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# The Role of Information and Communication Technology (ICT) in Environmental Protection

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## ABSTRACT

*The advancement of technology in human life has resulted in multiple forms of contamination in the atmosphere, which has thrown off the environment's balance and proportionality. Today, one of the most critical issues in environmental economics is the role of information and communication technology (ICT) in reducing air pollution, which has impacted various aspects of human life in recent years. Environmental research and its application to lawmakers and the general public can benefit from the use of information and communication technology. The use of ICT can reduce dependence on environmental resources in order to decrease the environmental pollution due to the improper usage of natural resources. Applications of the ICT systems in the environmental protection is presented in the study to improve the quality level of monitoring and protections systems of the environment from the pollutions. The effects of ICT systems in the climate change, forest Degradation, hurricanes and typhoons anticipations, smart waste management systems, energy supply efficiency and tourism industry in terms of environmental protection systems is discussed in the study to suggest new ideas in the research filed. As a result, the research filed can be moved forward.*

**Keywords:** Information and Communication Technology (ICT), Environmental Protection

**Mathematics Subject Classification:** 94A05, 94A99

**Computing Classification System:** H.4

## 1. INTRODUCTION

The growing population of the world and the major trend towards urbanization and poor management of standard density and construction of urban neighborhoods have had catastrophic effects on the environment and urban spaces. The impact of technological action on global ecological environments has grown to the point that future generations' means of survival are threatened. Unfortunately, humans have been identified as the most important cause of environmental degradation, and human intervention in the conditions of the Earth's ecosystem has caused a lot of damage. While the major part of environmental problems and climate change is due to lack of public awareness in the field of environment and how to deal with the challenges of the environmental protection.

Information technology as one of the emerging technologies of the present century has been able to manage dramatic changes in various fields and create information. The usage of ICT in the

environment sector can be considered to organize and access data types and information in order to optimally manage the environment (Majeed 2018). The impact of information technology and its role in environmental and ecological sustainability, under the title of communications and green information technology, is an important issue in ICT management which has been given special attention in recent years (Asongu, Le Roux, and Biekpe 2018). In this category, the role of information technology in reducing environmental pollution, including the reduction of pollution is considered very important and positive. According to the latest reports from the World Telecommunication Union, reducing energy waste and increasing productivity using telecommunication technologies is a good way to reduce carbon dioxide emissions (Mohanty 2011).

Through providing more detailed knowledge about and understanding of processes and structures, as well as developing technologies for society to help return to a sustainable path, sciences can help solve the most critical matters on our planet, such as climate change, biodiversity loss, declining natural resources, and a lack of energy safety (Coroamă et al. 2020). The use of information and communication technology can help improve the quality of the environment and reduce environmental pollution; However, the visibility of this work in different countries with different levels of development requires case studies (Houghton 2009). Simultaneously with the rise in pollution intensity as a result of economic activities, information and communication technology has been able to moderate the rising trend of pollution accumulation in developed countries and enhance environmental quality through this process. In developed countries, however, this is less visible. In this regard, it appears that current gaps between developed and developing countries in terms of institutionalizing the use of information and communication technologies play a significant role (N'dri, Islam, and Kakinaka 2021). Creating a paperless office system with communication and information is possible, and thus, paperless or paperless technology, in the midst of environmental debate, once again demonstrates the importance of telecommunications as a savior of forests. If the Internet and communications can be used to reduce paper consumption by 50%, forests will be safe from aggression (Orantes-Jimenez, Zavala-Galindo, and Vazquez-Alvarez 2015). Environmental surveillance, the development of intelligent network networks, and the ability to download digital files to eliminate conventional physical products and lifestyle changes (green consumerism) from the beneficial effects and high energy usage of networking and information technology data center data hosting equipment. In addition, effective use of information and communication technology improves environmental protection and planning, natural disaster management, global energy conservation, and the rise of the "green economy" as a new source of sustainable economic growth (Kasemsap 2018). But, access to this technology, the presence of infrastructure, the ability to exchange and protect information, expense, and the lack of proper electronic device recycling can decrease the effects of ICT technology in the environmental protection. As a result, in order to preserve and enhance the quality of the environment for long-term growth, as well as consideration of all cultural, economic, political, and social factors successful implementation of these technologies is needed (Pouri and Hilty 2018). The various uses of the Internet and ICT technology over the past decade have made this possibility of linking a hypothesis that was once dubiously referred to as the "global village" a reality today for Earth's

inhabitants. The unique features of the Internet led to the emergence of a new form of commerce known today as e-commerce (Manjarrés et al. 2021).

Soori et al. proposed virtual machining systems and applications for analyzing and modifying machining operations in virtual environments (Soori, Arezoo, and Habibi 2017, 2014, 2013; Soori and Arezoo 2021; Soori, Arezoo, and Habibi 2016).

