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To cite this article: G M Sani *et al* 2023 *IOP Conf. Ser.: Earth Environ. Sci.* **1274** 012019

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IOP Conf. Series: Earth and Environmental Science 1274 (2023) 012019 doi:10.1088/1755-1315/1274/1/012019

Site selection for electric vehicle charging stations using GIS with MCDM AHP FAHP and TOPSIS techniques. A Review

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Abstract. Electric vehicles are becoming more popular because they are not only helping countries' economies by lessening dependency on oil but also helping in creating clean environments that are more habitable and sustainable. One of the most crucial issues in promoting the usage of electric vehicles is the availability of charging stations (CS). This study proposed to use GIS-MCDM methods to produce a model that could be used for selecting appropriate locations for EVCS. MCDM AHP, and FAHP techniques will be used to weigh the criteria regarding accessibility and influence on environment. Four main criteria are selected for this work these are environmental, geographical, urbanity, and transportation, the weight of different criterion will be determined. The results will be integrated into GIS for the selection of various suitable locations for EV charging stations. TOPSIS will be used to rank the sites and choose the best locations for charging stations. At the end of the study, it is expected to have a reliable model for the selection of suitable locations for EVCS, which could be used for the selection of proper location for EVCS, for efficiency and effectiveness of electric vehicles charging within cities and along highways, this will improve the adoption and acceptability of EV across the world.

1. Introduction

It has been noted that carbon dioxide (CO_2) emissions are one of the biggest difficulties in the transportation sector brought on by ICEs and contribute to global warming. To reduce carbon emissions in urban areas, EVs can help with a few environmental challenges. One of the most promising alternative transportation options is the electric vehicle (EV). The advantages of EVs in terms of economics and the environment have grown when compared to traditional cars [1]. Despite the benefits of using electric vehicles, there are still a several obstacles in the way of their general adoption. Now, there is only a small percentage of EVs on the market [2]. The biggest drawbacks of EVs are their limited range, scarcity of charging stations, and high initial costs [3]. Short driving distances and a lack of charging stations cause range anxiety among new purchasers, which reduces the economic benefits of EVs and contributes to their slow uptake in the automotive industry. Effective planning and allocation for charging stations is required, as the improper placement of EV charging stations (EVCS) could negatively affect the public's acceptance of EVs [4]. This necessitates continuous development of their charging infrastructure, particularly in terms of selecting the optimal site for the construction of charging infrastructures, which are intended for use in commercial and public applications and operate similarly to gas stations [5],[6]. Thus, the availability and strategic placement of electric vehicle charging facilities can help to reduce the range anxiety issues that are one of the major barriers inhibiting the broad adoption of EVs. A short-range deployment of such a reliable and efficient charging station would give EVs an unrestricted range [7].

It is necessary to understand that the issue of charging station distribution and location is extremely significant and needs to be handled properly if electric vehicle adoption is to be widespread. A reduction in the number of individuals buying new electric vehicles and concerns about driving range can both be efficiently addressed by strategically placing charging stations. For optimal charging station placement, it is important to understand the effects of location. If there are enough charging stations and they are positioned in suitable locations, EV drivers won't have to worry about running out of battery charge. Limited availability to charging stations can make EV drivers worried while commuting. If there aren't many charging stations or they aren't properly placed to meet the EV driving pattern, the movement may vary depending on the charging station's location [8].

1.1. Site selection strategies for EVCS

Finding the best position for the charging stations in the transportation network in such a way that it has the least impact on the distribution network's operational characteristics is the focus of the charging station and placement challenge. Scientists and academics are looking at charging stations since the transportation industry is electrifying and EVs are becoming more and more popular. The main issues with the mass deployment of EVs are, as was already indicated, the underdeveloped charging infrastructure, proper station placement, and charge scheduling in the stations. Even a few EV-related issues, like the cost and driving range of the vehicles, can be partially solved with a well-established charging infrastructure. It may be quite challenging to choose the ideal location for charging stations because EVs were not yet a reality when the road and grid infrastructure was built. Over the past few years, researchers have been paying attention to studies and have identified what they believe to be the relatively ideal places for EV charging stations [9].

