more informed policy making and a sustainable future. The Summit is expected to:

- a) Identify commonalities in existing environmental information networks in an effort to strengthen, align and synergize these initiatives while collectively filling the gaps through coordinated alignment of common efforts;
- b) Strengthen, synergize, and extend global processes for bridging the environmental knowledge gap and provide data, information and tools for decision-making (transformative action);
- c) Reinforce multilateral policies and institutional arrangements to leverage investments in environmental data while ensuring the preservation of the investment in this information to improve information infrastructure in countries needed to support more coordinated, effective and sustainable development;
- d) Support technical cooperation to accelerate the building of a federated global environmental information infrastructure;
- e) Accelerate capacity building and technology support programs around the world to further close the gap between developed and developing nations.
- f) Strengthen access to resources to support developing countries

This document presents a set of topical issues that are the initial outcomes of each Working Group based on collaborative research and evaluation by its members. This Thought Paper provides Issue Statements based on an identification of issues, the current situation regarding each issue, major stakeholders engaged in addressing these issues, opportunities and constraints, and the major impacts and outcomes that can be achieved by further addressing the identified issues as part of the Summit. The identified topical issues will be submitted to the Framework Committee for review that will lead to the selection of a subset of topics that the Working Groups will then focus on more intensively. Based on the selected topics, the Working Groups will expand each Issue Statement into a more detailed White Paper. During its second meeting, the Framework Committee will review the White Papers and use them as the basis for the development of the Summit program and special initiatives.

## 1.2 Process and Results

The planning, design and development of the Summit involves a very diverse range of issues and a large number of simultaneously moving parts. The Working Group and Framework Committee efforts, with the feedback from the Executive Advisory Board will in large part define the Summit content and special initiatives that will be the visible output of the Summit preparation process, and that will define the path forward for some years to come. In general, the process for defining the Working Group white papers includes the following:

Identification of Topical Issues. Working Groups will assess previous topical issues submitted by the stakeholder community and identify a set of topical issues they would like to address as part of their initial evaluation.

Develop Thought Papers. For the identified issues, a Thought Paper will be developed that elaborates each issue by illustrating the importance, implications, major stakeholders, potential impact and special initiatives that could be generated.

Framework Committee Review and Approval. The Thought Papers will be reviewed by the FC, which will recommend specific topical issues to be further developed into a more refined White Paper.

White Paper Development. White Paper development will treat each selected subject in more detail and will include the direct participation and buy-in of key affected stakeholders.

Final Nomination and Commitments. The Framework Committee will evaluate the White Papers and use the submitted information to develop the Summit program and to recommend if any White Papers should be featured as Special Initiatives to be announced during the Summit closing.

## 1.3 Working Group Definition and Purpose

Below is the working definition of this Working Group's scope of activity:

### **Technical Infrastructure Working Group (WG3)**

This Working Group will focus on the technical components of the environmental information federation frameworks, addressing information and communications technology interoperability, connectivity, data standards, data format and content standards, and other such issues. This includes standards for the capture, description, and structuring of scientific data, and the development and delivery of various products and services.

#### Themes

The primary initial themes to be addressed by this Working Group include the following:

- Shared, multi-purpose technical infrastructure;
- Current technology gaps and improving availability and access to environmental data and bridging the data gaps to meet today's environmental challenges;
- Recent technological advances in data collection: from satellites to ground sensors networks;
- Technology Support and Capacity Building.
- Data ontologies, semantics and standards;
- Product and service standards;
- Metadata and data discovery;

#### Intended Outputs

- Recommended framework for better access to good practice standards and case studies for various assessment reporting and indicators systems, and the experts who are most familiar with each;
- Better access to information regarding data gathering technologies and their applications;
- Recommendations for most critical technical infrastructure capacity building requirements;
- Recommendations for broadening and strengthening technical networks to enable more effective access to data content and format standards, applications, models and other resources;
- Recommended standards for data exchange.

NOTE: Although it will be possible to refine the WG definition following the WG's deliberations, the WGs are not expected to focus on definitional issues.

## 1.4 References

This report includes provisions that are more fully described in other documents and that are included by reference, including:

**Eye on Earth Summit Program Design.** Original Program Design dated 1 May, 2010. This document is being updated as part of the Summit detailed planning stage. Its provisions will have influence on the detailed activities of the GPC Team.

