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Optimizing Solid Waste Management Using the EDAS Method: A Multi-Criteria Decision-Making Approach

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Abstract: *Introduction: Globally, the production of municipal solid waste (MSW) has significantly increased as a result of the fast urbanization, industrialization, and population rise. Particularly in poorer nations, improper waste management poses major threats to the environment and public health. Effective and sustainable solid waste management systems are crucial to reducing the environmental impact of trash output, which is only expected to increase promote resource recovery. This research is significant as it addresses the pressing problem of managing municipal solid trash, an increasingly significant worldwide issue as a result of fast urbanization, population increase, and rising living standards. By analyzing waste management practices and challenges worldwide, the study provides valuable insights to develop sustainable solutions, reduce environmental risks, and enhance public health and living conditions. The Alternatives are Technical, Environmental, Economic, Social, Recycling & Material Recovery, Waste-to-Energy (WTE) Incineration. The Evaluation Parameters are Access to Technology (AT), Technical Reliability (TR) Environmental Feasibility (EF), Water Pollution (WP). The results show that Recycling & Material Recovery received the highest ranking, whereas Waste-to-Energy (WTE) Incineration received the lowest ranking. Recycling & Material Recovery has the highest value for solid waste management according to the EDAS approach.*

Keywords: *Municipal Solid Waste (MSW), Waste Management, Recycling, Incineration, Environmental Impact.*

1. INTRODUCTION

[1] The increasing demand for energy and goods, combined with rapid population growth and rising living standards, contributes to the significant generation of municipal solid waste. If not properly managed through disposal or recycling, this waste can pose severe environmental risks. Garbage, trash, refuse, and other abandoned materials from both urban and rural populations make up municipal solid waste. Around 2 billion tons of municipal solid garbage is produced globally each year, with nearly 33% remaining uncollected by local authorities. [2] For city officials in developing nations, managing solid waste continues to be a major concern. The main causes of this are the increased production of waste, the financial burden that high management expenses place on municipal budgets, and the absence of comprehensive understanding of the various factors influencing different stages of waste handling. Additionally, the necessary linkages for an efficient waste management system are often underdeveloped. A review of literature, focusing on research published between 2005 and 2011, revealed that only a limited number of studies provide quantitative data. This analysis was based on publications from the Waste Management Journal and Waste Management and Research, two prestigious scientific magazines. [3] In the past decade, growing concerns about air pollution from incineration facilities have led many countries to enforce strict air emission control regulations. These regulations have significantly raised the price of constructing and running incinerators. To reduce the quantity of post-recycled waste dumped in landfills, certain countries are already implementing novel tactics. They are promoting the use of incineration systems as part of an all-encompassing waste management strategy by limiting the amount of organic material in landfill-bound garbage to less than 5% approach. [4] Waste storage, collection, transportation, resource recovery, recycling, treatment, and disposal are all parts of Abuja, Nigeria's solid waste management system, which has been assessed. The Federal Environmental Protection Agency, the Abuja Environmental Protection Board,