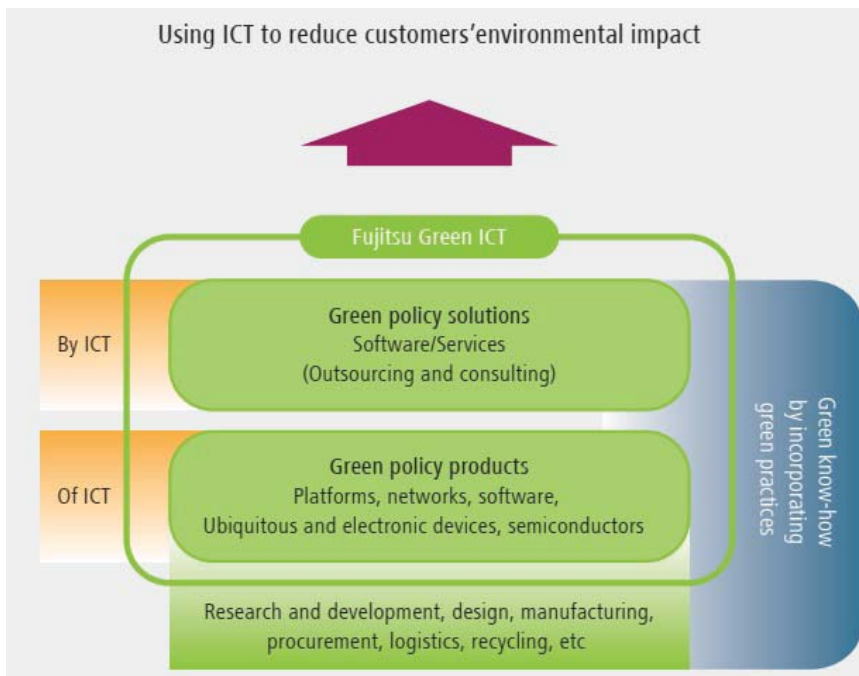
Dastres and Soori presented the use of the Secure Socket Layer in network and web protection in order to improve security measures in the data web (Dastres and Soori 2020b). Dastres and Soori evaluated the influence of the Meltdown bug on different processors and operating systems in order to improve CPU protection by preventing attackers from collecting data on computers or smartphones (Dastres and Soori 2020a). Dastres and Soori presented an analysis of recent developments in network danger and safety protocols in order to identify the presented research works and propose some possible research trends (Dastres and Soori 2021c). Dastres and Soori explored advanced image processing systems in order to apply new approaches to image processing techniques (Dastres and Soori 2021a). Dastres and Soori evaluated the performance of advanced signal processing systems to discuss the application of digital signal processing systems in communication technology (Dastres and Soori 2021b). Soori and Asamel presented recent research works to investigate the mechanical action of materials in cutting operations as well as Friction Stir Welding (FSW) operations (Soori and Asamel 2020; Soori, Asamel, and Solyali 2020). Soori and Asamel presented a summary of recent research works to improve the application of Computer Aided Process Planning systems in manufacturing systems (Soori and Asmael 2021). Application of virtual machining system is developed by Soori and Asmael to minimize the residual stress and deflection error in five-axis milling operations of turbine blades (Soori and Asmael 2021).

To improve the quality level of monitoring and protections systems of the environment from the pollutions, applications of the ICT systems in the environmental protection is presented in the study.

## **2. THE EFFECTS OF ICT TO CLIMATE CHANGE AND REDUCTION OF CO<sub>2</sub> EMISSIONS**

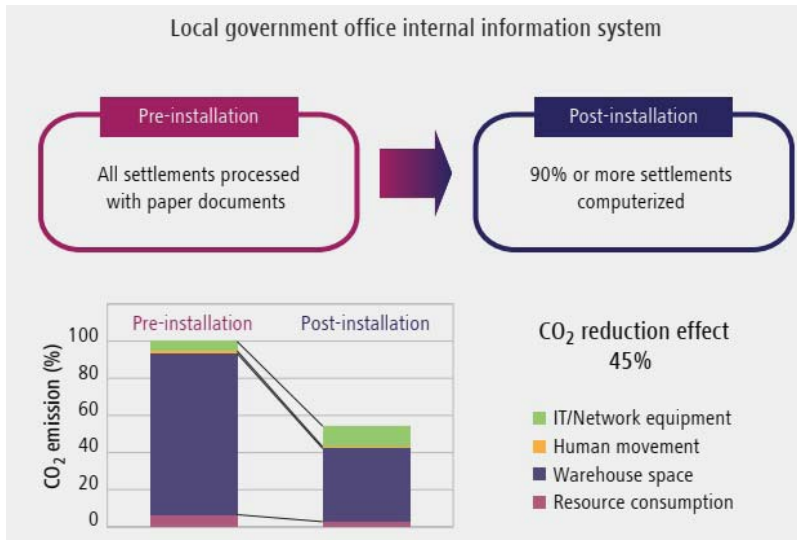
Climate change is one of humanity's most difficult challenges, and it seems to be intensifying in the coming years. Deadly gas and CO<sub>2</sub> emissions are one of the dangers of everyday industrial life. One of the important and basic needs related to environmental pollution is continuous control and monitoring of air pollution (Khan et al. 2018). Increasing the production of greenhouse gases and CO<sub>2</sub> at the top of them, the increase of this gas in the Earth's atmosphere has caused the solar radiation energy to be trapped in the Earth's atmosphere and the so-called greenhouse state and a relative increase in temperature. An average of 4 degrees Celsius increase in temperature, which can cause ice to melt in the Earth's poles, and ice melting can cause oceans to rise and small islands to flood, causing floods and droughts as well as severe storms (Asongu 2018). The application of ICT enables the transition to useful and effective resources and service-oriented communities by reducing the level of greenhouse gases, because the solutions provided by communications and information technology have the potential to reduce the high percentage of greenhouse gas emissions. Therefore, information and communication technology is considered as a low-polluting industry, which with its progress, reduces the amount of pollutants day by day (Moletsane 2019).

