

## ICT for Sustainability

Computing has many potential “green” applications including

- Improving energy conservation
- enhancing energy management
- reducing carbon emissions in many sectors
- improving environmental protection (including mitigation and adaptation to climate change)
- and increasing awareness of environmental challenges and responses.
- And it might also help in any problem solutions

According to the The report *SMART 2020: Enabling the Low Carbon Economy in the Information*, applying IT to sustainability can be divided three broad areas. They are consists of :

1. Built Infrastructure And Systems
2. Ecosystems Services And The Environment
3. Sociotechnical Systems

### **Built infrastructure and systems**

This area includes buildings, transportation systems (personal, public, and commercial), and consumed goods (commodities, utilities, and foodstuffs). The ICT contributes to sustainable in numerous ways :

1. Improved sensor technologies (e.g., in embedded sensors in smart buildings)
2. Improved system models
3. Improved control and optimization (e.g., of logistics and smart electric grids)
4. Improved communications and Human-Computer Interfaces (e.g., enabling people to make more effective decisions).

### **Ecosystems and the environment**

This area encompasses assessing, understanding, and positively affecting (or not affecting) the environment and particular ecosystems. These efforts represent crosscutting challenges for many sustainability efforts. The scale and scope of efforts in this area range from local and regional efforts examining species habitats, to watershed management, to understanding the impacts of global climate change. The range of challenges itself poses a problem:

1. How best to assess the relative importance of various sustainability activities with an eye toward significant impact. Additionally
2. How computational techniques will be valuable for developing scientific knowledge and engineering technologies
3. How improved methods for a data-driven science, modelling for environment
4. How simulation to improve the degree of scientific understanding in ecology

### **Sociotechnical systems**

Sociotechnical systems encompass society, organizations, and individuals, and their behavior as well as their technological infrastructure. Large and long-lived impacts on sustainability will require enabling, encouraging, and sustaining changes in behavior—on the part of individuals, organizations, and nation-states over the long term.

ICT, and in particular real-time information and tools, can better equip individuals and organizations to make daily, on-going, and significant changes in response to a constantly evolving set of circumstances.

### **Literature Search Results On Journals With Related Scope**

This literature search has been done by using a Citation Database, Scopus. The keywords has been used are “ICT” AND “Sustainability” limited to the Computer Science area. From the result, there are 230 documents (Articles and Proceeding papers) related and 13 papers related to “transportation”, 26 papers for “healthcare”, 74 papers for “energy”, 85 papers for “education” and 55 papers for “smart” areas related as shown in Figure 1. These papers have been analyzed which papers are focusing on how ICT has been used to improve sustainability. The papers have been reviewed, shortlisted into best cited papers as shown in Figure 2.

Keywords	Results
“ICT” AND “Sustainability” AND “transportation”	13
“ICT” AND “Sustainability” AND “healthcare”	26
“ICT” AND “Sustainability” AND “energy”	74
“ICT” AND “Sustainability” AND “education”	85
“ICT” AND “Sustainability” AND “smart”	55

