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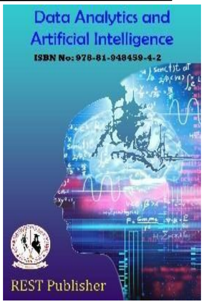

Assessing the Role of Information and Communication Technology (ICT) in Safeguarding the Environment through the Application of the MOORA Method

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Abstract. Information and Communication Technology (ICT) plays a vital role in bolstering endeavors aimed at safeguarding the environment, and the MOORA method offers a structured approach. ICT involves the use of digital tools and technologies to manage and transmit information, enabling real-time data collection, analysis, and communication. In environmental protection, ICT aids in various ways, such as monitoring air and water quality, tracking wildlife patterns, and managing waste disposal. The MOORA method is a decision-making technique that helps prioritize alternatives based on multiple conflicting criteria. In the context of environmental protection, the MOORA method assists in selecting the most effective ICT solutions. It evaluates various ICT options by considering multiple objectives, such as efficiency, cost-effectiveness, ecological impact, and scalability. MOORA computes ratios to compare alternatives against each criterion, enabling a comprehensive assessment. By assigning weights to the criteria, stakeholders can emphasize specific factors according to their importance. For instance, when choosing between different ICT systems for waste management, the MOORA method can quantify the ecological benefits of reduced emissions, energy savings, and waste reduction against factors like implementation costs and technological feasibility. This systematic evaluation ensures that the chosen ICT solution aligns with the overall goal of environmental protection while considering practical constraints. ICT leverages advanced technologies to bolster environmental protection, and the MOORA method provides a structured approach to assess and prioritize ICT solutions. This combined approach facilitates informed decision-making, leading to the adoption of efficient and sustainable technologies that contribute to a healthier planet. The Smart Grid System (A1), E-waste Recycling Program (A2), Air Quality Monitoring Network (A3), Water Pollution Detection Sensors (A4), Green Supply Chain Management Software (A5), and Virtual Environmental Education Platform (A6) are employed as alternative solutions. These alternatives are assessed based on their ability to achieve Reduction in Environmental Impact (C1), Enhancement of Efficiency (C2), Cost Efficiency (C3), and User-Friendliness (C4).The environmental production of E-waste Recycling Program is got first rank and Smart Grid System is got lowest rank.

1. INTRODUCTION

During the early 1970s, India initiated substantial efforts to combat environmental pollution. In 1973, the country organized its inaugural national conference focused on environmental preservation. At that time, a significant portion of major rivers had experienced declining water quality, urban areas were grappling with polluted river segments and groundwater sources, metropolitan regions were shrouded in dense air pollution and smog, extensive farmlands were deteriorating rapidly, and industrial as well as pesticide-related pollution had reached critical levels. In response to these circumstances, India embarked on its environmental protection journey with a predominant focus on mitigating and averting pollution.This article contributes to the identification of policy perspectives that can facilitate Indian's ongoing and future sustainable development by effectively balancing economic growth and environmental concerns. The paper commences by analysing policies, particularly focusing on significant shifts in Preserving the environment and promoting sustainable growth in Indiasince its global integration. Section 2 critically examines these changes. Building upon insights derived from policy transformations in India and other nations, and assessing current challenges in India's environmental and economic landscape, Section 3 presents and deliberates on the potential direction of key policies aimed at achieving sustainable development. Finally, the conclusions encapsulate the findings of this study. India, as a developing nation, initiated pollution control and ecological preservation measures when its GDP per capita was below $300. The strategies employed by the Indian government for environmental protection have evolved since the 1980s.Pesticides, fertilizers, industrial substances, and waste materials, along with emissions from fossil fuels and runoff from residential areas, have resulted in the contamination of a considerable portion of our freshwater reservoirs. About 33% of lake acreage and 15% of the total river length in the Indian region have been so heavily polluted by substances like mercury and PCBs that the Indian Environmental Protection Agency (EPA) has released advisories cautioning against consuming certain or all fish species due to safety concerns (Indian Environmental Protection Agency, 2003b). As numerous water bodies remain untested, the EPA suggests that pregnant women and young children restrict their consumption of fish caught from Indian freshwater sources to no more than six ounces and two ounces per week, respectively. The issue of mercury pollution is also prominent in oceans. For ocean-dwelling species, the EPA advises pregnant women and children to avoid consuming large types like shark and swordfish, and to limit their overall weekly fish intake to 12 ounces or less (Indian Environmental Protection Agency, 2002).In previous studies, companies were usually chosen randomly for examination, which could potentially result in a scenario where these companies only had favourable environmental news to share. This current research goes beyond that. It delves deeper into the analysis by exploring the ecological disclosure actions exhibited by a particular set of 20 Australian corporations in their reporting. These companies had been legally pursued and brought to legal action by the Environmental Protection Authorities (EPA) of New South Wales and Victoriain a defined timeframe.The enforcement of human rights among member nations has been minimal, as the UN system lacks the necessary authority to support the numerous treaties it has enthusiastically endorsed. Beyond the realm of human rights, such as environmental conservation, the issue of national sovereignty has posed a significant challenge, impeding the development of global or regional solutions needed to address various environmental crises. A clear illustration of this problem can be seen in the Copenhagen negotiations of 2009. To exacerbate the situation, the indifference towards the natural world, as mentioned earlier, is also apparent in a substantial portion of international human rights law. Consequently, governments disinterested in safeguarding the environment can exploit human rights-based arguments to justify harmful actions.

