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The Role of Information and Communications Technology (ICT) In Environmental Sustainability

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Abstract: *ICTs play a key role in the protection and sustainability of the environment. This paper provides an overview on how ICT can help tackle environmental challenges. It also examines the benefits of ICT in the environment and how ICT investments can help guide in setting policy that will promote societal sustainability. The paper further addresses effects of ICT on sustainability in the areas of education, energy, environment, and transportation. It observes that ICT can improve transportation via the use of smart meters to monitor traffic (resulting in congestion pricing) and make energy delivery and consumption more efficient with the use of smart thermostats. Tele- and video-conferencing can reduce travel needs, leading to reduced carbon emissions for the environment. Distance and online learning technologies can reduce the need for brick and mortar buildings as well as the need for transportation in delivering education. Finally, telemedicine, ehealth, and m-health have the potential to make delivery of public health more efficient. Adoption and proper utilisation of ICT thus have the potential to promote sustainability within the society at large.*

Keywords: *ICT, Environment, Protection, Sustainability*

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I. Introduction

Sustainability refers to the ability or capability to sustain (maintain) something. Thus environmental sustainability is the ability to maintain things or qualities that are valued in the physical environment. On the other hand, ICT for environmental sustainability means the optimal use of ICT for managing the environmental sustainability of societal activities with the aim to use ICT to minimise the environmental load caused by humans.

ICT is a generic term that is used to encompass all forms of technologies used to handle information and aid its communication in a digital format – creation, acquisition, processing, storage, retrieval, transmission, exchange, dissemination. ICT include hardware and software. Hardware encompasses computers (desktop, laptop, wearable), mobile phones, pen-based PDAs, printers, wireless and mobile telecommunications networks and so on. Software comprises associated applications and services, such as decision support system (DSS), service oriented architecture (SOA), enterprise resource planning (ERP), videoconferencing, e–commerce, e–learning, e–communities (i.e. virtual team), etc. ICT use spans over as diverse areas as business, industry, environment, government, communication, health care, scientific research, education, etc. Moreover, it is common that ICT is synonymous with IT as ICT is an umbrella term for information technology (IT) and communication technology. Indeed, IT is -the field of engineering that involves computer and communication systems – hardware and software – used to create, acquire, process, store, retrieve, transmit, disseminate and protect information, as well as the knowledge and skills needed to use ICT securely, intelligently and appropriately in a variety of contexts.

Information technology is defined by the Information Technology Association of America (ITAA) as 'the study, design, development, implementation, support or management of computer–based information systems, particularly software applications and computer hardware.' (Veneri, 1998). Communication technology entails, on the other hand, the activity of designing, constructing and maintaining communication systems which are used to facilitate virtual communication between individuals or groups.

ICT is increasingly recognized as the strongest change means humanity has to its disposal, and, at this time, must be mobilized and directed at promoting sustainable economic development. And as ICT becomes more sophisticated and more embedded in our social and organizational structures, we are in a better position than ever before to make sustainable development work (Alakeson 2003). In addition, considering the huge impact of ICT on the economy, it is certainly of strategic value to call to mind the urgency of strategizing ICT design with sustainability in mind.

Environmental sustainability refers to the long-term preservation, protection, and management of valued environmental resources in an ever-changing human context. Intricately linked to the concept of enduring development, environmental sustainability also implies sustainable human, social and economic development. Issues of environmental sustainability are more urgent now than ever before as the world faces an extraordinary array of challenges ranging from air and water pollution, food insecurity, climate change, natural disasters, an upsurge of slums, inadequate sanitation, unprecedented loss of forests and biodiversity, fragmented leadership at the local, national, and international levels, conflicts and complex emergencies, and glaring disparities in human development across the globe. Therefore, tools and strategies that enable environmental sustainability have become critical to development. Information Communication Technologies (ICT) is such a tool.

