Magyar Agrárinformatikai Szövetség
Hungarian Association of Agricultural Informatics

Agrárinformatika Folyóirat. 2012. 3. évfolyam 2. szám
Journal of Agricultural Informatics. 2012 Vol. 3, No. 2

Green Informatics: ICT for Green and Sustainability

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I N F O
Received 19 Nov 2012
Accepted 17 Dec 2012
Available on-line 28 Dec 2012
Responsible Editor: Rajkai, K.

Kulcsszavak:
Green Informatics, Green ICTs, e-m services, environmental protection, sustainability

A B S T R A C T

Green Informatics constitute a new term in the science of information that describes the utilization of informatics in the interest of the natural environment and the natural resources regarding sustainability and sustainable development. Nowadays, ICT has introduced the convergence of e-services with broadband network infrastructure, wireless technologies and mobile devices. The revolution of ICTs introduction in daily average life has also resulted in the increase of GHG, since the ''carbon footprint'' is continually increasing. The dimensions of Green Informatics contribution are: the reduction of energy consumption, the rise of environmental awareness, the effective communication for environmental issues and the environmental monitoring and surveillance systems, as a means to protect and restore natural ecosystems potential. EU has reinforced the environmental sector with focus on high level of protection and improvement of the quality of environment through the enacting of strategies, initiatives and measures. Future EU strategy aims to a low carbon European society by 2050 and to green/sustainable development, ICTs can play a key role in the environmental protection and sustainability, however, green behavior is still critical.

1. Introduction

In recent years, the role of ICT in the protection of the environment and combating climate change has received significant attention in different types of international forums. Increasing temperatures and sea level and frequent incidences of floods and storms constitute the evident impact of climate change, having also an effect on the balance of the ecosystems, water and food supply, public health, industry, agriculture and infrastructure. Combating climate change involves strategic objectives such as the improvement of energy efficiency, the increase the share of a country's energy use from renewab;e sources while ensutring the reliability of energy supplies, the secure the provision of reliable energy products and services and to promote green products, sustainable production. Nowadays, the energy market is undergoing deep reforms while new advanced energy technologies and continuous environmental issues appear and requirements arising from European and international cooperation as well as various intergovernmental agreements are factors shaping and harmonizing the institutional and legislative framework of the energy markets (YPEKA, 2012).

With growing concern concerning global climate change and unpredictability of energy markets, computing has begun to acknowledge green information and communication technologies (ICT), in which the environmental impact is taken into consideration in the design of new technologies and systems (Bronk et.al., 2010).

Events and discussions on the topic of "Green informatics" and "Green ICT'' are frequent and numerous and the interest in ICT's potential is not as much appreciated and often fails to get the attention it deserves to reflect solutions instead of problems (WWF, 2011). Green Informatics incorporate design techniques, construction techniques, the function and the information diffusion techniques and aim to the optimal environmental governance, in the interest of the natural environment and the natural resources regarding sustainability in combination to management of the energy requirements in a way that exploits the alternative energy sources. Web technology and broadband Internet along with web-based projects are emerging in a fast pace in useful devices everywhere in our society and a huge amount of information move across the WWW worldwide (Andreopoulou, 2009). Green Informatics are ICT tools, services and technologies in combination with green practices and green behaviour either for the ICT industrial sector or the ICT user/citizen

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that contribute not only to the protection and restoration of the environment but also to the enhancement of the quality of human life. So, the notion of ''Green Informatics'' has rather become synonymous with eco-friendly techs and software tools such as Virtualization, Recycling and Telecommuting.

Nowadays, ICT has introduced the convergence of electronic services (e-services) - broadband network infrastructure - wireless technologies and mobile services. This confluence resulted in a combination of devices, products, tools, services and technologies with enhanced social network abilities that are greatly recognized 24/7, almost globally in all sectors of human life.