2. MATERIALS AND METHOD

2.1. Material: The Smart Grid System (A1), E-waste Recycling Program (A2), Air Quality Monitoring Network (A3), Water Pollution Detection Sensors (A4), Green Supply Chain Management Software (A5), and Virtual Environmental Education Platform (A6) are employed as alternative solutions. These alternatives are assessed based on their ability to achieve Reduction in Environmental Impact (C1), Enhancement of Efficiency (C2), Cost Efficiency (C3), and User-Friendliness (C4).

Smart Grid System (A1): A cutting-edge ICT solution that intelligently manages electricity distribution, minimizing wastage and carbon emissions by optimizing power flow and integrating renewable energy sources, thus fostering a sustainable energy ecosystem.

E-waste Recycling Program (A2): Leveraging ICT tools to streamline the collection, processing, and recycling of electronic waste, this initiative promotes responsible disposal, resource recovery, and pollution reduction through efficient tracking and management of electronic waste materials.

Air Quality Monitoring Network (A3): Utilizing ICT infrastructure for real-time data collection and analysis, this network provides accurate air quality insights to support prompt interventions and policy decisions, ultimately enhancing public health and urban environmental quality.

Water Pollution Detection Sensors (A4): Employing advanced ICT sensors to detect and report water pollution incidents promptly, this technology safeguards water bodies by enabling rapid response measures and contributing to the preservation of aquatic ecosystems.

Green Supply Chain Management Software (A5): Integrating ICT solutions into supply chain processes, this software optimizes resource utilization, reduces waste, and enhances transparency, fostering sustainable practices across the supply chain while minimizing environmental impact.

Virtual Environmental Education Platform (A6): A web-based ICT platform offering immersive and interactive environmental education experiences, empowering users to explore, learn, and engage with eco-conscious content, raising awareness and promoting sustainable behaviour for a greener future.

Reduction in Environmental Impact (C1): This criterion measures the extent to which the ICT solution contributes to reducing environmental pollution, energy consumption, and resource depletion.
Efficiency Improvement (C): This criterion evaluates how effectively the ICT solution optimizes resource utilization, reduces waste, and enhances overall environmental efficiency.
Cost Effectiveness (C3): This criterion assesses the economic feasibility of implementing the ICT solution, considering initial costs, operational expenses, and potential cost savings over time.
User-Friendliness (C4): This criterion measures the user-friendliness and accessibility of the ICT solution, considering ease of use, intuitive interface, and user satisfaction.