**Executive Advisory Board, Framework Committee and Working Groups Charter.** This document provides the Charter for each of these Groups describing their purposes, processes, intended outputs and interdependencies.

**EoE Special Initiatives.** A critical objective of the Eye on Earth Summit is to ensure that there are compelling, specific, achievable outcomes that translate the principles of the Summit to “on the ground” commitments and actions. A target of 4-6 EoE Special Initiatives has been set, each of which is to be defined through the Summit preparation process, and announced during the Closing Plenary.

**WG Thought Papers.** As an initial input, the Working Groups each developed a Thought Paper that identified and articulated the initial set of issues and special initiatives each WG considered to be the important issues for which content should be developed around for presentation at the Summit and/or Exhibition. The Thought Papers become the starting point for the White Papers by further articulating and expanding on the notions originally presented such that the White Paper can be used to guide and develop the Summit Program.

**FC Feedback on WG Thought Papers.** This report synthesizes the Framework Committee’s feedback to the Working Groups on the submitted Thought Papers. This synthesis is based on the a review of the Thought Papers and Special Initiatives as part of the Framework Committee meeting that was held in Geneva, Switzerland on 27-18 July 2011.

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## 2.0 Information and Telecommunication Technologies for Environmental Challenges

### 2.1 Executive Summary

Information and communication technologies (ICTs) have now permeated into every aspect of society. Therefore it is pertinent to explore their roles in dealing with the challenges of managing and protecting the environment. ICTs contribute to environmental management in six areas, namely: monitoring, analysis, planning and management, and capacity building. In addition, ICTs have major impact on climate change mitigation and adaptation.

Earth observing satellites and other remote sensing systems provide vast amounts of data for monitoring the environment. These depend on ICTs systems, as do other sensor technologies. ICTs also facilitate the communication of the collected data sets, and provide the tools for performing computations and analysis to derive the information embedded in them, and present the knowledge for visualization and comprehension to make decisions. They provide tools for wide dissemination of varied information and knowledge products both for formal education and general awareness raising situations to involve the general public in dealing with environmental issues.

ICTs contributions for climate change adaptation and mitigation include support for measures to reduce GHG emissions, reducing or replacing travel with remote meetings and working arrangements, and improving energy efficiencies.

Developing countries have a challenge to utilize ICTs due to funding reasons or the need to build human capacities capable for adopting such technologies in their environmental decision making process. International cooperation is considered a key issue for enhancing the management of national and regional natural resources.

### 2.2 Setting the Foundation

The importance of a healthy environment for the well-being of individuals has since been established<sup>1</sup> and concerted efforts have continued to ensure the required healthy environment. Notwithstanding all the effort and commitment of resources, the world still faces enormous environmental challenges. The major environmental challenges facing the world include<sup>2</sup>: depletion of the ozone layer; loss of biodiversity; climate change; reliable supply of 'clean' energy; water supply and disposal of increasing volumes of waste, environmental governance, among others.

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<sup>1</sup> See, for example, Resolution A/RES/45/94 of the 68<sup>th</sup> Session of the United Nations General Assembly.

<sup>2</sup> See, UNEP Year Book 2011: Emerging issues in our global environment; EEA, 2010. The European environment — state and outlook 2010: synthesis.

Principle 10 of the Rio Declaration established that environmental issues are best handled with the participation of all concerned citizens at the appropriate levels, and that the citizens need appropriate access to information concerning the environment.

However, access to accurate and timely environmental information remains a challenge especially in developing countries. The challenges range from a dearth of the underlying data sets to create the information; to problems associated with the technology to collect, process, manage and disseminate the information. Advances in information and communications technologies have increased levels of citizen participation in public discussions on the development of policies.

ICTs are considered vital for monitoring, assessing, and managing environmental resources. They are key tools in providing national, regional and international cooperation for managing environment resources. Today, a world without information and communication technologies (ICT) is almost unthinkable. Across many countries they are integrated into most aspects of society and the economy. According to Information Telecommunication Union (ITU) data, there are now more than 5.3 billion mobile phone subscriptions worldwide, including 3.8 billion in the developing world, as well as nearly one billion subscribers to third-generation (3G) mobile services (also known as IMT-2000). Internet users have surpassed the 2-billion mark, with more than half million of them having high-speed broadband access.