2. GIS and MCDM method

Over the years, there has been an increase in the development of methods for choosing the best site for installing charging stations for electric vehicles. The EVCS was initially formed using a variety of techniques based on the operations involved, the availability of EVs in a specific setting, and the knowledge of industry specialists who sought out the best locations to build EV charging stations. However, due to their efficiency, precision, and dependability in site selection, Geographic Information System (GIS) and Multicriteria Decision-Making (MCDM) methodologies are now mostly used to identify locations for electric vehicle charging stations.

2.1. Geographic Information Systems (GIS) and its applications

To collect, map, and analyze geographically referenced data, geographic information systems (GIS) use locational and tabular data, computer hardware, and software. By producing maps and scenes, GIS users can arrange, visualize, and analyze many layers of data. Users may find patterns, comprehend trends, keep track of changes, and react to events by being able to clearly represent various forms of data, which helps users make better decisions. Supply chain management, facilities management, environment and natural resource management, transportation, insurance, forestry, urban planning, land information system, engineering, street network, and many more industries are just a few of the many industries where it has a wide range of applications [10]. GIS has the following advantages (table 1).

Table 1. Advantages and Disadvantages of GIS.

s/n	Advantages	Disadvantages
1	It can display the connections between the variables, populations, or issues.	1. High costs.
2	It can indicate the area where attention should be focused.	2. Negative consequences if something takes place incorrectly.
3	It could aid you in developing a deeper	3. The dust and moisture that led to the

	understanding of the region or community where you operate.	flashovers must be removed.
4	It can support the planning, execution, and evaluation of interventions.	4. GIS maps can affect the policy.
5	It can display how things have changed throughout time.	

2.2. Multicriteria Decision Making MCDM

Multicriteria Decision Making (MCDM) is the process of selecting the best practical answer based on predetermined criteria and issues that frequently arise in daily life. Site selection and placement planning for EVCSs are solvable multiple-criteria decision-making (MCDM) problems because of the complexity of the criteria [11],[12]. Many studies employed multi-criteria decision analysis to support site selection for the EVCS location. This technique consists of various methodologies that have been used to select the best option for a variety of applications. The various widely used MCDM approaches are shown in figure 1.

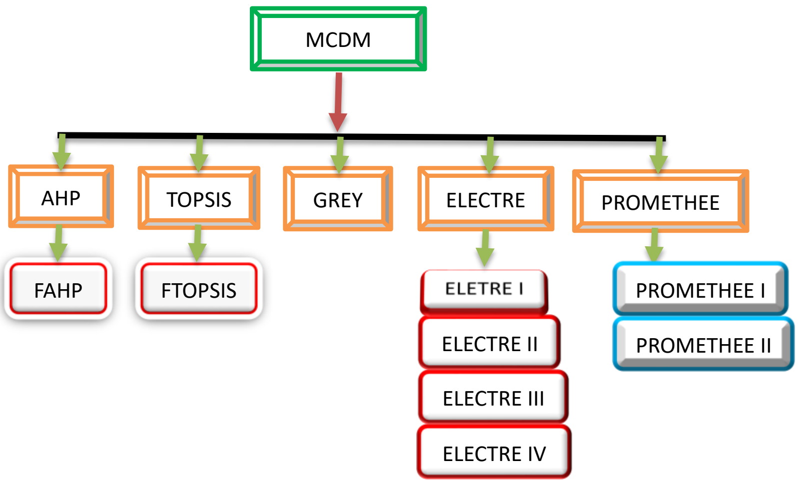

Figure 1. Multi-criteria decision-making Methodological hierarchy.

