Evaluation and Ranking of Electric Scooters: A Case Study

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Abstract:- In recent times, Electric Vehicles (EVs) have gained attention as a cleaner transport alternative. Conventional vehicles running on petrol and diesel have contributed significantly to pollution and emissions like Carbon Dioxide (CO2), impacting air quality and health. Rising fuel costs and environmental concerns necessitate a shift to cleaner technologies. Among Electric vehicles, Electric Scooters are popular for personal travel. However, the diverse range of models poses challenges for buyers seeking the best option. To deal with this kind of problems MCDM methods like TOPSIS and MOORA offer effective tools. This study employs TOPSIS and MOORA to evaluate and rank five E-Scooter models based on six specific criteria. Moreover, objective criteria weighting is achieved using the CRITIC method. The result identifies the top-ranked E-Scooter, Ola S1, highlighting the effectiveness of both MOORA and TOPSIS. This case study aids decision-makers in choosing the most suitable E-Scooter model.

***Keywords**:- TOPSIS; MOORA; CRITIC; MCDM; E-SCOOTER.*

I. INTRODUCTION

In today's rapidly evolving world, Transportation is a vital aspect of modern society, contributing significantly to economic development and social connectivity. Transportation has far-reaching economic, social, and environmental implications, particularly in urban regions. The widespread use of internal combustion engine vehicles has brought forth a host of environmental challenges, such as pollution and the depletion of natural resources. Internal combustion engines, using gasoline and diesel release harmful pollutants into the atmosphere during combustion.The accumulation of these pollutants in the air leads to adverse effects on human health, ecosystems, and the environment. This is a major problem in many major cities across the world.

The reliance on internal combustion engines heavily depends on fossil fuels like petroleum and diesel, finite resources extracted from the Earth's crust. The rapid depletion of these non-renewable resources raises concerns about availability and economic stability. Additionally, the extraction and consumption of fossil fuels contribute to environmental degradation, including habitat destruction, oil spills, and water pollution.

Limited availability of these resources and growing urbanization necessitates the exploration of sustainable alternatives to ensure the long-term viability of transportation systems.

There are several aims about sustainable transportation. To address these issues, it is imperative to adopt practices that minimize the consumption of non-renewable resources, additionally, reducing noise pollution and optimizing transportation efficiency. Addressing the environmental concerns associated with internal combustion engines requires a shift in transportation. Electric vehicles (EVs) offer a promising alternative that can help conserve natural resources and assist in greener transportation. EVs operate on electricity, producing zero emissions during use.

These EVs are considered eco-innovations with the potential to mitigate the environmental impact of the transportation sector. Given the depletion of fossil fuels and the increasing focus on environmental preservation, the adoption of EVs has gained momentum worldwide.Cities have the potential to significantly reduce the greenhouse effect and enhance overall quality of life by adopting more environmentally friendly fuel-based transportation technologies. Minimizing harmful emissions has become a global imperative to create a sustainable world for future generations. Consequently, systems powered by electrical energy have gained popularity due to their economic and environmentally friendly nature. Moreover, the advancements in renewable energy-based engines and transportation vehicles have made them increasingly viable options.

Apart from these primary considerations, electric vehicles (EVs) have the potential to enhance air quality by diminishing the dependence on fossil fuels for transportation. This trend has spurred an increasing fascination with EVs. As a result, a decrease in emissions from local sources can exert a favorable influence on air quality, thereby alleviating the health and environmental challenges linked to air pollution, especially within urban areas.

Recently, Electric Scooters have emerged as a popular mode of transportation in urban areas. As technology continues to advance, selecting the appropriate electric scooter is crucial for consumers seeking transportation options that are efficient, comfortable, and safe. Electric Scooters provide a zero-emission, reliable, and cost-effective personal transportation option, promoting sustainability and reducing energy consumption.

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A. Scenario of EV Sector in India

India, a fast-growing economy, is getting ready to become a big manufacturing center for various industries, like electric cars. The Indian government's plan is to make all electric cars in India through the 'Make in India' program. However, the electric car industry in India is just getting started and growing fast. The goal of the Indian government is to have 30% of all vehicles running on electricity by 2030.

According to Business Standards, the electric vehicle (EV) sector of India has reached the mark of one million units sold in the calendar year of 2022, contributing to 4.7% of total car sales. Ola Electric led the way, trailed by TVS Motor Co. and Ather Energy companies.