2.2. Method:MOORA presents a multi-dimensional approach to decision-making that offers substantial promise for comprehensive analysis evaluating different options in the face of significant diversity and a multitude of influential factors. MOORA, conceived by Brauers and Zavadskas in 2006, falls under the category of multi-objective optimization methods aimed at adeptly addressing complex decision-making dilemmas.This method aims to identify the optimal choice by taking into account a set of criteria that often conflict with each other. In essence, MOORA method simultaneously considers both advantageous and disadvantageous criteria. Noteworthy advantages associated with MOORA, in comparison to certain existing decision-making methodologies, encompass reduced mathematical computations, shorter computational durations, heightened simplicity, and greater stability when contrasted with various other multi-criteria decision-making approaches.Multi-objective optimization using ratio analysis (MOORA), sometimes called multi-criteria or multi-attribute optimization, encompasses the simultaneous optimization of two or more contradictory attributes (objectives) while maintaining predetermined constraints.This technique finds extensive utility in resolving decisions within intricate and contradictory realms of the supply chain domain. Its applications span a diverse spectrum, including tasks such as opting for warehouse locations, choosing suppliers, and selecting products and process designs. Whenever the need arises for optimal choices in decision-making, MOORA can be effectively employed. Decision-making, in this context, encompasses the process of establishing decision objectives, collecting pertinent data, and ultimately selecting the most advantageous alternative. Brauers and Zavadskas (2012) conducted an extensive analysis of notable MCDM (Multi-Criteria Decision Making) techniques. Drawing from this evaluation and considering the documented applications of the MOORA method in various journal publications, it becomes evident that the MOORA approach is highly effective and relatively user-friendly. Consequently, this paper introduces an enhancement to the MOORA methodology, facilitating the incorporation of triangular fuzzy numbers. This augmentation aims to broaden the method's applicability, enabling its utilization in tackling a wide array of decision-making challenges.Numerous strategies exist for multi-criteria decision-making (MCDM). These encompass various approaches such as the analytical hierarchy process (AHP), the technique for order preference by similarity to ideal solution (TOPSIS), utilization of graph theory and matrix methodology, VIKOR technique, and multi-objective optimization relying on the ratio (MOORA) principle.However, choosing the appropriate method for addressing fleet management challenges poses a notable difficulty and remains underexplored. Chakraborty (2011) highlighted some advantages of MOORA in comparison to other multi-attribute decision-making methods. MOORA stands out for its efficient computational time during mathematical calculations and its minimal parameter requirements, setting it apart from VIKOR and grey relational analysis methods, Karande and Chakraborty (2012) pointed out that the relative rankings of choices are impacted by the weights assigned to criteria and the normalization procedure.Moreover, certain methods in this realm can be intricate to grasp and demanding to apply due to their reliance on advanced mathematical knowledge. Hence, decision-makers seek a straightforward, coherent, and methodical approach for resolving fleet management concerns. To address these needs, the MOORA technique, reference point approach, and multi-MOORA methodology are selected as appropriate alternatives.

3. RESULT AND DISCUSSION

TABLE 1. Environmental protection

	C1	C2	C3	C4
A1	12.87	12.55	15.85	9.43
A2	16.65	14.53	15.55	7.98
A3	12.69	11.33	14.75	4.96
A4	12.56	12.64	13.85	7.89
A5	8.97	7.33	13.85	9.54
A6	15.38	16.77	15.76	10.64

Show the table 1 environmental production for using multi-objective optimization on the basis of ratio. The alternatives are Smart Grid System (A1), E-waste Recycling Program (A2), Air Quality Monitoring Network (A3), Water Pollution Detection Sensors (A4), Green Supply Chain Management Software (A5), and Virtual Environmental Education Platform (A6). The evaluation parameters are Reduction in Environmental Impact (C1), Enhancement of Efficiency (C2), Cost Efficiency (C3), and User-Friendliness (C4).