private businesses, locals, and the informal garbage industry were among the important players from whom data was collected. The assessment identified challenges within the existing waste management infrastructure and services. Additionally, the roles of informal recycling and scavenging, as well as the institutional, administrative, and legal frameworks, were analyzed. Based on these findings, suggestions for enhancing solid waste management's efficacy and efficiency have been proposed. [5] The group accepted the task of looking into the current state of solid waste management by gathering new data from 20 representative cities worldwide. This approach aimed to depict the actual waste management situation in high-, middle-, and low-income nations. Due to the tight publishing schedule, the collected data was primarily used to support discussions and shape conclusions, leaving limited time for in-depth analysis. [6] The Solid waste production is an unavoidable consequence of human activity, and its proper removal is essential for enhancing quality of life. Initially, solid waste management (SWM) focused on simply removing waste from living areas to protect public health. However, as the dangers of uncontrolled disposal became evident, sanitary landfilling emerged as a primary solution. In recent years, advancements in material and energy recovery technologies have been integrated into modern waste management systems. Today, global efforts are increasingly directed toward making SWM more sustainable. [7] The majority of the studies reviewed relied on established models and techniques for assessment. To assess waste management systems, new techniques have also been developed, but some of the more established ones have been added to or altered. The percentage distribution of assessment techniques employed in the reviewed papers is shown in Figure 1. Remarkably, life cycle assessment (LCA) was used as a tool for waste management system evaluation in almost 41% of the 151 papers that were examined. [8] The previous classification was based on each country's GDP, dividing them into three categories: developed (GDP: US$18,610–49,660), developing (GDP: US$7,670–18,610), and underdeveloped (GDP below US$7,670). In contrast, the updated classification considered the geographical regions of the countries, grouping them based on their continental location. Only countries with recent solid waste management (SWM) data were included to ensure the classification was representative rather than definitive. Additionally, information on modern technologies such as Life cycle assessment, waste management models, and artificial intelligence were gathered by reviewing recently published research specifically focused on SWM. [9] Due to the limited landfill capacity in Singapore and the need to preserve it for the future, landfilling has been identified as the least popular way to dispose of waste. To reduce the amount of waste reaching landfills, incineration despite its higher cost has been prioritized over other waste treatment options. Additionally, waste reduction at the source has been actively promoted across every area of the community for a number of years. This essay examines the different approaches and difficulties associated with solid waste management in Singapore. [10] Until recently, environmental concerns were not a major focus in developing countries like India, and The government and environmentalists did not prioritize solid waste management. Awareness of the issue only gained traction in recent years when certain NGOs began bringing attention to the inadequate quality of municipal trash services. This, in turn, prompted Indian policymakers to recognize the significance of waste management within environmental protection. India lacks a well-defined policy framework and guidelines for waste management services. As a result, municipal agencies have struggled to effectively fulfill their responsibilities. Although some regulations exist under various municipal acts, their weak enforcement has rendered them largely ineffective in addressing the issue. [11] Managing municipal solid trash is still quite difficult for countries worldwide and will continue to be a pressing issue in the future. This is especially true for developing nations, where rapid industrialization and growing urban populations have caused the production of municipal solid waste (MSW) to increase dramatically. However, with limited resources, reliance on basic treatment and disposal technologies, and weak enforcement of waste management regulations, these countries face serious difficulties. The most critical challenges include ensuring the safe disposal and effective recycling of MSW. [12] The poor state of waste management can largely be attributed to weakly formulated and poorly enforced environmental policies, among other factors. Additionally, waste management is a complex, multidimensional issue that has been further exacerbated in Nigeria by rapid urbanization and population growth. As a result, state environmental agencies struggle to control the growing amount of solid waste effectively. Furthermore, the failure to consider the economic, social, psychological, political, and cultural aspects of Nigerian society when planning and carrying out waste management programs has significantly contributed to their inefficiency. This discussion seeks to evaluate the difficulties of managing solid waste in Nigeria. [13] Incineration can also be part of a comprehensive waste management plan for major cities that must contend with landfill space constraints. However, its implementation is often limited by high costs and the possibility of emitting harmful substances. Municipal solid waste incineration procedure (MSW) not only emits dangerous air pollutants but also generates large volumes of solid residues that build up at different phases of the incineration process, such as fly ash, grate siftings, bottom ash, and air pollution control (APC) residues. [14] Political decisions have prompted society to pursue more environmentally friendly methods of trash handling. Waste landfilling directives [1,2] have been implemented at the European level. As a result, it will be necessary to switch from landfilling to alternate treatment methods for about 15% of the total municipal garbage. These regulatory shifts are likely to result in significant changes to waste management practices in Sweden. [15] Private companies are in charge of gathering garbage from specified collecting locations and delivering it to disposal facilities and transfer stations. Despite the high costs associated with collecting and transporting the large volumes of waste, these points are serviced once daily, typically in the early morning, to minimize environmental issues such as odors and flies. Efficient waste collection relies on the appropriate choice of vehicles. [16] Economists have been studying municipal solid waste for a long time faced challenges due to a lack of reliable data. Few municipalities kept accurate records of waste and recyclable material quantities, and no centralized databases existed for the limited data available. As a result, early economic studies relied on contacting individual municipalities or households to gather information, leading to data with limited reliability and scope. However, in the past decade, In addition to national panel data in a number of industrialized nations in Europe and Southeast Asia, high-quality statewide panel data is now accessible in the United States. [17] Integrated the idea of solid waste management, or ISWM, has persisted in evolve over time. It was initially designed to increase the effectiveness of the municipal solid waste management (MSWM) chain, which includes treatment, final disposal, transfer stations, source separation, collection, and transportation. Afterwards, ISWM expanded into a comprehensive management system designed to manage all waste produced in a certain geographic or administrative area, such as a city, from different sources, including residential, commercial, industrial, healthcare, construction and demolition, and agricultural sectors. Furthermore, ISWM developed into a procedure that aims to achieve the 3Rs (Reduce, Reuse, Recycle), which are to maximize the recovery of materials and energy from waste and minimize the quantity of garbage that needs to be disposed of. [18] During this period, American cities experienced rapid growth due to the industrial revolution, leading to densely populated urban areas that relied on importing goods and exporting waste beyond city boundaries. This era saw two significant developments: the establishment of infrastructure for drinking water and sewer systems, and the creation of institutional frameworks for public health and waste management. [19] Currently, landfilling remains the most cost-effective option for managing municipal solid waste (MSW). However, introducing a levy on landfill waste could narrow the cost difference between landfilling and alternative waste-treatment methods. This could lead to shifts in public perception and changes within the waste management industry. Increasing recycling rates may be achieved through financial incentives that promote the development of markets for materials recovered from recovery facilities, ensuring more stable market prices. Additionally, the relative cost of composting could be lowered by implementing legislative measures regionally or nationally that prohibit organic waste being dumped in landfills. [20] In Indian cities, managing municipal solid waste (MSWM) is a major environmental concern. Residents are at risk for health problems due to inadequate management of municipal solid waste (MSW). About 90% of MSW is incorrectly disposed of in landfills and open dumps, according to research, which has negative effects on the environment and human health. A thorough analysis of the properties, production, collection and transportation, disposal, and treatment technologies of MSW utilized in India is the goal of this study. Additionally, it evaluates MSWM's current status in Indian cities and identifies key challenges.