Figure 1 : Resulting number of papers in Keyword Search

No.	Title	Abstract	Reference
1.	Voice-based marketing for agricultural products: A case study in rural Northern Ghana	<p>This study present issues around the marketing of agricultural products and the need of mobile-based ICT solutions. The need for the spread of information and web access to communities in developing countries has given rise to the design and development of numerous ICT solutions, many of which have focused on the recent increase of mobile usage in developing countries.</p> <p>This paper consists of :</p> <p>1) Empirical results from a field survey run in Northern Ghana, which points to issues of a lack of buyers, low price offers and lack of transportation to sale points as the main issues in marketing of agricultural products and also points to the potential for mobile-based ICT solutions to mitigate the pertinent issues within the case study, but also in other areas.</p> <p>2) The development of a voice-based prototype that allows medium to large-scale farmers in rural areas to place advertisements on the World Wide Web. The prototype was evaluated based on functionality and feasibility, including financial sustainability.</p>	Dittoh, F., Van Aart, C. & De Boer, V. 2013, "Voice-based marketing for agricultural products: A case study in rural Northern Ghana", ACM International Conference Proceeding Series, pp. 21.
2.	Modelling uncertainty in the sustainability of Intelligent Transport Systems for highways using probabilistic data fusion	<p>The implementation of ITS to increase the efficiency of saturated highways has become increasingly prevalent. It is a high level objective for many international governments and operators that highways should be managed in a way that is both sustainable i.e. environmental, social and economically sound and supportive of a Low-Carbon-Energy Future. Some clarity is therefore needed to understand how Intelligent Transport Systems perform within the constraints of that objective. The paper describes the development of performance criteria that reflect the contributions of Information Communication Technology (ICT) emissions, vehicle emissions and the embedded carbon within the physical transport infrastructure that typically comprises one type of Intelligent Transport System i.e. Active Traffic Management - a scheme that is used to reduce inter-urban congestion. The performance criteria form part of a new framework methodology 'EnvFUSION' (Environmental</p>	Kolosz, B., Grant-Muller, S. & Djemame, K. 2013, "Modelling uncertainty in the sustainability of Intelligent Transport Systems for highways using probabilistic data fusion", Environmental Modelling and Software, vol. 49, pp. 78-97.

		<p>Fusion for ITS) outlined here. This is illustrated using a case study where environmental performance and pollution baselines (collected from independent experts, academic, governmental sources and suppliers) are processed using an attributional Lifecycle Assessment tool. The tool assesses the production and operational processes of the physical infrastructure of Active Traffic Management using inputs from the 'Ecoinvent' database. The ICT component (responsible for data links) is assessed using direct observation, whilst vehicle emissions are estimated using data from a National Atmospheric Emissions Laboratory. Analytical Hierarchy Process and Dempster-Shafer theory are used to create a prioritised performance hierarchy: the Intelligent Transport Sustainability Index, which includes weighted criteria based on stakeholder expertise. A synthesis of the individual criteria is then used to reflect the overall performance of the Active Traffic Management scheme in terms of sustainability (low-carbon-energy and socio-economic) objectives.</p>	
3.	<p>Improving the smarter city UX and accessibility</p>	<p>Smart and sustainable cities and communities constitute a "hot topic" on many current agendas, as the largest urbanization process in history is ongoing. Half of the world's population (and 75 % of Europe's) lives already in cities and another two billion are expected to "move in" by 2050. Smooth transports, healthcare, ICT services, energy efficient buildings, a smart use of the climate--resources, eco-efficiency, sustainable water supplies and many others topics are addressed and covered (to some relevant extent) by the work. Central topics, such as usable and accessible electronic and mobile societal ICT services with the right security, accessibility and social security, in combination with culture, education and tourism are expected to have a strong impact on the development of new smart and sustainable solutions, optimized around economic, social and environmental aspects and impacting the societal planning (Figure 1 illustrates some aspects): Standardization challenges-topics and aims of the workshop A coordination group (CG) between the European standardization organizations has been created,</p>	<p>Niman, B.V. &amp; Johem, J. 2013, "Improving the smarter city UX and accessibility", 22nd International Symposium on Human Factors in Telecommunication, HFT 2013, pp. 50.</p>

		<p>to address the area of "Smart &amp; Sustainable Cities &amp; Communities" (SSCC). This coordination group does not intend to develop new standards but to coordinate standardization initiatives within the area and provide advice. The work area is new to Europe and is foreseen to have a considerable impact on our everyday life and societies. The Swedish standardization organizations ITS, SEK and SIS (mirroring ETSI, CENELEC and CEN) have initiated a collaboration to address aspects related to: ICT, to improve the user experience, services and accessibility of smart cities; Smart grids and energy efficiency; and Sustainability. User centered perspectives are and will be further studied, analyzed and integrated with conceptual models and development work of SSCC. Possible needs such as continuous service access and roaming, societal accessibility services, multicultural user interfaces, benchmarking of service maturity levels applied to cities and citizens, common terminology and definitions, et cetera will be examined and addressed. The organizers intend to invite the participants to present themselves and introduce their experiences and discussion topics. The participants will be asked to prepare and asked to influence the topics of the workshop. Brief presentations will be welcomed. A structured discussion will take place between the organizers and participants and focus on identifying, agreeing and better understanding the model and key enabler elements (and their main attributes) applied to smart, accessible, secure and sustainable cities and communities. The goal is to develop and propose user centered, end-to-end standardization and coordination activities improving the user experience of smart cities and communities. We welcome people with diverse backgrounds-researchers, practitioners, industry experts and representatives, policy makers, user and consumer associations and anyone who would like to shape our future communities, cities and societies.</p>	
4.	Carbon footprint of IT-Services - A comparative study of energy consumption for offline and online storage usage	This paper focusses on the Carbon Footprint of IT-Services (CFIS) by presenting a comparative study of energy consumption for Offline and Online Storage. We therefore conducted a case study with an IT-Service	Grimm, D., Erek, K. & Zarnekow, R. 2013, "Carbon footprint of IT-Services - A comparative study of energy consumption for offline and online storage usage", 19th