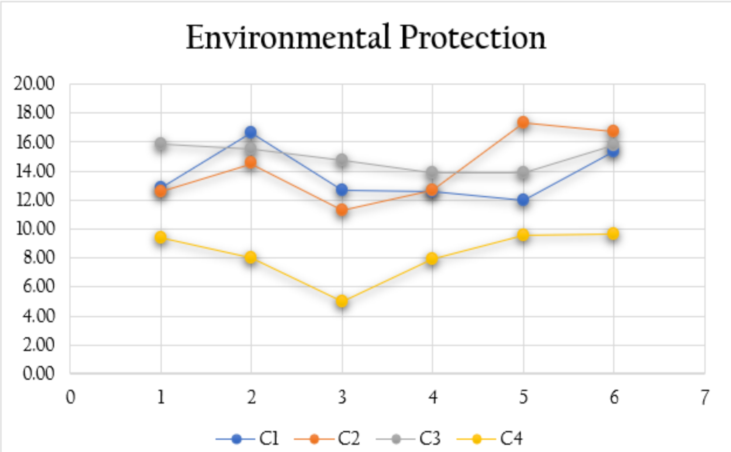

FIGURE 1. Environmental Protection

Show the figure 1 environmental production for using multi-objective optimization on the basis of ratio. The alternatives are Smart Grid System (A1), E-waste Recycling Program (A2), Air Quality Monitoring Network (A3), Water Pollution Detection Sensors (A4), Green Supply Chain Management Software (A5), and Virtual Environmental Education Platform (A6). The evaluation parameters are Reduction in Environmental Impact (C1), Enhancement of Efficiency (C2), Cost Efficiency (C3), and User-Friendliness (C4).

TABLE 2. Square value

	Square value			
A1	165.6369	157.5025	251.2225	88.9249
A2	277.2225	211.1209	241.8025	63.6804
A3	161.0361	128.3689	217.5625	24.6016
A4	157.7536	159.7696	191.8225	62.2521
A5	143.2809	300.3289	191.8225	91.0116
A6	236.5444	281.2329	248.3776	92.9296
Sum	1141.4744	1238.3237	1342.6101	423.4002

Shows the table 2 environmental production square root value and sum value.

TABLE 3. Normalized Data

	Normalized Data			
A1	0.3809	0.3566	0.4326	0.4583
A2	0.4928	0.4129	0.4244	0.3878
A3	0.3756	0.3220	0.4025	0.2410
A4	0.3718	0.3592	0.3780	0.3834
A5	0.3543	0.4925	0.3780	0.4636
A6	0.4552	0.4766	0.4301	0.4685

Shows the table 3 environmental production normalized data matrix value.The alternatives are Smart Grid System (A1), E-waste Recycling Program (A2), Air Quality Monitoring Network (A3), Water Pollution Detection Sensors (A4), Green Supply Chain Management Software (A5), and Virtual Environmental Education Platform (A6). The evaluation parameters are Reduction in Environmental Impact (C1), Enhancement of Efficiency (C2), Cost Efficiency (C3), and User-Friendliness (C4).

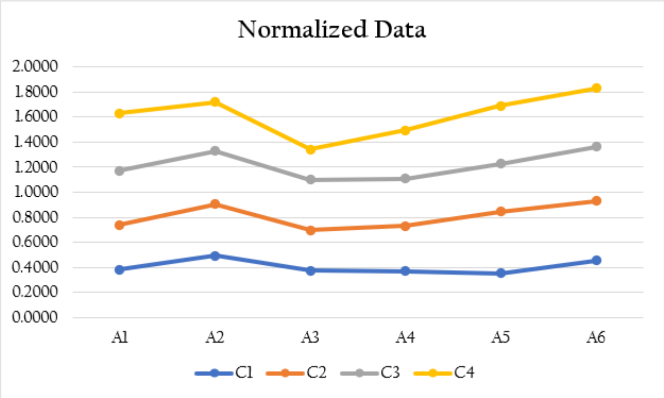

FIGURE 2. Normalized Data

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TABLE 4. Weight

	Weight			
A1	0.25	0.25	0.25	0.25
A2	0.25	0.25	0.25	0.25
A3	0.25	0.25	0.25	0.25
A4	0.25	0.25	0.25	0.25
A5	0.25	0.25	0.25	0.25
A6	0.25	0.25	0.25	0.25