2.3. Working Principles of MCDM AHP, FAHP and TOPSIS

2.3.1. Analytical Hierarchy Process (AHP). This is a technique that aids in solving challenging issues which was created by Saaty [13] in the 1970s, over time, it gained major advancements. AHP applies the factors that are crucial for making decisions. By offering the continuous phases, it creates a hierarchical structure. Ranking of criteria and sub-criteria will be obtained with overall goal, and after that alternative positions will be decided. When constructing pairwise comparison matrices, decision-makers will choose how significant one criterion contrasts with another criterion. The following three levels need to be considered when utilizing this AHP technique.

- The problem's top focus or overall objective
- Multiple criteria that define middle-level sub-criteria
- Competing sub-criteria are at the bottom.

With such extremely abstract criteria, the following procedures will be taken to develop sub-criteria progressively through a multi-level hierarchy:

i. A hierarchy of MCDM problems will be constructed.

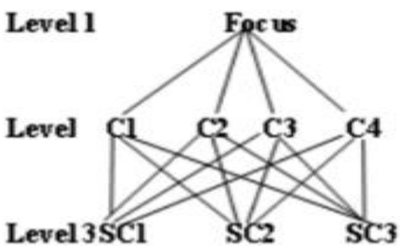

Figure 2. Analytical hierarchy process Diagram (AHP).

ii. To aid in decision-making, pairwise comparisons in the matrices will indicate the relative's relevance among the criteria. The following table provides suggested values to indicate the degree of favour between two items [14]. Compromises between the desires can be represented by the middle values (2,4,6, & 8).

Table 2. nine – point intensity scale for pairwise comparison.

Preference pairwise comparisons	Preference Numbers
Equally significant	1
Slightly more significant	3
Much more significant	5
Stronger and more significant	7
much more significant	9

iii. Comparing criteria in a matrix pairwise with respect to sub-criteria.
iv. Obtaining the weight of each component in the matrix created in the previous steps. Additionally, Saaty (1980) recommended that the geometric mean of a row be determined using.

a. Multiplying nth elements in each row, and root of nth will be taken to prepare a new column for the resulting numbers.
b. After that, the new column was normalized by dividing each number by the total number of numbers.
c. Finally, the overall priority for each alternative will be determined by summing the product of the criteria weight and the contribution of sub-criteria regarding that criterion. This is done by aggregating the resulting weight vertically.

- To determine the pairwise matrix and average of relative scores equation is given below:

$$M = \begin{bmatrix} C_{11} & \cdots & C_{1n} \\ \vdots & \ddots & \vdots \\ C_{1n} & \cdots & C_{nn} \end{bmatrix} \quad (1)$$

Then, to create and normalize the rows of matrix A to acquire the eigenvector W, we will use the square root approach:

- Determine the highest Eigenvalues. Eqn. 2 contains the eigenvalues.

$$AW = \lambda_{max} W \quad (2)$$

$$\text{Where } \lambda_{max} = \frac{1}{n} \sum_i \frac{(AW)_i}{W_i} \quad (3)$$

- To be sure that the experts' scores are consistent, and ensure that the relative scores are effective, the consistency ratio need to be checked, and is given by:

$$CI \quad = \frac{\lambda_{max}{}^{-n}}{n-1} \tag{4}$$

$$CI \quad = \frac{CI}{RI} \tag{5}$$

Where, according to the matrix dimension, RI stands for the mean consistency index and CI for the consistency index. The consistency of the matrix is satisfactory if the index CR is less than 0.1. The pairwise comparison judgment should be carried out one more when CR 0.1

2.3.2. Fuzzy Analytical Hierarchy Process (FAHP). Numerous applications of multi-criteria decision making make use of the fuzzy version of the analytical hierarchy process (AHP). Pairwise comparisons are used in AHP to determine the weight of each item assessment as well as the evaluation values for each product and alternative. The result of the pairwise comparisons, however, is not 0,1, but rather a numerical number that indicates the degree. In fuzzy AHP, in addition to the conventional constraint that the total of all potential weights can be reduced to 1, the weight is expressed by a necessary measure or a possibility measure [15]. To establish the relative's weight in the selection criteria, the following processes will be taken. by comparing two things.