The last decade has seen the proliferation of ICT worldwide. Due to its ability to reduce interaction costs, expand markets, and make information flows more efficient, ICT has been credited with unprecedented global gains including GDP growth, global connectivity, information exchange, and capacity building. Subsequently, many stakeholders purport ICT are a viable means to improving the wellbeing of the global citizenry.

How ICT can help tackle environmental challenges

ICTs can create jobs via the leap frog effect (e.g., mobile computing), thus providing income and creating purchasing power for food hence, eradicate extreme poverty and hunger. ICTs can enable distance and online learning via the Internet and mobile devices. Distance and online learning technologies can reduce the need for brick and mortar buildings as well as the need for transportation in delivering education.

ICTs can promote e-democracy as well create economic opportunities via broad band, micro financing and crowd sourcing, and mobile computing and devices (e.g., mobile currency to enable banking). On different health dimensions, such as reducing infant mortality, improving maternal health, and combating HIV/AIDS, malaria, and other diseases,

ICTs can play a critical role via e-health, m-health, telemedicine, and other applications that promote education, communication and dissemination, and delivery of public health, ICTs can improve transportation via the use of smart meters to monitor traffic (resulting in congestion pricing) and make energy delivery and consumption more efficient with the use of smart thermostats. Tele- and video-conferencing can reduce travel needs, leading to reduced carbon emissions for the environment. Telemedicine, ehealth, and m-health have the potential to make delivery of public health more efficient (Wu and Raghupathi, 2012).

Security threats, concerns and other challenges in the country are multi-dimensional in nature and scope. Traditionally, crime and security establishments throughout Nigeria have operated largely bureaucratic, paper based institutions which have stifled the process of information sharing, it is therefore important to recognize that the traditional ways of meeting the challenges need to be expanded to encompass new non-traditional threats. The use of ICT is slowly emerging as one response to critical issues faced in the country.

As such there are a number ICT implementations beginning to take shape in response to incidents that have affected the country which will lay the foundation for further evaluation of regulatory mechanisms for handling crimes in the country some of them include: Automated Fingerprinting Information Systems (AFIS) e.g. the introduction of the fingerprint authentication system during JAMB examination registration and election process, Mobile Banking, Global System for Mobile Communication in almost all parts of the country, Use of Geographic Information Systems, e-commerce etc. Also, various sectors of the crime and security forces have been moving toward the implementation and use of ICT technology such as the Public Security Communications System (PSCS) to install CCTV cameras in Lagos and Abuja, to monitor crimes and address criminality in order to assist the police their efforts (Emma, 2013).

The benefit of ICTs on the environment within the society

The role of ICT in **environmental monitoring and data gathering** is paramount and serves as the cornerstone for technological advancements. ICT such as satellite imagery, wireless sensor networks, geographic information systems (GIS), and communications hubs enable a wide variety of applications for environmental sustainability. The International Telecommunications Union (ITU) found ICT like data recording technologies and surveillance systems greatly contribute to observing, monitoring, and ultimately understanding the environment. However, the task of acquiring relevant data and the ability to draw pertinent conclusions for future actions requires appropriate tools.

ICT have proven to be an **effective method by which data can be gathered and analyzed in an attempt to remedy situations** such as land and groundwater, pollution, poor sanitation, and riverbank erosion, pose obstacles to economic development and the improvement of living conditions for people. Hence, having the ability to analyze topographical changes on already settled land, as well as looking at changes over time through retro-grade satellite imagery, can tell the story of a city's growth and development as well as help cast

predictions as to how certain patterns will affect the future development of the city, especially in light of climate change forecasts predicting rising sea levels.

