ICT:
Sustainable Development

Shubham Goswami

A b s t r a c t

As the world economy begins to recover from one of the worst economic crises in decades along with environment degradation and uneven development of society, Information and Communication Technologies (ICT) is bound to play an increasingly central role in ensuring sustainability. The domain of ICT for sustainability (ICT4S) is still fragmented and fairly unexplored research area. The present paper attempts to understand the negative and positive impacts of these new technologies on the environmental, social and economic dimensions, and how we may use them for moving towards sustainable development.

Key words: *ICT, environmental, social, economic and Sustainable Development*

Dr. Shubham Goswami
Assistant Professor, School of Management
Sir Padampat Singhania University
Udaipur -313601
Rajasthan
Email: shubham.goswami@spsu.ac.in
Mobile: 946134756

Along with the rapid growth of population and industrial output, world has also witnessed uneven development and severe environmental consequences of the chosen development paths. Techno-logy plays critical role in achieving the long-term balance between human development and the natural environment that is essential for sustainable development (Souter et al., 2010). The last decade are characterized by triple threats: the worst economic crisis since the Great Depression, continuing food and fuel price fluctuations, and the effects of climate change. All these issues give raise to concept of sustainable development (SD). United Nation (UN) World Commission on Environment and Development (1987) define sustainable development that satisfies the needs of the present without compromising the ability of future generations to meet their own needs (Brundland, 1987).

It is also widely recognized that new technologies, particularly ICTs, are having a major impact on economic and social

relationships among individuals, communities and nations. Its unique function as a key element of infrastructure for efficient industries and a critical productivity enhancer is crucial for sustaining recovery and laying the foundations for economies that are competitive in the long term. As the world economy begins to recover from one of the worst economic crises in decades, information and communication technologies (ICT) is bound to play an increasingly central role in ensuring economic sustain-ability. Digitalization of economies is fundamental changes affecting the relationship between individual, changing our everyday life (such as: shopping, communications, transportation, enter-tainments, education, level and style of consumption), the business models, the way to think and act in policy and economies. Technology is also developing innovative solutions to diminish other sectors' energy consumption and improve environmental sustain-ability across industries. As far as social sustainability is concerned, ICT enables greater access to basic services by all segments of society and improves the ways these basic services (e.g., education, finance, and healthcare) are provided to citizens.

The interaction and development of information and communication technologies and the need for sustainability, is an emerging but still fairly unexplored research area. The domain of ICT for sustainability (ICT4S) sometime overlap with other discipline research including sustainable HCI (Human Computer Interaction), environmental informatics, greening through IT, and cleanweb. This paper does not stay on the differences between them and uses ICT for Sustainability as a general term. The paper improves our understanding of ICT for sustainability, understanding the positive role of ICT and also present the future challenge in deploying sustainable policies. The present research is an attempt to understand the negative and positive impacts of these new technologies on the environment and how we may use them for moving towards sustainability.

LITERATURE REVIEW

a. Information and Commu-nication Technologies

Information and communication technologies (ICT) is an overarching term for the various digital technologies used for manipulating information, such as computers and mobile phones. While ICT is a quite generic term, in this text this term is used mainly to refer to computers (including equivalent mobile devices), and internet (including the network infrastructure). Internet is a decentralized global computer network used by billions of users. It supports different services, from serving hypertext documents, file systems, email to voice (VoIP) or television (IPTV). Internet has followed a fast growth trend, reaching in 2012 2.2 billion users worldwide (ITU, 2011).

Mobile phones have became the most widespread technological device in human history in a short time, with more than 5.6 billion subscribers or 70% of the global population (ITU, 2011), and still growing. Mobile phones are getting increasingly used to access internet. Computers are getting smaller and adding mobile connectivity option. ICT is also a focus of interaction design and the human-computer interaction (HCI) tradition. Interaction design is the process of deciding and creating the user oriented qualities of digital artifacts. These interdisciplinary areas of research focus not only in the technology, but in how it is used and its consequences, and they also share a practical stance.

It is widely accepted that new technologies are having major positive and negative impacts on economic and social relationship and, especially, on environment. But, the sustainable development cannot be expanding without global communications and knowledge exchange (MacLean, 2007). Cohen et al. (2000) underlies the presence of digital economy in every important domains of the society and suggests the reconstruction of political agenda, integrating the issues of environmental impact of digital economy.

b. Sustainable Development

Sustainability and Sustainable Development (SD) has its roots in the political discussion including UN Conference on the Human Environment, the Brundtland Commission and the Earth Summit in 1992. World Commission on Environment and Development (1987) define Sustainable Development as the development that satisfies the needs of the present without compromising the ability of future generations to meet their own needs. The key point in this definition is bringing together environmental and humanitarian concerns under the concept of equity (between and within generations). It frames the environmental problems not as something external to human society, social and economic systems.