i. The relative relevance of each pair of elements will be estimated in the fuzzy matrix $\tilde{R}$, which will be built:

$$\tilde{R} = \begin{matrix} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{matrix} \begin{matrix} \begin{matrix} C_1 & C_2 & \cdots & C_n \end{matrix} \\ \begin{bmatrix} \check{r}_{11} & \tilde{r}_{12} & \cdots & \tilde{r}_{1n} \\ \tilde{r}_{12} & \tilde{r}_{22} & \cdots & \tilde{r}_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ \tilde{r}_{n1} & \tilde{r}_{n2} & \cdots & \tilde{r}_{nn} \end{bmatrix} \end{matrix} \tag{6}$$

ii. Following that, based on the matrix $\tilde{R}$, determine the fuzzy estimates for the weights or priorities of the decision criterion using equation. ---(6).

iii. Under each of the criteria separately, pairwise comparisons of the sub-criteria will be performed, and then n matrices ($\tilde{R}^1$, $\tilde{R}^2$…. $\tilde{R}^n$), These are constructed, each of which includes fuzzy estimates for the relative importance of each pair of options:

$$\widetilde{R^{\iota}} = \begin{matrix} \\ A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{matrix} \begin{matrix} A_1 & A_2 & \cdots & A_m \end{matrix} \\ \begin{bmatrix} \widetilde{r^{\iota}}_{11} & \tilde{r}^{i}{}_{12} & \cdots & \widetilde{r^{\iota}}_{1m} \\ \widetilde{r^{\iota}}_{12} & \widetilde{r^{\iota}}_{22} & \cdots & \widetilde{r^{\iota}}_{2m} \\ \vdots & \vdots & \ddots & \vdots \\ \widetilde{r^{\iota}}_{1m} & \widetilde{r^{\iota}}_{2m} & \cdots & \widetilde{r^{\iota}}_{mm} \end{bmatrix} \end{matrix} \tag{7}$$

iv. Based on the matrices ($\tilde{R}^1$, $\tilde{R}^2$…. $\tilde{R}^n$), the fuzzy estimates weight of each sub-criteria under each criterion will be generated independently using equation (7)

v. The final score for each sub-criteria will be calculated after all calculations from the matrices by summing the weights for each sub-criteria acquired in step 4 and multiplying by the weights of the relevant criteria obtained in step 2.

2.3.3. Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). The TOPSIS method makes it easy to describe the ideal solutions that are both positive and negative since it assumes that each criterion tends to monotonically enhance or reduce utility. To determine how closely the alternatives approximate the ideal answer, the Euclidean distance approach is recommended. A series of assessments of their relative distances will establish the preferred order of the alternatives. Like the ELECTRE method and the TOPSIS approach before turning the various criteria dimensions into non-dimensional criteria [16]. According to the TOPSIS theory, the selected alternative should be the one that is both most like the positive ideal solution (PIS) and least different from the negative ideal solution (NIS). This technique is used to achieve the best results in multi-criteria decision-making as well as for ranking purposes. All the criteria have been rated according to region after being evaluated using the FUZZY TOPSIS approach in each region [17].

The initial data matrix is created as follows, assuming there are m items to be analysed and that each object has n indicators:

$$M = \begin{bmatrix} X_{11} & \cdots & X_{1n} \\ \vdots & \ddots & \vdots \\ X_{1n} & \cdots & X_{nn} \end{bmatrix} \tag{8}$$

- Create a weighted canonical matrix, vectorize the attributes, and then perform the analysis.

$$\overleftarrow{X_{ij}} = \frac{x_{ij}}{\left(\sum_{i=n}^{m} x_{ij}^2\right)^{1/2}} \tag{9}$$

- The normalization matrix Z is obtained by normalizing the X matrix.

$$Z = \begin{bmatrix} Z_{11} & \cdots & Z_{1n} \\ \vdots & \ddots & \vdots \\ Z_{1n} & \cdots & Z_{nn} \end{bmatrix} \tag{10}$$

