INFORMATION AND COMMUNICATION TECHNOLOGIES (ICTS) AND ENVIRONMENTAL CONSERVATION: CHALLENGES FOR DEVELOPING COUNTRIES

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Abstract
Information and Communication Technologies (ICTs) offer new ways for communicating and exchanging information and knowledge in various sectors including the environmental sector. The impact of environmental degradation in many developing countries include degrading agricultural lands, shrinking forests, diminishing supplies of clean water, declining fisheries, and the threat of growing social and ecological vulnerability from climate change and loss of biological diversity. ICTs have a potential for improving the accessibility of environmental information, and if appropriately applied, they can empower local people to make informed decisions regarding environmental issues, thus enhancing environmental conservation. However, the challenge is on how to define particular roles that environmental information can play and where ICTs can effectively be applied for environmental conservation. This paper addresses the role of ICTs in environmental conservation. This includes maintaining a delicate balance between the human needs to improve lifestyles and feeling of well-being on one hand, and preserving natural resources and ecosystems on the other hand. It also discusses challenges of using ICTs in improving the accessibility of environmental information in developing countries. Recommendations are also presented for proper integration of ICTs for the enhancement of environmental conservation in the developing world.

Introduction
The protection of environment and natural resources is an important part of development. Environmental protection contributes to improving human health conditions, sustaining agricultural and other primary production, and reducing risks of disastrous floods as well as wildfires, mudslides and other natural disasters (World Bank Group, 2005). Without adequate initiatives to protect environment, development activities are affected and this in turn may reduce the resources available for investing in combating environmental damage (World Bank, 1922 cited in Katima, 2005).

Information and Communication Technologies (ICTs) present new ways in which information and knowledge can effectively be shared to enhance developmental activities including environmental protection. The provision of information through ICTs can empower people with unprecedented understanding of environmental issues, their policy implications, and of the interplay between environment

and development (World Bank Group, 2005). Particularly, ICTs can be of benefit to the rural poor in developing countries which are more disadvantaged with regard to the access of environmental information.

About 75% of the population (90% in Africa) in developing countries lives in extreme poverty (Academy for Educational Development and Winrock International, 2003). Most of them are rural-based and derive their livelihoods mainly from agriculture (World Bank, 2002). These rural people are characterized by geographical isolation, low literacy level, degrading agricultural lands, shrinking forests, diminishing supplies of clean water, dwindling fisheries, climate change and loss of biological diversity, poor infrastructure and services such as education, health, transport, communication and other social services (Lwoga and Geoffrey, 2006). While these challenges are also global, their impacts are most severe in the developing world especially among people living in poverty, who have the least means to cope and most often are being deprived from accessing the timely environmental information. ICT presents an immense potential for improving the accessibility of such information.

Access to ICTs has been on the increase in developing countries, exceeding economic growth. This growth is being driven by both demand-side factors, such as the increasing popularity of mobile phones and the Internet, and by supply-side factors, such as regulatory reforms, falling costs and prices, and technological innovation (Gray and Magpantay, 2005:9). For instance, the global use of mobile phones has rapidly been increasing, and since 2002 there are more mobile than fixed telephone subscribers around the world. The number of mobile cellular subscribers increased from 11 million subscribers in 1990 to 1.4 billion by the end of 2003, experiencing an annual average growth rate of 45% compared to just 6% for fixed telephone line subscribers. In terms of users, one in five people around the world today has a mobile phone, up from one in 339 people in 1991 (Gray and Magpantay, 2005:9). Telecenters which provide access to information at the grassroots level have also been established in many rural areas of various countries. These countries include Australia, Brazil, Canada, some European countries, South Africa, and the United States. Currently, most of these telecenters are self-sustaining (Munyua, 2000).

Despite the rapid growth of access to and use of ICTs, the digital divide has slightly been reduced especially in developing countries. Digital divide refers to a gap between groups or individuals in their ability to use ICTs effectively due to differing literacy and technical skills, and the gap in availability of quality and useful digital content (Oguya, 2006). Digital divide in developing countries is compounded by many factors, which include: increasing the purchasing power of the poor, training and building human capacity, raising levels of literacy, improving electricity supplies and accessing capital and attracting investments (European Commission, 2001). Thus, the challenge is not only to increase access to ICTs, but also to make them appropriate to the rural people, the majority of whom are poor, illiterate and actually have inadequate means to access and use ICTs (Sife *et al*, 2004).