There are many environmental burdens associated with conventional face-to-face educational systems, including CO<sub>2</sub> pollution generated by people needing to travel to training facilities and the delivery of resources such as paper texts. The problems can be solved by using the ICT technologies in the educational systems of the countries. Moreover, the online business and office activities can decrease the demand of travelling for the people in the cities which can leads to the reduction of CO<sub>2</sub> emissions (Wang, Rodrigues, and Evans 2015). The environmental load needed for transportation can be minimized by reducing the movement of people and materials. The impacts of ICT systems on the environment can be divided into seven groups, which include material resource use, people or goods transportation, office and warehouse space, ICT facilities, and data communication networks. The emergence of new phenomena such as e-learning, e-commerce, e-health and in a word e-government is proof of this claim. For example, we can mention the establishment of call centers in order to perform the duties of employees and receive the services of applicants, or in the field of various postal services such as e-shopping, we can reduce unnecessary travel and help preserve the environment (Shehzad, Xiaoxing, and Sarfraz 2021). The application of the ICT systems to reduce customers environmental effects is shown in the figure 1 ("Green Policy of Fujitsu Company").



**Fig. 1.** The application of the ICT systems to reduce customers environmental effects ("Green Policy of Fujitsu Company").

Applications of the ICT systems in reduction of CO<sub>2</sub> emission According to a study conducted by Fujitsu company is shown in the figure 2 ("Green Policy of Fujitsu Company").



**Fig. 2.** Applications of the ICT systems in reduction of CO<sub>2</sub> emission According to a study conducted by Fujitsu company ("Green Policy of Fujitsu Company").

Also, the smart industries and manufacturing systems can be developed in order to reduce CO<sub>2</sub> emissions in process of part production. Applications of the Industry 4.0 in the environmental protection systems can be developed in order to decrease the CO<sub>2</sub> emissions in terms of part manufacturing process (Huang et al. 2017).

### 3. APPLICATION OF THE ICT IN BUSINESS AND BANKING SYSTEMS

E-commerce or digital economy is one of the current topics in the world of technology. The development of the Internet and e-economy has brought a new world to the trade and sale of many products, and in fact this pervasive system is having a positive impact on the unhealthy environment and the price of retail goods. Many macro and sound e-commerce policies help save energy and materials for production and delivery. Environmental strategists should analyze different support networks to evaluate energy consumption and the effects of different elements on commodity price adjustment to provide appropriate scientific and practical results to policymakers to take a special look at information technology and environment in development programs (Radnan and Purba 2018).

The Smart Business Platform is a management tool for displaying performance information in organizations that makes it possible to access, analyze and manage data with less time and cost. With smart business, managers can easily access the information they need, view information analysis, and monitor their organization's performance metrics in full and online (Hossain et al. 2020).

The role of information technology in the banking industry is very important and undeniable, which has opened new doors to new markets, services and products in the banking industry, online electronic banking, mobile banking and Internet banking are just a few examples. Nowadays, banks are widely

connected to their computer systems not only in small cities but also in other parts of the world, which is done by using high-speed networks and connecting them to the world wide web, ie the Internet. Information systems and networks are increasingly expanding today. The IT revolution has opened the door to an unprecedented increase in financial activity around the world, with global networks networking significantly reducing the cost of transfers of global funds (Acheampong and Moyaid 2016). Technology has enabled banks to meet expectations Identify and fix more customers, for example, customers can check the facilities of different banks in the fastest possible time and have a choice tailored to their needs, they can request the facility at any time and at any time. The need to use information technology in the insurance industry has been felt by private and public companies which has important role in the business and marketing of the companies. For examples, the developed systems of the ICT in the insurance company of oil tankers can decrease the risk of envirmetal damages and oil pollutions in the oceans (Gjino 2015).