Broadband has been the gateway to the networked economy, since its potential to transform the daily processes in both work and life, opens a door to new business models and growth opportunities at a time when many countries are struggling to jumpstart their economies during global economic crisis (Broadband Commission, 2012). Services provided using broadband access on the Internet insure high and fix transmission rate for quality internet almost globally. Some of the most common web-based products of the suite of e-services are e-learning, e-working, e-banking, e-voting, e-government, e-commerce, e-shop, e-research, e-medicine and e-payment. In recent years, useful mobile broadband services (m-services) tailored to the needs of people have been built which combine elements of user-generated content with network-based enhancements. Transforming economic and social activities, the mobile technologies contribute to sustainable development through green banking, green commerce, green governance, green constructions, etc.

The revolution of ICTs introduction in daily average life has also resulted in the increase of green house effect, since the ''carbon footprint'' is continually increasing. Carbon footprint (CF) – also named Carbon profile – is the overall amount of carbon dioxide (CO_2) and other greenhouse gas (GHG) emissions (e.g. methane, laughing gas, etc) associated with a product, along its supply-chain and sometimes including from use and end-life recovery and disposal (European Commission, 2007). In this case, it refers to the energy needed and the pollution generated in ICT production processes and within the final use of ICTs (Figure 1). In 2007, Gartner released a study which showed that the total amount of CO_2 emissions from the ICT industry could amount to 2% of global carbon emissions. At the same time, ICT applications are acknowledged to be the tool for the global environmental protection strategy and they present a huge potential to improve performance across the economy and society, as it concerns the remaining 97-98% (OECD, 2009).

	2009	2015	2020
Data Centers	121.30	229.87	369.48
PCs	126.69	222.41	516.55
Mobiles	1.54	3.74	6.58
Gaming Consoles	11.23	26.04	40.22
Carbon Conversion Number (CCN)	1.3	1.265	1.23
Total	260.77	482.06	932.84

Figure 1. ICT sectors carbon footprint in megatones of CO_2

Source: Bronk et.al., 2010

2. The Dimensions of Green Informatics Contribution

The dimensions of contribution of Green Informatics to the environment and environmental sustainability are:

- Reduction of energy consumption/carbon footprint while production and usage towards low carbon economy

- Rise of environmental awareness with information diffusion, training and education
- Effective communication for environmental projects and networks
- Sustainable environmental governance.

2.1. Reduction of energy consumption and gas emission

Green Informatics can contribute through:

- Inventing innovative energy saver systems, technologies and ''smart'' devices, using ''smart energy management''
- Applications for energy saver policies using renewable sources, solar energy and photovoltaic, wind energy, bio-fuel, bio-climatic technology, anti-pollutants technology, etc
- Recycling and reducing of e-waste such as old IT systems, chips, PC, hardware, printers, mobile phones, etc.

The 40% of the total energy consumption is due to households, therefore innovative ''smart houses'', green constructions of bio-climate material and green architecture making use of innovative energy sensor – IT systems can achieve to measure, manage and reduce electricity consumption and air-conditioning requirements. During the last decade, technical and industrial products manufacturers were essentially obliged to change direct, about their energy consumption, as a result of the economic crisis in addition to the increased environmental awareness of the public. The concern taken by the producer towards energy reduction covering every computing device, from the laptops and mobiles to the data centres, has been and will be presumably successful. Actually, consumers show their preference for smart devices, new, noticeably less energy-consuming technologies, renewable energy sources and updated, more efficient cooling systems with improved energy management software (INFOCOM, 2012). Qualifying products are rewarded with official certification for meeting or exceeding efficiency guidelines (Bronk et.al., 2010). The transition to a low-carbon society by 2050 includes the vision to live and work in low-energy and low-emission buildings, with intelligent heating and cooling systems. Cars and trains should be electric and hybrid and therefore our living-environment will be less polluted and cleaner. It is also important during global economic crisis that the sector of green construction and house energy improvement can lead to new job places. In Figure 2, it is presented the the average per capita final energy consumption of households in 2005 and 2010, divided into electricity consumption and other energy types (EU, 2012).