This paper discusses the role of ICTs in environmental conservation with a focus on the challenges that face developing world in integrating ICTs for the provision of information for environmental conservation. Recommendations are also presented for proper integration of ICTs for the enhancement of environmental conservation in the developing world.

Core issues

Role of ICTs in environmental conservation
ICT can efficiently support environmental conservation as communication technology rather than as information-processing or production technology to the rural poor (Heeks, 1999). This fact emanates from the following: (1) the poor need knowledge to access, assess and apply existing information and need resources for action more than they need access to new information; (2) the poor need access to new, locally-contextualized information more than access to existing information from an alien context; (3) the poor information needs may be met by more informal information systems than by formal ICT-based systems; and (4) the poor will reap the fullest benefits of ICTs only when they know and control both the technology and its related know-how (Heeks, 1999). Hence, apart from ensuring that the information is being accessed to the poor, the mode of communication is also of great importance.

ICTs can effectively support rural poor if the following are considered, (1) Connectivity: are the services available? (2)

Affordability: can potential clients afford the access? (3) Capability: have the potential users the skills required for access? The users' skills relate to technical abilities, language and literacy (Gerster and Zimmermann, 2003b) and (4) Policy environment e.g. community access to ICT for all (Gerster and Zimmermann 2003a, Gerster and Zimmermann, 2003b). Hence, the users' capacities matter, not only when accessing information but also when transforming and communicating it into practical opportunities.

ICTs are argued to support environmental conservation in several ways. ICT can disseminate knowledge about the environment to improve people's awareness on environmental issues and their policy implications. This tool can guarantee that the environmental information and knowledge are disseminated to a large audience, especially by using electronic media to educate people about the importance of conserving environment for socio-economic development (World Bank Group, 2005). ICTs allow unprecedented intensity of communication on such issues among all sectors of society. Almost any intervention that can be identified to improve sustainability or reclaim degraded environmental systems can benefit from appropriate applications of ICTs.

ICTs can also make a valuable contribution to sustainable environmental management by permitting unprecedented monitoring of environmental quality, and unprecedented accuracy in detecting the sources and projection of the development of environmental problems (UNDP, 2001). For instance, ICTs can be used to improve monitoring and response systems such as the environmental disaster. This situation is demonstrated in Mexico, where fire emergency services are using satellite images to direct response teams to critical areas, resulting in significant reductions in casualties and property loss (UNDP, 2001).

Further, ICTs can enable a better understanding of issues such as climate change and biodiversity and helps to monitor ecological conditions so that prevention and mitigation measures can be activated. In Nepal, computer imaging has been used to build a land resource database for the Arun River basin. This has generated the first ever basin-wide map of land use indicating forest degradation hotspots. The database, together with simulation models, was crucial

to designing and implementing the land management program for the area (UNDP, 2001).

Application of ICTs can be used to reduce the consumption of energy, water and other essential natural resources through more efficient agriculture and industrial procedures. For example, precision agriculture techniques using Geographic Information System (GIS) and Global Positioning System (GPS) can facilitate weather and soil monitoring, crop forecasting and the ability to optimize farm return on investment and ensuring more efficient use of scarce resources (Bedi, 1999).

ICTs can also facilitate environmental activism and enable more efficient resource use. Scarcity of relevant and reliable information has always been a substantial obstacle to more effective environmental management (World Bank Group, 2005). Hence, the power of ICTs as information and networking media can enable citizens to act as environmental enforcement agents, alerting decision makers to compliance infringements and leveraging the power of ICTs to reach and influence public opinion. Fighting environmental degradation and desertification, arresting deforestation, promoting proper management of water resources and protecting biodiversity require the active participation of rural communities through communication processes.

