IT as a Green Enabler to Save the World for the Future of Life on Earth: A Review.

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DOI: https://doi.org/10.51584/IJRIAS.2024.909007

Received: 23 August 2024; Accepted: 16 September 2024; Published: 30 September 2024

ABSTRACT

As global environmental challenges escalate, the role of Information Technology (IT) as a catalyst for sustainable development has become increasingly significant. This research explores how IT can be leveraged as a green enabler to address environmental issues, reduce carbon footprints, and foster ecological resilience. This study illustrates how digital technologies contribute to energy efficiency, resource optimization, and the transition to a circular economy by critically reviewing current IT innovations, such as cloud computing, big data analytics, and the Internet of Things (IoT), additionally, the study examines the potential of IT to influence behavioral change, enhance environmental monitoring, and support policy-making aimed at sustainability. The findings suggest that by integrating IT into environmental strategies, we can create scalable solutions that not only mitigate the impact of climate change but also ensure the preservation of life on Earth for future generations.

Keywords: Information and communication technologies, Environmental Management Plan.

INTRODUCTION

The 21st century is marked by unprecedented environmental challenges such as: climate change, biodiversity loss, and resource depletion. As these issues intensify, the urgency to develop innovative and sustainable solutions has never been greater. Information Technology (IT), traditionally viewed as a driver of economic growth and efficiency, is now emerging as a pivotal force in the global effort to combat environmental degradation. This paper explores the transformative potential of IT as a "green enabler"a tool that can significantly contribute to environmental sustainability and the preservation of life on Earth. The concept of IT as a green enabler revolves around the idea that digital technologies, when harnessed effectively, can lead to substantial reductions in environmental impact. From optimizing energy use in data centers to enabling smarter resource management through the Internet of Things (IoT), IT has the capacity to revolutionize the way we interact with our environment. Additionally, advancements in big data analytics and artificial intelligence (AI) are providing new insights into environmental trends, allowing for more informed decision-making and proactive interventions. This paper will investigate various ways in which IT can be deployed to reduce carbon emissions, enhance energy efficiency, and promote sustainable practices across industries. It will also explore the role of IT in supporting the transition to a circular economy, where waste is minimized, and resources are continuously reused. Furthermore, the paper will consider the broader implications of IT-driven sustainability, including its potential to influence public policy, drive behavioral change, and empower communities to take action for the environment. As we confront the environmental challenges of our time, it is clear that IT will play a crucial role in shaping a sustainable future. By examining the intersection of technology and environmental stewardship, this research aims to highlight the critical importance of IT as a green enabler, capable of driving the systemic changes needed to save the world for the future of life on Earth.

Initiatives towards Green ICT

The concept of Green Information and Communication Technology (Green ICT) involves the design, implementation, and use of ICT solutions in an environmentally sustainable manner. Green ICT aims to

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

minimize the environmental impact of ICT activities by reducing energy consumption, promoting efficient resource use, and mitigating electronic waste (e-waste). Over the past few decades, various initiatives have been launched globally to promote Green ICT, driven by the increasing recognition of ICT's role in both contributing to and solving environmental challenges. Initiatives towards Green ICT are crucial in the global effort to create a more sustainable future. By reducing the environmental impact of ICT operations, promoting energy efficiency, and encouraging the responsible management of resources, these initiatives are helping to align technological advancement with environmental stewardship. As Green ICT continues to evolve, ongoing collaboration between governments, corporations, and civil society will be essential to driving innovation and achieving meaningful progress in the fight against climate change

