How does ICT-use improve the environment? The case of Turkey

Feride Gonel
Department of Economics, Yildiz Technical University, Istanbul, Turkey, and
Atakan Akinci
Faculty of Economics and Administrative Sciences, Yildiz Technical University, Istanbul, Turkey

Abstract

Purpose – The purpose of this paper is to present the effects of ICT-use on environmental problems in Turkey.
Design/methodology/approach – The study focuses on the effects of ICTs on finding the solutions to environmental problems. Inspired by specific classification, these categories that the authors used are as follows: the consumption of material sources; the transportation of people and goods; office spaces and smart building; using data communication and monitoring; ICT equipment (the last category involves the negative effects of ICT equipment itself; since we focus on "by ICT" issues, the authors will not examine this category in detail).
Findings – First of all, as a developing country, Turkey has an ability to monitor and control data on environment and the country is working to improve on it successfully in cooperation with international-related institutions. At the same time, using ICTs, smart buildings are increasingly becoming popular in Turkey with the help of some regulations. Transportation is another area that uses ICT.
Originality/value – To make a connection between ICT and environmental problems, it is a very new issue in developing countries. It is also new for Turkey. Therefore, as the authors know, this is the first general review on this subject.

Keywords Energy, ICT, Environmental management, Smart buildings, Green economy, Environmental technology

Paper type General review

1. Introduction

The global world has struggled with environmental problems for more than 40 years. Among these problems, climate change is one of the major problems. In recent years, many research works have focused on the capabilities of the information and communication technologies (ICTs) to overcome the problems caused by climate change and other environmental problems. This study examines how ICTs can help in tackling environmental problems in Turkey.

At the beginning of Denmark's "Action Plan for Green IT," it is warned that when we use our computers and other IT equipment, we are responsible for 2 percent of total CO_2 emissions (Ministry of Science Technology and Innovation of Denmark, 2008, p. 3). It is also estimated that ICT equipment contribute around 2-2.5 percent of the worldwide global greenhouse gases (GHGs) emissions; 40 percent of this was reported to be due to the energy requirements of PCs and monitors, 23 percent due to data centers, 24 percent due to fixed and mobile telecommunications and 6 percent due to printers (Houghton, 2009). However, the plan has also emphasized that the use of energy-saving and energy-reducing electronic equipment realises environmental benefits that are more than the costs of these equipment. The relationship between the environment and ICTs is crucial and multidimensional, and this relationship has both positive and negative aspects that is sometimes called as an e-Environment. This concept includes "(i) the use and promotion of ICTs as an instrument for environmental protection, the sustainable use of natural resources (ii) the establishment of monitoring system and (iii) the initiation of actions and implementation of project and programmes for sustainable production and consumption and the environmentally safe disposal and recycling of discarded hardware and components used in ICTs" (International Telecommunication Union, 2008, p. 3). Therefore, we find more energy-efficient uses and/or cleaner production methods, high-tech treatment

World Journal of Science, Technology and Sustainable Development
Vol. 15 No. 1, 2018
pp. 2-12

2042-5945
DOI 10.1108/WJSTSD-03-2017-0007

facilities or de-materialization through the use of internet and other ICT equipment and applications. The ITU secretary general summarizes this situation with his words, "Climate Change is a global challenge that the world cannot lose" and "ITU is committed to achieving climate neutrality and to working with our membership to promote the use of ICTs as an effective tool to combat climate change" (International Telecommunication Union, 2009a, p. 1). Thus in 2009, one of the issues considered by World Telecommunication Policy Forum was the use of ICT and the environment. In this forum, they were called for comprehensive research works to fight against environmental problems on all fronts, including adaptation, mitigation, clean technologies, reforestation, resource mobilization, the development of energy-efficient working methods, the implementation of satellite and ground-based remote sensing platforms for environmental observation (such as weather monitoring), the use of ICTs to warn the public of dangerous weather events and provide communications support for government and NGOs (International Telecommunication Union, 2009b). Then in 2012 at the World Telecommunication Standardization Assembly (WTSA-12), ITU member states were encouraged to consider these issues again and they established a special study group which works on these issues (International Telecommunication Union, 2009c). In a similar way, OECD member countries have also agreed on the Green Growth Strategy and the OECD Council has furnished their governments a ten-point checklist including coordination among ICT, climate, environment and energy policies, adapting life cycle perspectives, supporting research and innovation in green technologies and services, developing green ICT skills, increasing public awareness of the role of ICTs in improving environmental performances, encouraging best practices and measurement, improving public procurement and governments attitudes and setting policy targets (OECD, 2010). Therefore, it is accepted all over the world that ICT products and services are efficienct and have the ability to reduce the use of materials and the burden upon the environment.