#### 4. WEATHER SATELLITES AND RADARS TO TRACK THE PROGRESS OF HURRICANES AND TYPHOONS

Satellite remote sensing method can be used to assess changes in the environment and predict natural disasters such as droughts, floods and volcanic eruptions, etc. This technique has been used to investigate the possibility of access to crude oil, mineral reserves and the location of geothermal energy sources (dependent on the earth's central temperature) (Bendre, Thool, and Thool 2015). In this regard, the use of modern satellite and communication technologies such as radars will be necessary to monitor and control environmental conditions (Amarnath et al. 2018). The application of the ICT systems in the monitoring and controls of the hurricanes and typhoons to the environment is shown in the figure 3 ("Hurricanes and Typhoons Forecasting").



**Fig. 3.** The application of the ICT systems in the monitoring and controls of the hurricanes and typhoons to the environment ("Hurricanes and Typhoons Forecasting").

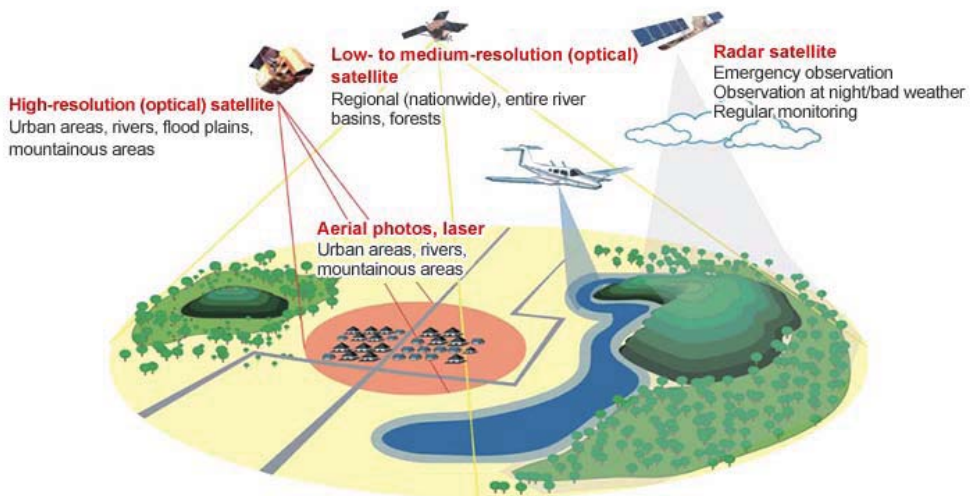
Ocean-based information systems warn people of hurricanes and other natural disasters, such as tsunamis, to prevent a humanitarian catastrophe by evacuating the area in a timely manner.

## 5. ICTS SYSTEMS IN HEALTHCARE INDUSTRIES

Policy makers will affect the use of ICTs to increase access to secure, reliable, and accessible care for common illnesses, especially among the poor. The advanced e-health systems can decrease the demand of patient travelling in order to decrease the environmental pollution in the cities (Haluza and Jungwirth 2018). Advanced data banks of drugs as well as smart drug delivery systems can increase the quality of health care systems in terms of decreasing the demand of travelling in the smart cities projects (Loshkovska and Koceski 2015).

## 6. APPLICATION OF THE ICT TO MONITOR DEFORESTATION AND FOREST DEGRADATION

Geographic Information System (GIS) has proven to be a very effective tool in environmental management. GIS is the technique of collecting various thematic maps using digital data. Different thematic maps contain digital information in different fields such as water resources, forest lands, soil type, agricultural lands, industrial growth, human habitation, etc., which are layered on top of each other using software (Lee et al. 2018). GIS has many applications, for example, it is very suitable for planning the use of different lands and for interpreting contaminated areas and destroyed lands. Suitable areas for industrial growth can also be identified with GIS (Liu et al. 2017). The advanced GIS systems compatible with remote sensing technology make it possible to track changes in locations and landscapes in time and space. Figure 4 depicts basic details on forests obtained by remote sensing from the air as well as satellite systems (Lausch et al. 2018).



**Fig. 4.** Basic details on forests obtained by remote sensing from the air as well as satellite systems (Lausch et al. 2018).



High-resolution optical and Radar satellite data can be implemented in order to monitor the current state of forests, the extent and density of forest cover, and its changes over time as is shown in the figure 5 ("FOREST MONITORING").



**Fig. 5.** Application of the Radar satellite data in monitoring of density of forest cover ("FOREST MONITORING").

Forest characteristics such as tree shape, height, and density using a mixture of data from optical and radar satellites, aerial photography, and laser data are studied in terms of Forest Degradation analysis. The basic data is used in a variety of areas, including designing forest management strategies and countermeasures, protecting wildlife, and fighting climate change (Kessy et al. 2016). Advanced ICT systems with automated sensors and data loggers have been created to quantify important plant and soil parameters for plant and soil science, physiological limits, water supply, climate change, plant genetics, breeding programs, and fundamental understanding of plant operation (Mohapatra and Rath 2019). Other contributions that ICT makes to climate change include tracking rainfall systems to fertilize them in arid and low-rainfall areas, thereby reducing the possibility of drought.

