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A Systematic Literature Review on MOORA Methodologies and Applications

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Abstract: *Recently, Multi-objective optimization by ratio analysis (MOORA) as a new and efficient Multiple-criteria decision-making (MCDM) method was applied in different areas for ranking alternatives and choosing the best ones. MOORA method evaluates the studied options by using positive and negative criteria. In this paper, a literature review is presented to study the MOORA methodology and its applications. So, all published papers in Science Direct journals are investigated and categorized from different perspectives (application area, journal of publication, year of publication, authors' nationality, and type of data in form of fuzzy /crisp). The papers covered several filed: material selection, energy, welding process, and surface roughness, automotive and wire, fuel selection, logistics and transportation, heat transfer, optimization, and other topics. It is hoped that the study is useful for researchers and also a useful reference for practitioners and academics to improve their future research. The highest amount of using the MOORA method with the number of 15 articles is related to material selection, which shows the importance of using the MOORA method for material selection. And the lowest amount of using the MOORA method with the number of two articles is related to fuel selection. The present study was able to provide a framework for future research by reviewing the MOORA method. The results show that the MOORA method is one of the most efficient methods for evaluating options in different fields, which can be used in different areas.*

Keywords: *MOORA, MCDM, Application area, Literature Review, Methodologies, Applications*

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1. Introduction

MCDM methods provide a reasonable approach to solving complex problems in the real world and evaluate various alternatives concerning different criteria in form of a decision matrix to choose the best one (Emovon et al., 2020). In MCDM methods, in addition to the decision matrix, measuring the weights of criteria is an essential part of the evaluation process. MCDM methods are helpful when an individual or a group of decision-makers are engaged in consideration problems and asked to share their experiences, perceptions, and knowledge (Erdoğan et al., 2019).

In recent decades, several popular MCDM methods, have been developed to analyze different decision-making problems practically, such as; the analytical hierarchy process (AHP), the technique for order preference by similarity to ideal solution (TOPSIS), Elimination and choice expressing reality (ELECTRE), preference ranking organization method for enrichment evaluations (PROMETHEE), complex proportional assessment (COPRAS), evaluation based on distance from average solution (EDAS), combinative distance-based assessment (CODAS) and multi-objective optimization by ratio analysis (MOORA) (Anilkumar et al., 2021). MOORA is one of the new MCDM methods where which uses a multi-objective optimization procedure to analyze decision-making problems. This method has simple operation steps which are based on grouping different predictions. One of the significant advantages of MOORA is that it can normalize under consideration alternatives using non-directional values instead of subjective normalization (Özkan et al., 2021).

MOORA, first introduced by Brauers and Zavadskas (2006), is an MCDM method with high efficiency for evaluating different problems in the presents of criteria and alternative diversity. Many positive points were identified for MOORA compared to other extended MCDM methods including; fewer mathematical calculations, more easiness, less computational time, and more stability compared with some MCDM techniques (Dabbagh and Yousefi, 2019). Two main reasons caused MOORA to be chosen in different studies, are; (1) MOORA is a new MCDM method that improved the weakness of older methods, and (2) MOORA requires a low solving time in different studies (Akkaya et al., 2015).

Since MOORA is easy to understand and implement among other MCDM methods (Ramkumar et al., 2021) and has the advantage in computation time comparing other methods, the computational easiness supports its' applicability. Also, additional parameters couldn't influence the implementation of the mathematical steps of MOORA, so then it's extremely useful for different decision-making problems (Gupta et al., 2021). On the other hand, MOORA doesn't require many parameters like VIKOR, PROMETHEE, and ELECTRE. So, it evaluates the alternatives simply and utilizes basic mathematical calculations to find out the best decision (Maji et al., 2017).

Amongst the other MCDM methods that utilize a decision matrix, TOPSIS is the most similar to MOORA. When MOORA is compared with TOPSIS, the total performance of every alternative is calculated on its distance from the positive ideal and negative ideal. However, MOORA shows an easier way to determine the total index (Maji et al., 2017). MOORA, like TOPSIS, uses a vector normalization procedure to normalize the decision matrix (Zarbakhshnia et al., 2020). As a

compensatory method (Chauhan et al., 2021), MOORA considers both positive (profit) and negative (loss) and also contradictory criteria for ranking a set of alternatives, simultaneously (Karande and Chakraborty, 2012). It's used to convert multiple targets into one objective function. In most research, a mathematical model is created to show the relationship between the overall quality index and parameters, in which the quality index is displayed as a function of process parameters, and then the model is applied in an experimental section (Liang et al., 2020). According to the above-mentioned sentences, this study aims to review existing literature on MOORA scientific articles published in Science Direct.

2. Methodology

In this research, all of the published articles on the MOORA method from 2012 to 2023 were selected to review. To this aim, a comprehensive search was conducted among papers published in the Science Direct database based on the "Title, abstract or author-specified keywords" field, where 88 papers were found to be reviewed. After the primary study of the papers, 50 papers were appropriate to further this study. As each paper was reviewed, it was classified by several categories: application area, year of publication, authors' nationality, and fuzzy or crisp nature of papers, as shown in Table (1).