There are various dimensions of the role of ICTs in providing sustainability of environmentally friendly status. According to Berkhout and Hertin (2001, p. 5), there are three categories of positive and negative effects of ICTs on the environment. For example, environmental monitoring is called as first-order (primary) positive effect, but some environmental results of production and use of ICTs such as electronic wastes are called as a first-order negative effect. These effects are based on the existence of ICTs. Similarly, de-materialization is a structural change that is called as the second-order (secondary) positive effect; however, incomplete substitution (such as "white vans" in addition to private shopping trips) is called as the second-order negative effect. These effects are based on the ability of ICTs to change processes such as production and/or transport processes. In order to define third-order (tertiary) positive and negative effects, Berkhout and Hertin gave green consumerism and growth of long-distance travel, respectively. In an OECD report, the similar effects are defined as direct effects (first order), enabling indirect effects (second order) and systemic effects (third order) (OECD, 2010, p. 8).

In this regard, some companies classify environmental effects into different categories, while the above literature uses order-type categorization. For example, at Fujitsu ICT effects on environment are classified into five categories: consumption of material sources, transport of people and goods, office and warehouse space, ICT equipment and data communication (Mazuka, 2009, p. 13). Some of these categories involve reducing the environmental effects of ICT equipment itself while some other categories refer to introducing various environmentally friendly solutions by using ICTs. In some of these cases, the environmental impacts are classified into a more broad frame such as minor (an emission which does not comply with the requirement of the license), limited (simple contamination, localized effects of short duration), serious (simple contamination, widespread effects of extended duration or significant effects on water quality), very serious (heavy contamination, localized effects of extended duration) and catastrophic (very heavy contamination, widespread effects of extended duration) (EPA, p. 11).

2. Finding solutions to the environmental problems by using ICT

One of the reasons for our work to find the relationship between environment and ICTs is benefiting from the capabilities of ICTs and other related technologies in order to find solutions to environmental problems. In this part of our study, we only focus on the effects of ICTs on finding the solutions to environmental problems. Inspired by the above classification, we classify this relationship into five categories:

(1) the consumption of material sources;

(2) the transportation of people and goods;

(3) office spaces and smart buildings;

(4) using data communication and monitoring; and

(5) ICT equipment.

The last category involves the negative effects of ICT equipment itself, but we will not examine this category in detail, since we focus on issues which are created "by ICT".

2.1 The consumption of material sources

One of the most effective ways to protect the environment is reducing waste at the beginning of the production process. It is well known that production of a new product requires considerable amount of raw material and energy, as raw material is extracted from the earth then use energy to process and then transport the output to the markets. As a result, CO_2 is released into the atmosphere at each stage of production. Therefore, it is necessary to reuse and/or use recycle products to prevent emissions. ICTs help in eliminating the production of some material goods by using virtual products. For example, since we do not require to use a separate setup for listening music such as radio, tape recorder or record player, we do not need to produce these appliances and their complementary items such as recorders, tape cassettes, CDs as we listen songs and albums online now. Similarly, e-books are also virtual and can be downloadable, so we do not need to cut trees for producing paper. Watching movies from internet or from other related ICT equipment has reduced the intention of going to film in theaters. People use gallery in their mobile phones or digital photo books instead of using old-fashion traditional photo albums.

Electrical and electronic ICT equipment may be a good example of reuse or recycling; the ICT sector itself uses natural resources and contributes to a considerable amount of GHG emissions in the environment. For example, in 2009 around one billion mobile phones, tablets, laptops and PCs were marketed and this led to 50 Mt of CO_2 emissions and around 400 million m^3 of fresh water uses (Dietrich *et al.*, 2014, p. 123); in 2015, ICT devices sold have increased to around 1.2 billion (Statista, 2016, p. 2). However, only in the USA, every day 85,753 PCs and around 370,000 mobile phones are thrown away (electronicstakeback.com, 2016, p. 2). It means these e-waste leaves behind lead, cadmium, mercury, and other hazardous wastes. Therefore, using second-hand ICT equipment or using recycled materials of ICT equipment eliminates the requirement for producing new ICT products.

However, it should be noted that the environmental effects of ICT's on reducing energy consumption have not always given positive results; according to Plepys (2002), the increase in efficiency in using energy can lead to a reduction in manufacturing costs as well as an increase in consumption, therefore "it is difficult to identify and measure the environmental effects of the productivity improvements induced by ICT are" (p. 510).