2. MATERIALS AND METHOD

Alternatives:

1) Technical: Refers to the practical aspects of waste management systems, encompassing the planning, execution, and upkeep of equipment and facilities involved in waste collection, transportation, processing, and disposal.
2) Environmental: focuses on how waste management techniques affect the environment, including pollution control, resource conservation, and minimizing emissions to air, water, and soil.
3) Economic: Involves the financial elements of waste management, including collection, treatment, and disposal expenses, revenue from recycling, and potential economic benefits of energy recovery.
4) Social: Relates to public acceptance, community involvement, health impacts, and how Waste management techniques have an impact on the community's standard of living.
5) Recycling & Material Recovery: The process of collecting, processing, and reusing products from waste, limiting the impact on the environment and the requirement for virgin resources.
6) Waste-to-Energy (WTE) Incineration: A technology that transforms non-recyclable garbage into fuel, power, or heat that can be used by combustion, reducing the volume of waste sent to landfills.

Evaluation parameter:

1) Access to Technology (AT): Refers to the availability and affordability of modern technologies for waste management and the potential of a region to implement them effectively.

2) Technical Reliability (TR): Indicates the consistency and dependability of waste management systems and technologies in performing their intended functions without frequent breakdowns or failures.
3) Environmental Feasibility (EF): Assesses whether a waste management option is environmentally sustainable and compliant with regulations, considering factors like emissions, resource use, and ecological impact.
4) Water Pollution (WP): Refers to contamination of water bodies (rivers, lakes, groundwater) due to improper waste disposal or leakage of hazardous substances from waste management facilities, affecting ecosystems and human health.