## 7. WASTE MATERIALS MANAGEMENT WITH SMART ICT

Studies show that reselling and updating computers and peripherals are more effective in environmental standards and patterns, and as a result, the return on environmental capital for recycling computer components is one of the lowest in economics and environmental science. Application of the internet of thing to the waste management process is shown in the figure 6 (Alqahtani et al. 2020).

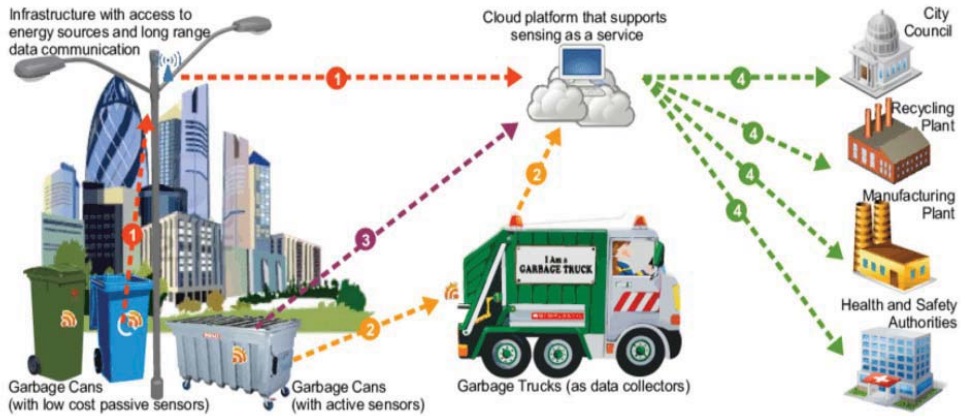


Fig. 6. Application of the internet of thing to the waste management process (Alqahtani et al. 2020).

The neural network systems is implemented in the flowchart of the smart waste management system as is shown the figure 7 (Alqahtani et al. 2020).

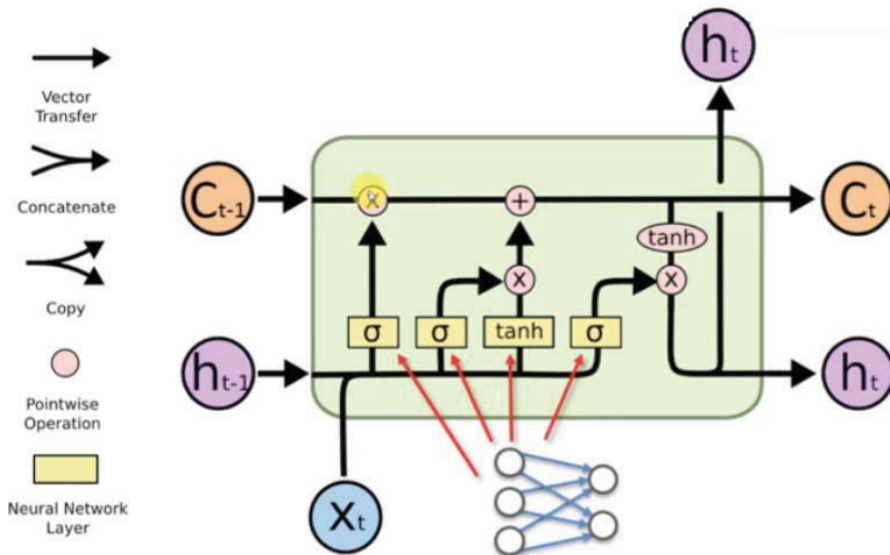


Fig. 7. the flowchart of the smart waste management system using neural network systems (Alqahtani et al. 2020).

## 8. ITC SYSTEMS IN ENERGY SUPPLY EFFICIENCY AND MAXIMIZE THE USE OF RENEWABLE SOURCES

Application of the ICT technologies can minimize energy consumption at the engine, plant, or business level. Undoubtedly, the measures taken by the ICT sector in all societies as well as in our country to improve productivity and reduce energy consumption have been significant (Bastida et al. 2019). The advanced ICT systems can be used in saving energy, improving transmission and distribution and generating power from renewable sources. The smart grid infrastructure for electrical

energy can be built to enhance electrical transport and distribution networks in cities in terms of efficiency enhancements in the energy consumption (Lange, Pohl, and Santarius 2020).

Smart motors as well as electric motors that which been engineered to operate at various speeds depending on the mission at hand, constantly adjusting their operation to the actual requirement (Dameri 2017). Many e-commerce policies help save energy and materials for production and delivery. Environmental strategists should analyze different support networks to evaluate energy consumption and the effects of different elements on commodity price adjustment to provide appropriate scientific and practical results to policymakers to take a special look at information technology and environment in development programs (Soma et al. 2016).