2.2 The transportation of people and goods

Transportation accounts for 14 percent of the GHG emissions (EPA), which has increased. In the USA, the share of transportation in GHGs emission has increased to 26 percent which is the second highest share after electricity (30 percent). GHGs emissions from transportation is the result of burning fuels such as gasoline and diesel. Burning fossil fuels such as CO_2, NO_2 and fine particular matter (PM10) leads to air pollution, consequently creating significant health problems. Therefore, the world is facing serious challenges while increasing mobility of people and goods. However, we can see the effects of ICT in the field of transportation and there are some solutions to reduce or organize these problems and their environmental effects. ICTs are applied in road transport for traffic management and/or smart use of transport networks. For example, intelligent transport systems (ITS) provide sustainable solutions which enable the integration of various transport modes with each other in order to establish a more efficient transport system. On the other hand, there are some micro project solutions, for example, in Hamburg, two companies (car-sharing company Car2go and car rental company Europcar) and the Hamburg Public Transport Association have introduced a kind of pilot project using ICT applications. In this project, customers can switch from bus or tram to car sharing or bike sharing at certain hubs across the city with the help of a card or any kind of applications (EYGM, 2015). According to ACEA Scientific Advisory Group Report, in 2014, five million members and almost 100 thousand vehicles are in the system and this system has reduced global CO_2 emissions by 482,170 tons in the USA (Le Vine *et al.*, 2014, p. 3).

Traveling for attending seminars, conferences, meetings or training courses creates serious intensive mobility across the world. For example, it is estimated that 40 million Americans attend a convention, trade show or conference each year. This figure excludes business meetings. This intensive mobility means environmental effects on the atmosphere include fuel consumption (plane, train, bus, car, etc.), electricity consumption (lights, heating, cooling), water consumption (laundry of sheets and towels in hotels) and paper consumption (training manuals, brochures, handouts, etc.). However, without physically attending to the above events, all activities can be performed successfully by ICTs; videoconferencing (VC) or using Skype, Blackboard Collaborate or WebEx have become convenient tools for these activities and these applications have considerable savings in CO_2, cash and time. At the same time, there are indirect effects in terms of reducing demand on transport infrastructure and offices such as conference buildings.

Similarly, e-learning is another substitute for traveling for education. For example in 2014-2015, the USA had around one billion international students and more than 70 percent of these students came from ten countries (such as China, India, South Korea, Saudi Arabia, Canada, Brazil, Taiwan, Japan, Vietnam and Mexico). If we assume that each of them go and return to his/her home country once a year, it means 845 kg CO_2 per flight[1]. In another example, Open University has measured the benefits of e-learning (i.e. distance learning); they found that e-learning activities consumes an average of 90 percent less energy and produces 85 percent less CO_2 emissions per student than conventional face-to-face courses[2].

New and rapidly developed information economy has become a dominant force to shape the world of trade; e-commerce is one of the most popular and common networks and it is continuously growing. Sales on internet have grown exponentially since the mid-1990s. For example, in 2015, the value of worldwide B2C e-commerce sales was $1.5 trillion and 55 percent of this value came from the USA (Statista, 2016). The figure of e-commerce was only $1 trillion in 2013.

The relationship between ICTs and e-commerce has some beneficial side effects for environmental improvement while there is also a threat to international trade and the environment. Reducing transport volume and vehicle emission has a positive effect of using ICTs in trade; online orders reduce people's shopping or trading activities. C2C e-commerce involves second-hand products which stimulate the reuse of products which is beneficial for the environment. However, it is also argued that shopping which is made on foot, bicycle or public transportation within the borders of the city, traditional way is more environmental friendly than home delivery type e-commerce activities using delivery vans (Weltevreden and Rotem-Mindali, 2009, p. 89). In terms of freight transport in international e-trade, the picture can be changed. In short, e-commerce changes the status of competition, price structure and consumption patterns but it also affects material flows, energy use, transportation infrastructure and land use. Therefore, it is not easy to measure the net environmental effects of e-commerce.

On the other hand, ICT applications and services for mobility have strong potential to yield environmental benefits. For example, in order to obtain benefit from fuel-efficient driving, smart electricity distribution networks are used which reduce transmission and distribution losses. Similarly, in-car fuel-saving devices such as on-board monitoring (computers), tire pressure monitoring system, reactive accelerator pedal and navigation applications (to avoid traffic jams or showing the least-fuel routing) are used for the same purpose.

