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Integrating Multi-Criteria Decision Making Methods For Plastic Waste Mitigation: A Systematic Literature Review

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ABSTRACT

Mitigation of plastic waste problem has been the centre of interest due to the growing and ever increasing of plastic consumption and waste. A myriad of solutions to plastic waste problem has been proposed, although the effectiveness might vary depending on factors such as location, population, and financial support. Therefore, selecting the most viable solution is crucial to ensure the success of mitigation efforts. This paper attempts to review recent research on plastic waste mitigation using analytical and prediction-based approach. To identify the application of Multi Criteria Decision Making (MCDM) in plastic consumption and waste management, a wide range of publications published between 2019 and 2023 were examined. The findings showed that the adoption of MCDM is prevalent in the manufacturing and waste management sector, with AHP and TOPSIS being the primary MCDM methods frequently used in previous studies. The environment, economic, and society domain of the Triple Bottom Line (TBL) are commonly applied to assess sustainability of activities or process, which often concludes with the selection of best solution and alternatives of the given problem. This review underscores the potential yet underexploited role of Multi-Criteria Decision Making (MCDM) in sectors like the food industry. Adopting this method helps address concerns about plastic consumption and waste mitigation by providing objective and reliable results, which is crucial for decision makers.

1. Introduction

The growing concern on ecological impact of plastics towards the environment has spurred research in understanding the issue in-depth and proposing solutions to mitigate plastic waste. Numerous studies have been conducted in areas such as food packaging, solid waste management, supply chain management, and marine pollution. These studies cover a vast interest such as understanding consumers behaviour towards reducing, reusing, and recycling plastics by adopting theory-based framework such as theory of planned behaviour (TPB) in Sarmas *et al.* [1], exploring the barriers to participating in 3Rs activities, intervention studies by default choice by Mundt *et al.*[2], using smart technologies by Roche Cerasi *et al.* [3], incentivizing recycling by Gibovic and Bikfalvi [4],

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zero waste campus by Baba-Nalikant *et al.* [5-6], green foodservice [7-8], plastic waste treatment, as well as reviewing policies and strategy related to plastic management by Kuan *et al.* [9]. Most outputs from this research will propose solutions or alternatives in managing plastic waste, with the goal of reducing plastic consumption and disposal in landfills, while also increasing the rate of recycling. Solutions include but are not limited to plastic bans and fees, strict legislation, buyback schemes, bioplastics, deposit scheme, and recycling. It is worthy to note that proposing solutions and actions may be easy to do, in reality, various factors and constraints come into play in making sure the success of the solution or actions. Additionally, feedback from each stakeholder is important as they will have different interests and preferences, which is beneficial to them, making them incline or reject the solution. With many options of strategy to choose from, it may be difficult to decision maker on which actions or strategy will be successful in implementing. Thus, many researchers have adopted the Multi-Criteria Decision Making (MCDM) techniques in helping decision makers to demonstrate how the methods can be used to predict, select, and rank alternatives.

According to Haseli *et al.* [10], MCDM methods are useful decision-making tools with high reliability to address problems under uncertainty. Many managements and operations are complex systems, due to the large number of interrelationships between the various elements of the system. As the complexity of the system increases, the decision-making process becomes more challenging, since all decisions imply a different prediction and outcome of the future, and as such a more systematic approach is required [11]. To support decision-makers in planning, managing, and facilitating decisions in an optimized and structural manner, Multi-Criteria Decision Making (MCDM) approaches are often utilized [12].

In Mahajan *et al.* [13], MCDM approach involves identifying and evaluating multiple criteria that are relevant to the problem concerned and uses a combination of mathematical algorithms and expert judgement to evaluate and rank the performance of actions or alternatives across all criteria. It allows for the consideration of trade-offs between different criteria and ultimately results in selection of the alternatives that best meet the requirements of decision makers. For example, recycling programs will require a clear mechanism for it to be a success. Attributes like location for drop-off, types of materials that can be recycled, as well as condition of plastic (washed, dry, and separate), need to be informed to the public. Otherwise, the public will be confused or find it inconvenient, thus rendering the program. From the perspective of local council, they will have to consider the feasibility of the program by assessing the location and cost for drop-off facilities, manpower in running the program, logistics for transporting collected items to recycling facilities, and promotional activities to disseminate info regarding the program. As reported by Latkin *et al.* [14], recycling symbol on plastic containers is widely misunderstood by the public which leads to reduced recycling efficiency. This shows the multifaceted attributes to a solution which requires input from various entities and angles.

Hence, this review discusses recent research in plastic waste management utilizing MCDM methods. To contribute knowledge in this area, there are four questions: (1) which areas or sectors integrate MCDM in plastic mitigation-related studies? (2) what are the criteria used to measure sustainability in plastic mitigation studies? (3) which MCDM methods are commonly used in plastic mitigation-related studies? and (4) what are the strengths and limitations of the common MCDM methods adopted in the studies?

In-depth examination of the many components or facets related to the adoption of MCDM in plastic waste management is covered in this paper. It aims to increase the visibility of the range of recent research and identify areas that would benefit from further research and development. An outline of the research design and procedures used to achieve the goals of this work is provided in the section that follows. The technique of data extraction and synthesis was described in more detail in the next section, which was then followed by a discussion based on three sub-themes. Areas for more research are suggested in the concluding section.

2. Methodology

This comprehensive analysis of the literature was conducted to evaluate the present application of MCDM approaches in plastic waste management. For the systematic review, this study applied the Kitchenham guidelines. The review approach is divided into four stages: developing the research questions, choosing the search strategy and articles to use, synthesising the findings, and reporting. The flowchart summarising each process is shown in Figure 1.

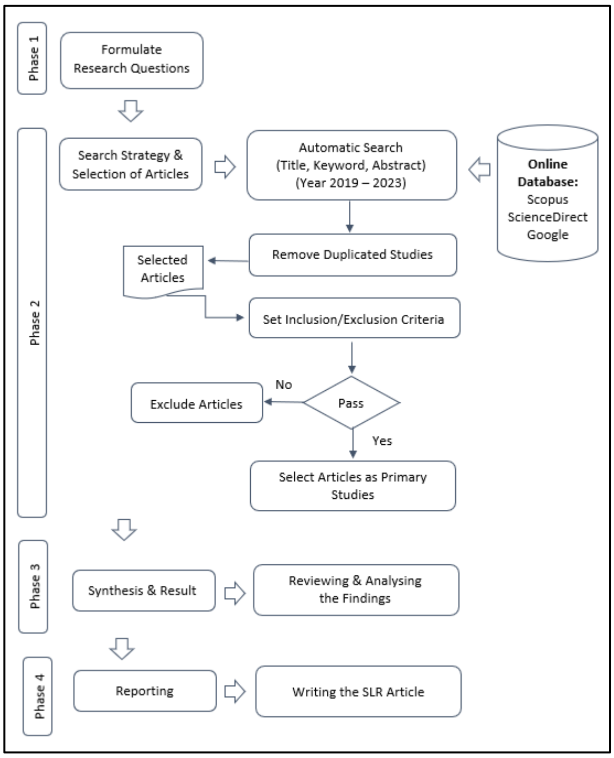

Fig. 1. Implementation review protocol

2.1 Formulating Research Questions

There are four RQs of this SLR as presented in Table 1. This subsection presents the RQ to address the relevant areas in this study. The following research questions are formulated to provide an overview of the approach to sustainable plastic waste management using MCDM. Furthermore, it discusses how each element can provide an objective assessment for plastic-related mitigation efforts and solutions.

Table 1
List of research questions and motivation of related studies

Research Questions	Motivation
Which areas or sectors integrate MCDM in plastic mitigation-related studies?	Summarize sectors or areas commonly adopting MCDM to assess plastic mitigation efforts.

What are the criteria used to measure sustainability in plastic mitigation studies?	Identify the criteria used to assess sustainability in plastic waste management.
Which MCDM methods are commonly used in plastic mitigation-related studies?	Identify commonly used MCDM methods in plastic mitigation studies.
What are the strengths and limitations of the common MCDM methods adopted for plastic mitigation-related studies?	Summarize the strengths and drawbacks associated with MCDM methods used in plastic mitigation studies.