Method: To evaluate alternatives, EDAS requires two metrics. With high values, these metrics are called PDA stands for positive distance from the mean while with low values; they are called NDA stands for negative distance from the mean. In light of low NDA and/or high PDA values, the other strategy is superior to the average option. By contrasting the effects of other MCDM or different approaches applied to the same cases, the current study uses some RSP examples from the relevant literature to demonstrate the applicability of EDAS as a suitable and successful MCDM method. To our knowledge, this study is the first to use EDAS for industrial robot selection. This study aims to illustrate the EDAS approach's applicability and effectiveness in contrast to the existing MCDM approaches for resolving industrial robot selection issues. In this regard, four sample issues that are frequently utilized in the literature were resolved, and the outcomes of the EDAS method were contrasted with the approaches taken to handle these samples. One of the four scenarios is selected using the EDAS approach, which is evaluated. The EDAS method was chosen for robot ranking because it is a new approach with a wide range of applications and lower computational cost than previous MCDM techniques. Since its answer is obtained, EDAS removes the chance of experts unjustly favoring other solutions the average solution. The main benefits of the EDAS approach are its ease of use and the reduction in the number of computations required. The proposed hybrid BW-EDAS approach allows robot preferences to be ranked based on a range of qualitative and quantitative variables. The suggested technique is a general procedure that may be used to handle any industrial selection problem with a limited number of selection criteria. In the future, we will compare our suggested method for the ranking process with EDAS approaches and apply the FUCOM methodology to calculate the weights. The work can be expanded to the fuzzy environment. However, it is evident that the application of fuzzy EDAS results in solutions that are vulnerable. One well-known area of decision-making is MCDM. To deal with ambiguity in decision-making issues, this method can be combined with fuzzy logic. Fuzzy MCDM approaches combine many transforming several, occasionally incompatible principles into parameters, which greatly increases the flexibility, objectivity, and suitability of the evaluation process for the various options. These are but a handful of the benefits of using fuzzy MCDM techniques to energy-related policy and decision-making problems. EDAS is a distance-based method that uses both positive and negative distances from the average answer to rank the available solutions. The various types of useful and non-beneficial criteria were used to calculate the positive and negative distance measurements. The option with lower NDA values or higher PDA (positive distance from average) values is the better one. EDAS is a great tool since it is easy to use and allows you to take into account a plethora of options and criteria while making decisions. Consequently, the existing methods usually include complex computations and give decision makers inflexible responses. This paper aims to address this issue by offering an approach based on the normal distribution's characteristics and the EDAS technique. As mentioned before, one of the MCDM strategies is the EDAS approach. Keshavarz Gorbea created this relatively new and effective technique. Based on the importance of the normal distribution, its characteristics, and the EDAS technique, this paper suggests an extension of the EDAS to efficiently handle the stochastic MCDM problems. Since the EDAS approach has never been used or extended for stochastic MCDM problems, the proposed approach is novel. The results of the stochastic EDAS technique are compared with those of a number of other currently used approaches, and to show how stable the results are when the weights of the criterion are changed, a sensitivity analysis is conducted. The proposed approach can be used to a variety of practical scientific problems, management, and engineering, even though it was used in this study to evaluate bank branches. As an example, we analyze a bank branch using the stochastic EDAS technique. To demonstrate the reliability and validity of the stochastic EDAS results, we also do a sensitivity analysis and a comparison in this section conclusion and directions for further research. Consequently, we can conclude that the suggested stochastic EDAS approach can help decision-makers consider data uncertainty while weighing their options. We have proposed a stochastic version of the EDAS method to solve MCDM issues using normally distributed data. To account for data uncertainty throughout the evaluation, we have set optimistic and pessimistic values for several of the parameters of the proposed technique. To address Interval-valued Pythagorean fuzzy numbers are used to solve fuzzy multi-criteria group decision-making problems with greater flexibility and a broader membership scope. This work extends the evaluation based on distance from the average solution (EDAS). An example of the car selection problem is used to illustrate the utility and applicability of the proposed model, and the results are compared with those of the intuitionistic interval-valued fuzzy EDAS technique. To see how the weights affect other ranks, a sensitivity study is also conducted. One of the extended fuzzy EDAS limits the decision makers' ability to express their preferences for alternatives, meaning that the sum of the upper end points of membership and non-membership degrees equals Additionally, because making decisions requires a lot of knowledge, process, removing these constraints enables decision makers to make more intelligent choices. As a result, the proposed methodology is more effective at removing these constraints than earlier fuzzy extensions of EDAS systems, providing decision makers with more flexibility in communicating this information and improved representation of uncertain information.

3. RESULTS AND DISCUSSION

TABLE 1. Solid Waste Management

	Solid Waste Management			
	Access to Technology AT)	Technical Reliability (TR)	Environmental Feasibility (EF)	Water Pollution (WP)
Technical	86	138	38	79
Environmental	93	159	96	68
Economic	82	147	78	38
Social	46	371	89	17
Recycling & Material Recovery	25	869	25	96
Waste-to-Energy (WTE) Incineration	34	167	14	100

Table 1 presents an analysis of solutions for solid waste management based on four key parameters: Access to Technology (AT), Technical Reliability (TR), Environmental Feasibility (EF), and Water Pollution (WP). Among the categories, Recycling & Material Recovery exhibits the highest Technical Reliability (869), indicating strong dependability but lower scores in other areas, suggesting challenges in technology access and environmental impact. Social factors show a high Technical Reliability (371), highlighting the importance of community involvement, but low scores in Access to Technology (46) and Water Pollution (17), pointing to infrastructure limitations. Waste-to-Energy (WTE) Incineration scores moderately in Technical Reliability (167) but shows significant Water Pollution (100), reflecting environmental concerns linked to emissions. In contrast, Environmental considerations score high across most parameters, especially in Technical Reliability (159) and Environmental Feasibility (96), underscoring its sustainability potential. Technical aspects are reliable (TR: 138) but face challenges in Environmental Feasibility (38) and Water Pollution (79), indicating a need for improved pollution control. Economic factors are balanced, with moderate scores across all parameters but lower Environmental Feasibility (78) and Water Pollution (38).