Table 1. The classification scheme for the literature review on MOORA method

N	Application Area	Journal of Publication	Year of Publication	Authors' Nationality	Fuzzy /Crisp
1					
2					
50					

On the other hand, 50 papers were categorized into 13 specific areas including; financial services, COVID-19 intensive care, material selection, energy, welding process and surface roughness, automotive and wire, fuel selection, logistics and transportation, heat transfer, and other topics.

The steps of MOORA method are listed as follows:

Step (1): Prepare a decision matrix. The decision matrix has consisted of the number of *m* alternatives evaluated based on the *n* criteria.

$$X = \begin{bmatrix} x_{11} & x_{12} \cdots & x_{1n} \\ x_{21} & x_{22} \cdots & x_{2n} \\ \vdots & \vdots & \vdots \\ x_{m1} & x_{m2} & x_{mn} \end{bmatrix} \quad (1)$$

Step (2): Normalize the decision matrix:

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}}. \quad (2)$$

$i = 1, 2, 3, \ldots, m$ and $j = 1, 2, 3, \ldots, n$, Where n is the number of alternatives and m is the number of criteria and x_{ij} is the performance index of i^{th} alternative on j^{th} attribute.

Step (3): calculate the weighted normalized matrix using:

$$Y_{ij} = W_j . n_{ij} \quad (3)$$

Where W_j indicates the weight of j^{th} criterion

Step (4): Determine the final preference values by:

$$y_i = \sum_{j=1}^{g} Yij - \sum_{j=g+1}^{n} Y_{ij} \; (j = 1, 2, \cdots, n) \quad (4)$$

y_i is the normalized assessment value of i^{th} alternative.

2.1. Analysis of MOORA Application Areas

As mentioned previously, 50 papers were studied in this review in 13 areas: material selection includes 15 papers (30%), logistics and transportation include 6 papers (12 %), energy includes 5 papers (10%), welding process and surface roughness includes 5 papers (10%), automotive and wire includes 4 papers (8%), heat transfer includes 3 papers (6%), fuel selection includes 2 papers (4%), and other topics include 10 papers (20%). On the other hand, in 2012; 1 paper; 2013; 1 paper, 2015; 4 papers, 2017; 3 papers, 2018; 7 papers, 2019; 8 papers, 2020; 4 papers, 2021; 17 papers, and 4 papers, 2022; 1 paper, 2023 were published in 14 different areas. Table 2, categorized applicable papers, figure 1 shows the frequency of applied papers by year, and figure 2 illustrates the applied papers by year as follows:

Table 2. Distribution of applied papers between 2012 to 2023

	2012	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**Total**
Material Selection	1	0	0	0	0	0	1	2	2	9	0	0	15
Logistics and Transportation	0	0	0	1	0	1	2	1	1	0	0	0	6
Energy	0	0	0	0	0	0	0	1	0	4	0	0	5
Welding Process and Surface Roughness	0	0	0	0	0	0	3	0	1	0	1	0	5
Automotive and Wire	0	0	0	1	0	0	0	1	0	2	0	0	4
Heat Transfer	0	0	0	0	0	2	1	0	0	0	0	0	3
Fuel Selection	0	0	0	1	0	0	0	1	0	0	0	0	2
Other Topics	0	1	0	1	0	0	0	2	0	2	3	1	10
Total	**1**	**1**	**0**	**4**	**0**	**3**	**7**	**8**	**4**	**17**	**4**	**1**	**50**