ICT can be successfully **used to organize and disseminate information regarding biodiversity**, which can be used by governments and the private sector when planning and evaluating projects. For example, the Integrated Biodiversity Assessment Tool (IBAT) a collaboration between internationally renowned organizations such as the United Nations Environmental Program, Birdlife International, and Conservation International, and private corporations such as BP, Microsoft, Bank of America, and Rio Tinto, make a biodiversity database available to businesses seeking to incorporate environmentally sustainable measures into their projects. This enables decision makers to obtain relevant information about endangered species, at risk areas, and other environmental concerns from a single, reputable source.

Having early access to this information enables project developers to account for environmentally sensitive factors and to adjust their plans accordingly. This is not only beneficial to the environment but also to the firm because doing so could ultimately limit their exposure to lawsuits resulting from inadequate knowledge about the environmental impact of their endeavor. Additionally, IBAT can be used to retroactively evaluate the environmental impact of projects already completed.

The datasets presented in IBAT are derived from the World Database of Protected Areas (WDPA) and provide the user with information regarding both legally protected sites, as designated by a governmental body, as well as *globally important sites for biodiversity*, which are submitted by local partners. These sites are operationalized as any location "…known to hold one or more globally threatened species, endemic species, globally significant concentrations or populations, significant examples of biological communities, or any combination of these features." (Integrated Biodiversity Assessment Tool, 2010). The ability of corporations and governments to have access to this database will promote environmental sustainability in the private sector. Since its launch in 2008 IBAT has become the authoritative source for all data concerning biodiversity, endangered and at risk species, and environmentally sensitive areas. Already BP has used this database to assess the effect of propose pipelines on the local environment and modified their plans accordingly. (Andrea, 2010)

Another area where ICT is beneficial is **the use of sensors and sensor networks to boost water usage efficiency**. This technique, known as *precision agriculture*, utilizes computer systems to collect data such as temperature and humidity through remote sensors. This information is then analyzed. The computer then calculates the exact amount of water necessary to obtain maximum crop yields, which is an integral step towards economic growth. This is a vast improvement over farmers who generally irrigate their fields with uniform amounts of water.

COMMONSense Net (CSN) is a project researching and applying the use of wireless networks on small farms in rural India. CSN reports that unpredictable and fluctuating rainfall in the already arid region of central India adversely affects poor farmers because they are less likely to invest in yield boosting resources such as additional seeds, fertilizer, or improved technology.14A low cost alternative to drilling water wells, which also run the risk of not providing enough water, is to construct wireless networks that enable precision agriculture. CSN has constructed such a wireless sensor network in Tumkur, India, although evaluative information is not yet available. Therefore, precision agriculture can be especially beneficial for resource poor farmers. ICT, such as those used by CSN, can achieve this goal. Doing so will lead to more efficient use of water, which may also aid in overcoming other development obstacles as well.

ICT can enhance national hazard and disaster management systems across the board, positively affecting everything from alerting populations about an impending disaster like a heat stroke or tsunami and the appropriate actions to take, including: evacuation or additional cover; the exact location and type of services available should one fall ill or need assistance; and how a country should prepare overall for the next disaster and what its response could look like at the municipal, community and national levels. As climate change poses greater challenges for already stressed communities, with imminent sea level rises and temperature fluctuations, preparedness and adaptation mechanisms—particularly geared towards the poor and disadvantaged groups—can go a long way in securing development achievements that are often "washed away by the storm".

Another new (and better) way of doing old things through the use of ICT is **an electronic forest fire detection system** known as Firehawk. The system was developed, patented and trademarked in South Africa by Digital Imaging Systems in 2000. It has replaced or enhanced manned lookout towers in plantations in KwaZulu Natal. Millions of dollars are spent annually in the combat of fires but nothing is done about their early detection. While manned lookout towers have been the norm for hundreds of years, human error and late reporting can lead to destruction of forest assets and even death. Through the use of rotating digital cameras, continuous picture and video are taken of large forestry areas. These are then transmitted to several base stations where the Firehawk software differentiates between fire, smoke and glow and automatically raises the appropriate alarm. During the past six years the system has been installed and tested in various forestry areas throughout South Africa.