## **9. ICT TECHNOLOGY IN THE TOURISM INDUSTRIES**

It is one of the most important applications of information technology in the tourism industry and this industry is of great importance in various dimensions such as creating employment, source of income for the government and improving social services. Tourism is an information-driven industry, and information technology acts as a major driver in the tourism industry (Ali and Frew 2014). By using the ICT systems, a tourist can view tourist information about a country's historic buildings on the internet and get good audio, video and textual information about them. Then, this person becomes eager, he becomes interested in traveling to the country through the relevant channels. Now it is time to book tickets through the site of hotels and museums or historical cultural centers of the destination country. Even if the site of the country's airports is a destination, it provides the possibility of online ticket reservation for and according to the passenger schedule. The process can decrease the demand of travelling for the tourism industries (Boes, Buhalis, and Inversini 2016). Moreover, the environmental damages due to the tourism industries can be decreased by using the advanced web of data related to the environmental concerns of the destination country for the tourists (Shrestha and Jeong 2016).

## **10. CONCLUSION**

The influence of technological action on global ecological environments has become so serious that future generations' means of subsistence are in threat. The world's rising population, the primary trend toward urbanization, and inadequate management of standard density and urban neighborhood building have had disastrous consequences for the environment and urban areas. Therefore, in order to save resources, time and energy in cities, the concept of "intelligence" in the city and can provide an effective way to improve the quality of urban life. The use of ICT systems in the field of environment can increase the efficiency of environmental pollution reduction and decrease operating costs. The use of information technology with the capability of green industry, modification of vehicles to reduce pollution, integrated management of fuel consumption, modification of methods and proper disposal of waste and containment of desertification are technical solutions that can reduce environmental problems if implemented. ICT can play a valuable role in efficient and sustainable environmental management by improving control and response systems, facilitating environmental

activism and more efficient use of resources. On the other hand, ICT can have a negative impact on the environment through channels such as electronic waste.

In order to benefit from information technology to protect and improve the environment, strategic and integrated management is needed. Investing research in the field of information technology synergy and environmental protection and improvement can be effective in terms of environmental protection development methodologies. Moreover, it is practical to Pay attention to the issue of information technology in order to protect and improve the environment in the macro development programs of the country. To use information technology in the environmental protection systems, proper planning as well as strategies to change the lifestyle of individuals in society should be provided. Different scenarios regarding the positive effects of using information technology on energy saving and conservation of non-renewable resources should be analyzed in order to present the effective solution to the challenge of environmental pollution. Reducing the price of electronic purchase of goods in relation to face-to-face referral for purchase in order to encourage people in usage of electronic devices such as smart mobile phones as well as laptops in purchasing process can be effective in terms environmental protection projects. Planning and emphasizing on the development of information technology in all parts of the country while maintaining the quality and updating of equipment can also provide an advanced methodology in the environmental protection. Education and public information along with incentive policies to the people in order to save the environment condition by using the electronic devices can be practical method in order to decrease the level of pollution in the nature.

## 11. REFERENCES

Acheampong, O., Moyaid, S.A., 2016, *An integrated model for determining business intelligence systems adoption and post-adoption benefits in banking sector*. Review of. *Journal of Administrative and Business Studies* **2** (2), 84-100.

Ali, A., Frew, A.J., 2014, *ICT and sustainable tourism development: an innovative perspective*. Review of. *Journal of Hospitality and Tourism Technology*.

Alqahtani, F., Al-Makhadmeh, Z., Tolba, A., Said, W., 2020, *Internet of things-based urban waste management system for smart cities using a Cuckoo Search Algorithm*. Review of. *Cluster Computing* **23**, 1769-80.

Amarnath, G., Simons, G., Alahacoon, N., Smakhtin, V., Sharma, B., Gismalla, Y., Mohammed, Y., Andriessen, M., 2018, *Using smart ICT to provide weather and water information to smallholders in Africa: The case of the Gash River Basin, Sudan*. Review of. *Climate Risk Management* **22**, 52-66.

Asongu, S.A., 2018, *ICT, openness and CO 2 emissions in Africa*. Review of. *Environmental Science and Pollution Research* **25** (10), 9351-9.

Asongu, S.A., Le Roux, S., Biekpe, N., 2018, *Enhancing ICT for environmental sustainability in sub-Saharan Africa*. Review of. *Technological Forecasting and Social Change* **127**, 209-16.

Bastida, L., Cohen, J.J., Kollmann, A., Moya, A., Reichl, J., 2019, *Exploring the role of ICT on household behavioural energy efficiency to mitigate global warming*. Review of. *Renewable and Sustainable Energy Reviews* **103**, 455-62.

Bendre, M., Thool, R., Thool, V. 2015. Big data in precision agriculture: Weather forecasting for future farming. Paper presented at the 2015 1st International Conference on Next Generation Computing Technologies (NGCT).

Boes, K., Buhalis, D., Inversini, A., 2016, *Smart tourism destinations: ecosystems for tourism destination competitiveness*. Review of. *International Journal of Tourism Cities*.