Valentin & Spangenberg (1999) presented a prism of Sustainability Model which defines four dimensional goals of sustainability: 1) social — representing human capital and aimed at strengthening social coherence and justice, 2) environmental — depicting natural capital and aimed at

safeguarding the environment, 3) economic — representing man-made capital and aimed at satisfying material needs, and 4) institutional — depicting social capital and promoting participation and co-decision making. World Conservation Union (2006) presents three pillar of SD Model considering three dimensions of sustain-ability: economic growth, environmental protection and social progress. Adger and Jordan (2009), SD is underpinned by five principles: 1) to contribute to poverty alleviation, 2) to pursue environmental policy integration, 3) to achieve intra- and inter-generational equity, 4) to ensure public participation in decision-making and 5) to address technological and environmental limits to growth. Sustainability usually comprises three main elements:

1. Economic development – reducing and seeking to eradicate income poverty and enabling continued gains in economic welfare.

2. Social development – reducing and seeking to eradicate other dimensions of poverty, improving the quality of education, health, housing and other aspects of the welfare of individuals and communities, and enhancing the quality of social interaction, engagement and empowerment.

3. Environmental protection – reducing pollution and other negative impacts on the environment, mitigating the effects of industrialization and human activity, and seeking to achieve sustainable use of resources in the interest of future generations.

THE VIRTUOUS TRIANGLE OF ICT FOR SUSTAINABILITY

In 2003, the World Summit on the Information Society (WSIS) declared its challenge "to harness the potential of information and communication technology (ICT) to promote the development goals of the Millennium Declaration" with a "commitment to the achievement of sustainable development."

This 'Virtuous Triangle' of ICT (figure 1) goes well beyond the simple cost-saving benefits that have always been apparent, evolving the role of ICT to become a key enabler for more sustainable business as a whole.
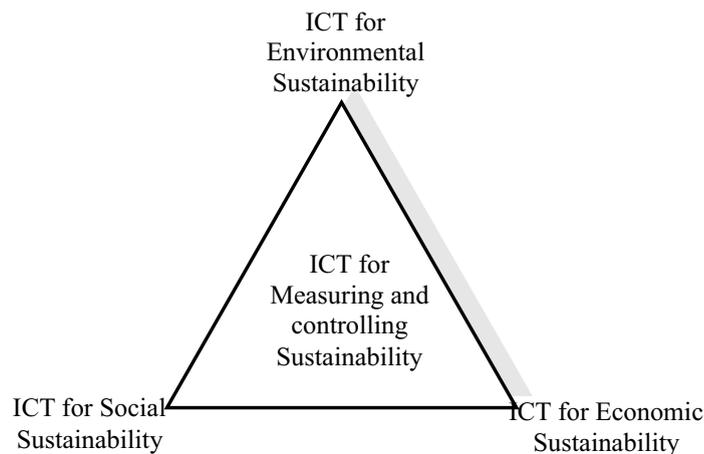
Figure 1: Triangle of ICT for Sustainability

1. ICT for Environmental sustainability

Traditionally, environment policy was considered separate from economic and social development policies. Over last years the perspective of sustainable development and environmental issue has became more comprehensive. Sustainability research has emerged as an interdisciplinary research field.

The relationship between ICT in environmental sustainability can be roughly classified in two areas, the first-order and the second-order impacts (Hilty et al., 2006). The first order impacts of ICT are the negative environmental consequences connected with the Life Cycle related with production, use, disposal of ICT technology. It concerns with the energy and resources used during the production of hardware, the energy

consumed by the equipment (both the personal devices such as computers but also the infrastructure such as network equipment and servers) and the toxicity and social impacts of the disposal of electronic waste. Second order effect includes positive impact of using technology for sustainability. This is the impact of dematerialization, that is, the displacement of physical with virtual activity. ICT reduces the environmental impact of existing services by dematerializing physical assets such as books, bills, music, and activities that used to require physical presence, such as meetings or visits to the bank office. These efficiency measures are also being applied to other fields, such as agriculture. For instance ICT based smart irrigation systems can reduce water usage and carbon emissions by context aware watering schedules? using weather data and/or soil moisture and evapotranspiration sensing (Mutchek and Williams, 2010). Third order effects of ICTs on climate change are those that result or will result from the kind of large scale behavioural and social structural changes. Innovations such as social networking and homeshopping not only have immediate direct impacts on individual behaviour, but also have longer term direct and indirect impacts on the ways in which societies and organizations work. However, third order effects of this kind are difficult to predict (IISD, 2010).