- Choose the best and worst answers. The ideal response to the highest value of each column of components in Z makes up Z+.

$$Z^{+} = \left(max\left\{Z_{11,} Z_{21}, \cdots Z_{n1}\right\}, \cdots\ max\ \left\{Z_{1m,}\ Z_{2m,}\ \cdots\ Z_{nm}\right\}\right) = \left(Z_1^{+}, Z_2^{+}, \cdots Z_m^{+}\right) \tag{11}$$

$$Z^{-} = \left(min\left\{Z_{11,} Z_{21}, \cdots Z_{n1}\right\}, \cdots\ min\ \left\{Z_{1m,}\ Z_{2m,}\ \cdots\ Z_{nm}\right\}\right) = \left(Z_1^{-}, Z_2^{+}, \cdots Z_m^{+}\right) \tag{12}$$

- To determine the distance between each evaluation object and the best and worst solutions, use the formulas below:

$$D_1^{-} = \left(\sum_{j=1}^{m} w_j \left(Z_j^{-} - Z_{ij}\right)^2\right)^{1/2} \tag{13}$$

$$D_1^{+} = \left(\sum_{j=1}^{m} w_j \left(Z_j^{+} - Z_{ij}\right)^2\right)^{1/2} \tag{14}$$

Where W_j is the weight assigned by the AHP technique to the j attribute.

- Calculate how closely each evaluation object comes to the ideal answer.

$$\boldsymbol{C_i} = \frac{\boldsymbol{D_i^{-}}}{\boldsymbol{D_i^{-} + D_i^{+}}} \tag{15}$$

$$\mathbf{0} \leq \boldsymbol{C_i} \leq \mathbf{1}$$

The better the solution, the closer C_i to 1 Sort solutions in order of C_i values.

3. Application of MCDM AHP FAHP and TOPSIS in site selection for EVCS

The major goal of employing MCDA methods is to make the final decision as quickly and readily as feasible while maintaining control over the decision-making process in situations where there are many alternatives and criteria. Multicriteria Decision Making (MCDM) methods provide a structured and systematic approach to handle conflicting criteria and make informed decisions [18]. MCDA techniques and GIS are combined in the decision-making process to reach final knowledge. This process transforms spatial data and links it to decision-makers' preferences [19],[20]. However, alternative MCDA methods are also currently in use, such as Elimination EtChoix Traduisant la REalite (ELECTRE), Grey, Complex proportional assessment (COPRAS), VIšekriterijumsko KOmpromisno Rangiranje (VIKOR), Preference Ranking Organization Method for Enrichment of Evaluations (PROMETHEE), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Analytic Network Process (ANP), Best Worst Method (BWM), Weighted Linear Combination (WLC) [21].

The AHP strategy that [22] recommends. The most popular technique for criterion weighting in site selection studies has been due to its simplicity. A critical component of applying the AHP technique is identifying the core criteria groups that are consistent with a purpose and the sub-criteria related to these categories in a hierarchical structure. The AHP approach focuses on a pair-wise comparison process and involves mathematical computations to enhance scales of preferences among alternative decisions [23]. The AHP technique can be used for stakeholder analysis and deals with various groups of decision makers and specialists [24],[25]. The procedure for calculating criterion weights for site selection analysis using the AHP approach is shown in figure 1, FAHP is an extension of AHP that incorporates fuzzy set theory to handle uncertainty and imprecise information [26]. TOPSIS is a simple and intuitive method that evaluates the performance of each alternative based on multiple criteria. The method considers both the positive and negative aspects of each criterion and ranks the alternatives accordingly. However, the method does not handle uncertainty well and may not be suitable for complex decision-making problems [27].

The best method for electric vehicle charging station site selection will depend on the specific needs of the decisions making problem, the resources available for the analysis, and the objectives and criteria that need to be considered. However, AHP and FAHP are commonly used, due to their simplicity, easy to understand, flexibility and suitability for decision making problems. TOPSIS is a simple method that evaluates the performance of each alternative but may not be suitable for complex decision-making problems. It is important to carefully consider the suitability of each method for the problem at hand and to seek expert advice where necessary.