2.3 Office spaces and smart buildings

E-commerce (particularly B2C type) can reduce the number of malls or shopping centers and their parking areas. As a result of growth of e-shopping, a new orientation for retail is observed. It means new locations for public transport. This re-orientation is also common in food delivery services; instead of servicing in restaurants food delivery services do not need big spaces and parking areas for their customers.

In order to save land use, home office and office-sharing systems provide another opportunity for using ICTs. Nowadays companies support people who want to work from home which in turn can reduce electricity use such as heating, cooling and lighting as well as use of land and buildings.

On the other hand, ICTs improve energy efficiency in buildings and electricity distribution. There are several studies and works on the effects of ICTs across the whole energy value chain. One of such studies is European SmartGrids. This project works under the intelligent value chain which tries to optimize, control, secure and sustain the procurement and supply of cleaner distributed energy anticipating till 2050 (European Commission, 2009, p. 8). In terms of consumer's perspective, smart building activities try to provide energy savings, for example, in Finland, smart metering encouraged consumers to increase energy efficiency by 7 percent (European Commission, 2009, p. 1). In EU, there are many studies dealing with smart and energy-efficient buildings (EeB) in order to reduce their energy consumption and CO_2 emissions. Since buildings account for 40 percent of EU final energy demand, specific attention i to smart buildings. According to the Climate Group's 2008, with the help of a building management system, by 2020, ICTs are expected to reduce the emissions of buildings upto 15 percent (Houghton, 2009, p. 10).

2.4 Using data communication and monitoring

Monitoring systems, which gather monitor and analyze data on every kind of environmental observations, such as environmental pollutants, are very crucial to support environmental management activities and decision making for environmental protection. In order to collect data, several ICT applications are actively used such as these are GPS, photographic cameras, optical remote-sensing devices, electronic noses, gas detector tubes, sound-level analyzer and such other devices. For example, radio-based remote sensors are the main tools for receiving environmental data in order to monitor climate changes. Several national and international organizations work on data communication and monitoring for environment.

Cloud computing[3] is another model in which sharing the pool of configurable computing resources is easily managed. This model gives various computing solutions in order to improve their efficiency, productivity and management. According to a study by Microsoft, Accenture and WSP Environment & Energy[4], Microsoft's cloud solutions can reduce energy use and carbon emissions by more than 30 percent; according to the study of Pike Research, cloud computing can reduce total energy spending by as much as 38 percent by 2020 and also GHGs emissions (eLAC Newsletter, 2011, p. 11). The study has calculated the carbon footprint of Microsoft's different applications (such as e-mail, content sharing and customer relationship management) and they have found that cloud computing reduces carbon emission much more than physical infrastructure. Energy use and emissions can be reduced by more than 90 percent with a shared cloud service, particularly for small deployments (Accenture and WSP Environment & Energy, 2010, p. 2).

Data communication and monitoring provides useful data and advanced climate change modeling which leads to more further predictive climate models. Therefore, monitoring and understanding climate changes will help to reduce GHGs emissions through early warning system applications, developing new methods for disasters caused by climate changes and such other applications.

3. How Turkey uses ICT in the environmental issues

It is obvious that using ICTs in environmental protection has become an increasingly important issue and Turkey is not indifferent to this situation. Turkey is becoming increasingly aware of the noticeable increase in the country's temperature and dramatic changes in its water cycle. Similarly, the country has its own challenges in meeting its increased energy demand. However, its activities in terms of sustainable development have accelerated after becoming a part of the Framework Convention on Climate Change. After the ratification of Kyoto Protocol in 2009, Turkey has decided to prepare National Climate Change Adaptation Strategy (2010-2020) and started to implement this issue in five areas such as water resources management, agricultural sector and food security, ecosystem services, biodiversity and forestry and natural disaster risk management and public health. In this framework, the country has prepared National Climate Change Action Plan (NCCAP) which was based on its Ninth Development Plan (2007-2013) and it has implemented in 2011. The NCCAP includes strategic principles and goals on GHG emission control and adaptation to climate change for the period of 2011-2023.

3.1 The consumption of material sources

The implementation of e-government applications was first introduced in 1987 via the PERSIS which is the personnel information system then the second applications started in 1998 via the VEDOP I (Project of Tax Office Automation) which is a kind of Tax Office Automation Project. As an intensive implementation area of e-government, it is a web-based application on which all tax offices in Turkey work as a standard process and procedure. In 2004, VEDOP II and, in 2009, VEDOP III was introduced. These applications include e-collection, e-declaration, e-confiscation, e-invoice and other paperless correspondence. The system reduces to the transaction costs and informal economy and increases the transparency of the government and ability of the state's governance. These results have some connections with environment directly or indirectly. First of all, paperwork is reduced by e-taxation. This is one of the most direct environmental effects of ICTs on taxation. In addition, in Turkey, there is a municipality tax in the form of environment cleaning which is levied on residential and commercial buildings. Since this tax is the financial source of solid waste management service, it is important to be followed in terms of accountability.

