SCIENTIFIC OASIS

Spectrum of Mechanical Engineering
and Operational Research

Journal homepage: www.smeor-journal.org
eISSN: 3042-0288

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Spectrum of Mechanical Engineering and Operational Research
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A Decision-Making Approach to Establish a Sustainable-Circular Waste Management System: A Case Study of Istinye University

Alper Bora Koçak[1], Abdullah Almarestani[1], Erfan Babaee Tirkolaee[1,2,3,*]

[1] Department of Industrial Engineering, Faculty of Engineering, Istinye University, Istanbul, Türkiye
[2] Department of Industrial Engineering and Management, Yuan Ze University, Taoyuan, Taiwan
[3] Department of Mechanics and Mathematics, Western Caspian University, Baku, Azerbaijan

ARTICLE INFO

Article history:
Received 11 February 2025
Received in revised form 30 March 2025
Accepted 3 May 2025
Available online 11 May 2025

Keywords:
Sustainable-circular waste management; Decision-making; Resource efficiency; Environmental impact; Stakeholder engagement.

ABSTRACT

This study presents a decision-making approach for establishing a sustainable-circular waste management system at Istinye University. The approach integrates sustainability principles and circular economy concepts to minimize waste generation, promote recycling, and enhance resource efficiency. A comprehensive analysis of waste management practices at Istinye University was conducted, identifying key areas for improvement. The proposed system utilizes the Analytical Hierarchy Process (AHP) and the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) to evaluate and prioritize waste management strategies. These methods enable a structured and quantitative assessment of environmental, economic, social, and technical sustainability criteria. The findings highlight the benefits of adopting a circular waste management system, including reduced environmental impact, cost savings, and increased stakeholder engagement. This research contributes to the growing field of sustainable logistics and supply chain management by providing a practical framework applicable to educational institutions and similar organizations.

1. Introduction

1.1 Objectives and Questions

A sustainable, circular waste management system is one that is designed to minimize waste and maximize resource recovery. This type of system typically includes a waste reduction hierarchy that prioritizes waste prevention, followed by reuse, recycling, and finally, disposal. Waste prevention strategies seek to avoid the generation of waste in the first place. This can be accomplished through source reduction, which involves reducing the amount of materials used or purchased, or through product redesign, which involves making products that are easier to reuse, repair, or recycle. Reuse strategies aim to extend the life of products and materials by finding new ways to use them. This can be done by repairing or refurbishing products, or by using them for a different purpose than they

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[*] *Corresponding author.*
E-mail address: Erfan.babaee@istinye.edu.tr

https://doi.org/10.31181/smeor21202539

were originally intended. Recycling strategies aim to turn waste into new products or materials. This can be done by breaking down materials into their component parts and then using those parts to create new products, or by using waste as a fuel source to generate energy. Disposal strategies aim to safely and responsibly eliminate waste that cannot be prevented, reused, or recycled. This can be done by incinerating waste to generate energy, or by sending it to a landfill. A well-designed waste management system will take into account the unique needs and resources of the community it serves. It will also be flexible, so that it can adapt as the community's needs change over time. This paper will utilize an efficient decision-making approach to design a sustainable- circular waste management system.

The term "circular economy" (abbreviated "CE") was coined in 2010 as an "overall idea" with the goal of developing a more resource-efficient economic structure. It aims to close material and energy loops in production processes, making them more sustainable. The CE is a key instrument in achieving sustainable development. This is why governments, investors, businesses, and the public all show increasing enthusiasm for its advocacy. There is little to no impact on the economy or the environment from this passion. Systems that adopt circular ideas, promote circularity, or are themselves part of the circular economy may not always be the most environmentally friendly option. There are financial and ecological costs associated with the procedures needed to reintroduce previously used and/or recyclable materials in accordance with the CE principle. Others see the direct connection between CE and sustainable development and see it as an important part of CE's mission. Some writers go farther, arguing that CE is a precondition notion for sustainability that necessitates a shift in value creation, conceptualization, and model creation in business and management. As an alternative to the necessary transition to a new development model, related to strategies for developing sustainable business models, the suggestion of circular integration of the activities of smart manufacturing may be the best option.

However, the interaction between CE and the economy, society, and the natural environment is still complicated, and the impact of CE on environmental sustainability is not yet thoroughly demonstrated. However, the circularity of materials, components, and finished goods is defined and identified by the CE via the waste management procedures of waste avoidance, reuse readiness, recycling, other recovery, and disposal/landfill. Even though one of CE's weaknesses is that it fails to take into account non-material flows, it has been argued that the usage of renewable energy, water, and land should be included in any evaluation of CE. Indicators that can track the CE's development are needed for its implementation. To efficiently manage waste created, it is necessary to implement new systems that categorize, divert, or experiment in the reduction of waste, even if the CE is mainly concerned with the architecture and circularization processes of open or conventional production lines.