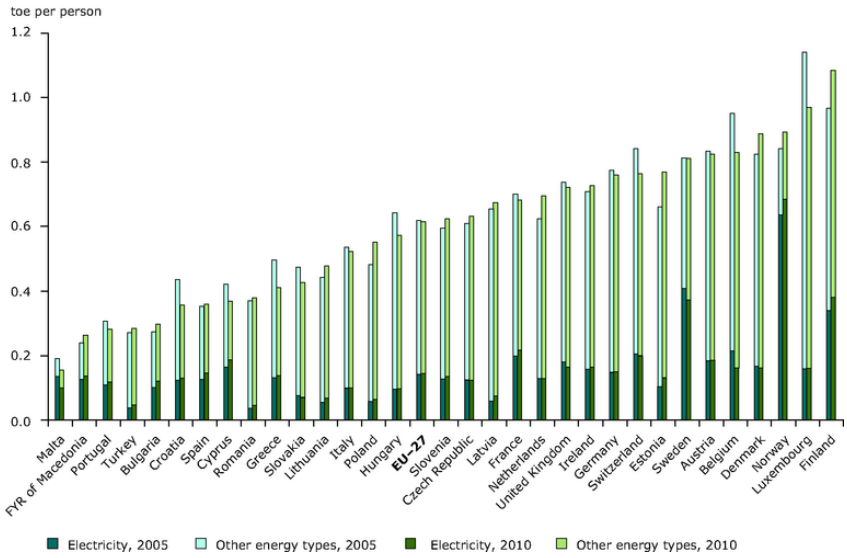

Figure 2. Average per capita final energy consumption of households in 2005 and 2010, divided into electricity consumption and other energy types (*Source: EEA)*

It's optimistic that many citizens have begun to accept the concept of human caused climate change, resource depletion, as well as the imperative nature of acting on this knowledge. This has led many to make personal lifestyle changes. The "living green" trend includes many aspects such as green constructions, green roofs, renewable energy use, energy saving at home, the extended use of

eco-friendly products, a recycling perspective, even using sustainability checklists, designed to help evaluate how sustainable ar home is, as well as provide ideas for increasing home sustainability that include many no or low cost actions (World Green, 2012). Moreover, clever use of e- and m-services can be a tool for less energy consumption in everyday life and in work. In the case of paper use it is important that nowadays correspondence of files, studies, data, photos, maps, etc can be acquired in digital type using internet and smart devices. The production and distribution of new products and services through broadband tends to minimize the needed energy that is estimated through carbon footprint.

Teleconferences have a direct positive effect on environmental protection and GHG emissions reduction due to reduced transportation needs. More specifically, teleconferences can prevent the production of approximately 540.000tn CO_2 per year that would cause the air transportation of people. Teleconferences are viable alternative solutions that exploit broadband networks, especially for executive trips. Airplane trips have been estimated to contribute global pollution by 2%. Recently, during the week of volcano dust, 700 teleconferences rooms were created within a week to serve teleconferences between 124 countries.

Using Green Informatics tools and services through broadband / 3G Internet, there is a profit for the environment and for the citizen with the decrease of cost and time to access government divisions (24 hours/7 days services), with energy save (no transportation), with degradation of pollute emission (carbon footprint). Similarly, in the sector of e-commerce and e-business new innovative business solutions are in favour of either the entrepreneur or the final customer.

2.2. Rise of environmental awareness with information diffusion, training and education

Rise of environmental awareness with information diffusion, training and education helps people to understand environmental issues and the current environmental policies that are practiced globally. Remote and isolated populations can be encouraged to learn and be environmentally aware through (wireless/mobile) internet, especially when it is difficult to satisfy through traditional channels (newspapers, TV, radio, magazines, etc).

There are thousands of special internet sites, blogs, forums, social network groups, internet polls, etc that share environmental information. These internet sources are local or international interests and so, they provide an open tribune for everyone to ''speak'' and participate.

The enhancement of people's skills and awareness can be achieved through learning. Some of the learning software packages are the presentations and educational games and generally the use of e-services such as e-class, e-learning, distance-learning, web-based learning, lifelong learning.

2.3. Communication of environmental networks

The communication of environmental networks can be effective through innovative ICTs for environmental projects and networks in local, regional, national, cross-border and trans-national level. The success of environmental projects prerequisites the effective communication of stakeholders participants, secured through innovative Green Informatics tools and services. Green Informatics secures information flow for their viability and quick/safe communication. Environmental networks can survive including various scientific stakeholders:

- Environmental groups, societies, unions, clubs, etc
- Research Institutes
- Government Organizations / divisions / ministries
- Non-government Organizations (NGO)
- Local authorities
- Research groups.