Despite these contributions of ICTs, for many years, communication initiatives in support of environmental and natural resources management have mainly focused on the dissemination and adoption of technical packages. These efforts have been met with limited impact. ICTs offer an alternative for improving communication and dissemination of environmental information. Participatory approaches can facilitate the dialogue and exchange of knowledge and information, increase the community knowledge-base (both indigenous and modern), promote agricultural practices which are compatible with the environment, and develop awareness among policy makers, authorities and service providers on environmental conservation (UNDP, 2001). For example, in ten Information Shops in villages near Pondicherry, India, the use of the local language and multimedia (to facilitate illiterate users), and the participation by local people are the major contributing factors for the diffusion of ICTs in the communities. About 300 users utilize a range of ICT services in the

information shops in a day (Arunachalam, 2004). Thus ICT projects in the rural areas should be owned locally and the participation of the community should part and parcel of the project implementation from the beginning for sustainability purposes.

ICT application for environmental conservation in developing countries

In the developing countries including African countries, there are several ICT projects which provide relevant environmental information to communities. The following examples show how ICTs are applied to disseminate environmental information to the rural communities in developing countries.

Short messaging services (SMS)

Using SMS technology is an ideal and accessible way for the public to take action as well as increase their awareness of environmental issues. By applying these mobile mass-messaging services, the communities are able to share information on environmental issues. In the Philippines, Environmental Non-Governmental Organizations (NGOs) and civil society organizations have developed SMS-based initiatives to reach out to the public in monitoring the environment, and empowering people to report cases of environmental pollution or degradation (Alampay and Tiglao, 2005). Flora & Fauna International and Resource Africa teamed up to create "SMS Communities" a system for relaying important information to community members living near South Africa's Kruger National Park. The aim was to tackle the human-wildlife conflict issues by allowing messages about errant animals to be broadcast quickly and widely to warn residents and Park staff of wild animals that may be dangerously close. The system is also used to keep local communities informed about park management meetings (Flora and Fauna International, 2006).

Community radio

Community radio can also play an important role to stimulate the community participation in different environmental and socio-economic issues especially to those who depend on agriculture and/or environment for their livelihood. Community radio is an effective approach to disseminate environment information to the rural poor because it is directed specifically to rural people and their information needs. In many cases, the information needs of rural people are virtually ignored by national radio networks. A rural radio approach is an alternative to narrow, city-centered urban radio (FAO,

1998:10). For example, although there is very little farm radio programming on South African community radio stations, through different formats of the radio programmes, they have managed to make a massive impact with regard to agriculture and/or environment issues (Mosotho, 2001). This is because they give people an opportunity to voice their opinions during the discussion of a particular topic including the environmental issues. In Uganda, community radios such as radio Paidha, Apac and Rhino contribute to the unity, social and economic development of the local communities through offering quality programmes and community active participation by way of information gathering, sharing, processing and dissemination (Padania and Silvani, 2005). Community radios offer wide penetration particularly in more remote areas, and can disseminate information in a relevant way for its listeners. They can offer ordinary people a relatively low-cost way to participate in discussions about environmental issues. Radio may play a greater role in disseminating environmental information in rural areas because in rural areas there is limited access to other ICTs, such as television. Also, radio is affordable to the majority of rural people and it can be operated by batteries unlike television which needs electricity. Moreover, there is no electricity in many rural settings, and even if it were available the majority could not afford it.

Combination of Internet and radio broadcasts
The mixture of radio broadcasts and Internet offer a range of possibilities for disseminating environmental information to the rural poor. Kothmale Radio in Sri Lanka is one of the examples that have combined radio and Internet access. During "radio browsing programmes", presenters browse the Web in the studio on behalf of the listeners who provide requests/input by phone or post (Kenny, 2001). Such initiative can be used to disseminate environmental information to the rural poor to enable them to make informed decisions with regards to environment conservation.