2.2 Search Strategy and Selective Articles

This systematic literature review was performed based on articles extracted from academic journals accessed through Scopus, ScienceDirect and other relevant reports and websites about plastic waste accessed through Google, published from 2019 to 2023. As seen in Figure 2, the search approach for this review is based on the PRISMA flow diagram [15]. This paper adopted the Scopus and ScienceDirect search engine for the initial "title/abstract/keyword" search. Four terms – “multi” AND “criteria” AND “plastics” AND “waste” were used as the primary search terms to find literature. This produced 105 and 5567 papers respectively. The search was restricted to peer-reviewed publications and review papers published during 2019–2023, which helped to focus the search results. This round's major goal was to demonstrate the extent of scientific interest in plastic waste. The number of papers was further reduced to 417 in Round 2 when the scope was narrowed to the subject area and the language "English". In Round 3, 28 papers were found after publications were examined visually and screened by abstracts and keywords. Studies addressing the use of MCDM in managing plastic waste plastic waste and its impact were retrieved as the target. The papers that were excluded are focused primarily on plastic waste conversion and studies adopting MCDM in areas not focusing on plastic waste such as supplier selection and e-waste. Out of the 28 publications, 20 papers were reviewed after removing duplicates. This area of interest for study was reviewed using a total of 35 sources of information, which includes publications searched using the snowball approach. The chosen publications' number (27) was then investigated using in-depth content analysis.

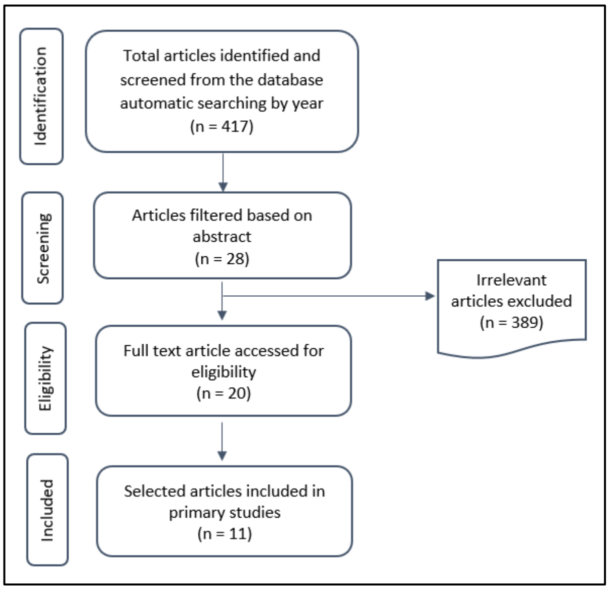

Fig. 2. Selection process

2.3 Inclusion and Exclusion Criteria

The relevance of the publications and articles chosen for this study were assessed using specific criteria for inclusion and exclusion. This is done to guarantee that the RQs are defined accurately and that the selection criteria are reliable. Table 2 lists the specific criteria for assessment in detail.

Table 2
Inclusion and exclusion criteria

Inclusion	Exclusion
Research paper published between 2019 until 2023. Peer-reviewed and review paper Research papers that are free to access Studies related to the adoption of MCDM in plastic waste management. English publication	Research papers that are not free to access. Studies focusing on plastic waste conversion and MCDM related studies in other areas or sectors (i.e., supplier selection). Non-English publication

2.4 Data Extraction and Synthesis

As mentioned in the previous section, this systematic review selected the publication between 2019 and 2023. Figure 3 presents the number of selected primary studies published over five years.

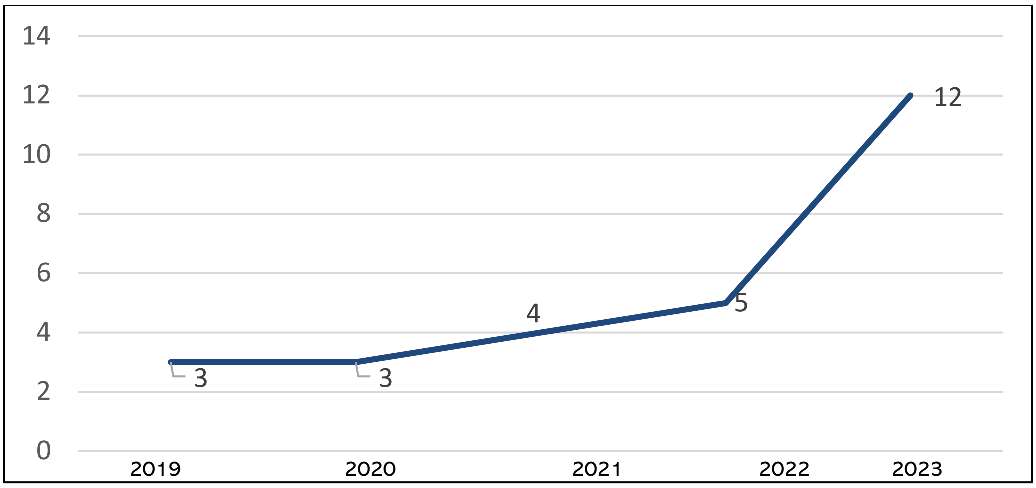

Fig. 3. Number of publications integrating MCDM in sustainability domain (2019-2023)

A sharp growth in number between 2021 and 2023 is evident, perhaps in response to the worldwide focus on the crisis posed by plastic waste and the global attention on sustainability. Out of 27 articles, 12 (44.4%) were published in 2023, followed by 5 (18.5.1%) studies in 2022, 4 (14.8%) studies published in 2021, and 6 (22.2%) released between 2019 to 2020.

In the literature identified, 5 papers have been published in Journal of Cleaner Production, Sustainable Cities and Societies with 2 publications, and Procedia CIRP with 2 publications. The top three journals contributed 9 publications out of 27 publications. Table 3 provides details of each selected article based on year, publication title, number of citations, and publication name.

Table 3
Lists of selected studies for the SLR

Pub. title and name	Reference	Findings
A multi-criteria assessment of the implementation of innovative technologies to achieve different levels of microplastics and macroplastics reduction. *Marine Pollution Bulletin*	Cunha et al. (2023)	Utilising cutting-edge technologies can efficiently decrease both microplastics and macroplastics, with the level of success depending on the technique employed.
Assessing the performance of marine plastics cleanup technologies in Europe and North America *Ocean and Coastal Management*	Brouwer et al. (2023)	The efficacy of marine plastic cleanup solutions differs throughout Europe and North America, with certain technologies exhibiting superior performance in certain regions.
Selection of plastic solid waste treatment technology based on cumulative prospect theory and fuzzy DEMATEL. *Springer Berlin Heidelberg*	Mao et al. (2023)	Advanced mechanical recycling and thermal treatment technologies are preferred due to their effectiveness and feasibility
Circular plastics packaging – Prioritizing resources and capabilities along the supply chain *Technological Forecasting and Social Change*	Stumpf et al. (2023)	Optimising the allocation of resources and competencies throughout the supply chain is essential for improving the efficiency of circular plastics packaging and attaining sustainability objectives.
An integrated Best–Worst Method and Interpretive Structural Modeling approach for assessing the barriers to circular economy implementation. *Decision Analytics Journal*	Debnath et al. (2023)	Offers a thorough comprehension of the primary obstacles to the implementation of a circular economy and the connections between them.
Modelling the Barriers to Sustainable Waste Management in the Plastic-Manufacturing Industry: An Emerging Economy Perspective *Sustainability Analytics and Modeling*	Debnath et al. (2023)	The primary obstacles are insufficient infrastructure, weak regulatory enforcement, and inadequate stakeholder involvement.
Identifying Waste Supply Chain Coordination Barriers with Fuzzy MCDM *Sustainability*	Liang et al. (2023)	Fuzzy MCDM systems are efficient in identifying and prioritising barriers to cooperation in waste supply chains.
Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions. *Journal of Cleaner Production*	Jagoda et al. (2023)	Highlighting the importance of using a holistic life cycle strategy to enhance environmental sustainability plastic packaging.
An integrated multi-criteria decision-making framework for the selection of sustainable biodegradable polymer for food packaging applications *Environment, Development and Sustainability*	Mahajan et al. (2023)	Polybutylene succinate (PBS) is considered one of the most appropriate biodegradable polymers for food packaging.
An innovative probabilistic hesitant fuzzy set MCDM perspective for selecting flexible packaging bags after the prohibition on single use plastics. *Scientific Reports*	Jeon et al. (2023)	Identified suitable flexible packaging bags as alternatives to single-use plastics.
In the nexus of sustainability, circular economy and food industry: Circular food package design *Journal of Cleaner Production*	Kazancoglu et al. (2023)	Integrating sustainability and circular economy principles significantly enhance environmental performance and resource efficiency.