In Northern Kwa-Zulu Natal during the 2000 fire season a total of 153 fires were detected. Of these, 87 fires were detected at night. Results at the end of the season showed a burnt area rate of less than one hectare per fire (0.7 ha per fire), whereas during the 1998 fire season, before the Firehawk system was installed the burnt area rate was 5.68 ha per fire. (Jake, 2000)

ICT investments as a guide in setting policy topromote societal sustainability

National government participation is an integral part of the success of ensuring environmental sustainability. With increased climate risks and the number of natural disasters on the rise, environmental issues have become a priority for developed and developing countries alike, but several issues limit success in this area.

Awareness of the need for sustainable development remains a barrier in many countries. Where awareness is present, proper data collection and information needed to facilitate environmental decision-making is lacking. Budget shortfalls curtail investment for environmental projects and policies at the national level and; balancing priorities of economic development preclude environmental sustainability and can prevent holistic approaches. Countries are often caught unprepared for dealing with shocks and risks associated with the forces of global change, migration, conflict, and disasters that induce local and regional instability and render government action inept. Finally, lack of stakeholder participation in formulating government policies in managing resources remains a barrier, especially at the local level. Given these and other challenges, countries face the daunting task of promoting growth and utilizing their natural resources while effectively preserving them for the benefits of generations to come.

National governments hold a unique and powerful leadership position to foster change and growth across sectors. Through the use of ICT, many opportunities exist for governments to proceed effectively to integrate principle of sustainable development into country policies and reverse the loss of environmental resources.

Along with the debate on climate change, the discussion about sustainable development has pervaded all levels. Without elaborating on the causes of climate change in more detail, it should be stated that beside the possibilities resulting from several positive market factors, the societal Still, active citizens and local communities have a central role in promoting sustainable everyday practises. ICT solutions can be utilized to provide channels to influence other people as well as policy makers. There is also an apparent need for governmental support and incentives for promoting environmentally sustainable ICT. The government could play several roles. Firstly, it could continue to support the creation of innovations and environmental information contents via existing mechanisms, especially those with global potential. Secondly, it could take actions to support the creation of environmental knowledge and innovations with specific measures to advance greener alternatives through regulations and subsidies, comparative frameworks, databases and verification systems. Thirdly, it could support research attempts to build methods to understand and structure the ties between sustainable development and innovation design e.g. by making these ties more visible. Simultaneously, the government would increase producers' interest in applying these benefits and turning them into actions. And fourthly, it could act as a key customer and lead the way by taking into use the state-of-the-art and environmentally sustainable ICT solutions.

In the future, ICT will increasingly be present in our everyday lives, and as users we have more and more possibilities to customize products and services to reflect our individual needs. Simultaneously, background systems are globally interconnected and optimized, working faster, and collecting more and more small-scale information. And as the development of ICT integration continues, it might not be too bold to predict that e.g. tomorrow's car producer could be Intel or Microsoft instead of GM. Despite uncertainties in terms of predicting the future, one thing seems to be apparent: environmental sustainability is here to stay, since the challenges it involves are ongoing, and increasingly, it is also becoming a competitive factor.

Challenges to the use of ICT in Environmental Sustainability

The following three broad categories are obstacles, challenges and constraints to the full utilization of ICT for environmental sustainability:

(1) Access, Availability, and Connectivity: Science and technology, in general, are often viewed as inherently gender, culture, and language- neutral. However, when it comes to the application and use of technology, it is clear that the design and implementation of technology often reflect dominant—even, negative—paradigms of society. For example, most manuals, Internet sites, and operating systems are written in only one of four "world" languages: English, Chinese, German, and Japanese, obstructing use by much of the world's populations that are not familiar with these languages. A recent study found that out of over 1300 African websites, only 3.22% were written in an African language.(Joint UNESCO and ITU 2006)For real, extensive, and effective use of ICT to occur in the environmental sector, it is imperative that content be made more accessible to the poor and those living in slums and rural areas.