Participatory Geographical Information Systems
Geographical Information Systems (GIS) focuses on the collection, storage, analysis, display and application of geographic data (Mansell and When, 1998). GIS allows access to information and provide a support system to manage and monitor environmental issues. GIS can be regarded as an advanced equivalent of a traditional map from which a wide range of information can be extracted for specific

purposes that can be useful in the integration of information on climate, soils, and terrains from different sources. Participatory GIS and community mapping are useful tools and methods for bringing GIS potentials closer to rural communities. They are also useful tools for bridging the gap between geographic information technologies and capacities found among marginalized, isolated, and frequently natural resource-dependent communities. During the last few years, Participatory three-dimensional modeling has been rapidly evolving in the Philippines in the sectors of biodiversity conservation, natural resource management and human rights advocacy, both from technical and political points of view (Rambaldi and Callosa-Tarr, 2002). Participatory GIS is a very useful tool as it involves the communities in context during mapping, thus the final map (GIS output) in three-dimensional modeling become easily visualized as it has included community inputs, that in some cases experts could not find on their own.

Telecenters

ICT facilities are commonly made available to rural poor in the form of community-based telecentres (Harris, 2004:14). There are various initiatives, which focus at providing access to ICTs particularly in rural areas of developing countries. In Africa, telecentres are growing rapidly due to the support of organizations like the United Nations Educational, Scientific and Cultural Organization (UNESCO), the International Telecommunications Union (ITU), the International Development Research Centre (IDRC), the World Bank, the British Council, the Food and Agriculture Organization (FAO), the World Health Organization (WHO), the United Nations Development Programme (UNDP), and many more (Chisenga, 2002). Tanzania is among the six African pilot telecentre countries within the framework of ITU / UNESCO / IDRC initiative. Currently, there are nineteen telecenters in Tanzania that offer various ICT services (COSTECH, 2005). Despite the rapid growth of telecenters, studies show that many of these rural ICT initiatives are equipped with expensive facilities, which are often used at less than 5% of their capacity. Often, users pay no attention to computers, but are keen to use the telephone, the photocopier or watching some TV programmes (Benjamin, 2001). Similarly, a study to assess the use patterns of telecentres in both South Africa and Uganda reveal that certain services, especially those related to computers and information services tend to be poorly utilized, whilst some others, including telephone and photocopying,

enjoy moderate to high levels of demand (Parkinson, 2005). Among the impediments to the use of telecentres are the relatively high costs of services, equipment, maintenance and supplies, inadequate physical facilities, poor management, hours of operation, inappropriate location, poor publicity, and low literacy levels and the dominance of European rather than local languages in ICT content especially on the Internet (Zeleza, 2005).

Reduction of urbanization pressures
ICTs offer new opportunities to enable transactions to take place over geographical distances at low cost, and thus may help in efforts to decentralize and disburse economic activities more evenly in developing nations. ICTs offer services at a distance (e.g. telebanking, telemedicine, distance education, radio and TV) that may help to reduce urbanization pressures, hence contribute to environmental conservation. Urbanization pressures, emanates from the fact that the urban environment, in which people are highly concentrated in developing countries raises environmental concerns such as deforestation and overuse of infrastructure, which is a source of grave health risks. Additionally, job creation occurs largely in the urban areas, and people from the rural areas always move to the cities to get those jobs. It seems possible that part of the reason for the concentration of job creation has been due to the difficulties of conducting transactions over long distances. Goods and services have generally had to be purchased from close by. Thus, the wide use of ICTs can help to reduce urbanization pressures, hence contribute to environmental conservation in developing countries.

Challenges of ICT integration for environmental conservation in developing countries
The potential of ICTs as affordable remote access interventions has firmly taken root in developing countries. However, for effective implementation of the ICT initiatives, particularly in the rural areas for environmental sustainability, certain pre-requisites need to be considered. Therefore, this section explores the challenges, which need to be considered by the developing countries in order to integrate ICTs for environmental conservation.