Information and communications technologies, such as satellites, mobile phones or the Internet coupled with applications powered by sensing and positioning devices, play a key role to address the major challenges related with the protection of environment and sustainable development. ICTs are fundamental to monitor climate change, mitigate and adapt to its effects and assist in the transition towards a green economy.

ICTs assist in environmental research and comparative analysis through observing, describing, recording and understanding the environment, including tools to manipulate and visualize environmental information. IT also allows sharing of information and data as well as processing power: data warehouses, clearing houses and data/information servers; environmental networks and grids, etc. ICTs support the environmental decision making process in early warning systems, risk assessment, mitigation and management.

The ICT sector has positive and negative effects on the Climate Change challenge. The negative effects arise due to increased rates of utilizing ICT equipment and also to the short life expectancy of the new devices. These factors combined are resulting in an electronic waste crisis especially for developing countries. The positive effect of ICTs is that they are facilitating Climate Change mitigation and adaptation for other sectors such as better enabling reduction of emissions of GHG, especially in industries that are major emitters, including energy generation, waste disposal, building construction and transportation.

### 2.3 Issues, Challenges and Opportunities

ICTs can provide major contributions in supporting different environmental applications. These applications may be categorized in 6 categories: monitoring, analysis, planning and management,

capacity building, and climate change mitigation. Without appropriate ICT infrastructure, it would be a major challenge to reasonably achieve the tasks within each of these categories. Developing countries have a major challenge in acquiring such capabilities due to funding. Current advancement in ICTs could provide better services with less cost.

### **2.3.1 Information and Communication Technology Infrastructure Challenges**

ICT Infrastructure has a major impact on the ability to monitor and manage the environment. Access to the Internet is still a substantial challenge in developing countries and increasing such access is a major component in lessening both digital and economic divides.

Mobile, wireless, and Internet technologies are considered primary assets in overcoming the challenge of accessing environmental data. These types of technologies are getting cheaper and their capabilities are continually increasing.

One of the main issues is broadband access to the Internet. In May 2010, ITU, together with the UN Educational, Scientific and Cultural Organization (UNESCO), established the Broadband Commission for Digital Development. This has a membership of very high-level leaders of government, industry and relevant agencies, and has the aim of promoting the spread of broadband in every country, to provide many more social and economic opportunities and help achieve the Millennium Development Goals. Better broadband access would provide opportunities for enhancing access to environment database and knowledge hubs. Another challenge is the access to fibre optic backbones. Lack of access limits the capabilities of countries. Without access to an adequate fiber optic backbone, countries are unable to reasonably utilize Internet services such as video conferencing and eLearning. In addition to enhancing learning and communication, these capabilities are able to contribute to the reduction of green house gases.

Another challenge is access to computers in developing countries. This issue is due to the high price of computers compared to incomes in developing countries. There are some efforts to provide low cost solutions such as exporting used equipment to developing countries, but this approach also increases environmental problems by accelerating electronic wastes in receiving countries.

Mobile technologies are considered an optimistic solution for enhancing access to environmental information in developing countries. Mobile handsets are more widely available than PCs in developing countries. There are different experimental efforts to use mobile networks for disseminating and gathering environmental related data. The Eye on Earth portal is one such example.

### **2.3.2 ICT for Environmental Monitoring and Analysis**

Different ICT technologies are being utilized for performing environmental monitoring. Remote sensing is a primary ICT technology used for this task. Advances in earth observation satellites have provided huge amounts of digital data that can be used efficiently for assessing the status of

the environment and providing early warning systems. Spatial information systems have allowed enhancement of decision-making processes arising from environmental monitoring and have enhanced the early warning of environmental disasters. The expensive cost of commercial geographic information systems may be a barrier that some organizations are trying to minimize by using open source systems. However, increased costs for information infrastructure may be advisable in many instances where increased capabilities are provided and needed.

With the spread of wireless networks, collection of environmental data directly from the field through mobile hand-held has been possible. ICTs have a major role in telemetric networks and systems. Web-enabled capabilities have provided new means of social network integration for the monitoring of environmental resources. The Eye on Earth portal that implemented by the European Environment Agency provides a clear example of how citizens can have a role in monitoring water and air quality. One challenge here is trust of the quality of the collected information.