Another dimension of greening through IT is 'Green computing' or 'green IT' which is the study and practice of environmentally sustainable computing. San Murugesan's (2008) definition of 'Green IT' includes "designing, manufacturing, using and disposing of computers, servers, and associated subsystems efficiently and effectively with minimal or no impact on the environment." Green computing can also develop solutions that offer benefits by "aligning all IT processes and practices with the core principles of sustainability, which are to reduce, reuse, and recycle; and finding innovative ways to use IT in business processes to deliver sustainability benefits across the enterprise and beyond" (Donnellan, Brian et al. 2011). Green ICT Strategies also include offering degree and postgraduate programs that provide training in a range of information technology concentrations along with sustainable strategies in an effort to educate students how to build and maintain systems while reducing its negative impact on the environment.

2. ICT for economic reform

ICT enables economic growth by broadening the reach of technologies such as high-speed Internet, mobile broadband, and computing; expanding these technologies itself creates

growth, and the fact that technologies make it easier for people to interact and make workers more productive creates additional benefits. The Global Information Technology Report 2009–2010 shows a positive correlation between ICT readiness—the availability of broadband, computers, and software in a country— and competitiveness with strong recommendations that ICT improves the overall performance of its economy in the long run.

A report by United Nations Environmental Programme (UNEP) on Decoupling Natural Resource Use and Environmental Impacts from Economic Growth (UNEP, 2011) focuses on the issue of decoupling, namely resource decoupling, impact decoupling. Resource decoupling leads to a gradual dematerialization of the economy, because it becomes possible to use "less material, energy, water and land resources for the same economic output" and impact decoupling, means reducing negative environmental impacts per unit of economic activity like extraction of required resources (such as groundwater pollution due to mining or agriculture), production (such as land degradation, wastes and emissions), the use phase of commodities (for example, transport resulting in CO_2 emissions), and in the post consumption phase (again wastes and emissions).

The Indian Tobacco Company, an Indian conglomerate, illustrates ICT productivity gains for an economy. Their agri-business division, one of India's largest exporters of agricultural commodities, created e-Choupal in 2000 as a supply chain management system to reach farmers. These have traditionally sold their products through inefficient physical marketplaces where they are forced to take whatever price is offered because they have limited access to information on market prices. E-Choupal, a kiosk with computers and Internet access, is a virtual marketplace where farmers can sell their products (e.g., soy, tobacco, wheat, shrimp) directly to producers, without paying fees to traders or commissions to agents. The tool also provides information in local languages about the weather, market prices, and farming best practices, as well as general news.

a. From 'Digital Economy' to 'Green economy'

The profound changes in technologies and economics of communications where knowledge and networks play a more pre-eminent role than capital, named *digital economy*. Miller and Wilsdon (2001) propose the concept of sustainable digital economy as a solution for the environmental issues good of economy, environment, and society.

'Digital economy' or 'knowledge economy' is relatively a new concept but basically it is a global network of economic and social activities that are enabled by information and communications technologies, such as the internet, mobile and sensor networks. Beside the economic and social impact, the environmental dimension of the digital economy deserves special attention because it is one of the important aspects of sustainable development (Cohen et al. 2000).

Green economy is seen as a framework for restoring economic growth meanwhile responding to the climate change and other subjects of environmental sustainability. The 'green' economy can be considered synonymous to a 'sustainable' economy. Ecological economics, industrial ecology and environmental/ resource economics are the three closely related disciplines to the notion of the Green Economy (Huberman, 2010). In 2010, a UNEP (United Nations Environment Programme) report on Green Economy Report defines the green economy as "*the process of reconfiguring businesses and infrastructure to deliver better returns on natural, human and economic capital investments, while at the same time reducing greenhouse gas emissions, extracting and using less natural resources, creating less waste and reducing social disparities.*"

Opportunities for synergy between digital economy and green economy strategies have been recognized in the developed countries. Many countries have made in broadband infrastructure, smart electricity grids, buildings and transportation systems, and e-health and e-education applications as part of the stimulus packages they adopted to restore growth in the aftermath of the 2008–2009 financial and economic crisis.

ICTs can support the development of the green economy in three principal ways (IISD, 2010):

1. *Direct effects* through improved energy and material efficiency, time efficiency, increased use of renewable energy sources, reduced use of toxic materials and improved recycling (Hilty et al., 2006). Efficiency is usually meant using ICT for optimization of a system or process with a sustainability objective. It argues that by using ICT we can make existing systems smarter and reduce emissions and resource consumption while maintaining or increasing utility (Climate Group, 2008). ICT applications that are suggested to increase efficiency also include inventory reduction, eco-driving, route optimization (Satoh, 2008).