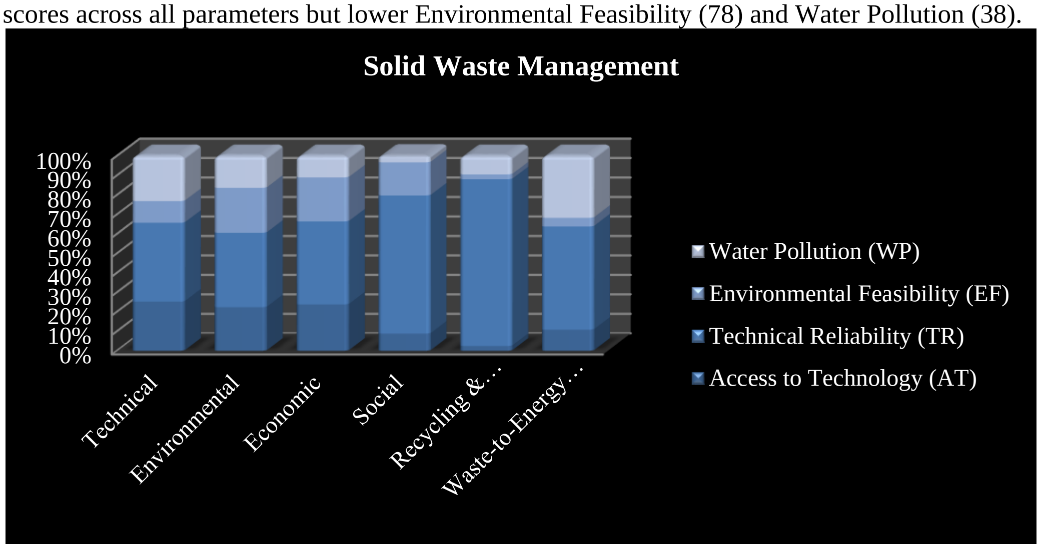

FIGURE 1. Solid Waste Management

Figure 1 evaluates solid waste management options using four parameters: Access to Technology (AT), Technical Reliability (TR), Environmental Feasibility (EF), and Water Pollution (WP). Recycling & Material Recovery shows the highest Technical Reliability (869) but struggles with Access to Technology (25) and Environmental Feasibility (25), indicating effective operations but limited infrastructure and environmental challenges. Social aspects rank high in Technical Reliability (371), emphasizing the importance of community involvement, but score low in Access to Technology (46) and Water Pollution (17), revealing infrastructure gaps and environmental concerns. Waste-to-Energy (WTE) Incineration demonstrates moderate Technical Reliability (167) but faces significant Water Pollution (100), highlighting environmental risks. Environmental approaches are well-rounded, with high scores in Technical Reliability (159) and Environmental Feasibility (96), suggesting sustainable potential. Technical and Economic methods show balanced reliability but need better environmental management. The analysis underscores the requirement for sustainable, integrated waste management solutions.

TABLE 2. Positive Distance from Average (PDA)

	Positive Distance from Average (PDA)			
	Access to Technology (AT)	Technical Reliability (TR)	Environmental Feasibility (EF)	Water Pollution (WP)
Technical	0.4098361	0	0.329412	0
Environmental	0.5245902	0	0	0
Economic	0.3442623	0	0	0.427136
Social	0	0.202593	0	0.743719
Recycling & Material Recovery	0	1.816856	0.558824	0
Waste-to-Energy (WTE) Incineration	0	0	0.752941	0

Table 2 presents the Positive Distance from Average (PDA) for various solid waste management strategies across four parameters: Access to Technology (AT), Technical Reliability (TR), Environmental Feasibility (EF), and Water Pollution (WP). A higher PDA value indicates better performance compared to the average. Recycling & Material Recovery stands out in Technical Reliability (1.816856) and Environmental Feasibility (0.558824), reflecting exceptional operational efficiency and moderate environmental sustainability. However, it shows no advantage in Access to Technology or Water Pollution, suggesting infrastructural and environmental challenges. Waste-to-Energy (WTE) Incineration scores highest in Environmental Feasibility (0.752941), highlighting its potential for sustainable waste reduction, but lacks positive impact in other areas. Social aspects exhibit significant PDA in Water Pollution (0.743719), indicating minimal environmental harm, but low scores elsewhere highlight technological and operational limitations. Technical and Economic methods perform moderately in Access to Technology but require improvements in Environmental Feasibility. Environmental strategies are balanced but show no positive distance in Environmental Feasibility, implying room for improvement in sustainability. Overall, the data suggests that no single method excels in all areas, emphasizing the need for integrated approaches to optimize solid waste management.