LITERATURE REVIEW

Empirical evidence from various economies around the world support the idea that energy-ICT has significant benefits with regards to the promotion of energy efficiency, emissions reduction, and economic growth. According to Lungu et al, (2014) demonstration using numerical simulations observed that a smart grid integrating micro-generation, energy storage, and efficient appliances can effectively improve energy efficiency. Additionally, ICT as the core technology of smart grids collects data and provides optimized feedback, hence constituting a two-way communication path with consumers. Consequently, the energy-ICT model saves the energy cost and improves energy efficiency. Lu Y., (2021) research on a panel dataset of 12 Asian countries from 1993-2018, shows that increases in carbon emissions is a result of increases in energy consumption and GDP, whereas the development of Green ICT reduces carbon emissions. Lange S, & Santarius T., (2020). Study on Green ICT concludes that Green ICT plays a major contribution to the country's energy efficiency improvement, especially in the sectors of manufacturing, building, transportation, agriculture, and public services (Wabwoba et al, 2016). Both of them acknowledged that the combination of new energy sources and ICT helps replace and reduce the proportion of traditional fossil fuels. Additionally, they made a suggestion that green ICT development should be advocated for through enactment of national- level policies and also pilot demonstration projects ought to show how green ICT can fit into China's natural and social environment in order to make contributions. Analysis into the 2002– 2017 sectoral data of China, (Dao V., Langella I., Carbo J., 2011) established that even though ICT accounts for a 4.54% increase in China's energy intensity, the net effect of ICT development is to reduce energy consumption in China. Moreover, the positive net effects of ICT development are even larger in the service and technology-intensive sectors. They conclude that the deeper and wider development of ICT is preferred from a social viewpoint rather than from the viewpoints of energy savings and productivity enhancement. Another study by (Lange S, & Santarius T, 2020) established that the smart grid helps maintain the power supply and consumption and hence brings down the impacts. Therefore, the smart grid becomes even more handy after the COVID-19 pandemic, as observed by (Kuo B., 2015) the enhancement of ICT, including digitalization and the Internet of Things (IoT), supports the circular economy and renewable energy development under the COVID- 19 pandemic impact.

Problem of the Study

The rapid advancement of Information Technology (IT) has brought about significant benefits, including improved efficiency, connectivity, and economic growth. However, these advancements have also contributed to substantial environmental challenges. The energy consumption of data centers, the proliferation of electronic waste (e-waste), and the carbon footprint associated with IT infrastructure are growing concerns. As society becomes increasingly dependent on digital technologies, the environmental impact of IT is expected to rise, potentially exacerbating the very issues it aims to solve. The central problem addressed by this study is the paradox of IT's dual role as both a contributor to and a potential solution for environmental degradation. While IT has the potential to act as a powerful enabler of sustainable practices, the sector's own environmental footprint cannot be ignored. This duality presents a significant challenge: how can IT be effectively harnessed as a green enabler without exacerbating its environmental impact? This study aims to explore and address these challenges by investigating how IT can be optimized as a green enabler. It will analyze current trends, identify barriers to sustainable IT practices, and propose strategies to mitigate the environmental impact of the IT sector. By doing so, the research seeks to contribute to a deeper understanding of how IT can be leveraged to save the world for the future of life on Earth, while ensuring that its own footprint is minimized

ISSN No. 2454-6194 | DOI: 10.51584/IJRIAS |Volume IX Issue IX September 2024

METHODOLOGY

Content Analysis is a research method for interpreting and quantifying textual data such as speeches, interviews and articles. The researcher employed Content Analysis Research method in ascertaining whether Green ICT determinants have an impact on implementation of the energy-ICT model that saves the energy cost and improves energy efficiency and are also eco-friendly. A search in several academic databases and search engines, such as ACM Digital Library, Web of Science, Science Direct, and IEEE Xplore Digital Library was carried out to gather evidence from scholarly articles. The keyword used was "green ICT". Through these searches, we identified 435 papers focused on green ICT and/or green IT. Titles and abstracts were analyzed to identify the articles related to determinants of green ICT from a business perspective. This process led to a final number of 70 articles that were considered for further analysis. The review covered the period between the years 2008 through 2024. The choice of the year 2008 as the starting point was guided by the fact that, the concept of green ICT had only become significant and attracted the attention of researchers from this year.