2. *Enabling effects* by improvements in the efficiency of production, distribution and consumption of goods and services throughout the economy and society. Dematerialization is the whole or partial substitution of virtual products and services for their physical equivalents (Berkhout and Hertin, 2004). This decoupling of content from a physical container reduces the energy needed for creating and transporting the product. The environmental impact of reading electronically is less per book versus traditionally in paper (Moberg et al. 2011). Presence dematerialization includes virtual presence, learning, videoconferences, and services such as e-learning, e-banking or e-government.

3. S*ystemic effects* that result in the transformation of behaviour, attitudes and values of individuals as citizens and consumers. Information technology is used to visualize and communicate data that is relevant for sustainability such as energy use, water use or carbon dioxide emissions (Froehlich, 2000). This is seen as a precondition for acting and increasing sustainability.

The investigation of synergies between green and digital economy may offer a common solution with long-term effects.

3. ICT for Social development

Beyond economic benefits, the ICT industry is uniquely positioned to help build a more socially sustainable future. Beyond encouraging economic growth, the ICT industry is helping to achieve social sustainability by improving the way societies and governments provide education, healthcare, and services to citizens. ICT is being applied to optimizing existing services for saving resources, making existing systems such as transportation, housing, cities, "smarter" by increasing efficiency

a. Role of Electronic Governance

The inability of nations to sustain growth in most parts of the world also hinders the economic and social progress in respect to poverty reduction. This highlights the importance of governance for development. The governance is the linkage between development with pro-poor policy framework, public administration and civil service reform, and decentralization and service delivery. Since governance is central to any development effort, a good governance and practices are necessary condition in achieving any form of development including sustainable development (Coleman, 2008; Finger, 2005).

Increasingly, governance processes are supported by ICT. This form of Electronic Governance (e-Gov) entails strategic

use of ICT technologies like internet and mobile computing to support governance processes which is transforming the relationships between government and citizens, businesses and other arms of government. Electronic Governance received numerous definitions in the literature, none of them becoming an accepted standard. According to Dawes (2008, pp 586) "e-Governance comprises the use of Information and Communication Technologies (ICTs) to support public services, government administration, democratic processes, and relationships among citizens, civil society, the private sector, and the state."

In particular, e-Gov helps to deliver public services over electronic and traditional channels, engage various social actors in decision and policy-making processes. Online services are cheaper, faster and more readily available, especially from remote areas with fewer multitudes of human errors than the manual processing. It provide an excellent opportunity for improve quality government services to people with focus on three broad qualities of good governance like improve transparency, people participation and public services that should be cost-effective and accountable to citizen.

The concept of e-governance also supports the SD domain. This domain focuses on the use of ICT to enhance the efficiency of internal government operations with SD-oriented ICT strategies; applying ICT to support the poor and small businesses; delivering services at the minimum environmental cost; using ICT to increase participation of the poor in government decision and policy formation. Figure 2 depicts a mapping of three primary domains contributing to e-Governance for Sustainable development (EGOV4SD), where the primary domains are Governance (GOV), Sustainable Development (SD) and Information and Communication Technology (ICT).
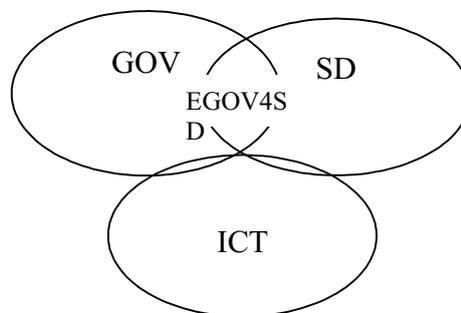
Figure 2: e-Governance for Sustainable development

b. Improving information access and communication

ICT is changing the way people access information (with Google and Wikipedia, for example) and interact with each other (through blogs, social networking sites and so forth). Social networking websites have changed the job recruitment rules. Today these sites are *the* places to find a job and recruit talent. All these examples show new ways in which innovative ICT technologies are having a profound impact on the way people interact and communicate with each other. Many of these technologies will undoubtedly lead to new social benefits.

c. ICT impact on Education and Health

The ICT sector has already dramatically changed the way people study. A wide range of information is available free on the Internet. Today educational institution has Partnerships with multinational companies such as Microsoft and Cisco have enabled the equipment, with computer labs and broadband Internet putting efforts for providing education to every division of society overriding the constraints of distance and infrastructure resources.