Since CE is expected to herald in a new age of economic initiatives and programmers, it will stimulate the regeneration of current development networks by forcing changes in the way they approach design and manufacturing, it is imperative that all industrial processes be evaluated with a long-term perspective and incorporated with CE. More than €600 million in cost savings may be realized by European businesses via eco-design, prevention, and reuse. In light of this, it has been recommended to conduct research on the ecological effects of the waste-management procedures used by the enterprises that make up the Collective System of Extended Producer Responsibility System (hereinafter, CPR).

As a means to this end, we have settled on the carbon footprint (hereafter, CF) as a sustainability indicator due to its close association with life cycle thinking, widespread adoption by businesses, availability of standardized methods for measurement, and presence in public records for recording results. The regulatory board also wants them to be minimally vetted. Green house gas (GHG) emissions from these operations may be calculated using this indicator, but so can the source, nature, biodegradable nature (if relevant), and utilization of the energy supplies employed in these procedures, all of which are crucial to the notion of CE for environmental sustainability. By calculating CF, an environmental sustainability measure that takes into account non-material flows of waste circularization, we may learn how sustainable the CE's waste management operations are.

The overarching goal of this effort is to demonstrate the interdependence and importance of eco-design and waste management. The former reduces trash production, whereas the latter promotes economic recirculation. To demonstrate the necessity for further in-depth study, we use the carbon footprint as a sustainability indicator to critically analyze the structure and results of an existing CPR. The subject of "How much emissions a CPR creates to complete the loop of existing Extended Producer Responsibility Systems (EPR) from present goals of CE?" is investigated on this basis.

The following are the necessary measures to achieve the aforementioned goals: First, a consideration of how the CE framework may be applied to waste management systems for extended product producers; second, a decision of whether or not these systems can be maintained in the long run-in terms of carbon footprint (CF). To do so, we shall use the SBA (Small Business Approach) model, an activity-based sustainability management framework. For the purpose of investigating the ecological consequences generated by CPRs in their own tire waste management process, CPRs of particular interest are those that have estimated their environmental impact in a transparent way by implementing the ISO 14064-1 and ISO 14069 benchmarks for the establishment of current assets and categorization of GHG emissions.

1.2 Questions

1. What kind of Multi-Criteria Decision-Making (MCDM) method [1] can be the most applicable one in our case?
2. How can we validate the efficiency of the MCDM method?
3. How can we gather the required information?
4. Who are the experts in our case?
5. Are the adverse effects of improper waste management very detrimental to human health?
6. What is the extent of improper waste pollution in the university without the intervention of a sustainable-circular waste management system?
7. What are the available interventions to improve waste management within the university?
8. Is a sustainable-circular waste management system the answer to improper waste management in the university?

1.3 Contributions

The difference between our study and other ones is that this paper is focused on a specific environment and population which is Istinye University. Consequently, it proposes a particular solution to the improper waste management menace within the university which is expected to be implemented on approval of the research.

Next, we perform a literature review of CE models, waste disposal, and cooperation systems of product stewardship, focusing on ELT and its impact on climate change and environmental sustainability via the lens of carbon footprint. The third section elaborates on the SBA paradigm, often known as activity-based sustainable management and how it is used to assess the climate-change-related viability of a CPR's approach to dealing with used tires. The study paper's findings and suggestions for the future are revealed towards the end.

TOPSIS was introduced in the 1980s as a multi-criteria-based decision-making method [2]. TOPSIS chooses the alternative of shortest the Euclidean distance from the ideal solution and the greatest distance from the negative ideal solution. In our paper, we will be discussing by analyzing İstinye University on basis of sustainability, circularity, and some other factors. We will define the weights and impacts of this method.

AHP is a method for organizing and analyzing complex decisions, using math and psychology [3]. The popularity of AHP stems from its simplicity, flexibility, intuitive appeal, and ability to mix quantitative and qualitative criteria in the same decision framework. Based on our criteria we assign weights with respect to our objectives which we mentioned previously. For the further steps, we assess the relative value or priority of each decision criterion, calculate the weights of the criteria and priorities and analyze consistency.

1.4 Structure of Research

This report will be organized into small sections with the intention of making it well-presented and understandable. Section 2 represents the literature in order to find the works that have been done in waste management with the help of sustainability and circularity. Section 3 describes the proposed methodology of research which includes AHP and TOPSIS. Section 4 reviews the progress report to examine what we did search for and what we achieved so far.

1.5 Literature Review

Korhonen *et al.*, [4] proposed the CE within this framework, defining it as "a sustainable development effort with the objective of reducing the social systems of production-consumption of materials and energy of linear performance through the deployment of circular, renewable materials and cascading energy flows." Together with traditional recycling and the development of innovative systems aimed at fostering cooperation among manufacturers, shoppers, and other social players in the name of sustainable development, the circular economy promotes the use of high-value circular materials.