B. E-Scooters Considered in this Study

- **Ola:** Ola Electric Mobility is an Indian electric two-wheeler manufacturer, based in Bengaluru, Karnataka, India.Ola Electric started in 2017 and is the biggest maker of electric scooters in India. Right now, they have an electric scooter called the Ola S1, which comes in three types: Ola S1 Air, Ola S1, and S1 Pro. In this study Ola S1 is considered for evaluation.
- **TVS:** TVS Motor Company, commonly known as TVS is an Indian multinational motorcycle manufacturer. TVS iQube Electric is an electric scooter manufactured by TVS Motor Company. In this study TVS iQube is considered.
- **Ather:** Ather Energy is two-wheeler electric vehicle manufacturer in India. It manufactures electric scooters named the Ather 450X and the Ather 450X Pro. Ather 450X is considered in this study.
- **Bajaj Chetak:** Bajaj Group is an Indian multinational company. The Bajaj Chetak is a motor scooter produced by the company. Bajaj Auto unveiled a new electric version of their Chetak scooter.In this study the Bajaj Chetak Electric is considered.
- **Ampere:** Greaves Cotton Ltd. (GCL) is a big engineering company. They own Ampere Electric Vehicles, a company in Coimbatore that makes electric vehicles. In this study Ampere Magnus Ex EV is considered.

C. Muti Criteria Decision Making Methods

The diversity and increasing performance of EVs, with the developing technology, make it challenging for buyers in decision-making. MCDM methods prove effective in assessing and selecting sustainable transportation alternatives based on a range of factors.

Multi-Criteria Decision-Making (MCDM) methods are a set of techniques used to evaluate and rank alternatives based on multiple criteria or objectives. These methods are commonly applied in various fields, including business, engineering, finance, environmental management, and public policy, where decision-makers need to make choices among several competing options.

For this study, five different electric scooters are examined. Comparing them based on factors like speed, Range, maximum power, battery capacity , charging time, and cost.

In this study, TOPSIS and MOORA methods are applied as decision-making techniques for evaluating and ranking the E-Scooter. CRITIC method is used for weighting the criteria. Then the results of solutions are compared and evaluated.

D. TOPSIS Method for Decision Making

TOPSIS stands for Technique for Order of Preference by Similarity to Ideal Solution. TOPSIS ranking method was developed by Hwang and Yoon (1981).

It is a Multi-Criteria Decision-Making (MCDM) method used to rank a set of alternatives based on their distance to the ideal solution and the anti-ideal solution in a multi-criteria environment. The ideal solution represents the best possible values for each criterion, while the anti-ideal solution represents the worst values.

TOPSIS is a practical and efficient method for decision-making in situations where there are many factors to consider. It considers the positive (best) and negative (worst) aspects of the alternatives, which helps to give a fair evaluation and ranking of the alternatives.

E. MOORA Method for Decision Making

MOORA stands for Multi-Objective Optimization on the basis of Ratio Analysis. It is a Multi-Criteria Decision-Making (MCDM) method used to rank a set of alternatives based on multiple criteria, considering both the benefits and costs associated with each criterion. The MOORA method has two primary versions that are widely used: the ratio system and the reference point approach. MOORA is particularly useful for decision-makers who must handle multiple criteria or goals that could be in conflict.

F. CRITIC Method

The CRITIC, also known as the Criteria Importance Through Inter-criteria Correlation.

In this study, CRITIC method which is objective rating method is considered to determine the relative weights of the input and output variables. The CRITIC method utilizes correlation analysis to identify differences among criteria. It falls under the category of correlation methods. This technique involves systematically examining the decision matrix to extract information about how different criteria are used to evaluate options.

G. Criteria Considered for Evaluation

In this study, the criteria involved are described as follows:

- Criteria-1, Speed (km/hr): high values are ideal
- (max: +);
- Criteria-2, Range (km): high values are ideal
- (max: +);
- Criteria-3, Maximal power (kW): high appraisals are preferred (max: +);

- Criteria-4, Battery capacity (kWh): high values are ideal (max: +);
- Criteria-5, Charging time (hr): low values are ideal (min: –):
- Criteria-6, Cost (lacs): low values are ideal (min: –).