PRESENTATION OF FINDINGS

The scholarly articles on Green ICT /IT were acquired across the digital libraries and databases across the Globe and the content scope is from the year 2008 through 2024

Table 1: Green ICT/IT scholar Articles from Electronic Databases and Libraries source:

Data Sources	**2008**	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**
ACM Digital Library	**1**	**3**	**5**	**7**	**8**	**6**	**5**	**4**	**6**	**3**	**3**	**3**	**2**	**3**	**3**	**5**	**4**
Web of Science	-	**2**	-	**1**	-	-	**2**	**1**	-	**1**	-	-	**1**	-	-	**1**	**2**
Science Direct	-	**2**	-	**1**	-	-	**2**	**1**	-	**1**	-	-	**1**	-	-	**1**	**2**
IEEE Explorer	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**2**	**2**	**1**	**1**	**1**
Google Scholar	-	**1**	**1**	**1**	-	-	**1**	**1**	**1**	**1**	**1**	-	-	**1**	-	-	**1**
Scopus	-		**1**	**1**	-	-	**1**	-	-	-	-	-	-	-	-	-	-
ISI Web of Science	-	**1**	**1**	**1**	-	-	**1**	-	-	-	-	-	-	-	-	-	-
Wiley InterScience	-	**1**	**1**	**1**	-	-	**1**	**1**	-	**1**	-	-	-	-	-	-	-
Research Gate	-	**1**	**1**	**2**	**1**	**2**	**1**	**1**	**1**	**2**	**1**	**1**	**2**	**2**	**2**	**1**	**2**
Springer Link	-	-	-	**1**	-	**1**	-	-	-	-	-	-	-	-	-	-	-
Emerald.	-		-	**1**	-	-	-	-	-	-	-	-	-	-	-	-	-
Total	**3**	**10**	**12**	**17**	**11**	**11**	**14**	**10**	**10**	**9**	**6**	**5**	**7**	**8**	**6**	**8**	**11**

DISCUSSION OF FINDINGS

Green ICT adoption is influenced by three categories of determinants: motivational determinants (competitiveness, legitimacy and social responsibility), organizational determinants (related to the internal environment of organizations such as human resources and capabilities), and technological constraints (related

to ICT available on the market that can significantly limit the field of green ICT initiatives) as depicted by Kuo B., (2015). ICT manufacturers encounter competitiveness in terms of pro-environment characteristics , and this has seen larger companies competing for supremacy, according to studies published by Green Peace (2010). Two other determinants were identified, and they include: stakeholders' pressure and ethical motivations. The stakeholders can be external (regulators, community, suppliers) or internal (employees, management, and shareholders). The ethical motivations are the desire to "do well" for the environment out of a sense of social obligation. The sample population for the study was 53 companies in the UK and Japan and it unveiled that the motivations were driven by three contextual conditions: field cohesion, issue salience, and individual concern. Another category of factors constitute the changes or initiatives stimulated at national and international levels .Those initiatives include among many wide environmental priorities set by the European Union and this strategy highlighted the following objectives: investing 3% of gross domestic product in research and development, a 20% reduction in emissions of greenhouse gases (even 30% if the conditions are favorable), a 20% increase in the percentage of renewable energies and increasing energy efficiency by 20% as depicted by Johnstone et al (2010). Additionally, some components of green ICT involve major investment and hence makes the financial strength of the company another important factor for the use of ICT consistent with the company's environmental footprint. Large companies have an edge over small ones since they have the financial resources to invest in ICT hence their ability to replace equipment and applications with eco-friendly ones is higher or, more appropriately, opportunities to invest in innovation in green ICT are bigger.