Performance of Sustainable Alternatives Using an Integrated Multi-Criteria Method: Evidence from Brazilian Food Sector *Process Integration and Optimization for Sustainability*	da Silva et al. (2023)	Selected sustainable packaging alternatives for the Brazilian food sector
Stratified hybrid decision model with constrained attributes: Recycling facility location for urban healthcare plastic waste *Sustainable Cities and Society*	Torkayesh & Simic (2022)	Determine best locations for recycling facilities based on a combination of factors and constraints relevant to urban healthcare plastic waste.
An approach to assess PWR methods to cope with physical barriers on plastic waste disposal and exploration from developing nations. *Expert Systems with Applications*	Narayanamoorthy et al. (2022)	Main challenges in managing plastic waste in developing nations include inadequate infrastructure, limited resources, lack of public awareness, weak regulations, physical barriers, and economic constraints.
Barriers in the adoption of buyback schemes for used plastic packaging material – a contextual relationship analysis. *Resources, Conservation and Recycling*	Vimal et al. (2022)	The obstacles to implementing buy back schemes for used plastic packaging encompass economic, logistical, and regulatory difficulties.
Integrated TOPSIS-COV approach for selecting a sustainable PET waste management technology: A case study in Qatar. *Heliyon*	Al-Thani et al. (2022)	Identifies chemical recycling as the most suitable technology for managing PET waste in Qatar
Barriers to organic waste management in a circular economy *Journal of Cleaner Production*	Kharola et al. (2022)	Obstacles to managing organic waste in a circular economy include insufficient infrastructure, low public awareness, and lack regulatory assistance.
Packaging Plastic Waste Management for a Circular Economy and Identifying a better Waste Collection System using Analytical Hierarchy Process (AHP) *Procedia CIRP*	Balwada et al. (2021)	Selected a multi-bin waste collection system as the most effective approach for managing packaging plastic waste.
An integrated sustainability assessment of drinking straws *Journal of Environmental Chemical Engineering*	Chang & Tan (2021)	Plastic straw found to be more sustainable than stainless-steel straw
The hesitant Pythagorean fuzzy ELECTRE III: An adaptable recycling method for plastic materials *Journal of Cleaner Production*	Geetha et al. (2021)	Chemical recycling and mechanical recycling, which incorporate improved sorting techniques, are considered superior to traditional recycling procedures.
Measuring sustainability performance using an integrated model *Measurement: Journal of the International Measurement Confederation*	Rayhan Sarker et al. (2021)	The integrated model offers a comprehensive and efficient framework for assessing and enhancing sustainability performance.
Consumer-based actions to reduce plastic pollution in rivers: A multi-criteria decision analysis approach. *PLoS ONE*	Marazzi et al. (2020)	Engaging in plastic reduction, actively participating in clean-up campaigns, and endorsing sustainable products can significantly aid in mitigating plastic pollution in rivers.
Analysis of barriers that impede the elimination of single-use plastic in developing economy context. *Journal of Cleaner Production*	Vimal et al. (2020)	Primary obstacles include insufficient waste management infrastructure, weak enforcement of regulations, limited public awareness, and fiscal restraints.

Multi-criteria decision analysis (MCDA) method for assessing the sustainability of end-of-life alternatives for waste plastics: A case study of Norway. *Science of the Total Environment*	Deshpande et al. (2020)	Modern recycling technologies and waste-to-energy choices are considered the best sustainable alternatives for managing waste plastics at the end of their life cycle.
Materials selection of 3D printing filament and utilization of recycled polyethylene terephthalate (PET) in a redesigned breadboard *Procedia CIRP*	Exconde et al. (2019)	The use of PET as a material for 3D printing filaments shows both environmental advantages and practical viability.
Identifying critical success factors to facilitate reusable plastic packaging towards sustainable supply chain management. *Journal of Environmental Management*	Gardas et al. (2019)	Critical components include efficient collaboration among stakeholders, resilient infrastructure, and substantial regulatory backing.
Method based on life cycle assessment and TOPSIS to integrate environmental award criteria into green public procurement. *Sustainable Cities and Society*	Vidal & Sachez-Pantoja (2019)	The most sustainable options are those that reduce environmental impact, use recycled or renewable materials, are energy efficient, and minimize waste.

3. Results

3.1 Thematic Focus

The analysis of 27 research papers revealed that these studies had examined various constructs to highlight the assessment of possible solution to plastic waste issues using objective approach inherent in MCDM. The results of the analysis are discussed in this section under three different focus areas: (a) MCDM approach in various sectors dealing with plastic waste issue, (b) criteria used to assess viable and sustainable options in mitigating plastic waste, and (c) MCDM methods adopted in plastic waste mitigation studies and the advantage as well as drawbacks associated with the methods.

3.1.1 Adoption of MCDM approach to deal with plastic waste issue

To fully understand the interest of plastic waste issue and growing relevance on ways to mitigate plastic waste, it is necessary to find out the application of MCDM in various fields to seek possibility of the techniques being used in other fields or discipline as well identifying areas that may have yet to fully utilized these techniques. This will provide the necessary information regarding the suitability of the approach in helping decision makers in their complex decision-making process. The MCDM approach has been widely used in various disciplines ranging from manufacturing, waste management, and even location selection [16-18]. In the tourism and hospitality sector, MCDM techniques have been utilised to evaluate holiday destinations [19], assessing the quality service of restaurants [20], and selecting best online food delivery service [21]. Although it is usually used from the business or management perspectives, individuals may also benefit from this method as it provides systematic and objective assessment of a related problem [13]. A recent example is its use in assisting the public with mobile phone selection [22] and the evaluation of courier service preferences [23]. MCDM has also been widely applied in other domains such as education and information security, assisting decision-makers in making more informed and rational choices [24-25].

Among the various studies integrating MCDM in decision process for plastic mitigation, the manufacturing and waste management sector is seen as adopting these techniques more than other sectors. This could be since manufacturing is involved in production which ultimately produces waste, while waste management deals with waste daily which requires effective and efficient ways to manage waste. A study conducted by Chang and Tan [16] compares sustainability between plastic and stainless-steel straw manufacturing via the Life Cycle Assessment (LCA) coupled with Analytical Hierarchical Process (AHP). Surprisingly, plastic straw was found to be more sustainable than stainless-steel straw, as shown by their low impact value. In addition, LCA and fuzzy AHP (FAHP) were used to compare packaging design for ketchup bottles [26]. Other studies using MCDM focusing on selection of materials include choosing eco-friendly packaging using a combination of weighted sum method (WSM), weighted product method (WPM), weighted aggregated sum product assessment method (WASPAS), and technique for order of preference by similarity to ideal solution (TOPSIS) by Mahajan *et al.* [13], and identifying the most selected flexible packaging bag by integrating WASPAS in Jeon *et al.* [27].

With regards to recycling and treatment of waste associated with plastics, several authors have proven the usefulness of MCDM tools in selecting the best alternatives. These include selection of plastic waste collection methods using AHP [28], select the best PET waste treatment by applying AHP with the addition of fuzzy TOPSIS [12], finding out the adaptability of recycling methods for plastics materials by integrating other MCDM approach which is the Hesitant Pythagorean Fuzzy (HPF) and ELimination and Choice Expressing Reality (ELECTREE III) [29], address the recycling center location selection problem in Istanbul using hierarchical stratified best-worst method with the constrained combined compromise solution (CoCoSo) and the constrained weighted aggregated sum product assessment (WASPAS) methods, called H-SBWM-C-CoCoPAS [18], and to assess plastic waste recycling methods to cope with physical barriers to plastic waste disposal by applying AHP and Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE-II) [30].

MCDM can also be used to identify the most influential barriers and examine the interrelationship between the barriers by using Decision Making Trial and Evaluation Laboratory (DEMATEL) [17, 31]. A study concerning the barriers responsible for the difficulty in eliminating single-use plastics reveal that lack of manufacturing facilities for biodegradable products, lack of financial support for development of alternatives, and lack of government initiatives were responsible for the concerned problem [31]. Similarly, Debnath *et al.* [17], focuses on the barriers to implementing solid waste management in the Bangladeshi plastic industry and shows that individual attitudes and awareness towards plastic waste disposal attributes to the said problem. Vimal *et al.* [31] took different approaches of MCDM known as the Total Interpretive Structural Modeling method (TISM) and Matrice d'Impacts Croisés Multiplication Appliqués à un Classement (MICMAC) analysis to develop contextual relationship-based structural model. Their study concluded that unclear and unstable policy is the most influential barrier, whereas consumer motivation as the least influential and most dependent barrier. Another study uses the same method as Vimal et al. [31], to identify critical success factors (CSFs) of the reusable plastic packaging (RPP) system and to establish their interrelationship in the context of manufacturing industries [32].