TABLE 3. Negative Distance from Average (NDA)

	Negative Distance from Average (NDA)			
	Access to Technology (AT)	Technical Reliability (TR)	Environmental Feasibility (EF)	Water Pollution (WP)
Technical	0	0.55267	0	0.19095
Environmental	0	0.4846	0.69412	0.02513
Economic	0	0.5235	0.37647	0
Social	0.245902	0	0.57059	0
Recycling & Material Recovery	0.590164	0	0	0.44724
Waste-to-Energy (WTE) Incineration	0.442623	0.45867	0	0.50754

Table 3 illustrates the Negative Distance from Average (NDA) for different solid waste management strategies across four criteria: Access to Technology (AT), Technical Reliability (TR), Environmental Feasibility (EF), and Water Pollution (WP). Higher NDA values indicate performance below the average. Recycling & Material Recovery shows the highest NDA in Access to Technology (0.590164) and Water Pollution (0.44724), highlighting technological challenges and environmental concerns. Conversely, it performs well in Technical Reliability and Environmental Feasibility. Waste-to-Energy (WTE) Incineration also faces technological limitations (AT: 0.442623) and environmental risks (WP: 0.50754), revealing the need for enhanced infrastructure and pollution control. Social strategies exhibit significant NDA in Access to Technology (0.245902) and Environmental Feasibility (0.57059), suggesting limitations in technological adaptation and environmental impact. Environmental approaches show high NDA in Environmental Feasibility (0.69412), indicating sustainability challenges. Technical and Economic methods experience moderate setbacks in Technical Reliability but fare better in other criteria.

TABLE 4. Weight

	Weight			
Technical	0.25	0.25	0.25	0.25
Environmental	0.25	0.25	0.25	0.25
Economic	0.25	0.25	0.25	0.25
Social	0.25	0.25	0.25	0.25
Recycling & Material Recovery	0.25	0.25	0.25	0.25
Waste-to-Energy (WTE) Incineration	0.25	0.25	0.25	0.25

Table 4 presents the weight distribution for evaluating solid waste management strategies across four criteria: Access to Technology (AT), Technical Reliability (TR), Environmental Feasibility (EF), and Water Pollution (WP). Each category—Technical, Environmental, Economic, Social, Recycling & Material Recovery, and Waste-to-Energy (WTE) Incineration—is assigned an equal weight of 0.25 for all criteria, indicating an even consideration of each factor. This uniform weighting reflects a balanced evaluation approach, implying that no single criterion is prioritized over another. It suggests a holistic perspective on solid waste management, where technological, environmental, economic, and social aspects are deemed equally important. This approach promotes comprehensive decision-making, ensuring that solutions are not overly biased towards cost efficiency, technical feasibility, or environmental impact alone. However, this equal weighting may overlook contextual priorities. For instance, if environmental sustainability or cost-effectiveness were more critical for a specific community or region, an adjusted weighting scheme could provide more relevant insights. Consequently, while the balanced approach ensures fairness, customizing the weights based on local priorities and challenges could enhance the strategic relevance of the waste management solutions.

TABLE 5. Weighted PDA, SPi

	Weighted PDA				SPi
Technical	0.10246	0	0.08235	0	0.184812
Environmental	0.13115	0	0	0	0.1311475
Economic	0.08607	0	0	0.10678	0.1928495
Social	0	0.05065	0	0.18593	0.2365779
Recycling & Material Recovery	0	0.45421	0.13971	0	0.5939198
Waste-to-Energy (WTE) Incineration	0	0	0.18824	0	0.1882353

Table 5 displays the Weighted Positive Distance from Average (PDA) values for solid waste management strategies, calculated by multiplying the PDA scores by their respective weights across four criteria: Access to Technology (AT), Technical Reliability (TR), Environmental Feasibility (EF), and Water Pollution (WP). The final column, SPi, sums these weighted values for each category, indicating the overall positive performance. Recycling & Material Recovery achieves the highest SPi (0.5939), suggesting it most effectively exceeds the average performance, particularly in Technical Reliability (0.45421) and Environmental Feasibility (0.13971). This highlights its strong potential for sustainable waste management. Social ranks second (0.2366), driven by its high score in Water Pollution (0.18593), reflecting its capacity to mitigate water-related environmental impacts. Technical, Economic, and Environmental strategies show moderate SPi values (0.1848, 0.1928, and 0.1311, respectively), indicating balanced but less outstanding performances. In contrast, Waste-to-Energy (WTE) Incineration has the lowest SPi (0.1882), despite scoring well in Environmental Feasibility (0.18824), suggesting limited advantages compared to other methods.