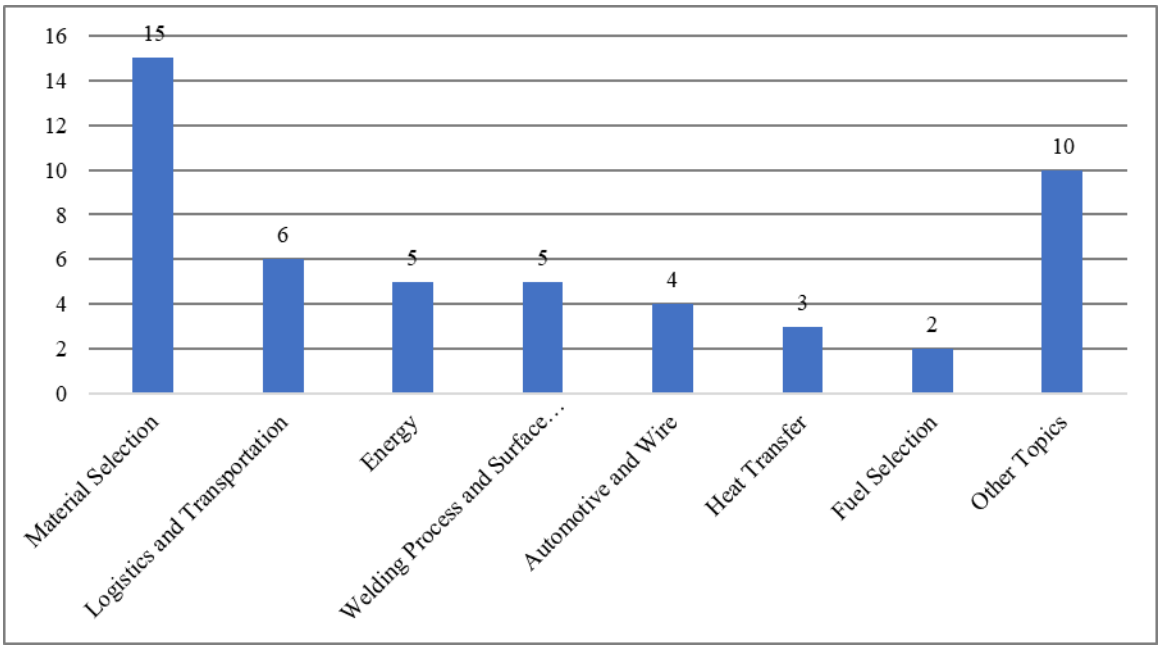

Figure 1. Frequency of papers by application area

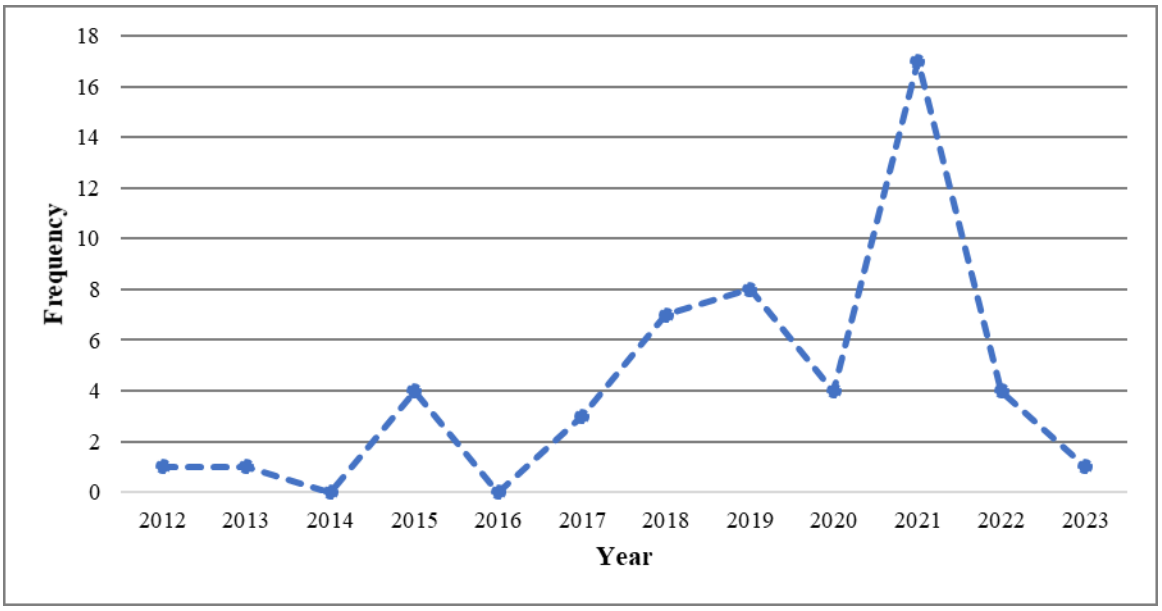

Figure 2. Frequency of applied papers by year

2.2. Material Selection

In MOORA's application area, most of the papers are related to the topic of material selection. In this study, Material selection has covered different specific areas such as optimization of material selection, graphene nanofluids, bio-polymer selection, sustainable material selection, rotational molding process, and screening of waste material. In the context of material selection, 15 papers were published. Moradian et al. (2019) used MOORA to investigate multi-criteria decision-making

techniques for material selection. The results show the alternative materials were ranked and were found the best material for the brake booster. Anandan et al. (2021) employed AHP and MOORA to investigate graphene nanofluids on various environmental factors in manufacturing and the result showed graphene nanofluids considerably decreased the surface roughness temperature.

In one study, Ram Kumaretal et al. (2021) used CRITIC, TOPSIS, COPRAS, and MOORA methods to select material for spur gear. The result showed that the Alloy steel and Aluminum Silicon Composite material ranked as either the second or third material option in both the MCDM methods. Anandan et al. (2021) employed AHP and MOORA methods to investigate the influence of graphene nanofluids on different environments. The results demonstrate that graphene nanofluids considerably decline surface roughness, tool wear, and cutting temperature. Anilkumar et al. (2021) utilized a hybrid approach of AHP, TOPSIS, MOORA, CRITIC, EDAS, and Entropy to choose the optimum selection of phase change material for solar box cooker integrated and the result showed that erythritol is the best alternative for thermal energy storage. Karanda and Chakraborty (2012) applied MOORA to select the best materials. The result showed that the obtained ranking of the alternative is more accurate than other studies. Shihad et al. (2019) in their study, utilized MOORA to optimize of process cladding of stainless steel on mild steel, and MOORA has successfully optimized the process parameters considered. Teraiya et al. (2018) applied a hybrid approach like Entropy, AHP, TOPSIS, COPRAS, MOORA, VIKOR, and ARAS to find the various connecting rod materials.