Coroamă, V.C., Bergmark, P., Höjer, M., Malmodin, J. 2020. A Methodology for Assessing the Environmental Effects Induced by ICT Services: Part I: Single Services. Paper presented at the Proceedings of the 7th International Conference on ICT for Sustainability.

Dameri, R.P. 2017. "ICT intensity in smart mobility initiatives." In *Smart City Implementation*, 85-108. Springer.

Dastres, R., Soori, M., 2020a, *Impact of Meltdown and Spectre on CPU Manufacture Security Issues*. Review of. *International Journal of Engineering and Future Technology* **18 (2)**, 62-9.

Dastres, R., Soori, M., 2020b, *Secure Socket Layer in the Network and Web Security*. Review of. *International Journal of Computer and Information Engineering* **14 (10)**, 330-3.

Dastres, R., Soori, M., 2021a, *Advanced Image Processing Systems*. Review of. *International Journal of Imaging and Robotics* **21 (1)**.

Dastres, R., Soori, M., 2021b, *A Review in Advanced Digital Signal Processing Systems*. Review of. *International Journal of Electrical and Computer Engineering* **15 (3)**, 122-7.

Dastres, R., Soori, M., 2021c, *A Review in Recent Development of Network Threats and Security Measures*. Review of. *International Journal of Computer and Information Engineering* **15 (1)**, 75-81.

"FOREST MONITORING." 2021. <https://www.remote-sensing-solutions.com/forest-mapping-monitoring-carbon-mrv/>.

Gjino, G., 2015, *Internet theory banking in system banking*. Review of. *European Journal of Business, Economics and Accountancy* **3 (4)**, 45-51.

"Green Policy of Fujitsu Company." 2021. <https://www.itu.int/net/itunews/issues/2009/10/14.aspx>.  
Haluza, D., Jungwirth, D., 2018, *ICT and the future of healthcare: aspects of pervasive health monitoring*. Review of. *Informatics for Health and Social care* **43 (1)**, 1-11.

Hossain, S.A., Bao, Y., Hasan, N., Islam, M.F., 2020, *Perception and prediction of intention to use online banking systems: An empirical study using extended TAM*. Review of. *International Journal of Research in Business and Social Science (2147-4478)* **9 (1)**, 112-6.

Houghton, J., 2009, *ICT and the environment in developing countries: opportunities and developments*. Review of. *Organization for Economic Cooperation and Development*.

Huang, Z., Yu, H., Peng, Z., Feng, Y., 2017, *Planning community energy system in the industry 4.0 era: Achievements, challenges and a potential solution*. Review of. *Renewable and Sustainable Energy Reviews* **78**, 710-21.

"Hurricanes and Typhoons Forecasting." 2021. <https://www.downtoearth.org.in/news/natural-disasters/hurricane-dorian-a-big-slow-and-very-unpredictable-storm-66468>.

Kasemsap, K. 2018. "Cloud computing, green computing, and green ICT." In *Cloud computing technologies for green enterprises*, 28-50. IGI Global.

Kessy, J.F., Nsokko, E., Kaswamila, A., Kimaro, F., 2016, *Analysis of drivers and agents of deforestation and forest degradation in Masito forests, Kigoma, Tanzania*. Review of. *International Journal of Asian Social Science* **6 (2)**, 93-107.

Khan, N., Baloch, M.A., Saud, S., Fatima, T., 2018, *The effect of ICT on CO 2 emissions in emerging economies: does the level of income matters?* Review of. *Environmental Science and Pollution Research* **25 (23)**, 22850-60.

Lange, S., Pohl, J., Santarius, T., 2020, *Digitalization and energy consumption. Does ICT reduce energy demand?* Review of. *Ecological Economics* **176**, 106760.

Lausch, A., Borg, E., Bumberger, J., Dietrich, P., Heurich, M., Huth, A., Jung, A., Klenke, R., Knapp, S., Mollenhauer, H., 2018, *Understanding forest health with remote sensing, part III: requirements for a scalable multi-source forest health monitoring network based on data science approaches.* Review of. *Remote sensing* **10 (7)**, 1120.

Lee, S., Lee, S., Lee, M.-J., Jung, H.-S., 2018, *Spatial assessment of urban flood susceptibility using data mining and geographic information System (GIS) tools.* Review of. *Sustainability* **10 (3)**, 648.

Liu, X., Wang, X., Wright, G., Cheng, J.C., Li, X., Liu, R., 2017, *A state-of-the-art review on the integration of Building Information Modeling (BIM) and Geographic Information System (GIS).* Review of. *ISPRS International Journal of Geo-Information* **6 (2)**, 53.

Loshkovska, S., Koceski, S. 2015. *ICT innovations 2015: Emerging technologies for better living.* Vol. 399: Springer.

Majeed, M.T., 2018, *Information and communication technology (ICT) and environmental sustainability in developed and developing countries.* Review of. *Pakistan Journal of Commerce and Social Sciences* **12 (3)**, 758-83.