As the applications for bandwidth intensive communication such as video and flash technology increase, countries must update their ICT infrastructure so that these applications remain viable solutions. Connectivity infrastructures of this nature are not only initially expensive, but are also subject to periodic damage, both intentional and unintentional in origin, and the costs of subsequent repair and routine maintenance. Electricity, phone, and fiber optic lines in developing nations are at a greater risk, resulting in higher costs. (IT News Africa, 2010)

(2) Information Gathering and Sharing: A principal function of ICT is to collect, analyze, and ultimately facilitate in the dissemination of data. Doing so allows for decision makers to have access to accurate and current data at the earliest stages of their projects.

However, there are presently several barriers to information gathering and sharing that prohibit ICT's full use towards environmental sustainability projects. As Denko et al. state there are serious missing links in the information chain when it comes to environmental data because much of the data is gathered in the field, and is not readily available to other practitioners, decision makers, and stakeholders (Jha and Strous, 2007). Instances where ICT are employed without uniformity and coordination amongst the vested interests can lead to the creation of islands of information as was the case when India's various forestry departments went "electronic" (Anil Oberoi, 2010). These *islands* often employed different software, and ultimately led to duplication of efforts, needlessly high costs and prevented interoperability and any efforts at sustained sharing and collaboration. Additionally, there are few places where the data is organized and displayed for stakeholder analysis. While there are currently websites attempting to tackle this issue, such as Akvo and IBAT, there is still a great amount of work that needs to be done. A more centralized approach between the efforts of national governments, international institutions, and the private sector would help to overcome issues in data gathering and sharing.

(3) Cost as ICT Barrier: Many of the information and communication technologies that could be of best use for promoting environmental sustainability, like precision agriculture, require great amounts of capital, thereby severely limiting widespread implementation. This is especially true for the hardware, software, and infrastructure, an ICT system consists of. However, the world cannot wait for the price to fall as opportunities for ICT use, especially in the developing and least developed countries, pass us by. Here, multi-stakeholder collaboration and international funding become critical. (Corinne, 2009)

Another funding obstacle is the protracted costs commonly associated with ICT. Many of these initiatives require funding for an extended period of time. In many cases this is attributable to associated training and education programs as well as maintenance and repair. Since many of these projects require funding for months or even years, investors and donors tend to view them as riskier and are less willing to invest.

The recent economic recession and financial crisis have put additional strains on the limited money available for such ventures. However, as noted by many prominent development economists, long term environmentally sustainable practices are a necessary part of the development process and consequently require increased attention and funding.As is the case for all nations, developing countries are bound by budgets, and must prioritize opportunity costs accordingly. However, unlike developed countries, those countries still in the development phase not only have a harder time attracting investments to fill budgetary gaps, but they also pay a higher price for doing so. Thus, the high cost of capital among least developed countries remains an impediment for full implementation ICT for development.

II. Conclusion

ICTs are enablers for economic, social and enviromental growth because of their crosscutting nature thus affecting all sectors.ICT for environmental sustainability means the optimal use of ICT for managing the environmental sustainability of societal activities with the aim to use ICT to minimize the environmental load caused by humans. It also implies sustainable human, social and economic development. Issues of environmental sustainability are more urgent now than ever before as the world faces an extraordinary array of challenges ranging from air and water pollution, food insecurity, climate change, natural disasters, an upsurge of slums, inadequate sanitation, unprecedented loss of forests and biodiversity, fragmented leadership at the local, national, and international levels, conflicts and complex emergencies, and glaring disparities in human development across the globe.