Organization characteristics also play an important role in determining green ICT adoption. Ashford A., (2010) observes that Organization characteristics entail desire, exploitation of opportunities and the ability to innovate. Desire is influenced by the attitude towards the industry, by the comprehension of possible options and solutions and the ability to evaluate alternatives. The exploitation of opportunities is concerned with the supply and demand in the company's activity field. This takes into consideration possible gaps between existing technologies in the company and industry and the pressures arising from relationships with partners that could stimulate investment innovation. Potential savings might trigger the demand for adoption of greener products due to pressures from the consumers and employees. Ashford A., & Hall R., (2011) also observed that the company's "capacity to innovate", is reflected in the company's desire to be involved in the innovative process, as well as the existence of the necessary skills and collaboration with the external environment. Since Green ICTs have specific determinants as well, these make this field different from the other EMPs. Cloud Computing model integrates existing technologies and models, in order to optimize the use of physical and logical resources. In the case of cloud computing, the responsibility for software updates, security, disaster recovery and storage of information is under the responsibility of the cloud services provider. The support for the implementation of EMPs is another specific determinant of adopting green ICT. Green ICT can be used for measuring, monitoring and performance-checking of the various emissions generated by the devices employed in the organization's activities. However, green ICT provides the necessary tools for comparing the performance in reducing carbon emissions across organizations and multiple industry sectors as well as facilitating the understanding of the economic advantage of green initiatives among competing organizations as depicted by (Rexhäuser et al,2015).The implementation of some collaborative green business processes, based on green web services, is conditioned by the adoption of green ICT and constitutes the base of the corporate environmental strategy. The situation is similar for modelling and implementation of new green processes, which is impossible to achieve without adoption of green ICT, and, at a broader level, without implementing a green information system. Finally, the last determinant specific to the adoption of green ICT that we have identified is harnessing the potential of the presence in the virtual environment without adversely affecting the company's image. Virtual environments promote environmental protection (such as green cloud computing, green web, green social networks, etc.) and help to minimize its influences on the ecosystem.

IMPLICATIONS AND RECOMMENDATIONS

The desire for Green ICT adoption by the industry is an ecologically friendly initiative, however, it is subject to both internal and external drivers in the Information Technology industry. The initiatives stimulated at the international and national level help manufacturers align their products as per the requirements from the collaborative grids. Furthermore, organizational characteristics agitated by the supplies and consumers of ICT products pushing manufacturers to conform to recommendation of parameters from the collaborative grids.

However, the financial stamina of the manufacturers has been a predicament towards realization of the requirements from the collaborative grids since only big companies have been able to implement the initiatives.

SUMMARY AND CONCLUSIONS

The rapid evolution of Information Technology (IT) has not only transformed global economies but also significantly impacted the environment. As this research highlights, IT possesses a unique duality: it is both a contributor to environmental challenges and a powerful enabler of sustainable solutions. This dual role places IT at the heart of the global effort to address climate change, resource depletion, and other critical environmental issues. The study has examined the potential of IT to act as a green enabler, focusing on how digital technologies can reduce carbon footprints, enhance energy efficiency, and promote sustainability across various sectors.

Key findings from the research underscore the transformative power of IT in fostering a sustainable future. Initiatives such as energy-efficient data centers, sustainable ICT procurement, and green networking technologies demonstrate how IT can be optimized to minimize environmental impact. Moreover, the integration of advanced technologies like cloud computing, the Internet of Things (IoT), and artificial intelligence (AI) into environmental strategies has shown promise in enhancing resource management, reducing waste, and improving environmental monitoring.

However, the research also identifies significant challenges that must be addressed to fully realize IT's potential as a green enabler. The energy consumption of IT infrastructure, the growing problem of electronic waste, and the sector's carbon footprint are critical concerns that require urgent attention. The study emphasizes the need for a balanced approach that leverages IT for sustainability while mitigating its environmental impact.

Conclusions

IT holds immense potential to drive the systemic changes needed to save the world for the future of life on Earth. By harnessing IT as a green enabler, we can develop scalable and sustainable solutions that address the most pressing environmental challenges of our time. However, realizing this potential requires a concerted effort from governments, corporations, and civil society. Policies and regulations must be strengthened to encourage sustainable IT practices, while businesses must adopt innovative approaches to reduce their environmental footprint. Furthermore, raising awareness and educating stakeholders about the importance of Green ICT is essential for the widespread adoption of sustainable practices. The research reaffirms that IT is not merely a tool for economic growth but a vital component of the global sustainability agenda. By integrating environmental considerations into the design, deployment, and operation of IT systems, we can ensure that technological advancement goes hand in hand with environmental stewardship. As we move forward, it is imperative that IT continues to evolve in ways that support and enhance sustainability, ultimately contributing to a healthier, more resilient planet for future generations.

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