2.4. Sustainable environmental governance

Green ICTs have become the way to advance the public sector's performance in terms of information and service delivery, to encourage citizen participation in the decision-making process

and to make government more accountable, transparent and effective. ICTs are key elements supporting the growth of e-governance initiatives, strategies and projects. Governance constitutes a distinct policy regarding management issues and designates processes with special focus on decision making, while it indicates the total sum of given and anticipated mechanisms. Presently, the governance of natural ecosystems, forests, lakes, rivers, natural resources and agricultures has to face the increased diversity of connections between different environmental characteristics and decisions of local, regional, national, and supranational relevance, with high coordination and exchange between administrative entities and actors across the public/private and the expert/stakeholder divide (Andreopoulou et al., 2011).

3. ICT for Green and Sustainability

Using e-mobile innovation we solve environmental problems and we ensure the sustainable environmental management with environmental data. ''ICT for sustainable growth'' is a specific process that focuses on greening with ICT (and also on greening of ICT). Six policy areas have been selected as priorities (Ernst and Young, 2011):

a) Energy Efficiency of the ICT Sector (greening of ICT)
b) Smart Sustainable Cities (greening with ICT)
c) Energy Efficient Buildings (greening with ICT)
d) Smart Grids (greening with ICT)
e) Water Management (greening with ICT)
f) Climate Change Management (greening with ICT).

Green Informatics supports the construction and improvement of natural environment and resources surveillance systems, as a means to protect and restore natural ecosystems potential (forests, lakes, rivers, wetlands, etc) and introduce prevention actions, such as observatories, innovative tele-detection for forest fires - river floods - land erosions - climate change, monitoring and alarm systems, improvement of infrastructure and communication equipment, GIS technology, etc.

For EU decisions/projects/tasks/measures/initiatives about agriculture, fishery, forestry, transportations, energy, commerce, development, etc there is always focus on and needed for innovative ICT tools. Forests and agricultural land are important to climate change mitigation because of the significance of their carbon stock and also for their exchange of greenhouse gases between the atmosphere and soils and vegetation that can go both ways. Over 120 million trees are harvested annually to supply US book and newspaper industries, emitting over 40 million metric tons of CO_2 per year (Green Press Initiative, 2008).

Although research attempts are carried out locally successfully, in Institutes and research centers, at often considerable cost, their use remain limited and local. Effective organization, access and management of all-available information in environmental databases constitute an important factor within decision-making process.

Environmental projects have to manage large interdisciplinary multivariable data sets that include a lot of variables from different sources and with different structure (meteorological, biological, economic, etc) and this has been successfully achieved through multidisciplinary environmental data management with databases.

Environmental monitoring is an extremely useful tool for a large proportion of people. Network technologies can integrate geospatial technologies aiming to sustain agricultural and environmental observation networks and mission-critical agricultural and environmental applications can be deployed. Sensor networks through wireless networks can help to collect from remote places time-series of environmental data. They are sent wirelessly/automatically to local databases in Institutes, Labs, etc and then data are analyzed for the study of sensitive environmental parameters. Data are analyzed with enhanced software and visual graphs are continuously produced for comparison. The analysis of data provides simulation models that simulate effectively the environmental reality. Models can provide future forecasts. Decision-makers can evaluate alternative future scenarios with decision support system (DSS). DSSs are Information Systems given certain parameters we can

provide wise management aiming to environmental sustainability. Decision support information systems may use:

- Environmental databases
- GIS
- ARIMA modeling (time-series analysis)
- Multi-variant analysis/multi-criteria analysis
- Fuzzy logic
- Expert systems, etc

to help local authorities/stakeholders to decide towards sustainable environmental management, wise use of natural resources and also protect from natural disasters.

Whereas world opinion, business, and Information Systems units acknowledge problem, the IS academic community seems largely ignorant of the challenge of sustainable development, with a few exceptions (e.g., Avital et al. 2007, Watson et.al., 2010).