Circular integration (CI), a concept introduced by Walmsley *et al.*, [5] for the development of eco-friendly systems, fits in this vein. The goal of CI is to optimize overall sustainability via a systemic approach to creating circular systems in which designs, operations, and maintenance of each subsystem span numerous scales and dimensions. The ability to consider the impact of a product or service on the environment from its initial creation to its final disposal is an example of life cycle thinking.

Despite the promise of CE, Korhonen *et al.*, [4] found six barriers to its widespread use. There are six types of limits: (1) those imposed by thermodynamics; (2) those imposed by the system's space and time; constraints imposed by management and administration, those enforced by cultural and societal conceptions, and those imposed by the physical size of the economy. Resource cycle, sustainable sources, and downstream energy flow-based manufacturing and consumption systems are impacted by the aforementioned elements. It's possible that similar expenses would arise if additional linear characteristics were converted to circular ones. CE should serve as a model for sustainable development, it has the same limitations and challenges as conventional economic theory, including issues with growth and equity.

Achillas *et al.*, [6] referred to the use of Multi-Criteria Decision Analysis (MCDA) to tackle waste management problems. In their paper, they showed that there are many factors and influences – often mutually conflicting – criteria for finding solutions in real-life applications by presenting a review of the literature on multi-criteria decision aiding in waste management problems for all reported waste streams. They used MCDA and AHP techniques and documented them in graphs. The registration of applied methods provides the ability for a decision-maker to check the consistency and increase the reliability of each waste management alternative's result. I am thankful for how they conduct their tools effectively.

Soltani *et al.*, [7] presented a few previous studies on the use of MCDA for solving Municipal Solid Waste Management System (MSWM) problems with more consideration of the studies that presented multiple stakeholders that get involved in the process of finding suitable waste management or strategies. The outcomes that they reached were that AHP was the most used method with multiple stakeholders, experts, and governments being the most common participant in these studies.

Jovanovic *et al.*, [8] used MCDM for the selection of the best strategy for municipal solid waste management: This paper presents the procedure for selecting the most suitable MSW for the region of Kragujevac city (Republic of Serbia) based on the MCDM method. Compare proposed Waste Management Strategies (WMS) using his two methods of Multi-Attribute Decision-Making (MADM): SAW (simple additive weighting) and TOPSIS. Each strategy created was simulated with the software package Integrated Waste Management Model 2 (IWM2). The proposed strategies were then laid out in the form of tables and charts obtained based on both MCDM methods.

Goulart *et al.*, [9] discussed the use of MCDM to support waste management. Their article presented a literature review on MCDM applications in this field, provided a critical assessment of current practices, and offered suggestions for future work. After outlining the basic concepts, they analyzed 260 articles and concluded that research employing MCDM in solid waste management primarily targets municipal solid waste issues related to facility location or management strategies. Coban *et al.*, [10] evaluated 8 solid waste dumping alternatives based on 7 criteria by implementing the TOPSIS, PROMETHEE I, and PROMETHEE II methods. Based on this evaluation, their findings highlighted the importance of recycling and landfill technologies for developing countries.

Aung *et al.*, [11] showed that the application of multi-criteria decision-making method to analyze the medical management system of Mynamar healthcare services inevitably generates medical waste that can become hazardous to public health and the environment. Their study developed a new framework for evaluating the management of medical waste based on the World Health Organization (WHO) guidelines on the safe management of waste from medical activities. MCDM was used to model the endpoint framework for hospital waste management.

Garcia-Bernabeu *et al.*, [12] developed a circular economy composite indicator to benchmark EU countries' performance because the monitoring framework in the circular economy action plan lacked it. They used a multi-criteria approach to create a composite circular economy index based on the TOPSIS methodology. In addition, they demonstrated a new aggregation method to construct a composite metric, considering different levels of compensability of the distances to the ideal and anti-ideal (or negative ideal) values of each metric. Pamučar *et al.*, [13] talked about the importance of Healthcare Waste Management (HCW) and offered a novel integrated multicriteria decision-making model based on D numbers for processing fuzzy linguistic information. The purpose of the model was to aid the management in the public project 'Zdravstvo Brčko.' The outcome of this study was that the A1 alternative provided the most optimal outcome, and A5 provided the worst outcome.

Garcia-Garcia [14] referred to the topic of MCDM application to perfect solid waste management. MCDM is surrounded by several types of methods that support the multiple criteria of decision-making. It is one of the most sustainable solutions to manage solid waste and the most relevant MCDM methodologies. Alao *et al.*, [15] chose the best waste-to-energy (WTE) technology with respect to a subjective view of a decision maker and objective rating of the real-life result of each option. By using a new hybrid MCDM model that is applied to 4 alternatives with 14 sub-factors, they produced a result for the most sustainable WTE technologies as the order below: digestion ≻ gasification ≻ pyrolysis ≻ incineration.