TABLE 6. Weighted NDA, SNi

	Weighted NDA				SNi
Technical	0	0.13817	0	0.04774	0.18591
Environmental	0	0.12115	0.17353	0.00628	0.30096
Economic	0	0.13088	0.09412	0	0.22499
Social	0.06148	0	0.14265	0	0.20412
Recycling & Material Recovery	0.14754	0	0	0.11181	0.25935
Waste-to-Energy (WTE) Incineration	0.11066	0.11467	0	0.12688	0.35221

Table 6 presents the Weighted Negative Distance from Average (NDA) and the corresponding SNi values, reflecting the negative performance of various solid waste management strategies across key criteria. Waste-to-Energy (WTE) Incineration shows the highest SNi (0.35221), indicating the greatest negative impact among all strategies. This suggests significant challenges related to environmental feasibility and water pollution, highlighting the need for technological improvements or regulatory adjustments to mitigate adverse effects. Environmental strategies rank second in negative performance (SNi = 0.30096), primarily due to constraints in technical reliability and environmental feasibility. This reveals potential limitations in current environmental management practices that could be addressed through policy enhancements or advanced technologies. Recycling & Material Recovery exhibits moderate negative impacts (SNi = 0.25935), which are relatively lower compared to WTE Incineration. This suggests that although recycling is highly effective in material recovery, certain environmental and technical challenges persist. Technical and Economic strategies have moderate SNi values of 0.18591 and 0.22499, respectively, reflecting manageable negative impacts. Meanwhile, Social strategies display the lowest SNi (0.20412), indicating minimal negative consequences, particularly in water pollution and technical reliability.

TABLE 7. NS Pi, NS Pi, ASi

	NS Pi	NS Pi	A Si
Technical	0.3111732	0.472166	0.39167
Environmental	0.2208169	0.1455	0.183159
Economic	0.3247063	0.361193	0.34295
Social	0.3983331	0.420449	0.409391
Recycling & Material Recovery	1	0.263645	0.631823
Waste-to-Energy (WTE) Incineration	0.3169372	0	0.158469

Table 7 presents the NS Pi, NS Ni, and ASi values for different solid waste management strategies, reflecting their normalized positive performance, negative performance, and overall assessment scores, respectively. Recycling & Material Recovery achieves the highest NS Pi (1), indicating its outstanding positive performance compared to other methods. Its relatively low NS Ni (0.263645) results in the highest overall score (ASi = 0.631823), solidifying its position as the most effective strategy. This outcome reinforces its strong potential for sustainable and efficient waste management. Social ranks second in overall performance (ASi = 0.409391), with balanced positive and negative scores, showing its effectiveness in social acceptance and environmental impact mitigation. Economic and Technical strategies follow closely with ASi scores of 0.34295 and 0.39167, respectively, reflecting moderate positive impacts but also notable limitations. Waste-to-Energy (WTE) Incineration has the lowest ASi (0.158469), attributed to its NS Ni (0), indicating substantial challenges and trade-offs despite its potential for energy recovery. Environmental strategies show the weakest positive performance (NS Pi = 0.2208169), highlighting areas for improvement.

TABLE 8. Rank

	Rank
Technical	3
Environmental	5
Economic	4
Social	2
Recycling & Material Recovery	1
Waste-to-Energy (WTE) Incineration	6

Table 8 presents the ranking of solid waste management strategies based on their overall performance across key criteria. Recycling & Material Recovery secures the top spot (Rank 1), highlighting its superior effectiveness in resource recovery, environmental feasibility, and minimal negative impacts. Its high ranking underscores the sustainability and efficiency of recycling systems in managing solid waste. Social strategies rank second, reflecting their strong community acceptance, social benefits, and relatively low environmental and technical drawbacks. This indicates that socially inclusive waste management practices, such as community engagement and educational programs, are effective and sustainable. Technical and Economic strategies occupy third and fourth positions, respectively. Their moderate ranking suggests balanced performance in terms of technical reliability and economic feasibility but highlights areas for improvement in environmental impacts and public acceptance. Environmental strategies rank fifth, possibly due to challenges in technical implementation and environmental feasibility. This indicates the need for enhanced environmental technologies and policies to improve effectiveness. Waste-to-Energy (WTE) Incineration is ranked last (sixth), reflecting significant environmental concerns, particularly related to air and water pollution. Despite its potential for energy recovery, its negative environmental impacts hinder its overall sustainability.