In a study, Gomes et al. (2020) used CRITIC, MOORA, and TOPSIS methods for screening waste materials. The results showed that the most significant factors for decision-making were the removal efficiency of pathogenic microorganisms, acid neutralization capacity, and germination index. Kalel et al. (2021) investigated the selection of the right kind of stainless-steel particles for copper-free brake pads. Finally, the results revealed that the ranking of the brake pads was done by using the MOORA. Manivannan et al. (2021) applied MOORA to investigate abrasive water jet machining parameters on reinforced polyester composites. The outcome of this study indicated that the optimal machining parameters are A3, B2, and C2. Ramkumar et al. (2021) used MOORA for the injection molding process. The outcome of this study indicated that Poly Glycolic Acid can be employed as a base resin in production. Gupta et al. (2021) used TOPSIS and MOORA for selecting material rotational molding process. The outcome of this study was satisfactory and the coir has been concluded as the material with the highest ranking. Agrawal. (2021) employed MOORA, TOPSIS, VIKOR, and Saw methods to select sustainable materials. The outcomes of this study can help decision-makers in the selection of the best materials to help cleaner production. Patnaik et al. (2020) utilized AHP and MOORA methods to composite material selection for structural application. The outcome of these studies indicated the ranking obtained by the AHP-MOORA and these methods are much easy and simple for ranking the material alternatives. The papers published on the topic of 'Material selection' are in table 3.

Table 3. The applied papers on the topic of 'Material selection'

Author(s)	Year	Application Area	Other Methods
Teraiya, et al	2018	Material Selection	Entropy, AHP, TOPSIS, COPRAS, MOORA, VIKOR, ARAS
Moradian, et al	2019	Material Selection	AHP, VIKOR, TOPSIS

Shihab, et al	2019	Materials Selection	-
Gomes, et al	2020	Screening of Waste Materials	CRITIC, TOPSIS
Patnaik, et al	2020	Material Selection	AHP
Anandan, et al	2021	Material Selection	AHP
Anilkumar, et al	2021	Material Selection	TOPSIS, EDAS, AHP, Entropy, CRITIC
Ram Kumar, et al	2021	Material Selection	CRITIC, TOPSIS, COPRAS
Anandan, et al	2021	Material Selection	AHP
Kalel, et al	2021	Material Selection	-
Manivannan, et al	2021	Material Selection	-
Ramkumar, et al	2021	Material Selection	Entropy
Gupta, et al	2021	Material Selection	AHP, Entropy, TOPSIS,
Agrawal	2021	Material Selection	TOPSIS, VIKOR, SAW

2.3. Logistics and Transportation

Logistics and transportation are also other significant application selections in the literature of MOORA which is related to the aspects of transportation, outsourcing sustainable reverse logistics, sustainable supplier selection, supplier evaluation, selection of transport and handling resources, and Airline. In the context of logistics and transportation, 6 papers were published. Dinçer et al. (2017) applied a hybrid approach such as fuzzy DEMATEL, Fuzzy ANP, and MOORA methods to investigate the performance of European airlines. The results indicated that customer dimensions and profit per customer are the most important factors. Pamucar and cirovic (2015) utilized a hybrid approach with MOORA and other MCDM methods to the selection of transport and handling resources. The results showed that MOORA, TOPSIS, COPRAS, SAW, and VIKOR methods do not sit one or more of the situation set. Liou et al. (2019) utilized a hybrid model of DANP and MOORA methods for green supplier evaluation and performance improvement. The outcome of this study indicated that the model help managers solve the problem of green supplier selection and prepare strategies to improve effectively. Zarbakhshnia et al. (2020) employed fuzzy AHP and MOORA methods for outsourcing sustainable reverse logistics. The results indicated that the proposed approach offers a more viable performance with qualitative data and input uncertainties.

Arabsheybani et al. (2018) developed fuzzy MOORA and FMEA methods for sustainable supplier selection and these methods showed that the model increases total profit and also increases the risks that impose on sustainability. Kabak et al. (2018) employed AHP and MOORA methods for the evaluation of Bike-share stations, and the result showed a database of criteria and alternative sites using a geographic information system. Table 4 shows the papers on the topic of 'Logistics and transportation.

Table 4. The applied papers on the topic of 'Logistics and transportation'

Author (s)	**Year**	**Application Area**	**Other Methods**
Pamučar & Ćirović	2015	Selection of Transport and Handling Resources	MABAC, DEMATEL, MOORA, TOPSIS, SAW, VIKOR
Dinçer, et al	2017	Performance Measurement of European Airlines	Fuzzy DEMATEL, Fuzzy ANP
Arabsheybani, et al	2018	technique for Sustainable Supplier Selection	FMEA

Kabak, et al	2018	Transportation with Bike-share Stations	AHP
Liou, et al	2019	Supplier Evaluation and Improvement Strategies	DEMATEL, ANP
Zarbakhshnia, et al	2020	Outsourcing Sustainable Reverse Logistics	Fuzzy AHP

2.4. Energy

The publications on the topic of energy are focusing mainly on the key aspects of energy consumption, selection of renewable energy, energy cost, and green supply chain management with 5 published papers. In the context of energy, Moldoven and Slowik (2021) employed MOORA to investigate the energy consumption prediction of appliances using machine learning and multi-objective binary for feature selection. The results ranked utilizing multi-objective optimization based on MOORA. Rubaiee and Yildirim, (2019) utilized MOORA to minimize total completion time and energy cost. The model allows decision-makers to work in challenging data environments and decline energy costs by optimizing production planning. Salameh et al. (2021) utilized CRITIC, Entropy, TOPSIS, WASPAS, MOORA, and EDAS for the optimal selection of renewable energy systems, and the outcome of this study depicted battery energy storage as the best case for economic, environmental, and social. Haiyun et al. (2021) used DEMATEL and MOORA methods of the innovation strategy for green supply chain management in the energy industry. The results showed that evaluating is the best alternative. Chauhan et al. (2021) employed SWARA-MOORA and SWARA-WASPAS to optimization of pineapple drying based on energy consumption. The results indicated that Microwave oven drying has the potential to dry pineapple efficiently. The papers published on the topic of 'Energy' are in table 5.