Zhao *et al.*, [16] worked on measuring zero waste city performance of a coal resource with the MCDM approach. Their study proposed a practical integrated MCDM approach to assess the performance of the ZW city and applied the approach to a typical coal resource-based province in China. The performance levels increased during the study period. As a result, the study uses the natural breakpoint method to classify the evaluation results, which are divided into four levels: high, medium, low, and extremely low. In conclusion, they reduce solid waste production at source and improve the utilization rate of industrial solid waste resources.

Van Thanh [17] presented a fuzzy MCDM model for a solid-waste-to-energy plant location in Vietnam. By using the AHP model they identified potential landfill sites as the main finding. The Fuzzy Analytic Hierarchy Process (FAHP) technique is also utilized to analyze the relative weight of the primary and secondary evaluation elements. As a result, Hai Phong was found to be the optimal location to build a solid-waste-to-energy plant. The work might be expanded to the TOPSIS model though. Seker [18] talked about IoT-based sustainable smart waste management system evaluation using the MCDM model under interval-valued q-rung ortho pair fuzzy environment waste management technologies, Information and Communication Technology (ICT), and Internet of Things (IoT) play a key role in the field of municipal waste management in terms of sustainability aspects such as business, economic, social, and environmental.

Considering future development and environmental sustainability, choosing the most proper smart technology to manage waste collection can have a lasting impact. This paper aims to evaluate IoT-based smart waste collection systems based on uncertain parameters by applying modified entropy measurement and MCDM.

2. Methodology

This study tried to establish a circular waste management system in the university campus using different waste management interventions. Date from the staff members will be collected using an online survey form. 4 different aspects/ criteria for the proposed or included interventions were considered in this study, namely environmental, social, economic, and technical aspects. The gather data will be analyzed using MCDM, particularly through AHP and TOPSIS [19].

2.1 Selection Criteria for Proposed Alternatives

2.1.1 Environmental aspects

These aspects incorporated the extent to which different proposed interventions will be affected by the anthropogenic activities. These aspects are highly important to be included in the analysis as they have a direct relationship with public health protection, reduce natural resources depletion, and ensure sustainable development. The important criteria considered for accounting for the environmental impacts include:

i. Resources-energy requirements /abiotic depletion
ii. Land use
iii. Water pollution
iv. Air pollution

2.1.2 Economic aspects

Similarly, the economic impacts are associated closely with the costs and benefits required for adopting any proposed or considered waste management intervention. Four major criteria considered for evaluating the economic impacts of the proposed/ considered interventions include:

i. CAPEX (Capital Expenditure)
ii. OPEX (Operational Expenditure)
iii. Revenues
iv. Resource recovery

2.1.3 Social aspects

The socio-cultural impacts are also important for the improvisation of working environments, profits, and access to social resources. 5 main criteria considered for assessing the socio-cultural impacts include:

i. Public health
ii. Job creation/employment
iii. Acceptance
iv. Implementation
v. Adaptability

2.1.4 Technical aspects

Technical impacts are related to the level and ability of technology applied during the process of treatment. Five main criteria considered in technical impacts include the following: -

i. Adaptability to existing systems
ii. Machine/equipment
iii. Time to complete the process
iv. Local labor
v. Handling capacity

2.2 Circular Waste Management Interventions

The possible solid waste management interventions include any of the following:

i. Composting of Organic and Paper Waste
ii. Crushing of Plastic Waste and Selling it to Recyclers
iii. Landfilling the Plastic Waste (Single Use)
iv. Selling the Glass

2.3 Analysis Techniques

AHP and TOPSIS methods will be used for the assessment of collected data and recommend the most suitable option for circular waste management at the campus.

2.3.1 AHP Method

Brief details of the steps carried out under the AHP procedure are explained below:

Step-I: Define the Problem and Criteria.

Step-II: Develop a hierarchy of criteria. The criteria are broken down into smaller, more manageable parts and organized into a hierarchy. The top-level of the hierarchy represents the overall while the lower-level criteria represent the factors that contribute to achieving that objective.

Step-III: Define pairwise comparison matrices for each level of the hierarchy. Pairwise comparison matrices are used to determine the relative importance of each criterion in relation to the other criteria at the same level. The comparison matrix entries are made on a scale ranging from 1 to 7, where 1 represents equal importance, and 7 represents extremely important.

Step-IV: The criteria weights are calculated using the AHP approach. This involves calculating the geometric mean of each row in the matrix and normalizing the results to obtain the weight vector for each level of the hierarchy.