Collected environmental data have little value without proper analysis tools that ICTs provide. These tools can provide analysis about the status of land, soil, water, and climate quality. Analysis tools might enable correlation of raw monitored data with second order environmental measures, such as biodiversity and the analysis results can lead to more appropriate management of natural resources or may indicate the need for early warning alerts. Analysis may require high computational power in some instances and this might be expensive for some organizations. GRID computing could provide such capabilities by linking a number of computers that can perform the required analysis. GRID computing depends on the broadband infrastructure to allow organizations to be connected physically to remote arrays of computers capable of providing the required computational power. Another important concept is Cloud Computing that allows users to be connected to existing computing and network resources.

The utilization of ICTs, especially modelling software, has provided a method to better model complex ecosystems. The enhancement of microprocessors has provided efficient computing power to conduct numerical analysis that is essential for environmental analysis and requires high computing power. Climate modelling is a major area that has been enhanced substantially from increased processing power and high-speed Grid computing.

### 2.3.3 ICT and Environmental Planning

Environmental planning has become a substantial component of development projects. Major funding organizations, such as the World Bank, will not approve a loan without an environmental impact assessment study that shows the effect of the project on the environment, including planning activities. Environmental impact assessments require the availability of different types of data, including environmental data. ICTs can play a vital role in arriving at high quality results for such tasks.

Different ICT tools can be used for environmental planning including decision support systems, database management systems, geographic information systems, computer models, and Web enabled knowledge hubs. Land use classification systems are but one example of information

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systems that are capable of enhancing the planning process for better utilization of environmental resources.

### 2.3.4 ICT and Climate Change Adaptation and Mitigation

There are two aspects to responding to climate change: mitigation and adaption. ICTs are used in both responses. In responding to the climate change challenge, ICTs may be used in mitigation or adaptation. ITU (2008) explains that “[Mitigation] refers to efforts to reduce emissions (or capture carbon) so as to reduce the extent of climate change [and] adaptation refers to actions designed to reduce the negative impacts of climate change.”

In a report on using ICTs to tackle climate change *mitigation*, ITU lists five areas of action, namely:

(1) Reducing carbon emission in other sectors: The increased permeation of ICTs systems in the society may be expected to result in an increase in carbon emissions due mainly to the increased demand on energy use and the resulting waste. However, the use of ICTs will result in great reduction in the ability of other sectors to balance out the expected increase from their usage. Areas of contribution for ICTs include smart motor systems, smart transportation, smart buildings and smart grids.

(2) Using smart grids to reduce carbon emissions: ITU (2008) defines a smart grid as “a set of software and hardware tools that enable generators to route power more efficiently.” The use of smart grids reduces the need for excess capacity and resulting wastages. They require a stable and standardized communication backbone to allow each part of the system to send and recognize appropriate signals.

(3) Promoting smart industries to reduce emissions: Industries and factories are major contributors to GHG emissions. Therefore approaches to deal with emissions must target them. ICTs have contributed in the design of motors that run at different speeds depending on the immediate tasks and thereby reduce energy consumption at the motor, factory, or across the business.

(4) Using ICTs to reduce or replace travel: Web-based services enable virtual meetings, including sharing of documents. This reduces the need for people to travel or ship by hard mail, thereby reducing their carbon footprints. Other ICT services include teleconferencing and videoconferencing. Other contributions of ICTs to reducing travel include telecommuting whereby people can log into their offices from remote locations and undertake work, and remote learning, where students can participate in classes from remote locations.

(5) Smart transportation: This refers to systems that use ICTs to optimize the movement and delivery of goods through the use of improved navigation and transport control systems. Examples of solutions include the use of GPS navigation and vehicle dispatch to reduce travel times, using PDAs or mobile phones to inform the driver of the next destination, smart traffic control, and smart parking to direct vehicles into empty spaces and road pricing schemes to reduce congestion.

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On *adaptation*, ITU (2008) notes that “[the] modern disaster prediction, detection and early warning systems based on the use of ICTs are essential for saving lives.” Specific applications of ICTs include:

(1) Monitoring the global environment/ecosystem: Scientists predict that average temperatures will rise by 1.1 to 6.4° in the 21st century. This rise in temperature will increase the risk of flooding and in low lying coastal regions, and of droughts in arid regions. ITU lists the ICT systems involved in the monitoring of the environment and climate, and in disseminating the collected data to include: weather satellites and radars, radio-based meteorological systems, earth observing satellite systems, terrestrial and satellite broadcasting systems and other terrestrial and satellite systems for disseminating information about disasters and supporting relief operations.