Table 5. The applied papers on the topic of 'Energy'

Author (s)	**Year**	**Application Area**	**Other Methods**
Rubaiee & Yildirim	2019	Improvement of Energy Consumption	WPM
Moldovan & Slowik	2021	Energy Consumption Prediction	-
Chauhan, et al	2021	Optimization of Pineapple Drying	SWARA, WASPAS
Salameh, et al	2021	Optimal Selection of Renewable Energy	CRITIC, Entropy, TOPSIS, WASPAS, EDAS
Haiyun, et al	2021	Green Supply Chain Management in the Energy Industry	DEMATEL, ANP

2.5. Welding Process and Surface Roughness

The welding process and surface roughness is another application area in welding process and surface roughness is another application area for MOORA which is related to the automated welding process and optimization of roughness. In the context of the welding process and surface roughness, 5 papers were published. Sahu et al. (2018) applied MOORA to the optimization of surface roughness, and the result showed that kind of tool is found to be the most significant

parameter. Liang et al. (2020) utilized MOORA for optimization in the automated welding process. It has successfully optimized the welding parameters. Majumber and Maity (2018) utilized the fuzzy MOORA for the optimization of surface roughness, and the outcomes of this study indicated improvement in quality characteristics. Chaudhari et al. (2018) utilized AHP, MOORA, and ARAS methods for the evaluation of welding process parameters. The result revealed that the improved penetration in weld achieves with the employ of fluxes sio2 and cr203. Table 6 shows the papers on the topic of 'Welding process and Surface roughness'.

Table 6. The applied papers on the topic of 'Welding process and Surface roughness'

Author (s)	Year	Application Area	Other Methods
Sahu, et al	2018	Optimization of Surface Roughness	-
Majumder & Maity	2018	Optimization of Surface Roughness	GRNN
Chaudhari, et al	2018	Optimization in the Welding Process	AHP, ARAS
Liang et al	2020	Optimization in Automated Welding Process	Entropy
Boopathi	2022	Optimization Welding	-

2.6. Automotive and wire

Automotive and wire as another application area of MOORA include 4 scholarly papers. The research on this topic has concentrated on automotive spare selection, automobile air conditioning systems, wire cuts, and wire feed. Jafarzadeh Ghushchi (2019) employed MOORA and fuzzy BWM in the automotive spare sections industry and the results showed a prioritization of the failures in comparison with other methods. Patel and Maniya, (2015) utilized AHP and MOORA methods to select wire-cut electrical. The results indicated that AHP and MOORA methods are satisfactory. Sreeraj et al. (2021) employed TOPSIS, MOORA, and PCA methods to optimize the setting of process parameters to enhance the machining performance, and MOORA indicated significant results because of its simplicity. Poongavanam et al. (2021) utilized TOPSIS, MOORA, and EDAS for selecting the best refrigerant for automobile air conditioning systems. The outcome of this study revealed the best refrigerant. The papers published on the topic of 'Automotive and wire' are in table 7.

Table 7. The applied papers on the topic of 'Automotive and wire'

Author (s)	Year	Application Area	Other Methods
Paul, et al	2015	Fuel Selection	AHP, PROMETHEE
Jafarzadeh Ghushchi, et al	2019	Automotive Spare Selection Industry	Fuzzy BMW
Sreeraj, et al	2021	Wire Feed Rate on Machining Characteristics	TOPSIS, PCA
Poongavanam, et al	2021	Automobile Air Conditioning System	Entropy, TOPSIS, EDAS

2.7. Heat Transfer

Heat transfer and thermal performance is also significant application area in the literature on MOORA. In the context of heat transfer, 3 papers were published. In one study, Maji et al. (2017)

utilized MOORA to investigate the heat transfer of a heat sink employing perforated pin fins, and the result showed that variation in fine-form heat transfer rate enhances significantly. Zeeshan et al. (2018) used MOORA to enhance the thermal performance of fin and tube heat exchangers, and vortex generators could reduce the pressure. Zeeshan et al. (2017) employed MOORA to investigate the optimal configuration of fin and tube compact heat exchangers with different tub shapes. The results indicated that the oval tube having the highest axes ratio is the optimum configuration based. Table 8 shows the papers on the topic of 'Heat transfer'.

Table 8. The applied papers on the topic of 'Heat transfer'

Author (s)	Year	Application Area	Other Method
Maji, et al	2017	Heat Transfer	Entropy
Zeeshan, et al	2017	Thermal Performance	-
Zeeshan, et al	2018	Thermal Performance	-

2.8. Fuel Selection

Two MOORA applications are suggested for the topic of fuel selection. The research on this topic has concentrated on selecting fuel. In the context of fuel selection, Erdoğan et al. (2019) employed ANP, SWARA, and MOORA methods to select the best fuel from different fuels, and the result showed the best fuel according to the determined criteria in the study. Paul et al. (2015) used MOORA, AHP, and PROMETHEE methods for the selection of tree-born oil as an alternative fuel. The results indicated that the best alternative is the Mahua blend which is the best alternative fuel. Table 9 shows the papers on the topic of 'Fuel selection'.