2.3.2 TOPSIS Method

Here, a decision maker has to select the best option out of various attributes and options. The following are the steps involved in the TOPSIS method:

Step-I: Convert the linguistic terms into numeral values scale. Make sure that all the attributes are either monotonically increasing or decreasing.

Step-II: Vector normalization (Euclidean) is used for all criteria (i.e., the same formula is applied for both benefit and cost criteria), and it can be represented as Eq. (1):

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m}\left(x_{ij}\right)^2}} \tag{1}$$

Step-III: A scale of relative importance, according to Saaty [20], was established for the intensity importance.

Table 1 shows Saaty's scale of relative importance, commonly used in the AHP to quantify expert judgments during pairwise comparisons of criteria.

Table 1
Saaty's scale of relative importance for the intensity of importance

Intensity of Importance	Definition
1	Equal Importance
3	Moderate Importance
5	Strong Import
7	Very strong Importance
9	Extreme Importance
2,4,6,8	Intermediate values
1/3, 1/5, 1/7,…..	Values for inverse comparison

Step-IV: After assigning the numeric values we plot the matrix of all the criteria across the criteria that we called it as a Pairwise Comparative Matrix to obtain a Normalized Pairwise Comparison Matrix.

Step-V: The average of each row calculated is considered as the weight.

Step-VI: Check the consistency of the weight obtained or not without normalization and take the weighted sum of each criterion.

Step-VII: Calculate the Lambda (λ) which is the weighted sum of value/ respective weight.

Step-IX: Compute the average of lambda.

Step-X: Check the consistency-by-consistency index= $(\lambda_{max} - n)/ n - 1$, where n is the number of criteria.

Step-XI: Find the Random Index (RI) or Standard Values based on *n*.

The consistency ratio (CR) is calculated. The Random Index (RI) value is found according to the relevant n (Table 2).

Table 2
Random Index (Standard Values)

n	1	2	3	4	5	6	7	8	9
RI	0	0	.58	.90	1.12	1.24	1.32	1.41	1.45

Consistency Ratio (CR) = CI/ RI

If the CR value is less than 0.10 then weights are acceptable else re-evaluated the pairwise comparison

Step-XII: Now, determine the weighted normalized decision matrix (*V*), as shown in Eq. (2):

$$V_{ij} = w_j \times r_{ij} \tag{2}$$

Step-XIII: Compute the Ideal best and Ideal worst from matrices. Ideal best means the lowest in terms of cost attribute while Ideal worst will be the scenario that cost high most value.

Step-XIV: Calculate the separation measure for each row in below Eq. (3):

$$\text{Ideal Separation: } Si = \sqrt{\sum_{j=1}^{n}\left(v_{ij} - v_j\right)^2} \tag{3}$$

Step-XV: Obtain the relative closeness to the ideal solution based on Eq. (4):

$$c_i = \frac{\overline{s_i}}{s_i + \overline{s_i}} \tag{4}$$

Step-XVI: Rank the options.

2.4 Model implementation

In the implementation phase, the AHP method will be implemented to ensure the weightage of any of the selected decision criteria, i.e., environmental, social, technical, or economical. Based on its outcomes, the TOPSIS method will be applied to determine the preference order among the various technologies being considered under this study.

3. Results

3.1 Participants' Details

The data was collected through an online questionnaire. The participants were university members, staff individuals, and students. Responses received from them revealed that the questionnaire was primarily answered by students from different departments in the university, sharing an overall percentage of 89.5%. Most of them Contrary to it 10.5% of the responses were received from the academic members (mainly from lecturers). However, none of the response was received from staff members. This information is briefly described in the form of a pie chart in Figure 1.

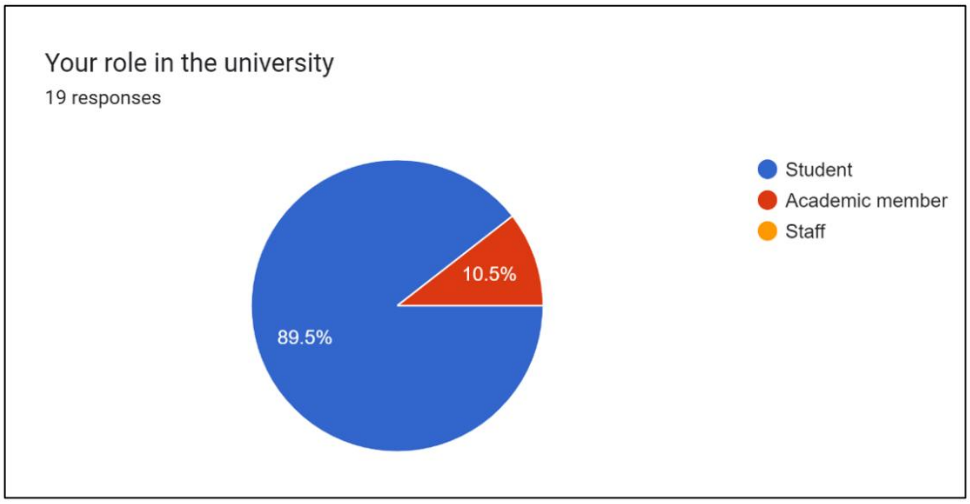

Fig. 1. Statistics of the survey participants.