(2) Addressing food security, water transportation and supply: Climate change is causing more frequent and severe storms, heat waves, droughts and floods. These phenomena affect the quality and availability of food and water. Addressing the attendant food shortages require systematic monitoring of food supplies and mapping of agricultural productions and food shortages. ICT can contribute machine-to-machine connectivity to support imaging spectrometers for high- and moderate-resolution systems for monitoring food and water resources; computers, servers and networks used to maintain databases for food security analysis, modelling and mapping; and communication infrastructure, including the Internet, for disseminating the information to farmers, decision makers and consumers.

(3) Monitoring deforestation and forest degradation: Tropical forests are important components of the natural sinks for greenhouse gases, and their depletion is estimated to release annually about 1.5 billion tons of carbon into the atmosphere, about 17% of total GHG emissions. ICTs contribute in dealing with deforestation by developing technological paths to sustainability and protection of tropical forests, as well as enhanced data collection.

(4) Electronic wastes: Ewaste is considered one of the major draw backs of ICT. Currently, there is much research on efficient design of ICT equipment to minimize Ewaste such as universal mobile chargers. Also, there are efforts to allow extending the life span of ICT equipment as the energy consumed during the production phase are much more than the energy used during the operational phase of the device

(5) Energy efficiency and utilization of renewable energies: One of the main environmental problems is the demand for more energy by the ever growing population, as well as the increasing modernization of lifestyles. ICTs are used to maximize the efficiency of power systems. They are used to find renewable resources, harnessing them and feeding into power grids efficiently. They are also used to control the load on the grids.

(6) Raising awareness on climate change: Dealing with the issues of climate change in particular and environmental problems in general, require the active involvement and participation of everybody, not just scientists and policy makers. This requires that the information be disseminated to wide and varied audiences in forms that they can understand. ICTs provide the means to deliver content in a variety of media and forms, from radio and television, through the

Internet and mobile devices; from structured class materials through flexible self-paced learning materials to free-form content.

(7) e-Health: In using ICTs in health care delivery it has been recognized that changes resulting from climate change will adversely affect economic activities and infrastructure and pose risks to human health. Extreme temperature variations will affect the pattern of vector borne diseases. Increased pressures on the health care system are being accommodated through electronic processes and communication. These include remote monitoring and telemedicine.

### **2.3.5 Using ICTs to enhance Citizens participation in environmental management**

ICTs have provided new opportunities for enhancing the engagement of citizens in environmental management. The Internet has been a catalyst for allowing access to environmental related information that has never been available widely or easily to the citizens. Also, ICTs have been able to engage citizens in environmental data collection, though mobile networks or the Internet. Social networking has been very effective in raising awareness about different issues with the environment being one of them. Reliable access to the Internet through computers or mobile technologies is a major contribution to the success of these social networks.

### **2.3.6 ICTs and the Transition for a Greener Economy**

After the global financial crisis, the world is searching for better mechanisms to insure sustainability. Greening the economy is considered one of the choices that would provide better opportunities. ICTs can have a major role in accelerating the transition to greener economy, one of these opportunities is through improving the efficiency of production, distribution, and consumption of goods and services. These can be accomplished through enhancing energy efficiency, consuming less material, and reducing waste generated. A good example of this is the Universal mobile phone that will use zero energy when it is not charging; it will be used by all mobile handsets, thus reducing the quantity of chargers produced as we will be able to charge more than one mobile handset with the same charger.

### **2.3.7 Opportunities provided by the ICT sector for the environment sector**

The ICT sector has provided the means for regional cooperation in managing natural resources that are spread among multiple countries such as ground water aquifers. This requires establishing information systems that are capable of providing timely and accurate information.

Broadband connectivity has provided facilitation mechanisms for sharing and accessing remote data hosted on multiple servers. It has also allowed organizations with a low cost solution to access remote computational power that are needed for analysis of observed data. This would enhance the management of natural resources efficiently.