4. European Union for the Environment

Thus, it is not a recent effort, in European Union, the Eco-label (Flower label) has been established in 1992 by the Environment Directorate of the European Commission as part of its strategy to promote sustainable consumption and production (EC, 2006, EC, 2006a). The European Eco-label stipulates the environmental impact analysis of products or services throughout their complete life cycle, including raw material extraction, production, distribution and disposal (OECD, 2009). At the same time, the enegry star is established as the US standard for electronic devices that are energy efficient.

Starting with Amsterdam Treaty (1997), EU has reinforced the environmental sector with focus on high level of protection and improvement of the quality of environment and the enacting of measures aiming to confront environmental problems. Today, the EU enhances projects and initiatives are to make Europe again a green continent and support sustainable European economy, which is climate-friendly and less energy-consuming by 2050.

Electric energy networks in EU have to be be upgraded either to meet growing electricity demand and also to transport and balance electric energy generated from renewable sources, expected to more than double in the period 2007-2020, whilst, the realization the EU's 2020 energy efficiency and renewable energy targets will be acheived with more innovation and intelligence in the energy networks at both transmission and distribution level, in particular through information and communication technologies (EC, 2012).

Since the 90’s, in EU emissions have decreased by 16%. If current green policies are fully implemented, the EU can achieve the first of 2020-targets of reducing emissions to 20% below 1990 levels. The second 2020-target is to raise the share of renewable energy resources in its total energy consumption 20%. However, the third 2020-target concerning improving energy efficiency by 20% is still in question. Presently, EU has set another long-term target of reducing emissions by 80 to 95% by 2050.

A roadmap has been designed for moving to a low-carbon economy in 2050 trying to keep global warming below 2°C. EU is targeted to Eco-innovation and green technologies since clean technologies are the future for Europe’s economy. The sectors responsible for Europe’s emissions-power generation, industry, transport, buildings and construction, intense agriculture, can turn to a low-carbon economy in the near future e-Innovations.

Sustainable Development stands for meeting the needs of present generations without jeopardizing the ability of futures generations to meet their own needs – in other words, a better quality of life for everyone, now and for generations to come. It offers a vision of progress that integrates immediate and longer-term objectives, local and global action, and regards social, economic and environmental issues as inseparable and interdependent components of human progress (European Commission, 2011). EU is present with legislation encouraging ICT involvement towards Sustainable Development (SD), also defined as green growth that encompasses the economic development, the social development-quality of life and the protection-improvement of the environment.

Some of the EU Biodiversity Strategy that aims to the environmental sustainability:

- Habitats Directive (ecosystems)
- Natura Network 2000 (protected areas)
- Wild Birds Directive (Biodiversity conservation, Sustainable tourism for economic and social profit).

Agriculture remains fundamental to economic development and environmental sustainability. In rural agricultural sustainability, it is important to have both expansion and innovation. New goods and services are demanded in rural areas regarding business opportunities and innovative ICTs and new technologies aiming to green development challenge, as a means to confront the economic crisis. Today, during the 4th Community Support Framework (EU), there are many programmes concerning agricultural funding and especially the innovative agricultural exploitations.

EU initiatives and measures support young farmers, which are the main drivers for most of the ICT projects in agriculture. Agricultural entrepreneurships can be modernized using:

- ICT infrastructure aiming to the automation of production, cultivation factors and inputs monitoring, e.g. precision technology etc
- Information and communication equipment for e-commerce and e-marketing, e.g. logistics, traceability systems
- Innovative e- and m- systems for water losses reduction.

5. Conclusions

Information and Communication Technologies can play a key role in the environmental protection, the environmental sustainability, the environmental education and the rural sustainable development. Green IT enhances the sustainability of computing through manufacturing lower impact materials and products, reduced energy consumption of data centers and computers, and better recycling and end of life management (Center for Sustainable Systems, 2011). Using Green Informatics tools, services and technologies can contribute to the Environmental and Rural Sustainability. Yet, Green Informatics cannot substitute people and their behaviour that still constitutes the most critical factor within environmental protection and sustainability.

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