3.1.1 Participants' Gender

Considering the gender variation among the participants who answered the survey, 68.4% of the respondents were male while 31.6% were females. Figure 2 represents this information in the form of the pie chart. Among all of the respondents, 52.6% reported that they had been visiting or working in the campus for 2 to 4 years, 5.3% for over 4 years, and 42.1% respondents are working or visiting the campus for less than 2 years.

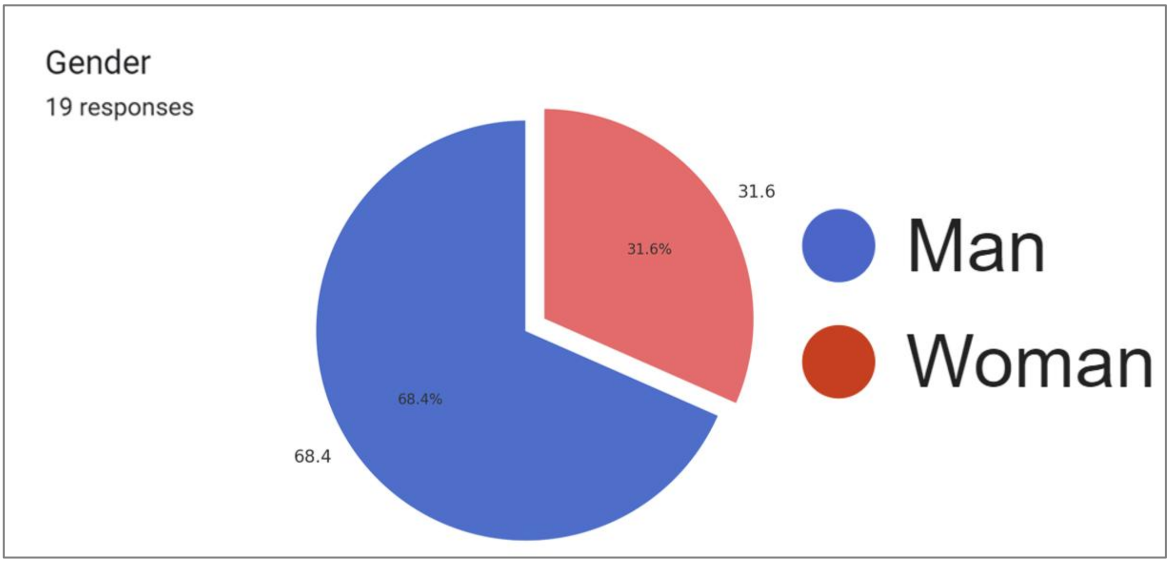

Fig. 2. Gender representation of the respondents.

When the respondents were asked about the extent of circularity of the waste management system existing inside the campus, 73.7% of them reported that it is circular whereas 26.3% of the participants did not think that the existing waste management system in the university campus is circular. Although 3-bin system is available and practiced up to some extent most of the time, generated solid waste is collected and disposed in the dumpsite.

3.2 Waste Management Options

Different options were provided in the questionnaire and responses were requested. As a result, the highest percentage of respondents (47.4%) supported that all the provided options must be considered for bringing the circularity in the existing waste management system in the university. 42.1% of respondents were of the view that selling reusable wastes such as glass can address this issue. 26.3% of respondents preferred composting for bringing circularity to the existing waste management system in the university whereas only 5.3% of them supported the concept of collecting and disposing the waste in the landfill site as shown in Figure 3.