The use of ICT for health (e-health) has the potential to transform healthcare by efficiently connecting people and improving information sharing. Currently, e-health is predominantly seen in developed countries. But as the availability of ICT spreads rapidly in the developing world, there is an opportunity to expand healthcare access to areas where distance, poverty, and scarce resources are currently barriers to even basic care. Doctors can access patients' medical records more easily, have immediate access to test

results from a laboratory, and deliver prescriptions directly to pharmacists.

4. ICT for measuring sustainability

Information technologies allow the analysis, modeling, control and communication of environmental information. One such discipline is environmental informatics, which focuses on using technology for the creation and processing of environmental information in traditional environmental disciplines and in institutions such as environmental agencies. One key advance in this area is the use of satellite images and advanced mapping technologies for the control and visualization of environmental variables such as land use and soil conditions (Hilty et al., 2006).

ICT is used in the work of sustainability research and practice, being central to the measurement, modeling and analysis of the data, for instance when making environmental impact analysis such as Life Cycle Assessment. Hilty et al., (2006) argues that ICT is central to promote life cycle thinking, providing tools for supporting decision making. Complex modeling studies such as life cycle assessments are made possible by the use of computer tools and databases. Modeling software that is widely used for creating environmental impact assessment includes SimaPro, OpenLCA and Umberto.

CHALLENGES

a. Investment Intensive

The economic and social benefits of ICT are clear. However, this impact could be significantly increased if the penetration of ICT, including mobile phones, broadband, and PCs will expand. Increasing the penetration levels of high-speed broadband, mobile, and PCs in developed and developing countries will be extremely costly and is not likely to be profitable for ICT companies alone. Making these investments work will require a concerted approach among all industry stakeholders including government. Initial government financial support to a country's ICT strategy is crucial since economic benefits and demand for some of the new services will necessarily be unclear for industry players.

b. Require Re-engineering

Creating these economic and social benefits will require not only large investments and commitment from different stakeholders but also changes to existing regulatory frameworks, compromises between governments and industries, and strong public engagement.

Further, it is no easy task to align the interests of the various stakeholders when so much is at stake: ICT companies seek revenue, governments seek access to innovative services and tax revenues as well as economic growth, and regulators seek consumer welfare and competition.

c. Adoption issue

However, barriers to adoption of more sustainable IT are still prevalent. Plus, the fact that many products are not even measured for their sustainability credentials. The final hole in the sustainability panacea is that IT buyers are then struggling to get hold of manufacturer information that qualifies whether a product is in line with current green transformation strategies.

d. The rebound effect

Some researcher argues that ICT has been in increasing productivity and efficiency which resulted in increasing output, not in reducing input. This is a classical rebound effect (Brookes 1990). A rebound effect is the lost gains in efficiency of technological progress due to: cost reduction leads to increase consumption of the same service. Like technology help for cars to have increased fuel efficiency, but the total impact of cars has grown as number increases. Some other classical examples of failed dematerialization due to rebound effects are the increase in paper consumption with the introduction of the computer, instead of the promised paperless office (Sellen and Harper, 2001). It means the ICT for efficiency measures is not enough precondition for saving resources, but that sufficiency measures restricting input and output are needed in order to avoid these unwanted rebound effects.

CONCLUSION

It can be concluded that the ICT sector has both a profitable opportunity and a critical role to play with other sectors to design and use solutions needed to create a green economy and society. ICT performance will remain crucial not only for developed countries for sustaining long-term competitiveness and enhancing their innovation potential but also for middle-income and developing countries in fostering structural transformations, increasing efficiency as well as reducing the digital, economic, and social divides within their territories.

Governments around the world are realizing that having an ICT vision matters—they need to understand how their ICT sector can best enable other parts of their economies and

social interests in order to convene industry stakeholders and align them to work toward that vision. Singapore, for instance, has a vision of becoming an information society by 2015. The government should work on stimulating the demand for ICT services by sponsoring a broad range of programs such as e-learning, e-health, and e-government. Moreover, Regulators and competition authorities will need to manage the way they design industry incentives carefully. They must allow the industry to generate enough profits to make their investments affordable while maintaining low carbon footprint. The key to reaping ICT's economic and social benefits is cooperation among the industry, regulators, and government policymakers.

The future research areas can be in the study of sustainable competitiveness of cities; the creation of competitive advantages for firms through driving sustainability; sustainability and the role of chief information officers (CIOs); broadband as an enabler for economic sustainability; cloud computing and its economic effects; and innovation in business models and policymaking to enhance environmental sustainability.

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