However, researchers attempting to provide solutions to the EVCS site selection problem have included numerous variables in their model constructions depending on the approach they use. The use of various attributes indicates the spatial target of the EVCS location selection model. Because GIS-based models can employ data from a range of sources, combinations of these data and weighting schemes are essentially limitless, multi criteria decision making is one of the powerful tools for obtaining the best choice for a complex decision-making situation for the evaluation and ranking of different criteria using various methods such as AHP, FAHP, TOPSIS, etc. and Multi Criteria Decision Making (MCDM) methods provide a structured and systematic approach to handle conflicting criteria and make informed decisions. Therefore, application of GIS with MCDM involved use of different criteria for decision making analysis, some of the criteria considered by the previous researchers are as follows figure 3.

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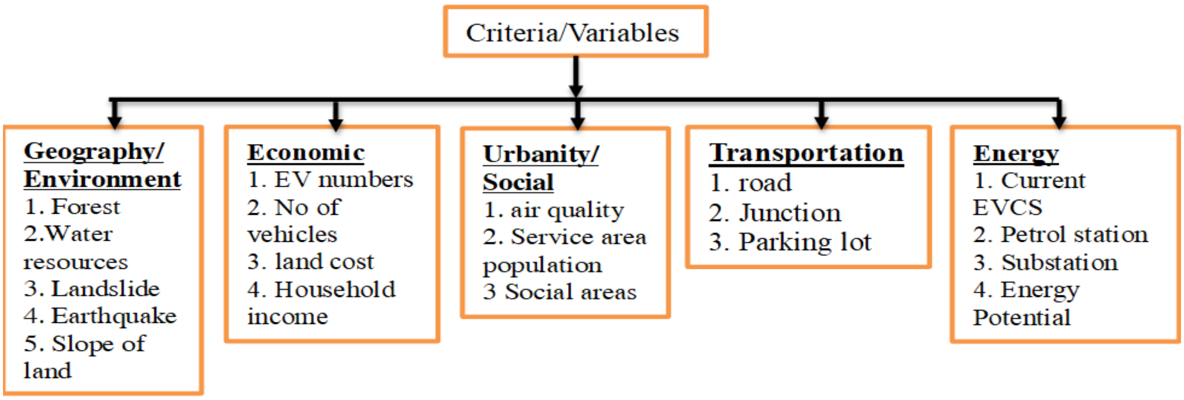

Figure 3. the most used criteria and variables in Site selection for electric vehicles

4. Research Findings

This review has considered the period of eight years from 2016 to 2023, using three different academic databases, Scopus, Web of Science, and Science Direct. The review identified 32 published research articles that used GIS with MCDM AHP, FAHP and TOPSIS tools, for electric vehicle charging station site selection, it was discovered that among the different types of MCDM techniques these three techniques are the most applicable by researchers in solving electric vehicle charging station site selection problems. The techniques used in different studies are presented in Table 3. The percentage used of each technique is represented in figure 4.

Table 3. Summary of studies on Electric Vehicles charging Station Site Selection using GIS with MCDM Techniques.