Other studies adopting MCDM techniques include the assessment of plastic reduction actions in freshwater pollution, the impact of food packaging design on sustainability, and the impact of disposal methods of waste fishing gears (mostly plastics). The authors, however, did not specify the MCDM techniques used in their studies [33-35]. The MCDM techniques used in various fields focusing on plastic mitigation are summarised in Table 4, while Table 5 presents publication of MCDM works in different fields of interest (non-plastics).

Table 4
Summary of recent articles applying MCDM in plastic waste mitigation-related studies

Reference	Country	MCDM tools	Areas of application
Mahajan et al. (2023)	India	TOPSIS, WSM, WPM & WASPAS	Packaging
Jagoda et al. (2023)	Sri Lanka	Fuzzy AHP	Packaging design
Cunha et al. (2023)	Mediterranean	PROMETHEE-TOPSIS	Cleanup technology
Debnath et al. (2023)	Bangladesh	DEMATEL	Solid waste management
Brouwer et al. (2023)	Europe & North America	SAW & TOPSIS	Cleanup technology
Kazancoglu et al. (2023)	Turkey	MCDM	Packaging design
Mao et al. (2023)	China	Fuzzy DEMATEL, Fuzzy TOPSIS & TODIM	Treatment
Stumpf et al. (2023)		AHP	Supply chain
Jeon et al. (2023)		WASPAS	Packaging
Al-Thani et al. (2022)	Qatar	AHP-TOPSIS	Treatment
Narayanamoorthy et al. (2022)		AHP-PROMETHEE-II	Recycling
Tavana et al. (2022)	USA	IT2TFS-BWM-CoCoSo	Packaging
Torkayesh & Simic (2022)	Turkey	H-SBWM-C-CoCoPAS	Recycling location
Vimal et al. (2022)	India	TISM & MICMAC	Buyback program
Balwada et al. (2021)	India	AHP	Recycling
Chang & Tan (2021)	Malaysia	AHP	Manufacturing
Geetha et al. (2021)		HPF ELECTRE II	Recycling
Deshpande et al. (2020)	Norway	MCDM	Solid waste management
Vimal et al. (2020)		DEMATEL	SUPs reduction
Marazzi et al. (2020)		MCDM	Marine plastic reduction
Exconde et al. (2019)	Philippines	ELECTRE	Manufacturing
Gardas et al. (2019)	India	TISM-MICMAC	Packaging

Table 5
Summary of recent articles applying MCDM in other fields of interest (non-plastic)

Reference	Country	MCDM tools	Areas of application
Liang et al. (2023)	China	DANP	Waste supply chain
Debnath et al. (2023)	Bangladesh	BWM-ISM & MICMAC	E-waste
da Silva et al. (2023)	Brazil	Fuzzy AHP & Fuzzy TOPSIS	Foodservice
Kharola et al. (2022)	India	DEMATEL	Organic waste
Rayhan Sarker et al. (2021)	Bangladesh	AHP, TOPSIS & VIKOR	Leather industry
Vidal & Sánchez-Pantoja (2019)	Spain	TOPSIS	Procurement

Referring to Table 4, recent studies on plastic mitigation using MCDM approaches focus mostly on packaging or manufacturing [13, 16, 26-27, 32, 36-37] and solid waste management [17, 35], especially on the efforts associated with recycling [18, 28-30, 34]. Few of the studies investigates the effectiveness of cleanup technologies in reducing microplastics in the sea [38-39]. In Table 5, MCDM has been applied in areas such as leather manufacturing, green procurement, and waste management [40-44]. This proves the applicability of the MCDM methods in any type of discipline. Nonetheless, it seems that the approach has yet to be fully utilized in some fields such as the foodservice sectors that are equally responsible in generating a huge number of plastics wastes. Moreover, nearly all the studies included are from the perspectives of business or management as they normally would be involved in decision making process of running an operation as efficiently and effectively, thus making MCDM a relevant tool. There is absence of studies using MCDM from the viewpoints of the opposite spectrum (i.e., public, end users, and public). It would be insightful to explore MCDM from their perspectives to guarantee representative judgement. As mentioned by

Marazzi *et al.* [33], the involvement of consumers in various actions holds significant importance in facilitating change and bolstering the efficacy of environmental initiatives and has a crucial role in facilitating the implementation of effective changes in decision-making processes.

3.1.2 Attributes for sustainable plastic waste-related evaluation

Policy makers and industry participants are placing more emphasis on the notion of sustainability or Sustainable Development (SD). The concept of sustainable development (SD) is expounded upon in the Brundtland report, which emphasises the equitable consideration of the needs of both present and future generations. The increasing attention towards sustainable development has underscored the need to evaluate the sustainability of various processes, making it more crucial than ever before [16, 45]. The concept of sustainability assessment is commonly understood as a tool that aids in the process of making informed decisions that align with the principles of sustainability as mentioned by Chang and Tan [16]. There exists a variety of tools that can be utilised for the purpose of conducting sustainability assessments. In general, the instruments can be classified into three overarching categories: indicators/indices, assessments connected to products, and integrated assessments. MCDM is a tool inside this framework of integrated assessments that evaluates conflicting evaluation criteria to determine the ideal solution. Applications of these methods are frequently observed in the context of policy or project decision-making processes, and their use is often depending on systems analysis method [16]. Depending on the application, each concerned problem or investigated issue possesses preferential attributes or criteria, which makes them superior compared to others [13]. In literature, authors have emphasized certain criteria qualities to be considered while selecting alternatives or options, with many applying the Triple Bottom Line (TBL) when assessing sustainability. The concept considers organizational practices related to environmental and social dimensions, added to financial performance [45].

The TBL dimensions is widely used and functions as guidelines for business or activities to achieve sustainability. Numerous studies have adopted this concept by having the three pillars of TBL as their main criteria in assessing process, activities, and solutions. Several authors exclusively adopted the TBL domains for their study [12, 16, 32, 39-40], while others expanded it by adding other attributes or criteria deemed necessary for the study [18, 27-28, 35, 45]. For instance, technical criteria were added to address the recycling location selection problem in Torkayesh and Simic [18] and selecting the most appropriate plastic solid waste treatment technology in Mao *et al.* [46]. Quality, resource, time, and marketing were included as an addition to TBL domain to prioritize the criteria and evaluate the performance of sustainable alternatives in restaurants [45], while ease of sorting is used to measure plastic waste collection methods [28]. On the other hand, some studies partly adopt the TBL domain, with economic and environment being the most selected attribute [13, 29, 33, 38, 43], whereas the social domain is not included as part of the assessment. For instance, Brouwer *et al.* [38], omitted the social domain as their focus is to assess the effectiveness of cleanup technologies in minimizing marine plastic waste. Other important criteria incorporate in past studies include safety, evidence, and feasibility [26, 33, 35]. Table 6 summarizes the list of criteria used in assessing sustainability in various disciplines.

Table 6
Summary of criteria used in previous studies to assess sustainability

Reference	Criteria						
	Environment	Economic	Social	Barriers	Feasibility	Technical	Others
Mahajan et al. (2023)		√		√			Thermal, mechanical
Jagoda et al. (2023)					√		Protection, communication
Cunha et al. (2023)	√	√	√				
Debnath et al. (2023)				√			
Brouwer et al. (2023)		√					Effectiveness of technologies
Liang et al. (2023)		√					Mechanism, subject behaviour, technologies & standards
Kazancoglu et al. (2023)						√	Customer expectation
Mao et al. (2023)	√	√	√			√	
Jeon et al. (2023)	√	√	√				Efficiency
da Silva et al. (2023)	√	√	√				Quality, resources, time, marketing
Al-Thani et al. (2022)	√	√	√				
Kharola et al. (2022)		√	√				Physical, strategy
Torkayesh & Simic (2022)	√	√	√			√	
Vimal et al. (2022)				√			
Balwada et al. (2021)	√	√	√				Ease of sorting
Chang & Tan (2021)	√	√	√				
Geetha et al. (2021)	√	√				√	Safety
Rayhan Sarker et al. (2021)	√	√	√				
Deshpande et al. (2020)	√	√	√				Evidence
Vimal et al. (2020)				√			
Marazzi et al. (2020)	√	√			√		Potential scale of change, evidence of impact
Gardas et al. (2019)	√	√	√				
Total	13	17	12	4	2	4	

As shown in Table 6, it is apparent that studies in the direction of sustainability will adopt TBL as their evaluation main criteria. The economics of the TBL component are denoted as productivity and return on investments, especially in the manufacturing sector. It covers decision criteria related to cost and financial operations related to productive activities [18, 45] – e.g.: collection cost, investment cost, operational cost, and material cost. In addition, Marazzi *et al.* [33] refers to economics as high or low financial costs or the impact for consumers and/or businesses.