Many developing countries do not have a national ICT policy framework that is important to create an enabling environment for developing countries to harness and exploit ICTs for socio-economic development (European Commission, 2001; Njuguna, 2006). For

instance, the 2002 statistics show that 16 African countries have developed ICT policies, while 21 countries are in the process of developing ICT policy. (Njuguna, 2006). Despite the fact that there are few countries with national ICT strategies, very little progress has been made to implement those policies (European Commission, 2001; Njuguna, 2006). The implementation of ICT policies in developing countries is apprehended with a lot of expenses in accessing the ICT infrastructure. For example, the telecom services in several countries are supplied in monopoly environment, which tend to be slow in meeting demands, charge comparatively high fees and provide relatively poor service (European Commission, 2001). For instance, "the cost for the same type of broadband access is $1000–8000 dollars/month in parts of Africa, and 100/month in a similar context in Central Europe, whereas it could soon cost local communities in Andhra Pradesh, India as little as $2.93/month as a result of the government's new broadband initiative" (Lal, 2005:15). Further, ICT projects in rural areas are very expensive because of connectivity which poses more challenges for ICTs to penetrate the rural areas. A study by Cecchini and Scott (2003) found out that in urban areas of India, each fixed telephone line connection costs at least US$650 and in rural areas it can cost at least US$1,500–1,700.

The ICT infrastructure of many developing countries is still poor. This is witnessed by the low penetration of telephones and internet connectivity to the rural areas. Currently, this connectivity is mainly limited to the urban and peri-urban areas. The rural communities are the most forgotten category because the telecommunication penetration is still limited. The situation limits opportunities to disseminate environmental information, thus contributing to environmental degradation. The government, funding agencies need to improve this situation, which should go hand in hand with other services such as the reliable electricity power supply.

Further, there is inadequate human capability to design, implement, manage and use ICT applications and services in most of the developing countries. For example, when Tanzania is compared with her neighbors in terms of developing human capacity in ICTs, it has only 5 polytechnic and university graduates per million inhabitants per year compared to Namibia which has 90 graduates (COSTECH, 2004). A poor human resource base compounded by other factors has adversely affected the penetration and use of ICTs for environmental

information provision. Thus, poor farmers and local entrepreneurs do not get access to information regarding environmental protection.

Moreover, the level of ICT awareness and literacy among rural communities in developing countries is very low. This is mainly contributed by the poor ICT infrastructure and limited human resources. However, the enhancement of ICT awareness and literacy is very important since this process ensures that the local communities know the importance of using ICT for the environment protection, which also improves the utilization of these facilities for the improvement of their life quality (Lwoga and Geofrey, 2006).

Most of the information exchanged via ICTs, whether in text format or broadcast orally, takes place in the languages of the developed countries. Therefore, people who do not understand these languages are being discriminated from using ICTs. Most ICTs use English language, and thus users who do not have basic English proficiency, are being discouraged from using ICTs. Such people include the majority populations of French-speaking Africa, the Middle East, Eastern Europe and Latin America.

The extent to which the content is relevant to the local context of developing countries including Africa is still low. For example, in a study conducted to find out if African governments are contributing to bridge the content divide through their websites, only 10% of the websites had information resources relevant to their citizens (Chisenga, 2004). This emanates from the fact that the developed countries are more ICT-enabled than developing countries, they have published more of their local content turning developing countries into consumers of distant and potentially irrelevant information that may undermine or overwhelm local cultural heritage and economic livelihoods (Ballantyne, 2002). Thus, this discourages the rural poor to access information from the existing ICTs such as internet and Television because the content is not relevant to their local needs.

In developing countries, women face many barriers limiting their levels of ICT use. Illiteracy is the most important obstacle for women's access to ICTs. This is because the use of ICT needs a variety of literacy skills and the majority of illiterate people in developing countries are women (Munyua, 2005). Other aspects that limits women access to ICTs include restricted mobility, male control over

information and media, lack of financial resources, lack of time and limitations of the media on gender issues (Hafkin, 2002; Marcelle, 2000).

Conclusions
The challenges facing developing countries in integrating ICTs for environmental conservation have been addressed in this paper. The main issue is how to appropriately integrate ICTs taking into consideration the situation in developing countries in order to achieve a better outcome. With the present focus on the Millennium Development Goals (MDGs), it is now a matter of immediate urgency that decision makers form a strategy which underscores the important link between ICTs and environmental conservation. ICTs can address the needs of the poor, empower and enlighten the majority on the environmental conservation issues if appropriately used and applied. ICTs could thus serve as a tool for enhancing the environmental sector.

Recommendations
For effective integration of the ICTs into the environmental conservation issues in developing countries, the following are recommended.