s/n	Authorìs	Method	Driving Techniques
1.	(Erbas et al., 2018)	GIS/MCDM	FAHP, TOPSIS
2.	(Ghorbanzadeh et al., 2020)	ArcGIS/MCDM	AHP
3.	(Guler & Yomralioglu, 2018b)	GIS/MCDM	FAHP
4.	(Kaya, Alemdar, et al., 2020)	ArcGIS/MCDM	AHP
5.	Dogus gular, et, al. 2020	GIS/MCDM	AHP - FAHP
6.	(Linzhao, 2020)	GIS/MCDM	AHP, TOPSIS
7.	ÿ mer Kaya, 2020	GIS/MCDM	AHP TOPSIS
8.	(Pradhan et al., 2021)	Q-GIS/MCDM	TOPSIS
9.	(A. Ghosh et al., 2021)	GIS/MCDM	FAHP, FTOPSIS
10.	(Guler & Yomralioglu, 2018a)	GIS/MCDM	AHP
11.	(Yu et al., 2022)	GIS/MCDM	TOPSIS
12.	(Schmidt et al., 2021)	GIS/MCDM	AHP, TOPSIS
13.	(Ward, 2016)	Q-GIS/MCDM	AHP
14.	(Sisman et al., 2021)	ArcGIS/MCDM	AHP
15.	(Kaya et al., 2022)	GIS/MCDM	FAHP
16.	(Asadi et al., 2023)	GIS/MCDM	AHP
17.	(Saraswat et al., 2021)	GIS/MCDM	AHP
18.	(Amarasinghe & Perera, 2021)	GIS/MCDM	AHP
19.	(Mohamed, 2020)	GIS/MCDM	AHP
20.	(Gil-garcȃ et al., 2022)	GIS/MCDM	FAHP TOPSIS
21.	(Kaya et al., 2021)	GIS/MCDM	AHP, TOPSIS
22.	(Kos & Sierpiski, 2023)	GIS/MCDM	AHP
23.	(Ghodusinejad et al., 2022)	GIS/MCDM	AHP
24.	(Hisoglu et al., 2023)	GIS/MDCM	AHP
25.	(Rane et al., 2023)	GIS/MCDM	TOPSIS
26.	Mohammad Sadegh, et. al. 2022	GIS/MCDM	TOPSIS, AHP,
27.	Aziz Sisman, 2023	GIS/MCDM	TOPSIS

28.	(Priefer & Steiger, 2022)	GIS/MCDM	AHP
29.	(Yagmahan & Yulmaz, 2023)	GIS/MCDM	AHP, TOPSIS
30.	(Azzioui et al., 2021)	GIS/MCDM	AHP
31.	Ali Khalife, et. al. 2022	GIS/MCDM	AHP
32.	Mostafa Mahdy, et. al. 2022	GIS/MCDM	AHP

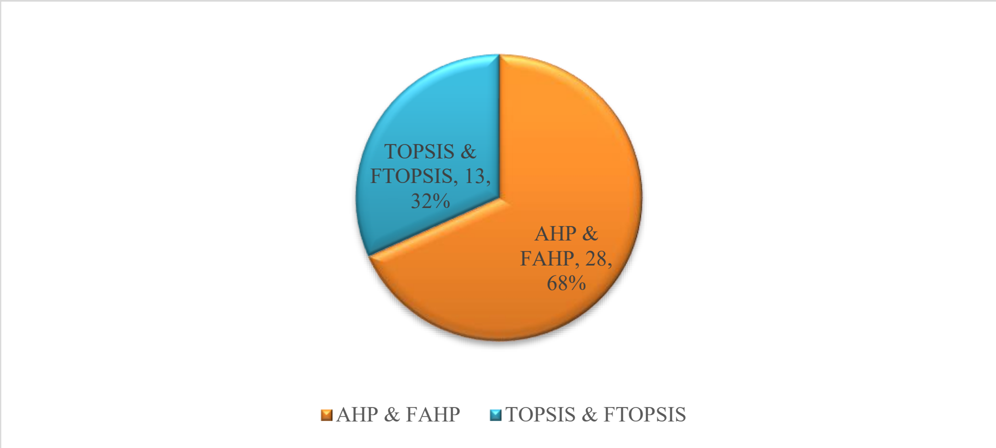

Figure 4. The percentage applications of different tools used in GIS – MCDM analysis according to the reviewed articles table 3.