Environment involves the influences of productive activities on natural and unnatural systems [45]. In other words, it addresses different aspects of ecosystem issues, with the aim of minimizing negative environmental impact [32]. It includes reduce packaging waste, plastic waste pollution reduction potential, increasing the volume of collected recyclable materials, and usage of biodegradable and compostable materials [27, 32-33, 46]. Finally, society is focused on how the productive sectors can contribute to society [45]. It also indicates preferences and behaviour of population around possible alternatives to a problem [18]. Put simply, it measures social acceptance, which is the willingness of population or social citizens have a high degree of acceptability.

Although the components of TBL suffice for sustainability study in general, authors should be critical in deciding whether to adopt exclusively, expand, or modify it to fit the nature of the study. Certain studies will require specific criteria to fully achieve their goals. In support of the argument, several authors have utilized the TBL domain but with the addition of 'technical' criteria [18, 29, 33, 46]. In Marazzi *et al.* [33], the technical criterion is included since the study is focusing on consumers action to reduce plastics footprint. Therefore, ease of implementation and usage, and availability factor is important for consumers to catalyst a change. Studies such as Geetha *et al.* [29] omitted social domain, using safety and technical criteria instead to evaluate adaptability of recycling method for plastic materials. Evidence is another important criterion that can be used with TBL in assessing sustainability. Several studies measure the evidence or evidence impact to show how the TBL domain contributes to sustainability. For example, Marazzi *et al.* [33] measures the evidence of impact of plastic reduction actions in freshwater environment to provide robust results. They predicted the amount of waste generated or reduced based on the actions performed. That being said, choosing the right criteria is essential to guarantee objective and reliable evaluation.

3.1.3 Multi-Criteria Decision Making methods

Multi-criteria decision making is an analytical method used to evaluate alternative decision options based on a set of common criteria and can be used to handle incomplete and uncertain information in a robust and flexible manner [33], since decision maker are often affected by subjective judgements [37]. The challenge associated with decision making in complex systems arises from the intricate interplay of both competitive and non-competing components inside the system, as well as the ever-changing character of such systems [12]. In an MCDM approach, different criteria are examined, and a total score is assigned to each alternative based on the evaluation provided often by a group of experts [37]. This process facilitates the examination of trade-offs among many parameters and ultimately leads to the choice of the alternatives that most effectively fulfils the application's requirements [13]. The following two dominant MCDM methods were identified throughout the review: (1) AHP and (2) TOPSIS. The subsequent sections of this paper will provide an overview and analysis of the examined research for each specific method. Subsequently, a brief examination of the general approach is presented, along with an evaluation of the merits and drawbacks associated with each method. Table 7 presents the summary of recent publication using MCDM in both plastic and non-plastic mitigation related studies.

Table 7
Summary of recent studies using MCDM

Reference	MCDM methods							
	AHP / FAHP	TOPSIS / FTOPSIS	DEMATEL / FDEMATEL	TISM	VIKOR / FVIKOR	MICMAC	ELECTRE	SAW	Others
Mahajan et al. (2023)		√							WSM, WPM, WASPAS
Jagoda et al. (2023)	√ (F)								
Cunha et al. (2023)		√							PROMETHEE
Debnath et al. (2023)			√						
Brouwer et al. (2023)		√						√	
Kazancoglu et al. (2023)									MCDM
Mao et al. (2023)		√ (F)	√ (F)						TODIM
Stumpf et al. (2023)	√								
Jeon et al. (2023)									WASPAS
Liang et al. (2023)									DANP
Debnath et al. (2023)						√			BWM-ISM
da Silva et al. (2023)	√ (F)	√ (F)							
Al-Thani et al. (2022)	√	√							
Narayanamoorthy et al. (2022)									AHP-PROMETHEE-II
Tavana et al. (2022)									IT2TFS-BWM-CoCoSo
Torkayesh & Simic (2022)									H-SBWM-C-CoCoPAS
Vimal et al. (2022)				√		√			
Kharola et al. (2022)			√						
Balwada et al. (2021)	√								
Chang & Tan (2021)	√								
Geetha et al. (2021)									HPF ELECTRE II
Rayhan Sarker et al. (2021)	√ (F)	√ (F)			√ (F)			√	
Deshpande et al. (2020)									MCDM
Vimal et al. (2020)			√						

Marazzi et al. (2020)									MCDM
Exconde et al. (2019)							√		
Gardas et al. (2019)				√		√			
Vidal & Sánchez-Pantoja (2019)		√							
Total	7	8	4	2	1	3	1	2	

3.1.3.1 Analytic Hierarchy Process (AHP)

The Analytic Hierarchy Process (AHP) was introduced by Thomas L. Saaty in 1984 [47] to tackle complex decision-making scenarios inside intricate contexts. It is a comprehensive and systematic framework that integrates principles from psychology and mathematics to assess the relative priority among a given set of choices. The primary concept underlying the AHP is to reframe a multifaceted problem by organising it into a hierarchical framework comprised of distinct elements: the overarching goal (i.e., the problem's objective), criteria (which constitute the second level), and alternatives (which represent the last level within the hierarchy) [26]. This method utilises pairwise comparisons, where decision-makers assess the relative significance of specific criteria using a 9-point scale [40]. The main benefit of AHP is its competence to check and reduce the inconsistency of professional judgments (i.e., ensuring reliability of results) by checking the consistency ratios of experts [28, 40]. However, the AHP method is not devoid of limitations. For instance, the 9-point judgement scale is considered imbalanced, which means that ambiguity and imprecision can have an impact on the pairwise-comparisons matrix. Moreover, this method is dependent on the subjective assessment of the relative contributions of parts within the hierarchy through comparison. Occasionally, the lack of expertise in the pertinent domain may result in less accurate decision-making [16].

In 1985, Buckley proposed the utilisation of the Fuzzy Analytic Hierarchy Process (FAHP) [48], which integrates fuzzy sets into the AHP methodology, to address these issues. In the context of the FAHP, decision-makers articulate their viewpoints in the form of interval values as opposed to rigid or fixed values, and finally the fuzzy weights of the criterion are determined using the geometric mean approach [40, 46]. This approach is preferred over the conventional AHP due to its greater robustness, particularly in situations when decision-making processes entail inherent uncertainty, and problems are not readily apparent [45]. The obtained weights of criteria can then be utilised by other MCDM tools to evaluate the performance of alternatives [40]. The Fuzzy Analytic Hierarchy Process (FAHP) method is therefore highly appropriate for calculating the relative weights of each index within a hierarchical structure during performance assessment.

Secondly, although this method can be used to determine the relative weights of different criteria and prioritise several alternatives, it neglects their interactions and dependencies since the criteria assumption in AHP are independent. The Analytical Network Hierarchy (ANP), an enhanced version of the Analytical Hierarchy Process (AHP), is capable of addressing the interdependence and feedback relationships among criteria [31]. Another drawback associated with AHP is the number of comparison matrices, resulting in lengthy calculation. The duration required to establish a hierarchy for AHP analysis is directly related to the number of decision levels present, as well as the computational load necessary to solve the problem. Therefore, when confronted with a complex procedure that entails multiple layers of criteria, the time required to arrive at a conclusion is extended [16]. For easy calculation and straightforward calculation, another MCDM method such as TOPSIS may be used [12].

The AHP and Fuzzy AHP have demonstrated effective capabilities in addressing complex decision-making situations. It has been successfully employed in several sustainability domain studies [12, 16, 17, 40, 45, 49-50]. A study by Stumpf *et al.* [50] identifies and prioritise the key resources and capabilities necessary for a successful transition towards a circular economy within the plastic packaging supply chain by employing a real-time Delphi approach in combination with an analytic hierarchy process (AHP). The integration of both methodologies serves to mitigate the inherent constraints of the AHP, namely its reliance on quantitative data and the restricted number of criteria that may be compared [50]. Balwada *et al.* [28] illustrated the use of AHP in identifying the best plastic waste collection methods, citing the ability of AHP to check and reduce the inconsistency of professional judgments as the main reason for choosing this approach. Their findings indicate that the Deposit and Refund method of garbage collection is very compatible with the principles of the circular economy. Chang and Tan [16] have combined LCA and AHP to compare sustainability between plastic and stainless-steel straw. Their study integrates AHP and Sustainability Assessment Framework (SAF), with the Triple Bottom Line pillars as their main criteria. The AHP results showed plastic straw as a more sustainable choice than stainless-steel straw.