Shows the table 4 environmental production weight are same value 0.25.

TABLE 5. Weighted normalized decision matrix

	Weighted normalized decision matrix			
A1	0.0952	0.0892	0.1081	0.1146
A2	0.1232	0.1032	0.1061	0.0970
A3	0.0939	0.0805	0.1006	0.0603
A4	0.0929	0.0898	0.0945	0.0959
A5	0.0886	0.1231	0.0945	0.1159
A6	0.1138	0.1191	0.1075	0.1171

Shows the table 5 environmental production weighted normalized decision matrixalternatives are Smart Grid System (A1), E-waste Recycling Program (A2), Air Quality Monitoring Network (A3), Water Pollution Detection Sensors (A4), Green Supply Chain Management Software (A5), and Virtual Environmental Education Platform (A6). The evaluation parameters are Reduction in Environmental Impact (C1), Enhancement of Efficiency (C2), Cost Efficiency (C3), and User-Friendliness (C4).

TABLE 6. Assessment value and Rank

	Assessment value	Rank
A1	-0.0383	6
A2	0.0234	1
A3	0.0135	2
A4	-0.0076	5
A5	0.0013	4
A6	0.0083	3

Shows the table 6 assessment value and rank of environmental production. A2 has the highest assessment value (0.0234) and is assigned the rank of 1, indicating that it has the best evaluation among the listed entities. A3 follows closely with an assessment value of 0.0135 and is ranked second (rank 2). A6 has an assessment value of 0.0083, earning it the rank of third (rank 3). A5 and A4 have assessment values of 0.0013 and -0.0076, respectively, resulting in ranks of fourth (rank 4) and fifth (rank 5). A1 has the lowest assessment value of -0.0383 and is ranked sixth (rank 6), indicating the lowest evaluation among all the entities.

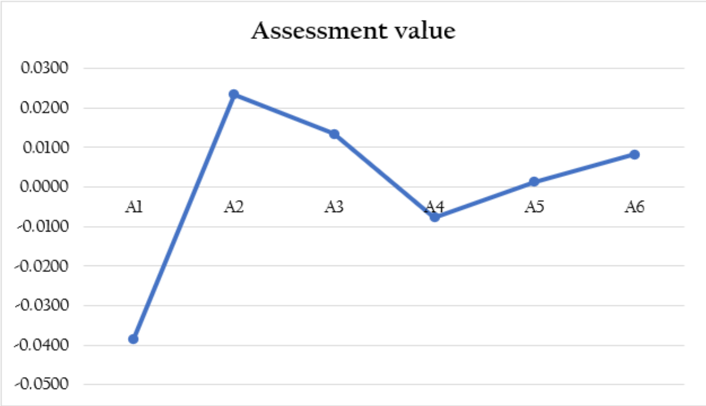

FIGURE 3. Assessment Value

Shows the figure 3 assessment value of environmental production. The assessment value for A1 is -0.0383. This suggests that A1 has received a negative assessment, indicating it may perform below a certain standard or expectation in the given context. A2 has an assessment value of 0.0234. This value is positive, indicating a relatively favourable evaluation or performance of A2 based on the criteria being measured. The assessment value for A3 is 0.0135. Like A2, this value is positive, suggesting that A3's evaluation is also relatively favourable, though perhaps to a slightly lesser extent. A4 has an assessment value of -0.0076. Similar to A1, this negative value implies that A4's performance or evaluation is below a certain standard. The assessment value for A5 is 0.0013. This value is very close to zero, indicating a neutral or nearly neutral assessment of A5. A6's assessment value is 0.0083. Again, this is a positive value, suggesting that A6's performance or evaluation is relatively favourable.