Therefore, tools and strategies that enable environmental sustainability have become critical to development. Information Communication Technologies (ICT) are such a tool that can help create jobs, enable distance and online learning via the Internet and mobile devices, e-democracy as well create economic opportunities via broad band, micro financing and crowd sourcing, play a critical role via e-health, m-health, telemedicine, and other applications that promote education, communication and dissemination, and delivery of public health, ICTs can improve transportation via the use of smart meters to monitor traffic (resulting in congestion pricing) and make energy delivery and consumption more efficient with the use of smart thermostats. Tele- and video-conferencing can reduce travel needs, leading to reduced carbon emissions for the environment.

It can be used to handle crimes in the country e.g. the introduction of the fingerprint authentication system during JAMB examination registration and election process, Mobile Banking, Global System for Mobile Communication in almost all parts of the country, Use of Geographic Information Systems, e-commerce.

ICT plays a vital role in environmental monitoring and data gathering, organizing and disseminating information regarding biodiversity, enhancing national hazard and disaster management systems. Beneficialin the use of sensors and sensor networks to boost water usage efficiency a technique, known as *precision agriculture*.

Finally, the three broad challenges to the use of ICT in Environmental Sustainability were looked into.

Recommendations

1. **The federal government should:**

- Create favorable strategic and policy frameworks that allow for ICT implementation and attract investment.
- Provide incentives for:
  - ❖ Innovation, research and development in the use of ICT for environmental sustainability
  - ❖ Collaboration amongst key stakeholders
- Support the efforts of civil society and international organizations working in ICT for environmental sustainability.
- Ensure that every ministry/department develops and manages computerized information systems.
- Ensure that every Government Ministry and Parastatal has an updated informative and interactive website.
- Create an e-Government Agency to coordinate and rationalize efforts by government entities working on ICTs.
- The government should pay more attention to founding of ICT, so that it can be of greater help tools in monitoring security system

2. **International Community should**: assist developing countries that lack capacity for environmental research, observation and analysis (especially high-tech and large scale efforts).

References

[1]. Andrea Wolfson ,2010: "The Brave New World of IBAT," Conservation International, 6 October 2008, <http://www.conservation.org/FMG/Articles/Pages/brave_new_world_IBAT.aspx>.

[2]. Anil Oberoi,2010: "ICT Initiatives in Madhya Pradesh Forest Department", <http://www.mpforest.org/pdf/MPFDICTINITIATIVES.pdf>

[3]. Corinne Ramey, 2009: "Using Mobile Phones to Map the Slums of Brazil," MediaShift Idea Lab <http://www.pbs.org/idealab/2009/11/using-mobile-phones-to-map-the-slums-ofbrazil311.html>

[4]. Emma, O. 2013: "Addressing National Security Challenges with Technology Tools". This Day Live. Retrieved fromhttp://www.thisdaylive.com/articles/addressing-national-security-challenges-with-technology-tools/158831/

[5]. Integrated Biodiversity Assessment Tool, 2010: Data Behind IBAT.<http://www.ibatforbusiness.org/default.php?t=SubPageTemplate&r=dbi> (16 April 2010).

[6]. Jake Oosthuizen, 2000: "Firehawk: Electronic Forest Fire Detection and Management System".<http://www.fire.uni-freiburg.de/iffn/country/za/za_18.htm>.

[7]. Jha and Strous, editors (2007). ICT for Development and Prosperity, p. 102.

[8]. Joint UNESCO and ITU 2006: Global Symposium on Promoting the Multilingual Internet, Measuring linguistic diversity on the Internet, Session 8,.

[9]. "Mauritius Completes First Phase of Lion Cable Project", IT News Africa, 31 March 2010, <http://www.itnewsafrica.com/?p=6638> (15 May 2010).

[10]. Richard Labelle, 2008: ICTs for e-Environment, **(**International Telecommunications Union), 26.

[11]. Wu, S., andRaghupathi, W. 2012: A panel analysis of the strategic association betweeninformation and communication technology and public health delivery. Journal of Medical Internet Research, 14(5): e147, http://www.jmir.org/2012/5/e147/(accessed May 20, 2013).

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