E-books have rapidly entered into the Turkey's publishing market which is a very new concept is new for Turkish people. In 2012, the Ministry of Education in Turkey has initiated a project which aims to provide tablet computers to all high-school students, to install smart boards in every classroom and to digitize every textbook. It is obvious that the project has a serious impact on the consumption of blackboards, chalk and textbooks. On the other hand, Turkey's first online bookstore Idefix was introduced into the was market in 2010; in a few years several private online bookstores followed this company. In 2016, the market size of e-book was around $8 billion and has been in a very rapid development path. However, in a comparative sense, Turkish e-book market has still a small share (0.4 percent) against the share of the US market (13 percent).

As we mentioned in Section 1.1, the 3Rs are other important points for the relation between ICTs and environmental protection. About 15-20 percent of scrap in Turkey constitutes of recoverable qualified waste, 68 percent of waste belongs to organic waste, 13 percent belongs to solid waste and 19 percent belongs to other types. The most important environmental protection issue in Turkey is to recycle the paper waste. Since cellulose is an expensive and imported substance, it becomes more important to recycle it, for example, the recycling of a ton paper means Turkey earns 700-1,000 dollars from its import costs. In 2013, the ratio of using waste paper in the production of paper, cardboard and corrugated cardboard was 45 percent and it is expected to increase 60 percent by 2020. In fact, the amount of waste paper in the country is rising steadily and stably.

The Regulation on the Control of Waste Electrical and Electronic Equipment was in force in 2012 and the regulation brings various obligations to industries, municipalities and public authorities. According to the regulation, it is expected to achieve collection levels of e-waste from 0.3 kg/inhabitant in 2013 to 4 kg/inhabitant in 2018 with the help of collection centers in cities.

3.2 The transportation of people and goods

In Turkey, ITS has been prepared by the Ministry of Transport, Maritime and Communication and documented as an ITS Strategy Document (2014-2023). Actually, the first ICT application for transportation in Turkey was the Smart Card. In 1999, Smart Card applications in public transportation was enacted and integrated in all transport modes. In the same year, open-road tolling system (AutoPASS) was introduced for FSM Bridge, then, in 2012, Express Pass System was to implemented in Bosporus Bridge and other paid motorways with the help of radio frequency identification application. This system is three times more efficient than the traditional traffic flow and the system can communicate with drivers via SMS.

Car sharing is enacted as another efficient way of transporting people. The car sharing system is becoming increasingly popular in big cities of Turkey, particularly in Istanbul; some applications have become widespread such as zipcar and atlagit.

On the other hand, in terms of transportation of goods, the first studies on e-commerce began in 1997 under the management of the Supreme Council for Science and Technology of Turkey. Then in 1998 Electronic Commerce Coordination Council was established and took the responsibility of the issue. However, the most important improvement on this area is the Law on the Regulation of Electronic Commerce which is enacted in 2015. In 2016, there were 22,000 active e-commerce websites (such as hepsiburada.com, sahibinden.com, gittigidiyor.com, markofoni.com, yemeksepeti.com, evim.net, Amway, etc.). For example, the biggest share in retailing market belongs to hepsiburada.com with its 15 percent followed by Gittigidiyor.com with its 8.1 percent market share (Marketing Türkiye, 2017). According to the TUBISAD report, the share of online spending in total retail spending is only 1.6 percent; the same figure is 12.2 percent in England, 8.4 percent in USA and 3.5 percent in Brazil. Despite its small share, the growth of e-commerce in Turkey is 31 percent average yearly.

3.3 Office spaces and smart buildings

According to the report of British Chamber of Commerce Turkey, in 2013, there were 40 certified "green buildings" in Turkey. When we made a comparison between smart buildings with conventional buildings, we fount that these buildings use less energy, emit up to 40 percent less CO_2, consume 40 percent less water and produce 70 percent less water waste (British Chamber of Commerce, 2016).

The first implementation of smart building in Turkey was constructed in 1984 but it was just for monitoring. However, the number smart buildings began to increase rapidly in the past two decades. Most of the smart buildings are situated in major cities of Turkey such as

Istanbul, Ankara, Izmir, Bursa and Adana. In İstanbul, Tekfen Tower, Polat Tower, Sabancı Center, Sun Plaza, Levent Loft, Sapphire, Kanyon, and Trump Towers are some examples of smart buildings. In Turkey, the share of energy consumption in buildings over total consumption is 37 percent. According to IBM data, 45 percent of the energy consumption in buildings is from heating and cooling systems, and 30 percent from the lighting systems.