		<p>provider as well as experimental simulation of customer's ICT hardware. Based on literature review, we initially present related work and describe underlying concepts e.g. Carbon Footprint of Products, Life Cycle Assessment (LCA) as well as ICT energy and performance measurement. The paper proposes a methodological framework for CFIS based on the phases of LCA. Geared towards the framework we present a comparison of ICT-related energy consumptions for Offline and Online Storage as well as allocation and calculation approaches. Finally, presented carbon footprint results are discussed in terms of limitations and further research directions. The CFIS is an inevitable step to advance Green IS/IT research, since it quantifies dependencies between IT-Services, ICT energy consumption and related greenhouse gas emissions.</p>	<p>Americas Conference on Information Systems, AMCIS 2013 - Hyperconnected World: Anything, Anywhere, Anytime, pp. 666.</p>
5.	Smart cities architectures a systematic review	<p>The smart cities concept arises from the necessity of managing several problems caused by the unbridled population growth at urban centers. To make a city become "smart" it is needed to employ Information and Communication Technologies (ICT) to access, process and deliver information according to the urban context. This information can be employed to mitigate several urban issues, such as traffic jams, high natural resource consumption, epidemics, sustainability, waste management, low quality and life expectancy of citizens, among others. Thus, the increasing need to create architectures that are able to interact with the Internet of Things, i.e., several built-in devices, appliances, sensors and actuators embedded in each urban context. This work is a systematic review regarding proposals for such architectures. After selecting the relevant approaches, we have identified a set of issues that these approaches aim to solve and some architectural patterns employed.</p>	<p>Tomas, G.H.R.P., Da Silva, W.M., Neto, P.A.D.M.S., Garcia, V.C., Alvaro, A. &amp; Gama, K. 2013, "Smart cities architectures a systematic review", ICEIS 2013 - Proceedings of the 15th International Conference on Enterprise Information Systems, pp. 410.</p>
6.	Sustainability of E-participation through mobile technologies	<p>The social sustainability of ICT for development projects such as e-government in developing nations remains a challenging issue. Particularly pertinent to the concept of e-government is that of electronic participation (e-participation) of citizens in services offered over an e-government platform, yet studies claim that such initiatives</p>	<p>Mawela, T. &amp; Ochara, N.M. 2013, "Sustainability of E-participation through mobile technologies", ACM International</p>