Rayhan Sarker *et al.* [40] presents a sustainability performance measurement model for the leather industry, integrating the Balanced Scorecard (BSC) perspective and the Fuzzy multiple-criteria decision-making (FMCDM) approach. Fuzzy Analytic Hierarchy Process (FAHP) was applied to compute the relative weights of each sustainability index. The performance of alternatives was then measured using three MCDM methods - Simple Additive Weighting (SAW), fuzzy Technique for Order Preference by Similarity to Ideal Situation (TOPSIS), and fuzzy Multi-Criteria Optimization and Compromise Solution (VIKOR). The authors proposed that the weights of sustainability indexes in their study may be used as a reference by expert groups to assess sustainability performance. This study, however, did not account for interrelationship among the sustainability indexes. A similar approach was conducted by da Silva *et al.* [45] by integrating two MCDM techniques to prioritize the criteria and evaluate the performance of sustainable alternatives for the restaurant sector. FAHP was applied to compute relative weights of seven criteria, while the performance of 24 alternatives was evaluated using FTOPSIS, as a continuation of the FAHP method. Using Fuzzy AHP, the weights for the criteria were generated, and the most important, in the view of restaurant managers, was the quality criterion. Their findings corroborate the findings of past studies, in which managers give higher priority to quality as a criterion that improves the sustainability of restaurants.

3.1.3.2 *Technique for Order of Preferences by Similarity to Ideal Solution (TOPSIS)*

The Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) introduced by Hwang and Yoon in 1981 [51] is a widely used approach in the field of multi-criteria decision making. The primary principle underlying the TOPSIS method is the identification of the alternative that exhibits the minimum Euclidean distance to the ideal solution (which represents the best performance in each dimension), while simultaneously maximising the Euclidean distance from the negative-ideal solution (which represents the worst performance) [41]. The TOPSIS method possesses several advantageous attributes. Firstly, its approach is characterised by rationality and clarity. Secondly, the calculations involved in TOPSIS are simple and easily computable. Thirdly, this approach has the capability to identify the optimal alternative from a set of multiple alternatives through a simplified mathematical representation. Lastly, the method incorporates objective methods within its calculations [12, 41]. Like AHP, fuzzy sets can be integrated into the TOPSIS methodology to deal with imprecise judgements as proposed by Chen and Hwang in 1992 [52]. In this context, fuzzy values are used to help capture the existing subjectivity in the decision-making process [45, 53]. Nonetheless, one notable drawback of TOPSIS method is that it assumes the factors as independent and does not execute causal interrelations [54].

Both TOPSIS and fuzzy TOPSIS have exhibited considerable efficacy in dealing with intricate decision-making scenarios. It has been effectively utilised in several studies pertaining to the topic of sustainability [12-13, 40-41, 45-46, 55]. For instance, owing to the multiple conflicting criteria involved in material selection, Mahajan *et al.* [13] explore sustainable eco-friendly food packaging solutions using several MCDM approaches including TOPSIS, SAW, WPM, and WASPAS. Their study integrated several MCDM approaches to address the gap of single method in previous studies and found that polylactic acid (PLA) is the most reliable polymer for food packaging applications after considering barrier properties, cost, mechanical properties, and technical properties. Although diverse scores were obtained by each alternative due to the variations in computing procedures, the ranking can be made possible by using the procedure known as the Degree of Membership (DOM) [13]. Brouwer *et al.* [55] evaluate the efficacy of current plastic litter cleanup technologies in Europe and North America by employing SAW and TOPSIS techniques. These methods were selected based on simplicity reason, and criteria were given equal weight. Unlike previous studies, their study is the first integrating MCDM in marine plastic litter cleanup technologies.

Mao *et al.* [46] employ fuzzy TOPSIS method and an acronym in Portuguese of the interactive and multi-criteria decision-making (TODIM) method to select the most appropriate plastic solid waste treatment technology. The fuzziness in MCDM problems arises from the imprecision and subjectivity inherent in environmental data and human preferences. Therefore, it is crucial to incorporate fuzzy logic and fuzzy set theory into the decision-making process to effectively handle the uncertainty and vagueness associated with these problems. Hence, fuzzy set theory was applied in Mao *et al.* [46], plastic solid waste treatment study and combined with the decision method of TOPSIS. The fuzzy TOPSIS technique is a very effective MCDM approach that prioritises options based on their proximity to the ideal answer, without taking into account the psychological elements of the decision makers (DMs). In contrast, the TODIM method, being bounded rational, does consider the psychological factors of the DMs. The comparison analysis demonstrates the significance of psychological elements and reference points in the decision-making process of plastic solid waste treatment.

In the area of waste management technology, Al-Thani *et al.* [12] used a holistic MCDM approach to evaluate the sustainability of eight different PET waste bottle treatment methods. They employ a combination of the technique for order of preference by similarity to ideal solution (TOPSIS) with analytic hierarchy (AHP; TOPSIS-AHP) and coefficient of variation (COV; TOPSIS- COV) approaches. Both AHP and COV were used to calculate the weights of performance indicator, with the latter being the first application in waste management domain. The reason for using the AHP and COV methodology is to compare subjective and objective weights whereby the COV method provides more objective and accurate weights while the AHP is influenced by the emotions and previous experiences of the decision-makers. Results generated showed comparable weights except for three performance indicators – cost, photochemical oxidant, and human toxicity. To improve the accuracy of the research, the authors suggested integrating data gathered through Life Cycle Assessment (LCA) of PET waste management system [12]. In da Silva *et al.* [45], the performance of 24 alternatives for the restaurant sector was evaluated using FTOPSIS, as a continuation of the FAHP method. The fuzzy TOPSIS is used to elaborate the performance ranking of the alternatives to verify which is the best alternative to help achieve better levels of sustainability in restaurants. The integration of both methodologies shows that the alternative with superior performance is the proper disposal and disposal of burnt cooking oil. Additionally, alternatives rank among the lowest were associated with several challenges or barriers. The study contributes using Fuzzy AHP and Fuzzy TOPSIS methods, indicating greater robustness to provide a rich understanding of the practice of the food sector, specifically the restaurant sector. A recommendation for future studies to create a framework to help restaurants put into practice the different alternatives evaluated is needed as emphasised by da Silva *et al.* [45].

4. Conclusions and Future Directions

This review has outlined the approaches and methods used to understand the application of MCDM in plastic waste mitigation related studies. This review categorized three main themes in plastic waste mitigation management: application of MCDM in related studies, sustainability assessment for activities or project pertaining to plastic waste management, and common MCDM approaches used in solving problems associated with plastic waste. To conclude, this review has made three contributions. Firstly, it highlights the application of MCDM in several areas of interest, particularly in the manufacturing and waste management domain. Certain sectors such as the foodservice have yet to fully employ this technique in assessing sustainability activities. Secondly, it discloses the main criteria for sustainability assessment, with Triple Bottom Line pillars of environment, economic, and social as commonly chosen attributes. Regardless of the setting of the studies (e.g., marine, manufacturing, and design), the TBL pillars are suitable to evaluate sustainability across many domains. Nevertheless, selection of criteria is imperative to achieve the goal of the study and should be considered thoroughly. Thirdly, it has discussed the common MCDM techniques in plastic waste related studies, with AHP and TOPSIS being widely used. Though several studies rely on a single MCDM method, many authors chose to combine several MCDM techniques to show robustness of the result and reliability of the methods applied. Both AHP and TOPSIS are flexible in integrating with other MCDM methods, making it fit for any decision-making problem. Due to the increasing concern on plastic consumption and waste issue, a decision must be made on how to mitigate this problem and to create a sustainable approach to plastic waste management. Therefore, several aspects that have the potential for further discussion and future direction are suggested as follows:

1. Application of MCDM in the foodservice sector to mitigate plastic consumption and plastic waste. Being one of the main contributors of plastic waste, especially single-use plastics, the foodservice sector needs to play an important role to reduce the reliance of single-use plastics in their daily operation. As presented in this review, studies applying MCDM in the foodservice sector are very scarce in comparison to manufacturing and solid waste management. The foodservice sector can benefit from this application as many strategies have been suggested in literatures gearing towards sustainability in restaurants. However, these suggestions have proven to be viable in certain geographies or with certain demographic populations, and not successful in different areas. Therefore, the integration of MCDM for the foodservice sector can help policy makers, local council and managers determine the best solution or alternatives for plastic waste mitigation efforts. This approach has proven to be time saving as it is capable of predicting the effectiveness of a solution or alternatives for a given problem.
2. Incorporating fuzzy logic and fuzzy set theory into the decision-making process. Environmental studies involving stakeholders will require judgement that is subject to human preferences or subjective assessments. For instance, studies to reduce plastic usage in restaurants will take the point of view of several stakeholders such as foodservice operators, local council, the public, and plastic alternative providers. The judgment will be affected by their individual preference and their knowledge of the matter. Therefore, it is important to

incorporate fuzzy logic and fuzzy set theory into the decision-making process to handle the uncertainty and vagueness associated with this problem.