Table 9. The applied papers on the topic of 'Fuel selection'

Author (s)	Year	Application Area	Other Methods
Paul, et al	2015	Fuel Selection	AHP, PROMETHEE
Erdoğan, et al	2019	Fuel Selection	ANP, SWARA

2.9. Other Topics

The last category, which covered the various publications is another application area including; financial services, COVID-19 intensive care, the problem of industrial engineering, occupational health and safety, mobility management in 5G networks, and dynamic scheduling in manufacturing systems. In the context of other topics, 10 papers were published. Dinçer et al. (2019) employed a hybrid approach based on DEMATEL-ANP and MOORA methods to evaluate the services in emerging seven (E7) economies. The results showed that these countries should consider the most important factors.

Özkan et al. (2021) utilized fuzzy AHP and MOORA methods in the evaluation of criteria and COVID-19 patients for intensive care. The results showed ranking is in line with the hospitals' behavior which validity is the approach. Akkaya et al. (2015) utilized fuzzy AHP and fuzzy MOORA to find the problem of the industrial engineering sector and the results showed that the sectors which have been preferred mostly within certain criteria have been determined by employing the fuzzy MOORA. Dabbagh and Yousefi, (2019) used FCM and MOORA methods for

occupational health and safety risk analysis, and the result showed that the company reveal that the score at issue can overcome some of the drawbacks of the traditional Risk Priority. Palas et al. (2021) applied the MOORA method to investigate handover mobility management in a 5G cellular network. The outcomes of this study indicated significant performance improvement in user throughput compared to other MCDM techniques. Jana et al. (2013) used fuzzy MOORA to investigate dynamic schedule executives in manufacturing systems. The outcome revealed that the cooperation best task helps the problem arising out of resources. The papers published on the topic of 'Other topics' are in table 10.

Table 10. The applied papers on the topic of 'Other topics'

Author (s)	Year	Application Area	Other Methods
Jana, et al	2013	Dynamic Schedule Execution in Manufacturing System	-
Akkaya, et al	2015	Problem of Industrial Engineering Section	Fuzzy AHP
Dinçer, et al	2019	Financial Services	DEMAEL-ANP
Dabbagh & Yousefi	2019	Occupational Health and Safety	FCM
Palas, et al	2021	Handover Mobility Management in 5G Network	Entropy
Özkan, et al	2021	COVID-19 Patients Intensive Care	Fuzzy AHP
Başaran & Tarhan	2022	offshore wind	-
Paula, et al	2022	Offshore Operations	CRITIC
Kumar, et al	2022	parametric optimization	-
Mugilan, et al	2023	Optimization of drilling	-

2.10. Distribution by journal of publication

Analyzing the 50 published papers on MOORA (Table 11), material today: proceeding has published the most papers (15 papers, 30%) related to the MOORA method. Then, the journal of cleaner production published (7 papers, 14%) and took second place. The percentage of the other journals is accessible below. Figure 3 shows the distribution by journals.

Table 11. Frequency of papers by journals

Journal Name	Frequency	Percent
Applied Soft Computing Journal	2	4
Computer Methods and Programs in Biomedicine	1	2
Journal of Traffic and Transportation Engineering	1	2
Expert Systems With Applications	2	4
Journal of Manufacturing Processes	2	4
Journal of Energy Storage	1	2
Journal of Safety Research	1	2
Renewable Energy	1	2
Journal of Cleaner Production	7	14
Materials Today: Proceedings	15	30
Materials and Design	1	2
Applied Soft Computing	1	2
Applied Thermal Engineering	2	4
Energy Conversion and Management	2	4
Journal of Air Transport Management	1	2
Computers & Industrial Engineering	1	2
Renewable and Sustainable Energy Reviews	2	4
Wear	1	2

Case Studies in Thermal Engineering	1	2
Computer Communications	1	2
Measurement	1	2
Journal of Manufacturing Systems	1	2
Procedia Computer Science	1	2
Results in Enginnering	1	2
Total	50	100