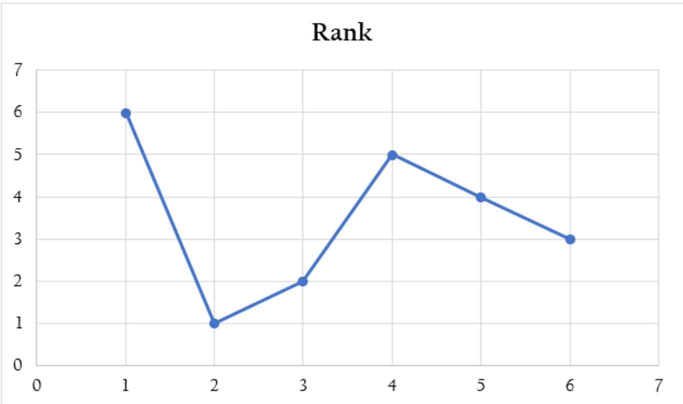

FIGURE 4. Environmental Protection Ranking

Shows the figure 4 environmental production ranking. we can interpret that A2 holds the highest rank (Rank 1), signifying that it is the most effective or significant contributor to environmental protection among the listed entities or factors. Conversely, A1 holds the lowest rank (Rank 6), indicating that it is the least effective or least significant in terms of environmental protection among the listed entities.

4. CONCLUSION

The incorporation of Information and Communication Technology (ICT) into environmental safeguarding, utilizing the MOORA approach, represents a significant stride in tackling the intricate challenges confronting our world today. This research delved deeply into the potential transformation brought about by the amalgamation of ICT and the MOORA method in the realm of ecological preservation. The results underscored the fundamental significance of this synergy in enhancing decision-making, resource allocation, and overall sustainability endeavours. The MOORA technique, renowned for its adeptness in handling diverse criteria and goals, emerged as a potent instrument for evaluating and prioritizing an array of initiatives for environmental protection. Its proficiency in evaluating both quantitative and qualitative elements provide a comprehensive framework for selecting the most effective strategies. Through harnessing the capabilities of ICT, the processes of data collection, analysis, and dissemination have been streamlined, enabling real-time monitoring and adaptive management. This dynamic approach empowers stakeholders to promptly respond to shifts in the environment, thus minimizing adverse effects and cultivating a more resilient ecosystem. Moreover, the triumphant application of ICT-driven MOORA methodologies hinges on collaborative endeavours involving governments, industries, academia, and communities. By means of open sharing of data, exchange of knowledge, and technological innovation, a collective force can drive sustainable development onward. The instances highlighted in this analysis vividly depict the tangible advantages arising from such partnerships, ranging from efficient waste management systems to intelligent energy consumption solutions. While envisioning the future, it becomes evident that the fusion of ICT and the MOORA technique is primed to play an essential role in shaping environmental policies and actions. Nevertheless, challenges such as digital equity, concerns surrounding privacy, and the rapid pace of technological progression must be addressed judiciously. Ethical considerations should steer the integration of these tools, ensuring that the benefits are equitably distributed and in alignment with the long-term well-being of the environment. In essence, the synergy between ICT and the MOORA method harbours immense potential for guiding humanity towards a more sustainable and harmonious rapport with our planet. By leveraging the potential of data, technology, and collective wisdom, we possess the capability to transcend existing limitations and forge a route towards a more ecologically sound, healthier future for generations to come. The path ahead necessitates unwavering dedication, innovation, and a shared resolve to safeguard our environment – a journey in which ICT and the MOORA method will unquestionably prove invaluable companions. The environmental production of E-waste Recycling Program is got first rank and Smart Grid System is got lowest rank.

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