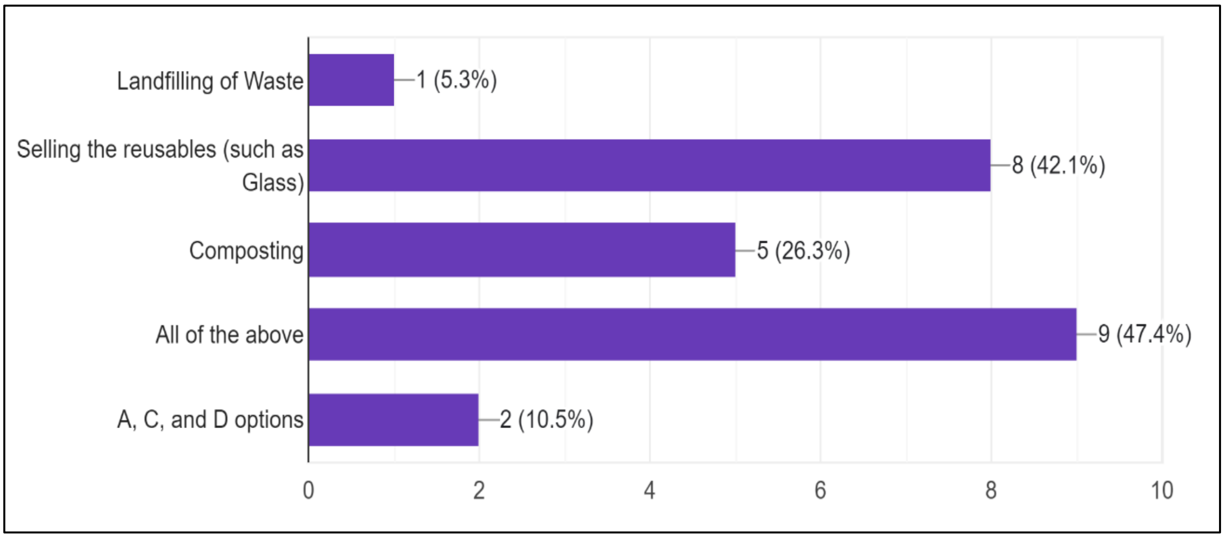

Fig. 3. Alternatives for bringing circularity in waste management system in the campus.

3.2.1 Important Criteria

Four important decision criteria considered include environmental, technical, social, and economic criteria. 73.7% of the respondents said that environmental are most important, whereas 10.5% preferred technical, 10.5% preferred social, and 5.3% preferred economic criteria. Figure 4 explains this information briefly.

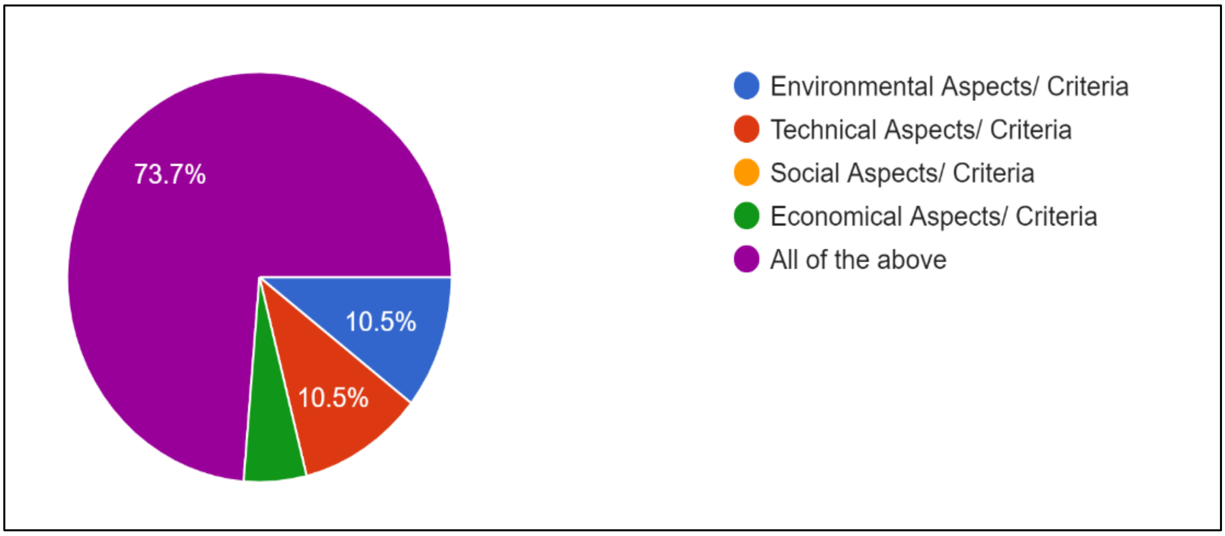

Fig. 4. Criteria for bringing circularity in waste management system in the campus.

3.4 AHP Analysis

According to the data collected from the participants, AHP analysis was carried out to estimate the weightage of 4 considered criteria (environmental, economic, technological, and social). The pairwise matrix prepared using the collected data is shown in Table 3.

Table 3
Pairwise matrix

Pairwise Comparison Matrix				
	Economic	Environment	Technology	Social
Economic	1	0.14	1	7
Environment	7	1	5	9
Technology	1.00	0.20	1	5
Social	0.14	0.11	0.20	1
Sum	9.1	1.45	7.2	22

Based on this pairwise matrix, a normalized matrix was developed as shown in Table 4.