3. Applying a combination of MCDM tools. The application of a single MCDM tool in measuring the performance of alternatives, however, does not ensure reliable results. Several previous studies have thus used more than one MCDM tool to measure the performance of alternatives. In short, findings from multiple MCDM methods are reliable compared to those based on a single method.

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References

[1] Sarmas, E., Xidonas, P., & Doukas, H. (2020). Multicriteria Decision Analysis Methods. Springer Optimization and Its Applications, 163(1), 19–34. https://doi.org/10.1007/978-3-030-53743-2_3
[2] Mundt, D., Carl, S., & Harhoff, N. (2020). A Field Experiment on Reducing Drinking Straw Consumption by Default. Frontiers in Psychology, 11. https://doi.org/10.3389/fpsyg.2020.565537
[3] Roche Cerasi, I., Sánchez, F. V., Gallardo, I., Górriz, M., Torrijos, P., Aliaga, C., & Franco, J. (2021). Household plastic waste habits and attitudes: A pilot study in the city of Valencia. Waste Management and Research, 39(5), 679–689. https://doi.org/10.1177/0734242X21996415
[4] Gibovic, D., & Bikfalvi, A. (2021). Incentives for plastic recycling: How to engage citizens in active collection. Recycling, 6(2), 29. https://doi.org/10.3390/recycling6020029
[5] Baba-Nalikant, M., Abdullah, N. A., Husin, M. H., Syed-Mohamad, S. M., Mohamad Saleh, M. S., & Rahim, A. A. (2023). The relationship between knowledge, attitudes, values, and technology in promoting zero-waste pro-environmental behaviour in a zero-waste campus framework. Recycling, 8(2), 40. https://doi.org/10.3390/recycling8020040
[6] Baba-Nalikant, M., Syed-Mohamad, S. M., Husin, M. H., Abdullah, N. A., Mohamad Saleh, M. S., & Abdul Rahim, A. A. (2023). A zero-waste campus framework: Perceptions and practices of university campus community in Malaysia. Recycling, 8(1), 21. https://doi.org/10.3390/recycling8010021
[7] Langgat, J., Fabeil, N. F., Pazim, K. H., & Pawan, M. T. (2021). Green Kopitiam: Operators' Awareness & Readiness. Global Business and Management Research: An International Journal, 14 (3).
[8] Martin-Rios, C., Demen Meier, C., & Pasamar, S. (2022). Sustainable waste management solutions for the foodservice industry: A Delphi study. Waste Management & Research, 40(9), 1412-1423. https://doi.org/10.1177/0734242X221079306
[9] Kuan, S. H., Low, F. S., & Chieng, S. (2022). Towards regional cooperation on sustainable plastic recycling: comparative analysis of plastic waste recycling policies and legislations in Japan and Malaysia. Clean Technologies and Environmental Policy, 24(3), 761–777. https://doi.org/10.1007/s10098-021-02263-0
[10] Haseli, G., Torkayesh, A. E., Hajiaghaei-Keshteli, M., & Venghaus, S. (2023). Sustainable resilient recycling partner selection for urban waste management: Consolidating perspectives of decision-makers and experts. Applied Soft Computing, 137, 110120. https://doi.org/10.1016/j.asoc.2023.110120
[11] Bennet, A. and Bennet, D. H. (2008). The Decision-Making Process for Complex Situations in a Complex Environment. Handbook on Decision Support Systems 1: Basic Themes. Berlin: Springer-Verlag.
[12] Al-Thani, N. A., Al-Ansari, T., & Haouari, M. (2022). Integrated TOPSIS-COV approach for selecting a sustainable PET waste management technology: A case study in Qatar. Heliyon, 8(8), e10274. https://doi.org/10.1016/j.heliyon.2022.e10274
[13] Mahajan, A., Singh, I., & Arora, N. (2023). An integrated multi-criteria decision-making framework for the selection of sustainable biodegradable polymer for food packaging applications. Environment, Development and Sustainability, 0123456789. https://doi.org/10.1007/s10668-023-03052-z
[14] Latkin, C.A.; Dayton, L.; Yi, G.; Balaban, A. The (Mis)Understanding of the Symbol Associated with Recycling on Plastic Containers in the US: A Brief Report. Sustainability 2022, 14, 9636. https://doi.org/10.3390/su14159636
[15] Moher, D., Liberati, A., Tetzlaff, J., Altman, D. G., The PRISMA Group. (2009). Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. PLOS Med, 6(7), e1000097. https://doi.org/10.1371/journal.pmed.1000097

[16] Chang, L., & Tan, J. (2021). An integrated sustainability assessment of drinking straws. Journal of Environmental Chemical Engineering, 9(4), 105527. https://doi.org/10.1016/j.jece.2021.105527
[17] Debnath, B., Bari, A. B. M. M., Ali, S. M., Ahmed, T., Ali, I., & Kabir, G. (2023). Modelling the Barriers to Sustainable Waste Management in the Plastic-Manufacturing Industry: An Emerging Economy Perspective. Sustainability Analytics and Modeling, 3(January), 100017. https://doi.org/10.1016/j.samod.2023.100017
[18] Torkayesh, A. E., & Simic, V. (2022). Stratified hybrid decision model with constrained attributes: Recycling facility location for urban healthcare plastic waste. Sustainable Cities and Society, 77(March 2021), 103543. https://doi.org/10.1016/j.scs.2021.103543
[19] Ahmad Sabri, I. A., Mohamad Noor, N. M., Ali, N. H., & Ismail, F. (2022). A personalized travel recommender system using fuzzy analytic hierarchy process. BIMP-EAGA Journal for Sustainable Tourism Development, 11(1), 15. https://doi.org/10.51200/bimpeagajtsd.v11i1.3914
[20] Mujiya Ulkhaq, M., Nartadhi, R. L., & Akshinta, P. Y. (2016). Evaluating service quality of Korean restaurants: A fuzzy analytic hierarchy approach. Industrial Engineering & Management Systems, 15(1), 77-91. https://doi.org/10.7232/iems.2016.15.1.077
[21] Wan Nurul Husna Wan Nordin, S. A. Othman, M. Ramli, S. A. Abdul Rashid, & N. N. Sukri. (2023). Utilizing the fuzzy analytical hierarchy process (FAHP) approach to identify the best online food delivery services. Journal of Mathematics and Computing Science, 9(1), 1-12. e-ISSN: 0128-0767.
[22] Lam, W. S., Lam, W. H., Liew, K. F., Bakar, M. A., & Lai, C. P. (2024). Evaluation and selection of mobile phones using integrated AHP-TOPSIS model. Journal of Advanced Research in Applied Sciences and Engineering Technology, 33(2), 25-39. https://doi.org/10.37934/araset.33.2.2539
[23] Liew, K. F., Lam, W. S., Lam, W. H., & Er, K. K. (2025). Evaluation on the preference of courier services using integrated AHP-TOPSIS model. Journal of Advanced Research Design, 125(1), 24-41. https://doi.org/10.37934/ard.125.1.2441
[24] Mohamed Yusof, Y. M. H., Romli, A., Arshah, R. A., & Abdul Aziz, A. (2023). A sensitivity analysis for roles selection in hybrid multi-criteria decision making. Journal of Advanced Research in Applied Sciences and Engineering Technology, 31(1), 210-225. https://doi.org/10.37934/araset.31.1.210225
[25] Loo, B. W., Tan, L. P., Tey, S. K., & Chin, W. Y. (2024). Authentication methods selection in information security through hybrid AHP and EGT. Journal of Advanced Research in Applied Sciences and Engineering Technology, 50(2), 171-185. https://doi.org/10.37934/araset.50.2.171185
[26] Jagoda, S. U. M., Gamage, J. R., & Karunathilake, H. P. (2023). Environmentally sustainable plastic food packaging: A holistic life cycle thinking approach for design decisions. Journal of Cleaner Production, 400(February), 136680. https://doi.org/10.1016/j.jclepro.2023.136680
[27] Jeon, J., Krishnan, S., Manirathinam, T., Narayanamoorthy, S., Nazir Ahmad, M., Ferrara, M., & Ahmadian, A. (2023). An innovative probabilistic hesitant fuzzy set MCDM perspective for selecting flexible packaging bags after the prohibition on single-use plastics. Scientific Reports, 13(1), 1–20. https://doi.org/10.1038/s41598-023-37200-2
[28] Balwada, J., Samaiya, S., & Mishra, R. P. (2021). Packaging Plastic Waste Management for a Circular Economy and Identifying a better Waste Collection System using Analytical Hierarchy Process (AHP). Procedia CIRP, 98(March), 270–275. https://doi.org/10.1016/j.procir.2021.01.102
[29] Geetha, S., Narayanamoorthy, S., Kureethara, J. V., Baleanu, D., & Kang, D. (2021). The hesitant Pythagorean fuzzy ELECTRE III: An adaptable recycling method for plastic materials. Journal of Cleaner Production, 291, 125281. https://doi.org/10.1016/j.jclepro.2020.125281
[30] Narayanamoorthy, S., Manirathinam, T., Geetha, S., Salahshour, S., Ahmadian, A., & Kang, D. (2022). An approach to assess PWR methods to cope with physical barriers on plastic waste disposal and exploration from developing nations. Expert Systems with Applications, 207(May), 117996. https://doi.org/10.1016/j.eswa.2022.117996
[31] Vimal, K. E. K., Mathiyazhagan, K., Agarwal, V., Luthra, S., & Sivakumar, K. (2020). Analysis of barriers that impede the elimination of single-use plastic in developing economy context. Journal of Cleaner Production, 272, 122629. https://doi.org/10.1016/j.jclepro.2020.122629
[32] Gardas, B. B., Raut, R. D., & Narkhede, B. (2019). Identifying critical success factors to facilitate reusable plastic packaging towards sustainable supply chain management. Journal of Environmental Management, 236(February), 81–92. https://doi.org/10.1016/j.jenvman.2019.01.113
[33] Marazzi, L., Loiselle, S., Anderson, L. G., Rocliffe, S., & Winton, D. J. (2020). Consumer-based actions to reduce plastic pollution in rivers: A multi-criteria decision analysis approach. PLoS ONE, 15(8 August). https://doi.org/10.1371/journal.pone.0236410
[34] Kazancoglu, Y., Ada, E., Ozbiltekin-Pala, M., & Aşkın Uzel, R. (2023). In the nexus of sustainability, circular economy and food industry: Circular food package design. Journal of Cleaner Production, 415(June), 137778. https://doi.org/10.1016/j.jclepro.2023.137778