Turkey has recently started to prepare smart grid and smart meter applications. In 2013, meter property was given to the distribution companies by the electricity market law. Currently, the Turkish electricity market is carried out by the replacement of stamp-expired meters with the new smart meters.

The law on "energy performance of buildings" is issued by the Ministry of Environment and Urbanization that requires buildings to meet the minimum performance criteria and standards concerning architecture, heat insulation, heating and cooling systems and electrification.

3.4 Using data communication and monitoring

In Turkey, the Regulation on Monitoring of Greenhouse Gas Emissions was adopted by the Ministry of Environment and Urbanization in 2012. It is an installation-level monitoring, reporting and verification system covering all major sources of GHG emissions from the industry and power generation sectors (Official Gazette of Turkish Republic, 2014). Under the authorities of Turkish State Meteorological Service (TSMS, which was founded in 1937), high atmosphere observations are made twice a day in eight different cities (Ankara, Adana, Samsun, Istanbul, Izmir, Isparta, Diyarbakir and Erzurum) of Turkey via the GPS technology (TSMS -Turkish State Meteorological Service, 2016). There are also 755 automated weather observing stations (AWOS), 56 airport AWOS and 42 maritime observation stations in Turkey. In these stations, all observations are completely measured and coded automatically sent to relevant organizations (TSMS -Turkish State Meteorological Service, 2016). In fact, all these computer-based observations are discussed and evaluated daily by experts with the help of VC system and are sent via SMS.

On the other hand, data collecting and monitoring system does not just belong to TSMS. According to the Regulation on the Continuous Emission Monitoring Systems which has entered into force in 2012, several private laboratories or companies are established and they measure the sooth, smoke, dust, vapor and aerosol type of emissions which spread into atmosphere as the result of industrial and power-generating activities. These companies follow real-time data which are based on the digital archives, reports and analyses. Therefore, these recorded data can be used for other plans and activities.

In the Turkish energy market, some subscribers with the help of smart phones and related applications can check their energy consumption and also can make online transactions such as paying electricity bills. By using such applications, the energy consumption is kept under control (ENERYA, 2016). Similarly, some wind turbines or related facilities in the market are being monitored 24 hours remotely and the data recorded by the same turbines are analyzed by experts (Bubik, 2016).

4. Conclusion

The world is witnessing into situation where it is unthinkable to live without ICTs. ICTs are ubiquitous and they have significant effects. One of the most crucial effects is on the environment and this paper has tried to point some of the most attractive areas. Since it is difficult for such a short paper to include all the aspects, this paper only provides some specific examples. However, some featured cases from Turkey have been provided. These cases show us the following:

- Turkey has the ability to monitor and control data on environment. The country is working to improve it in cooperation with international institutions. and many relevant laws have come into effect.

- In many environmental problems, access to data and the data collected can be brought together to provide a holistic picture of this environmental problems, therefore it is easy to find a solution.
- In Turkey, under the national legislation on waste management, National Recycling Strategy Action Plan (2014-2017) is considered.
- Smart buildings that use ICTs are increasingly becoming popular in Turkey. The country's movement toward urban renewal period also creates an opportunity for smart buildings. Particularly, Turkey benefits from the implementation of the smart building approach, in terms of energy savings.
- The transportation sector has been in Turkey using ICT recently and considering the share of the automotive industry in the country, progress has been very successful.

At the final point, ICTs have changed the world and these technologies have serious impacts on environment in both positive and negative aspects. The important thing is to be able to remove the negative effects with the help of positive effects and ICTs have the capacity to do this.

Notes

1. Our own calculation from the database, available at: www.icao.int/environmentalprotection/CarbonOffset/Pages/default.aspx, data on international students in the USA, available at: www.iie.org/Services/Project-Atlas/United-States/International-Students-In-US, (accessed August 15, 2016).
2. Available at: http://blogs.articulate.com/word-of-mouth/elearning-is-good-for-the-environment/ (accessed August 16, 2016).
3. As a definition, cloud computing is a type of computing where the computing resources are provided as a service over the internet.
4. Accenture is a global management consulting, technology services and outsourcing company and it works in more than 120 countries; WSP Environment & Energy is another consulting group; the group has 65 offices globally. Finally, Microsoft is the worldwide company that sells software, services and solutions.