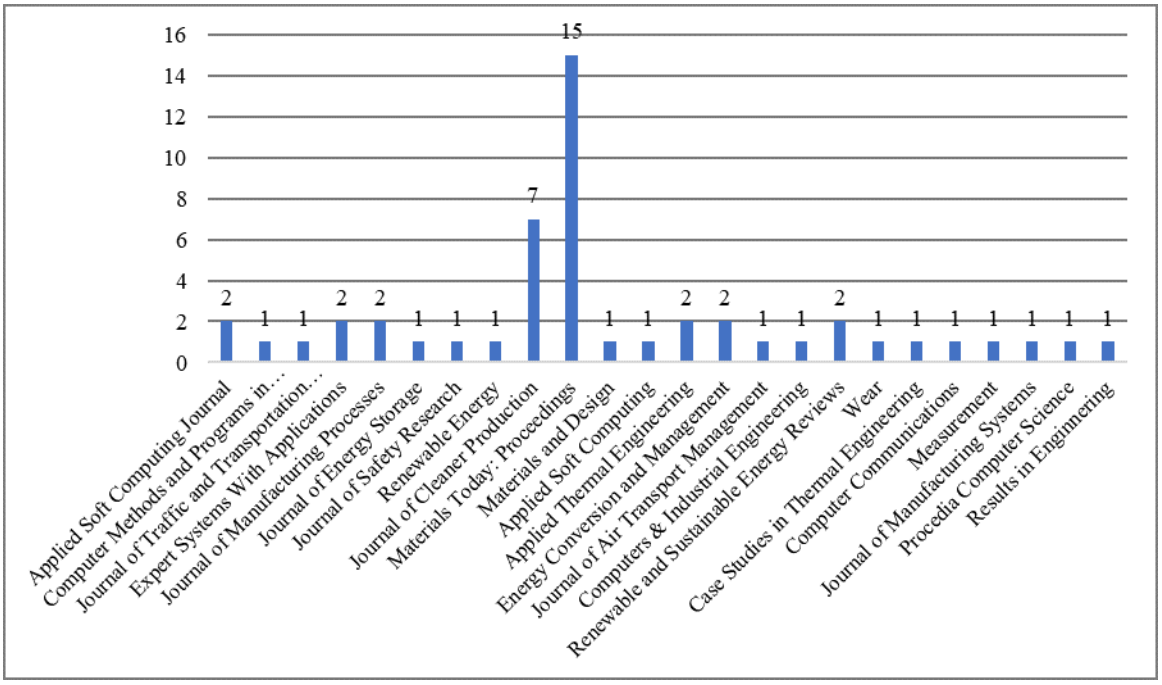

Figure 3. Distribution by journals

2.11. Distribution by Authors' Nationality

Recently, MOORA continues to be popular in different parts of the world such as Europe, Asia, Africa, and Australia. Table 12 shows the frequency and percentage of published papers in different countries. In this review, most of the authors are from India, and after that, Turkey and Iran took second and third place. 17 countries contributed at least one paper on MOORA. Among all, 27 papers belong to authors of one country, 10 papers related to two different countries, and 3 papers to three various countries.

Table 12. Frequency of papers by authors' nationality

Country	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Sum**	**%**
Australia	0	1	0	0	0	0	0	1	0.57
Bangladesh	1	1	1	1	0	0	0	4	2.30
Brazil	2	1	1	1	0	0	0	5	2.87
China	1	2	0	0	0	0	0	3	1.72
Denmark	0	0	1	1	0	0	0	2	1.15
Egypt	0	1	1	1	1	0	0	4	2.30
Emirates	1	1	1	0	0	0	0	3	1.72
India	29	24	19	8	3	0	0	83	47.70

Iran	5	4	3	0	0	0	0	12	6.90
Iraq	1	1	1	0	0	0	0	3	1.72
Korea	1	0	1	1	1	0	0	4	2.30
Lithuania	0	0	1	0	0	0	0	1	0.57
Poland	0	1	0	0	0	0	0	1	0.57
Portugal	1	1	1	1	1	0	0	5	2.87
Romania	1	0	0	0	0	0	0	1	0.57
Saudi Arabia	1	0	0	1	1	1	1	5	2.87
Serbia	0	1	0	0	0	0	0	1	0.57
South Korea	1	1	1	1	1	0	0	5	2.87
Span	0	0	1	0	0	0	0	1	0.57
Taiwan	2	1	0	0	0	0	0	3	1.72
Turkey	7	7	7	4	1	0	0	26	14.94
USA	0	1	0	0	0	0	0	1	0.57
Total	54	49	40	20	9	1	1	174	100

2.12. Distribution by Year of Publication

The distribution of MOORA articles by year of publication from 2012 to 2023 is shown in Table 13. Among 50 articles studied, 17 papers (34) were published in 2021, which is the highest number of publications, and only one paper (2) was published in 2012. The rest of the values are shown in Table 13 and figure 4.

Table 13. Frequency of papers by year

Year	Frequency	Percent
2012	1	2
2013	1	2
2014	0	0
2015	4	8
2016	0	0
2017	3	6
2018	7	14
2019	8	16
2020	4	8
2021	17	34
2022	4	8
2023	1	2
Total	50	100