Participatory approach and local ownership
Successful ICT projects at the grassroots level should be characterized by local ownership, the participation of the community and promotion of the concept of public commons (Arunachalam, 2004; Cecchini and Scott, 2003). A study by Robinson (2000) revealed failure of ICT projects in Mexico due to the lack of local ownership. Ensuring local ownership requires an approach that puts people first, their needs, theirs assets, their aspirations and their constraints. If the focus is on people and their needs, the use of ICTs will represent the widely varying information needs of people that have significant impact on the quality of their lives and the environment around them (Moetsabi, 1999). Poverty leads to overuse and destruction of natural resources where short-term development goals are pursued at the expense of long-term environmental sustainability. In some countries, the poverty of rural populations contributes directly to pressures on forests and bio-diversity. Growing populations of poor people cut wood for fuel, and are forced to divert marginal lands into subsistence agriculture. They hunt bush meat for survival, thus contributing to the loss of keystone species. Further, since these people lack information

regarding environmental conservation and nature, they normally address their social and economical needs at the expense of environmental degradation. Thus, the usage of this approach will enable the ICTs to be owned by the intended communities and hence contribute to environmental conservation.

Gender

ICT policies should include gender issues to encourage women to participate fully in all aspects of ICT development (Hafkin 2002; Munyua, 2005). Engendering ICT policy involves sensitizing policy makers to gender issues, and sensitizing gender advocates to information technology issues (Hafkin, 2002).

Training and awareness

Training and awareness are of great importance to increase the access to ICTs by the rural poor. Failure to involve the rural poor to use technology tends to lead to further marginalization (Cecchini and Scott, 2003). In the same context, rural poor should be empowered and given means to form advocacy networks. This will introduce social change and enable people to gain access to decision making process and put crucial environmental issues on the agenda of the decision markers, which can put long-term perspective on sustainable environmental conservation. For example, an organization of fishermen in Honduras learned to use video to document the destruction of their mangroves by politically powerful commercial farmers. These recordings are used to lobby politicians in the Honduran Congress. Similarly, a group of women in Kenya used videos to raise their voices and inform the decision markers about their needs (UNDP, 2001).

Relevant local languages and content

Steps must be taken to address the needs of developing countries in terms of their languages and content. A study by Roman and Colle (2003) suggests that there is a greater possibility of ICTs being adopted when the community finds that it incorporates local knowledge. Developing local content in local languages by involving the communities is important so that the content is totally responsive to the needs of the community. Building upon local knowledge in local languages enhances the attractiveness of ICTs. For instance, the community radio and telecenters which are designed in consideration of language and culture of the intended people are expected to be more beneficial and efficiently utilized. This is due to the fact that

people will understand the language of communication and at the same time the message communicated will be appropriate with their culture. Therefore, steps must be taken to deliver content that is locally-contextualized and which meets the information needs of the rural poor (Cecchini and Scott, 2003). This process will involve significant investment and support for local content (in broadcasting and the internet) and software design. This investment may help in disseminating environmental information which is more relevant to the people of developing countries.

Infrastructure
Providing access to better information and communication flows through reliable infrastructure is an important condition for fostering economic growth at a macro level. However, without intervening government policies, the benefits of that growth could be distributed very unequally within the society (Kenny, 2002). Therefore, developing countries will need to develop national ICT policies and regulatory framework that are necessary to support in harnessing and exploiting ICT infrastructure for socio-economic development. Further, developing countries will have to cooperate with each other and partner with other international agencies to lobby for infrastructure issues such as the Internet bandwidth and so on. They will also need to seek funds to improve the telecommunications, access to computers, and electricity in rural communities. This process will help to foster the accessibility of the environment information hence environment conservation in the rural areas.

Use of different types of ICTs
Combining variety of ICTs can enhance rural access. These varieties include the Internet, radio, mobile telephone, use of multimedia and drama. A promising option is sharing of costs among various users such as schools and local governments. A study by IICD, (2006) on 35 ICT projects in nine countries in Africa and Latin America to enhance agricultural livelihoods recommended that using combination of ICTs can overcome problems of rural access.

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