References

Accenture and WSP Environment & Energy (2010), "Cloud computing and sustainability: the environmental benefits of moving to the cloud", available at: http://gesi.org/files/Reports/AssessmentMethodologyCasteStudy_CloudComputingSustainability-Nov2010.pdf (accessed August 15, 2016).

electronicstakeback.com (2016), "E-Waste problem overview", available at: www.electronicstakeback.com/wpcontent/uploads/Facts_and_Figures_on_EWaste_and_Recycling.pdf (accessed August 15, 2016).

Berkhout, F. and Hertin, J. (2001), "Impacts of ınformation and communication technologies on environmental sustainability: speculations and evidence", OECD Report SPRU-Science and Technology Policy Research, Sussex, available at: www.oecd.org/sti/inno/1897156.pdf (accessed August 8, 2016).

British Chamber of Commerce of Turkey (2016), "Smart cities and green buildings: Turkey potential", available at: www.bcct.org.tr/news/smart-cities-and-green-buildings/15316 (accessed August 30, 2016).

Bubik, S. (2016), "Dijitalleşme Enerji Sektöründe Büyük Değişiklikler Getirecek", *Enerji ve Çevre Dünyası*, No. 125, pp. 96-99, available at: www.enerji-dunyasi.com/ (accessed August 17, 2016).

Dietrich, J., Becker, F., Nittka, T., Wabbels, M., Modoran, D., Kast, G., Williams, I.D., Curran, A., den Boer, E., Kopacek, B., Schadlbauer, S., Musterle, J. and Aionesei, C. (2014), "Extending product lifetimes: a reuse network for ICT hardware", *Waste and Resource Management*, Vol. 167 No. WR3, pp. 123-135.

eLAC Newsletter (2011), "ICT and environment", available at: www.cepal.org/socinfo/noticias/paginas/0/30390/newsletter14eng.pdf (accessed November 19, 2016).

ENERYA, "Enerya Doğalgaz Çözümleri Cebe Girdi", *Enerji ve Çevre Dünyası*, No. 123, p. 33, available at: www.enerji-dunyasi.com/ (accessed February 10, 2016).

EPA, "Guidance to licensees/COA holders on the notification, management and communication of environmental incidents", available at: www.epa.ie/pubs/advice/licensee/Guidance%20to%20licensees.pdf (accessed April 10, 2016).

European Commission (2009), "ICT for a low carbon economy. Smart electricity distribution network", available at: http://ec.europa.eu/information_society/activities/sustainable_growth/docs/sb_publications/pub_smart_edn_web.pdf (accessed August 28, 2016).

EYGM (2015), "Routes to prosperity. How smart transport infrastructure can help cities to thrive", available at: www.ey.com/Publication/vwLUAssets/EY-routes-to-prosperity-via-smart-transport/$FILE/EY-routes-to-prosperity-via-smart-transport.pdf (accessed August 16, 2016).

Houghton, J. (2009), "ICT and the environment in developing countries: opportunities and development", available at: www.oecd.org/ict/4d/44005687.pdf (accessed November 28, 2017).

International Telecommunication Union (2008), "ICTs for e-environment. Guidelines for developing countries with a focus on climate change", ITU final report, Geneva, available at: www.itu.int/ITU-D/cyb/app/docs/itu-icts-for-e-environment.pdf (accessed August 8, 2016).

International Telecommunication Union (2009a), "ITU symposium on ICTs and climate change ITU background report", CITIC, Quito, Geneva, available at: www.itu.int/dms_pub/itut/oth/06/0F/T060F00600C0004PDFE.pdf (accessed July 10, 2016).

International Telecommunication Union (2009b), "World telecommunication policy forum 2009", Document No. WTP09/4 (Rev. 1)-E, Part 1, Geneva, available at: www.itu.int/md/S09-WTPF-C-0004/en 08.08.2016

International Telecommunication Union (2009c), "Using ICT to reduce the burden on the environment", ITU News, December, available at: www.itu.int/net/itunews/issues/2009/10/14.aspx (accessed August 8, 2016).

Le Vine, S., Zolfaghari, A. and Polak, J. (2014), *Carsharing: Evolution, Challenges and Opportunities*, European Automobile Maufacturers Association (ACEA), Bruxelles, available at: www.acea.be/uploads/publications/SAG_Report_-_Car_Sharing.pdf (accessed August 30, 2016).

Marketing Türkiye (2017), "Rakamlarla 2017 Türkiye e-ticaret istatistikleri", available at: www.marketingturkiye.com.tr/haberler/rakamlarla-2017-turkiye-e-ticaret-istatistikleri/ (accessed November 28, 2017).