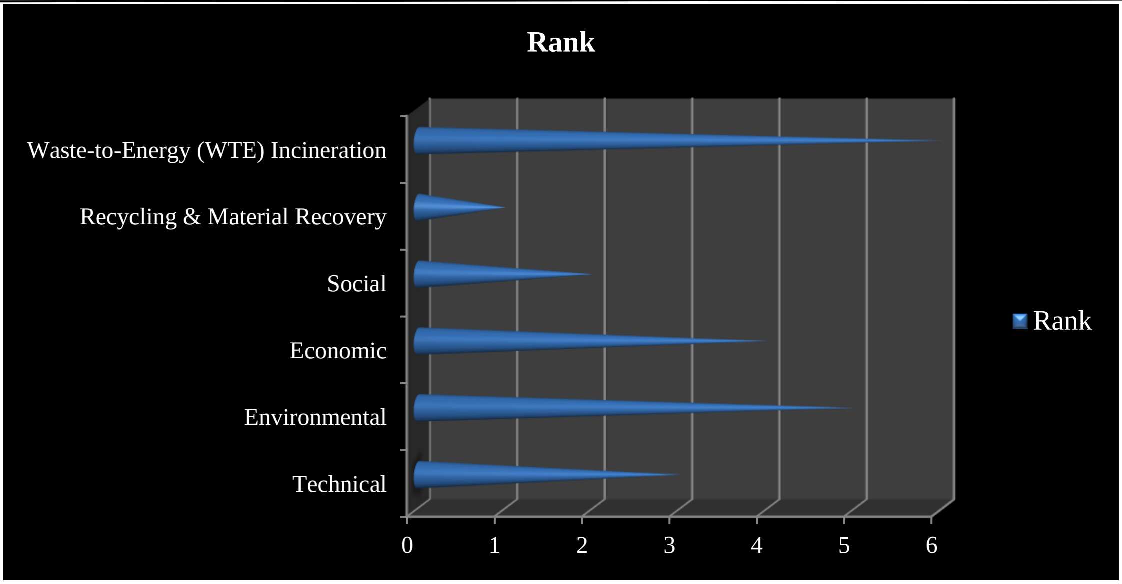

FIGURE 2. Rank

Figure 2 shows the ranking of solid waste management strategies, highlighting their relative effectiveness. Recycling & Material Recovery ranks first, emphasizing its superior performance in resource recovery and environmental sustainability. Its top position indicates strong environmental feasibility and minimal negative impacts compared to other strategies. Social strategies are second, reflecting high community acceptance and positive social impacts. This suggests that community involvement and educational programs are effective in waste management. Technical and Economic strategies rank third and fourth, showing balanced performance in technical reliability and cost-efficiency but needing improvement in environmental and social aspects. Environmental strategies are fifth, possibly due to challenges in technical application and environmental impacts. This indicates a need for enhanced environmental technologies. Waste-to-Energy (WTE) Incineration is last, primarily due to environmental concerns, including pollution. Despite energy recovery potential, its environmental drawbacks significantly affect its overall sustainability.

4. CONCLUSION

An important aspect of public health and the environment is solid waste management, or SWM challenge, particularly in rapidly urbanizing areas and developing countries. The increasing demand for energy and goods, coupled with population growth and improved living standards, has caused a notable increase in the production of municipal solid trash. Improper disposal and inadequate recycling of this waste pose serious environmental threats, including pollution and resource depletion. Despite advancements in SWM practices and technologies, many cities worldwide still struggle with effective waste collection, transportation, treatment, and disposal due to financial constraints, insufficient infrastructure, and weak policy enforcement. The evaluation of SWM systems using A methodical and adaptable approach to multi-criteria decision-making is offered by the EDAS (Evaluation Based on Distance from Average Solution) method. By taking into technical, environmental, economic, and social factors, the EDAS method facilitates a comprehensive assessment of various waste management alternatives, including recycling, waste-to-energy incineration, and landfill disposal. Its ability to utilize both positive and negative distance measurements makes EDAS a powerful tool for ranking solutions based on their proximity to the optimal outcome. Moreover, the method's adaptability to fuzzy logic enhances its applicability in complex, uncertain decision-making environments, offering decision-makers the flexibility needed for effective waste management planning. Including contemporary technologies like artificial intelligence and life cycle assessment, into SWM systems has further improved efficiency and sustainability. Countries adopting stringent air emission regulations and promoting waste minimization strategies, like limiting organic waste in landfills, demonstrate the potential of comprehensive SWM approaches to reduce environmental impacts. However, challenges remain, especially in developing countries where weakly formulated policies, limited resources, and inadequate infrastructure hinder effective waste management. Addressing these issues requires coordinated efforts involving public awareness, community participation, private sector involvement, and robust regulatory frameworks. The case studies from diverse geographical regions, including Abuja, Nigeria, Singapore, and Indian cities, reveal that context-specific solutions are essential for improving SWM efficiency. These examples highlight the importance of understanding local socio-economic, cultural, and political factors when designing and implementing waste management programs. Additionally, leveraging informal recycling sectors and enhancing resource recovery initiatives can significantly contribute to waste reduction and sustainable development.

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