Manjarrés, A., Pickin, S., Artaso, M.A., Gibbons, E., 2021, *AI4Eq: For a true global village not for global pillage.* Review of. *IEEE Technology and Society Magazine* **40 (1)**, 31-45.

Mohanty, C., 2011, *Reduce, reuse and recycle (the 3Rs) and resource efficiency as the basis for sustainable waste management.* Review of. *Proceedings of the Synergizing Resource Efficiency with Informal Sector towards Sustainable Waste Management, New York, NY, USA* **9**.

Mohapatra, H., Rath, A.K., 2019, *Detection and avoidance of water loss through municipality taps in India by using smart taps and ICT.* Review of. *IET wireless sensor systems* **9 (6)**, 447-57.

Moletsane, R. 2019. Awareness of Information and Communication Technology Induced Climate Change and the Developing Countries. Paper presented at the Computer Science On-line Conference.

N'dri, L.M., Islam, M., Kakinaka, M., 2021, *ICT and environmental sustainability: Any differences in developing countries?* Review of. *Journal of Cleaner Production* **297**, 126642.

Orantes-Jimenez, S.-D., Zavala-Galindo, A., Vazquez-Alvarez, G., 2015, *Paperless Office: a new proposal for organizations.* Review of. *Systemics, Cybernetics and Informatics* **13 (3)**, 47-55.

Pouri, M.J., Hilty, L.M. 2018. "ICT-enabled sharing economy and environmental sustainability—a resource-oriented approach." In *Advances and New Trends in Environmental Informatics*, 53-65. Springer.

Radnan, P.Y., Purba, J.T., 2018, *The use of Information Communication Technology (ICT) as the technology acceptance model (TAM) of mobile banking.* Review of. *Jurnal Manajemen dan Pemasaran Jasa* **9 (2)**, 283-98.

Shehzad, K., Xiaoxing, L., Sarfraz, M., 2021, *Envisaging the asymmetrical association among FDI, ICT, and climate change: a case from developing country.* Review of. *Carbon Management*, 1-15.

Shrestha, D., Jeong, S.R., 2016, *An ICT framework for tourism industry of Nepal: prospect and challenges.* Review of. *Journal of Internet Computing and Services (JICS)* **6**, 113-22.

Soma, K., Onwezen, M.C., Salverda, I.E., van Dam, R.I., 2016, *Roles of citizens in environmental governance in the Information Age—four theoretical perspectives*. Review of. *Current Opinion in Environmental Sustainability* **18**, 122-30.

Soori, M., Arezoo, B., 2021, *Virtual Machining Systems for CNC Milling and Turning Machine Tools: A Review*. Review of. *International Journal of Engineering and Future Technology* **1 (18)**, 56-104.

Soori, M., Arezoo, B., Habibi, M., 2013, *Dimensional and geometrical errors of three-axis CNC milling machines in a virtual machining system*. Review of. *Computer-Aided Design* **45 (11)**, 1306-13.

Soori, M., Arezoo, B., Habibi, M., 2014, *Virtual machining considering dimensional, geometrical and tool deflection errors in three-axis CNC milling machines*. Review of. *Journal of Manufacturing Systems* **33 (4)**, 498-507.

Soori, M., Arezoo, B., Habibi, M., 2016, *Tool deflection error of three-axis computer numerical control milling machines, monitoring and minimizing by a virtual machining system*. Review of. *Journal of Manufacturing Science and Engineering* **138 (8)**.

Soori, M., Arezoo, B., Habibi, M., 2017, *Accuracy analysis of tool deflection error modelling in prediction of milled surfaces by a virtual machining system*. Review of. *International Journal of Computer Applications in Technology* **55 (4)**, 308-21.

Soori, M., Asamel, M., 2020, *Mechanical Behavior of Materials in Metal Cutting Operations, A Review*. Review of. *Journal of New Technology and Materials* **10 (2)**.

Soori, M., Asamel, M., Solyali, D., 2020, *Recent Development in Friction Stir Welding Process: A Review*. Review of. *SAE International Journal of Materials and Manufacturing* **14 (1)**, 18.

Soori, M., Asmael, M., 2021, *CLASSIFICATION OF RESEARCH AND APPLICATIONS OF THE COMPUTER AIDED PROCESS PLANNING IN MANUFACTURING SYSTEMS*. Review of. *Independent Journal of Management & Production* **12 (5)**, 1250-81.

Soori, M., Asmael, M., 2021, *Virtual Minimization of Residual Stress and Deflection Error in Five-Axis Milling of Turbine Blades*, *Strojniski Vestnik/Journal of Mechanical Engineering*, **67 (5)**, 235-244.

Wang, Y., Rodrigues, V.S., Evans, L., 2015, *The use of ICT in road freight transport for CO2 reduction—an exploratory study of UK's grocery retail industry*. Review of. *The International Journal of Logistics Management*.