Mazuka, M. (2009), "Delivering greater value to our customer and to society", *New Breeze*, Vol. 21 No. 4, p. 13, available at: www.ituaj.jp/archive/nb/pb/nb_volumes/view/2009/04/index.html

Ministry of Science Technology and Innovation of Denmark (2008), "Action plan for Green IT in Denmark", available at: www.apc.org/en/system/files/Action_Plan_for_Green_IT_in_Denmark.pdf (accessed August 15, 2016).

OECD (2010), "Greener and smarter. ICTs, the environment and climate change", available at: www.oecd.org/site/stitff/45983022.pdf (accessed August 10, 2016).

Official Gazette of Turkish Republic (2014), *Regulation on Monitoring of Greenhouse Gas Emissions*, available at: www.resmigazete.gov.tr/eskiler/2014/05/20140517-3.htm (accessed August 29, 2016).

Plepys, A. (2002), "The grey side of ICT", *Environmental Impact Assessment Review*, Vol. 22 No. 5, pp. 509-523.

Statista (2016), "Vendors' sales of mobile phone sales to end users worldwide from 2010 to 2015", *The Statistics Portal*, available at: www.statista.com/statistics/263355/global-mobile-device-sales-by-vendor-since-1st-quarter-2008/ (accessed November 11, 2016).

TSMS -Turkish State Meteorological Service (2016), "Meteorolojide tahminler nasıl yapılıyor?", available at: www.mgm.gov.tr/kurumsal/haberler.aspx?y=2013&f=tumhaber (accessed August 17, 2016).

Weltevreden, J.W.J. and Rotem-Mindali, O. (2009), "Mobility effects of B2C and C2C e-commerce in the Netherlands: a quantitative assessment", *Journal of Transport Geography*, Vol. 17 No. 2, pp. 83-92, available at: www.sciencedirect.com/science/article/pii/S096669230800135X

Further reading

Edwards, J.B., McKinnon, A.C. and Cullinane, S.L. (2010), "Comparative analysis of the carbon footprints of conventional and online retailing. A 'last mile' perspective", *International Journal of Physical Distribution and Logistics Management*, Vol. 40 Nos 1/2, pp. 103-123.

International Telecommunication Union (2016), "ITU-T SG5: environment and climate change", available at: www.itu.int/en/ITU-T/studygroups/2013-2016/05/Pages/default.aspx (accessed August 16, 2016).

Isaoğlu, E.A. (2014), "Elektronik Haberleşme Sektöründe Yeşil Uygulamalar ve Türkiye için Öneriler, Ulaştırma", Denizcilik ve Haberleşme Bakanlığı Ulaştırma ve Haberleşme Uzmanlık Tezi, Ankara, available at: www.udhb.gov.tr/images/hizlierisim/0f8024190d658d5.pdf (accessed August 29, 2016).

Kumar, R. and Mieritz, L. (2007), "in John Houghton (2009)", "ICT and the Environment in Developing Countries: Opportunities and Developments", available at: www.oecd.org/ict/4d/44005687.pdf (accessed August 16, 2016).

Ozturk, A., Medeni, I.T., Ucuncu, B., Caylan, M., Akba, F. and Medeni, D.T. (2011), "Green ICT: a review of academic and practitioner perspectives", *International Journal of eBusiness and eGovernment Studies*, Vol. 3 No. 1.

Retailler (2015), "Türkiye'deki E-ticaret pazarı", available at: www.retailler.net/2015te-turkiyedeki-e-ticaret-pazar-buyuklugu-ne-kadar/ (accessed August 30, 2016).

Web reference

available at: www.sustainability-perspectives.com/article/the-power-of-ict-to-solve-global-sustainability-issues/ (accessed August 16, 2016).

About the authors

Feride Gonel holds a Bachelor's Degree in Economics from the Ankara University. She received her Master's Degree from the Bosphorous University and PhD Degree from the İstanbul University in Turkey. Currently she is working as a Professor in the Department of Economics at the Yildiz Technical University, Istanbul. She has published a number of research papers at the international and national level on the subject of international trade and sustainable development. She has a course book on development economics. Her present area of interest includes sustainable technology and international trade and income inequality. Feride Gonel is the corresponding author and can be contacted at: feride.gonel@gmail.com

Atakan Akinci holds a Bachelor's Degree in Political Science and Public Administration from the Istanbul University, and Economics from the Anadolu University. He received his Master's Degree in Economics from the Yıldız Technical University in Turkey. He presented some research papers at the international- and national-level conferences on the subject of technology and environment.