		<p>exacerbate social exclusion problem. Globally, and specifically in Africa, the ineffective participation of citizens is marked by waning confidence in service delivery capabilities of political institutions, yet e-government is considered as one of the reform instruments for the attainment of good governance. Governments and pressure groups in many countries are realizing that these trends are problematic, and are seeking to broaden and deepen citizen participation in governance, notably through the use of mobile technologies that continues to play a vital role in the trajectory of ICT development in Africa. This study advances the prominent role that mobile technology will play in anchoring e-participation strategies and policies to improve the social sustainability of ICT4D projects geared towards improving governance. The paper presents the results of cluster analysis of a South African survey aimed at assessing the accessibility, attitudes and the skills necessary for embedding mobile technology as part of an e-participation strategy. The results indicate that, despite the predominant perception that socially excluded groups typically lack the skills, equitable access and the right attitudes for e-inclusion mobile technology provides a viable platform for enhancing e-participation. The results also highlighted skepticism related to the potential of mobile technology in augmenting government services. Our analysis revealed that the skepticism is partly linked to aspects of electronic illiteracy. We therefore recommend that for e-government to achieve long term sustainability there should be a focus on electronic literacy in the formal educational sphere and also in work practices. Copyright 2013 ACM.</p>	<p>Conference Proceeding Series, pp. 131.</p>
<p>7.</p>	<p>Enabling Social Sustainability of E-Participation through Mobile Technology</p>	<p>The social sustainability of information and communication technology for development (ICT4D) projects such as e-government in developing nations remains a vexing issue. Particularly pertinent to the concept of e-government is that of electronic participation (e-participation) of citizens in services offered over an e-government platform, yet studies claim that such initiatives exacerbate the social exclusion problem. Globally, and specifically in Africa, the ineffective participation of citizens is marked by waning</p>	<p>Ochara, N.M. &amp; Mawela, T. 2013, "Enabling Social Sustainability of E-Participation through Mobile Technology", Information Technology for Development, .</p>

		<p>confidence in service delivery capabilities of political institutions, yet e-government is considered as one of the reform instrument for the attainment of good governance. Governments and pressure groups in many countries are realizing that these trends are problematic and are seeking to broaden and deepen citizen participation in governance, notably through the use of mobile technologies that continues to play a vital role in the trajectory of ICT development in Africa. This study advances the prominent role that mobile technology will play in anchoring e-participation strategies and policies to improve the social sustainability of ICT4D projects geared toward improving governance. The paper presents the results of cluster analysis of a survey aimed at assessing the accessibility, attitudes and the skills necessary for embedding mobile technology as part of an e-participation strategy. © 2013 Commonwealth Secretariat.</p>	
8.	<p>How much energy will your NGN consume? A model for energy consumption in next generation access networks: The case of Spain</p>	<p>The contribution to global energy consumption of the information and communications technology (ICT) sector has increased considerably in the last decade, along with its growing relevance to the overall economy. This trend will continue due to the seemingly ever greater use of these technologies, with broadband data traffic generated by the usage of telecommunication networks as a primary component. In fact, in response to user demand, the telecommunications industry is initiating the deployment of next generation networks (NGNs). However, energy consumption is mostly absent from the debate on these deployments, in spite of the potential impact on both expenses and sustainability. In addition, consumers are unaware of the energy impact of their choices in ultra-broadband services. This paper focuses on forecasting energy consumption in the access part of NGNs by modelling the combined effect of the deployment of two different ultra-broadband technologies (FTTH-GPON and LTE), the evolution of traffic per user, and the energy consumption in each of the networks and user devices. Conclusions are presented on the levels of energy consumption, their cost and the impact of different network design parameters. The effect of technological</p>	<p>Coomonte, R., Feijóo, C., Ramos, S. &amp; Gómez-Barroso, J.-. 2013, "How much energy will your NGN consume? A model for energy consumption in next generation access networks: The case of Spain", Telecommunications Policy, vol. 37, no. 10, pp. 981-1003.</p>

		developments, techno-economic and policy decisions on energy consumption is highlighted. On the consumer side, practical figures and comparisons across technologies are provided. Although the paper focuses on Spain, the analysis can be extended to similar countries.	
9.	Beyond being green: Simple living families and ICT	Motivated by a need in sustainable HCI for studies of everyday practices, and a belief that a holistic view on sustainability is crucial to deeper understanding of how to design ICT to support sustainability, we here present a qualitative study of 11 simple living families in the US. Simple living refers to a lifestyle which is voluntarily simple out of concern for both the environment and quality of life. Our goal was to learn about a holistic view on sustainability and the role of ICT in helping and hindering families to live simply. The study contributes new insights about how holistic sustainability could be a valuable lens for HCI, revealing that sustainability is important to a wider range of areas in HCI than previously discussed. We conclude with implications for HCI for how to support sustainable practices beyond being "about" being green.	Authors of Document Håkansson, M., Sengers, P. 2013, "Beyond being green: Simple living families and ICT", Conference on Human Factors in Computing Systems - Proceedings pp. 2725-2734

Figure 2 : Shortlisted Specific Best Cited Papers