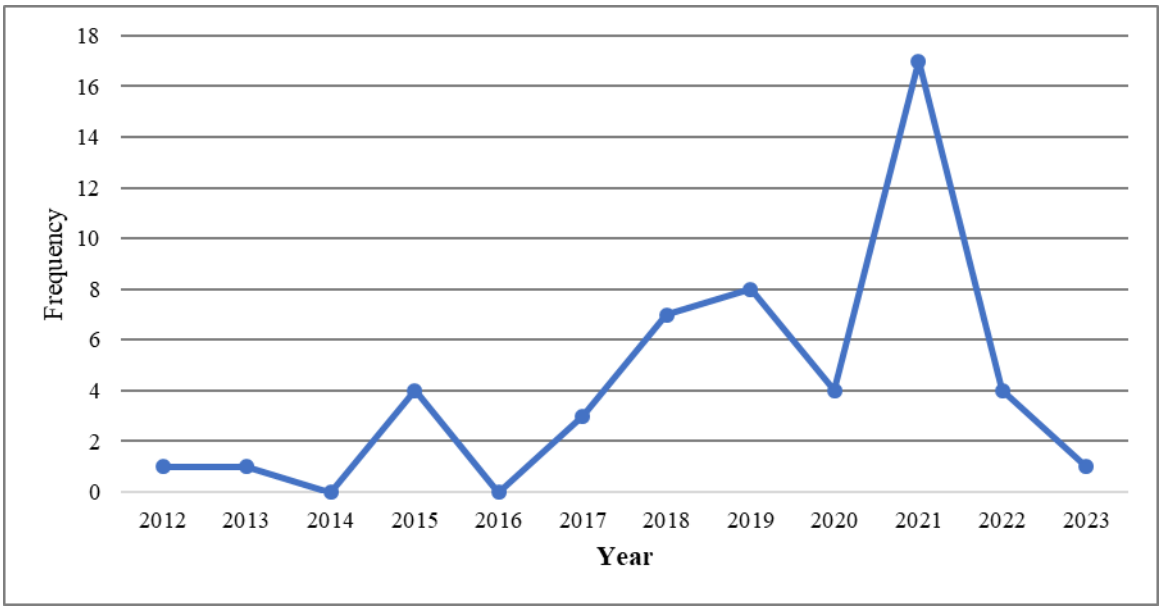

Figure 4. Distribution by year of publication

2.13. Distribution by Fuzzy or Crisp Nature

Among the 50 articles reviewed, most of the articles utilized classic MOORA. 43 papers (86%) used the crisp method, and only 7 papers (14%) used the fuzzy method in their research, which is shown in table 14 and figure 5. Fuzzy numbers are used to deal with uncertainty and ambiguity in linguistic data (Nasseri et al., 2020; Tootooni et al., 2020).

Table 14. Frequency of papers by type of data

Application Area	Fuzzy	Crisp
Material Selection	0	15
Logistics and Transportation	1	5
Energy	0	5
Welding Process and Surface Roughness	1	5
Automotive and Wire	0	4
Heat Transfer	0	3
Fuel Selection	0	2
Other Topics	5	4
Total	7	43

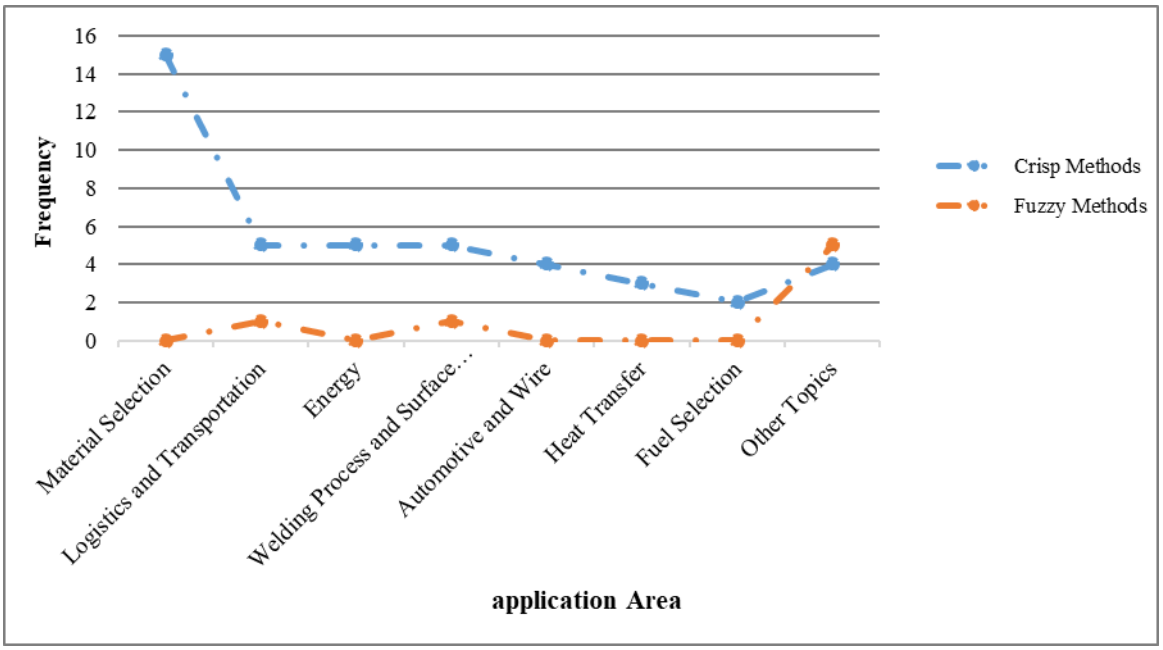

Figure 5. Distribution by type of data

3. Conclusion

This paper has presented an extensive review of MOORA methodologies and applications consisting of 50 papers from 24 journals of Science Direct engine in the Title, Abstract, and Keyword field. All papers were developed and classified into different categories. The investigated papers were classified by journal of publication, year of publication, and author's nationality. Other MCDM methods are examined as the hybrid approach with MOORA. Material selection with 15 papers (30%), logistics and transportation with 6 papers (12 %), other topics with 10 papers (20%), energy with 5 papers (10%), and welding process and surface roughness with 5 papers (5%), are the most interesting research of this method. The current review can be a framework for future researchers who want to use the MOORA method in their studies.

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