Table 4
Normalized pairwise comparison matrix

Normalized Pairwise Comparison Matrix					
	Economic	Environment	Technology	Social	Criteria Weights
Economic	0.1	0.10	0.139	0.32	0.17
Environment	0.8	0.69	0.69	0.41	0.64
Technology	0.109	0.14	0.14	0.23	0.15
Social	0.016	0.08	0.03	0.045	0.04
Sum	1	1	1	1	

Based on the normalized pairwise matrix prepared, the consistency of the collected information and compiled results were assessed as provided in Table 5.

Table 5
Consistency estimation table

Estimating the Consistency							
	Econ.	Environ.	Tech.	Social	Weighted Sum	Criteria Weights	Ratio
Weight	0.17	0.64	0.15	0.04			
Econ.	0.2	0.09	0.15	0.29	0.70	0.17	4.2
Environ.	1.2	0.64	0.77	0.37	2.94	0.64	4.6
Techn.	0.17	0.13	0.15	0.21	0.65	0.15	4.3
Social	0.02	0.07	0.03	0.04	0.17	0.04	4.0
Sum	1.5	0.93	1.10	0.91			

Since the consistency index of this data came out to be equal to 10%; therefore, these results are acceptable and can be used for executing the TOPSIS. Hence, the calculated percentage weightage of each of these criteria is given in the form of Table 6 where the ranking of alternatives is outlined in Table 7.

Table 6
Criteria weight Identification

#	Criteria	Estimated Weightage
1	Economic	17%
2	Environment	64%
3	Technology	15%
4	Social	4%

Table 7
Ranks of the considered alternatives

Alternative	Relative Closeness to Ideal Solution
Composting	0.956685942
Landfilling	0.168177577
Selling recyclables	0.043314058

3.5 Discussion

Sustainable development is one of the hot topics being discussed all across the globe. Countries are striving hard to limit the negative environmental impacts posed by industrial production. Waste generation and management are also associated closely with the achievement of sustainable development. Waste generated by industries and residential areas is properly managed and treated in developed countries. The concept of circular economy through waste management is becoming more and more important for them. Significant financial resources are being spent on redesigning the linear business models in these countries so that the negative environmental impacts can be minimized.

Particularly in the field of solid waste management and treatment, several treatment technologies have been developed such as pyrolysis (wet and dry), hydrothermal carbonization, incineration, composting (conventional, vermicomposting), Refuse Derived Fuel Manufacturing (RDF) and recycling and reusing the waste items. İn this study, several waste management alternatives have been considered against different criteria. According to the results obtained, participants highly preferred environmental criteria over other types, i.e., social, technological, and economical. After applying the AHP process, it was found that the composting is best technology for treating the waste in the campus. This finding is also in accordance with the outcomes received after applying AHP-TOPSIS together. In addition to the applied methods, this finding is also in line with the findings published in the literature.

4. Conclusions

This study evaluated 3 alternatives for managing the solid waste generated inside the university campus. The AHP method (alone) and AHP-TOPSIS approaches were used to obtain the results. The total number of survey participants who provided their feedback was 19. The results clearly depicted that the best method to be adopted is the composting of waste. This will enable the administration to tackle 50 to 55% of the waste produced. The second most preferred option is to sell the recyclable materials found in the waste stream. Landfilling of waste was the least preferred option according to the participants. It is due to the associated environmental impacts with this type of waste disposal method.

Adoption of the first or second alternative will result in decreasing the waste quantities and will simultaneously assist in improving the recycling rate in the city. Better results could be achieved if both the alternatives will be adopted at the same time. In addition to these advantages, the campus can set an excellent example for the citizens to practice the same techniques for tackling waste-related problems in their homes or communities where they live.

However, the number of participants was very limited in this study. Better results could be obtained if the number of participants can be increased further in the future. In addition, this study only emphasized finding the best practice for managing the waste or ranking the best alternative among the three considered. Future studies could be carried out on developing the implementation plan or designing a comprehensive solid waste management plan for the university campus. Another avenue for future research is to carry out the techno-economic comparison study which could also cover the financial aspects associated with these waste management techniques. The use of other MCDM techniques is also another aspect available for conducting future research.

Author Contributions

Conceptualization, E.B.T. and A.B.K.; methodology, A.B.K.; validation, E.B.T. and A.B.K.; formal analysis, E.B.T. and A.B.K.; investigation, A.B.K.; resources, A.B.K.; data curation, A.B.K.; writing—original draft preparation, A.B.K.; writing—review and editing, E.B.T. and A.B.K.; visualization, A.B.K.; supervision, E.B.T.; project administration, E.B.T. All authors have read and agreed to the published version of the manuscript.

Funding

This research received no external funding.

Data Availability Statement

Data will be provided upon a reasonable request from the corresponding author.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This research was not funded by any grant.

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