5. Discussion

As illustrated in figure 3, several GIS-MCDM based methods were applied to tackle the EVCS site selection problem. Each of the papers that were reviewed used GIS-MCDM methodology with various criteria to balance the interests of various stakeholders while considering the unique characteristics of the study area. The optimal type, size, and placement of the required EVCS infrastructure are chosen using these strategies, which make use of processed variables. The most important variables to consider are the method's effectiveness, adaptability, simplicity, convenience of use, and superior outcomes rather than choosing a method at random or based on how popular it is in the field of study. The character of the approach and the decision problem should also be carefully considered [28]. According to the comments and recommendations given by various authors, the tried-and-true methods outlined in this study can be carefully applied to solve the EVCS localization problem in a way that is satisfying. To facilitate the information transfer as previously indicated, one of the main goals of this research is to identify efficient MCDM approaches coupled with GIS techniques for site selection problem modelling to increase the stability of the service, those approaches should be used more often and the data, which includes criteria and pertinent qualities, should be of higher quality.

6. Conclusion

The location selection of electric vehicle charging stations is one of the most vital factors to enhance the use of electric vehicles. In this sense, this paper presented a finding of different researchers that used the approach that integrates Geographic Information System (GIS) techniques and Multi-Criteria Decision Making (MCDM) methods for the selection of suitable locations of electric vehicle charging stations. The results show that the approach offers a notable solution. Moreover, policymakers and administrators could benefit from these results to make efficient decisions for forward planning and strategies to improve the adoption of EVs. The EVCS placement challenge can be further investigated utilizing location modelling methods, which are most successfully integrated with GIS analysis, to assist policy makers' decision-making and the implementation of these initiatives. Confirming the use or rejection of transfers of GIS-MCDM AHP, FAHP, and TOPSIS based optimization techniques in Site selection for Electric Vehicle Charging Station is essential for the successful deployment of EVs.

This systematic review was developed to provide a thorough analysis of earlier work on GIS-MCDM AHP, FAHP, and TOPSIS based EVCS location selection methods to highlight the method's suitability and applicability, outline the benefits and advantages for promoting EV acceptance globally, and provide a direction for future work on the placement of EV charging stations. Given the rapid adoption of EVs in both developed and emerging nations, the use of GIS-MCDM research in actual site selection should receive a lot of attention in the field of EVCS spatial analysis. However, very few studies specifically incorporate geolocation data to deal with the CS placement problem for EV mobility. From the information shown above, the following advantages of applying these techniques in the site selection for electric vehicle charging stations are listed.

It is well recognized that the growth and adoption of EVs have been hindered by a lack of scientific planning and strategic placement of charging stations, leading many researchers to use various methodologies and criteria depending on the type and character of the study region. To meet the sustainability, efficiency, and performance objectives of communities adopting electric vehicle mobility, site selection for EVCS requires a multi-criteria decision-making approach. However, recent attempts by researchers involve the application of GIS with MCDM AHP, FAHP, and TOPSIS techniques with the consideration of various criteria, including social, technological, environmental, geographical, economically, urbanity, transportation, energy, and so many other factors. According to the previous researchers who used the examined publications as their source, this strategy demonstrated that it gave advantages and benefits to support the adoption of EVs in many nations with EV adoption policies, a GIS-based MCDM method identified an appropriate location for EVCS to maximize their effectiveness and hasten the growth and acceptance of EVs [29]. According to [30] the method is very helpful for urban planners, decision-makers, and researchers who are designing EV charging infrastructure to encourage the adoption of EVs. This approach offers a more precise and effective solution for high degree of uncertainty site selection problems for EVCS, as well as a scientific framework for evaluating, analyzing, and defining EVCS locations, which is a significant step for sustainable transportation [31]. If correctly used, the research will help to increase the acceptance of electric vehicles in both developed and developing nations.

Acknowledgement
The Universiti Teknologi Malaysia under Flagship CoE/RG (Ref: PY/2022/04698, Cost Centre No.: Q.J130000.5009.10G14) and UTMFR (Ref: PY/2022/01812, Cost Centre No.: QJ130000.3852.22H24) are both acknowledged for their financial support of the authors.

Declaration
The Authors have no bias or conflicting interest during this research work and the findings herein are with the utmost research credibility and integrity.

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