ICTs have major opportunities for assisting in decreasing the effect of climate change whether on adaptation or mitigation levels; normally this is being called Green ICT. There are many opportunities for utilizing video conference capabilities to reduce mobility. In addition, flexi work is another opportunity to reduce travel and enhance productivity. Also, management of Smart electrical grids has been possible with the utilization of ICT applications that are capable to optimize the routing of electricity generated without the need for excess capacity and resulting wastages. This will assist in reducing carbon emissions.

For climate change adaptation, ICTs have provided new opportunities for monitoring and especially for remote natural resources through wireless networks. This is considered an opportunity for developing such information system that use remote collected data and provide analysis capabilities. Also, the use of decision support systems is an important tool to predict best scenarios for climate change adaptation. There is a need to utilize such types of systems, especially in developing countries, to enhance the decision making process.

There is a need for building human resource capacities that are capable for utilizing such state-of-art ICTs and especially in developing countries. Without capable personnel, it will be very difficult to gain the benefits of ICT capabilities.

Social networks have utilized ICTs to provide citizens the opportunity to share their experiences and collect environmental data. Although there are challenges in ensuring the quality and accuracy of such information this new capability provides the public with an ownership interest that helps in the sustainable management of the available natural resources.

## 2.4 Direction and Way Forward

ICTs allow much better monitoring and control of systems of all kinds. Wireless technologies and global observation systems play a significant role in monitoring climate change. In addition, sophisticated remote sensing technologies and broadband networks can work with smart grids, manufacturing and process control systems to control and match energy generation and utilization, minimizing wastage and consumption of fossil fuel and emissions of GHG. Intelligent vehicle systems will reduce exhaust emissions and cut journey times and energy expenditures. Across the world, ICT networks can give early warning of climate and oceanographic changes, in real time, to allow governments to adjust and respond to natural disasters.

Because the penetration rate of mobile networks is higher than for computer based networks, dissemination of environmental information should accommodate mobile network standards as a mean for not only dissemination but also to interact with the public. Social networking is gaining more strength with the spreading of mobile networks.

The main contribution of ICTs in tackling climate challenges have been with facilitating the collection, processing, management and dissemination of data and information for making relevant decisions. This includes making it possible to perform complex computations that had not been

possible, communicating the results in a variety of novel forms and in a timely manner, and enabling more people to have access to both information and knowledge and the tools to manipulate them. However, the impact of these contributions has not been felt equally in all areas. Because the global environment is continuous, problems in any one area dilute the progress made elsewhere and therefore collective attention is required.

One of the areas that requires collective intervention relates to the development of content. Earth observation systems have been presented as one of the contributions of ICTs to the tackling of environmental challenges. It has been alluded above that challenges still remain in developing countries. Yet citizens in these regions need to be enabled to make appropriate contributions for global efforts to be effective and sustained. As a way forward, global environmental information systems should be designed to cover the territories of developing countries; failure to include these territories would lead to data holes in global data sets and incomplete knowledge.

Another contribution of ICT systems is the set of tools for making environmental information easily available and accessible to users, and for visualization in forms that are easy to understand. Other papers in this series have discussed technical infrastructure requirements to facilitate such wide dissemination, including techniques for managing metadata to enhance the discovery of information resources and tools for integrating crowd sourced data. Most of these techniques and tools rely on the Internet. While these advances have made the Internet the platform of choice for citizen engagement in environmental management, the solutions tend to require more bandwidth to achieve their full benefits.

Unfortunately, in many developing countries, broadband access is either not readily available, or is too expensive for most of the citizens. The result is that we have lost the mass citizen participation recommended for dealing with environmental problems. There are several contributing reasons for poor bandwidth in developing countries. In some cases, they are due to poor ICT policies, vis-à-vis public goods and the economics of downstream employment opportunities. In such cases, assistance with raising awareness among decision makers on policy options is required.

In other cases, the broadband services are simply too expensive compared to the incomes of most citizens. It has been observed however that in most developing countries, mobile phone usage has been on a steady rise and that most young people access the Internet are using mobile phones. This situation should be considered in the design of environmental information products for mass dissemination. That is, consideration – in fact emphasis – should be given to packaging the information for mobile phones and other handheld devices. Similarly, tools and techniques for crowd sourcing should accommodate and enable use of mobile phones and similar devices for contributing data.

## **2.5 References**

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