[35] Deshpande, P. C., Skaar, C., Brattebø, H., & Fet, A. M. (2020). Multi-criteria decision analysis (MCDA) method for assessing the sustainability of end-of-life alternatives for waste plastics: A case study of Norway. Science of the Total Environment, 719, 137353. https://doi.org/10.1016/j.scitotenv.2020.137353
[36] Exconde, M. K. J. E., Co, J. A. A., Manapat, J. Z., & Magdaluyo, E. R. (2019). Materials selection of 3D printing filament and utilization of recycled polyethylene terephthalate (PET) in a redesigned breadboard. Procedia CIRP, 84(March), 28–32. https://doi.org/10.1016/j.procir.2019.04.337
[37] Tavana, M., Shaabani, A., Di Caprio, D., & Bonyani, A. (2022). A novel Interval Type-2 Fuzzy best-worst method and combined compromise solution for evaluating eco-friendly packaging alternatives. Expert Systems with Applications, 200(March), 117188. https://doi.org/10.1016/j.eswa.2022.117188
[38] Brouwer, R., Huang, Y., Huizenga, T., Frantzi, S., Le, T., Sandler, J., Dijkstra, H., van Beukering, P., Costa, E., Garaventa, F., & Piazza, V. (2023a). Assessing the performance of marine plastics cleanup technologies in Europe and North America. Ocean and Coastal Management, 238(January), 106555. https://doi.org/10.1016/j.ocecoaman.2023.106555
[39] Cunha, M. C., Tsiaras, K., Marques, J. R., Hatzonikolakis, Y., Dias, L. C., & Triantaphyllidis, G. (2023). A multi-criteria assessment of the implementation of innovative technologies to achieve different levels of microplastics and macroplastics reduction. Marine Pollution Bulletin, 191(April), 1–12. https://doi.org/10.1016/j.marpolbul.2023.114906
[40] Rayhan Sarker, M., Mithun Ali, S., Kumar Paul, S., & Haque Munim, Z. (2021). Measuring sustainability performance using an integrated model. Measurement: Journal of the International Measurement Confederation, 184(July), 109931. https://doi.org/10.1016/j.measurement.2021.109931
[41] Vidal, R., & Sánchez-Pantoja, N. (2019). Method based on life cycle assessment and TOPSIS to integrate environmental award criteria into green public procurement. Sustainable Cities and Society, 44(October 2018), 465–474. https://doi.org/10.1016/j.scs.2018.10.011
[42] Debnath, B., Bari, A. B. M. M., de Jesus Pacheco, D. A., & Karmaker, C. L. (2023). An integrated Best–Worst Method and Interpretive Structural Modeling approach for assessing the barriers to circular economy implementation. Decision Analytics Journal, 7(March), 100250. https://doi.org/10.1016/j.dajour.2023.100250
[43] Liang, C., Sun, D., & Xie, D. (2023). Identifying Waste Supply Chain Coordination Barriers with Fuzzy MCDM. Sustainability, 15(6), 5352. https://doi.org/10.3390/su15065352
[44] Kharola, S., Ram, M., Goyal, N., Mangla, S. K., Nautiyal, O. P., Rawat, A., Kazancoglu, Y., & Pant, D. (2022). Barriers to organic waste management in a circular economy. Journal of Cleaner Production, 362 (2022) 132282. https://doi.org/10.1016/j.jclepro.2022.132282
[45] da Silva, D. J. C., de Castro, B. L. G., da Veiga, C. P., de Souza Campos, L. M., da Silva Stertz, E., de Fátima Paz Nunes, A., Pozzer, R. H. P., & Lopes, L. F. D. (2023). Performance of Sustainable Alternatives Using an Integrated Multi-Criteria Method: Evidence from Brazilian Food Sector. Process Integration and Optimization for Sustainability, June. https://doi.org/10.1007/s41660-023-00348-5
[46] Mao, Q., Chen, J., Lv, J., Guo, M., & Xie, P. (2023). Selection of plastic solid waste treatment technology based on cumulative prospect theory and fuzzy DEMATEL. In Environmental Science and Pollution Research (Vol. 30, Issue 14). Springer Berlin Heidelberg. https://doi.org/10.1007/s11356-022-25004-2
[47] Saaty, T. L. (1990). How to make a decision: The analytic hierarchy process. European Journal of Operational Research, 48(1), 9-26. https://doi.org/10.1016/0377-2217(90)90057-I
[48] Buckley, J. J. (1985). Fuzzy hierarchical analysis. Fuzzy Sets and Systems, 17(3), 233-247. https://doi.org/10.1016/0165-0114(85)90059-7
[49] Balwada, J., Samaiya, S., & Mishra, R. P. (2021b). Packaging Plastic Waste Management for a Circular Economy and Identifying a better Waste Collection System using Analytical Hierarchy Process (AHP). Procedia CIRP, 98(March), 270–275. https://doi.org/10.1016/j.procir.2021.01.102
[50] Stumpf, L., Schöggl, J. P., & Baumgartner, R. J. (2023). Circular plastics packaging – Prioritizing resources and capabilities along the supply chain. Technological Forecasting and Social Change, 188(May 2022). https://doi.org/10.1016/j.techfore.2022.122261
[51] Hwang, C. L., & Yoon, K. (1981). Multiple attribute decision making: Methods and applications. Springer.
[52] Chen, S. J., & Hwang, C. L. (1992). Fuzzy multiple attribute decision making: Methods and applications. Springer.
[53] Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8(3), 338-353. https://doi.org/10.1016/S0019-9958(65)90241-X
[54] Mark, V., & Patrick, T. H. (2013). An Analysis of Multi-Criteria Decision Making Methods. International Journal of Operations Research, 10(2), 56–66.
[55] Brouwer, R., Huang, Y., Huizenga, T., Frantzi, S., Le, T., Sandler, J., Dijkstra, H., van Beukering, P., Costa, E., Garaventa, F., & Piazza, V. (2023b). Assessing the performance of marine plastics cleanup technologies in Europe

and North America. Ocean and Coastal Management, 238(January), 106555. https://doi.org/10.1016/j.ocecoaman.2023.106555