II. LITERATURE REVIEW

- **Adalı et al. [1]** The multi-objective decision making methods based on MULTIMOORA and MOOSRA for the laptop selection problem. This study introduces MULTIMOORA and MOOSRA methods for laptop selection using multi-objective decision making. These novel approaches offer effective solutions.
- **Awasthi et al. [2]** Application of fuzzy TOPSIS in evaluating sustainable transportation systems. This paper employs fuzzy TOPSIS for appraising sustainable transportation systems, addressing uncertainty.
- **Aydın et al. [3]** Vehicle selection for public transportation using an integrated multi criteria decision making approach: A case of Ankara**.**
- **Brauers et al. [4]** Multi-Objective Contractor's Ranking by Applying the MOORA method, The MOORA method is applied for multi-objective contractor ranking in construction. The owner seeks cost-effectiveness, confidence, timeline, post-completion service, and quality. Contractors aim for client satisfaction, cost reduction, and efficient management. MOORA's ratio analysis facilitates the multi-criteria ranking.
- **Canals Casals et al. [5]** Sustainability analysis of the electric vehicle use in Europe for CO_2 emissions reduction. This study focuses the analysis on how the electric vehicle emissions vary when compared to internal combustion engine vehicles.
- **Çalışkan et al. [6]** Material selection for the tool holder working under hard milling conditions using different multi criteria decision making methods, Material selection for hard milling tool holder is addressed using MCDM methods. The model combines extended PROMETHEE II (EXPROM2), TOPSIS, and VIKOR, with criteria weighting via AHP-Entropy compromise. These methods rank candidate materials for comparison and evaluation.
- **Das et al. [7]** Comparative performance of electric vehicles using evaluation of mixed data, assessing electric vehicle performance considering mixed data is explored. Factors like battery capacity, charging time, price, and range impact EVs.
- **Gulçin Canbulut et al. [8]** Public transportation vehicle selection by the grey relational analysis method. Public transportation vehicle choice is studied using grey relational analysis. Expert opinions establish criteria, AHP assigns weights, and grey relationship analysis identifies the best alternative. MOORA, a popular MCDM method, validates the results' accuracy.
- **Erdogan et al. [9]** Selection of the most suitable alternative fuel depending on the fuel characteristics and price by the hybrid MCDM method. Choosing optimal alternative fuel based on characteristics and price is approached using hybrid MCDM. Nine specifications, including calorific value, cetane number, etc., are considered.
- **Gadakh et al. [10]** Application of MOORA method for friction stir welding tool material selection. In this paper, The MOORA method is employed to select the best tool material for FSW.
- **Hafezalkotob et al. [11]** An overview of MULTIMOORA for multi-criteria decision making: theory, developments, applications, and challenges.
- **Mustafa Hamurcu et al. [12]** Electric Bus Selection with Multicriteria Decision Analysis for Green Transportation, A MCDM using AHP and TOPSIS to to evaluate and compare six different electric bus options in Ankara. This evaluation is conducted based on seven different criteria.
- **Kecek et al. [13]** In this study, TOPSIS and MOORA are compared for laptop selection. Student preferences guide evaluation of 6 criteria and 11 brands. TOPSIS and MOORA analyze student evaluations, providing comparable outcomes.
- **Özcan et al. [14]** In this study, supplier selection for gas turbine rotor in NGCCPP in Turkey is addressed via AHP-TOPSIS. Among 6 potential suppliers, 3 criteria are defined. TOPSIS ranks suppliers using AHP-derived criteria weights for optimal choice.
- **V.V. Shimin et al. [15]** Electric vehicle batteries: A selection based on PROMETHEE method, EV battery types and selection are studied using PROMETHEE. Different EV batteries are discussed. PROMETHEE optimizes battery choice based on performance parameters for EV applications.
- **Pankaj Prasad Dwivedi et al. [16]** Evaluation and ranking of battery electric vehicles by Shannon's entropy and TOPSIS methods. In this study Fifteen EVs are evaluated using Shannon's entropy and TOPSIS. Ten criteria guide assessment, using data from manufacturers. Shannon's entropy derives criterion weights, while TOPSIS ranks EVs effectively.
- **Xiaosong Ren et al. [17]** This research utilizes sentiment analysis, MCDM, LDA model, DEMATEL technique, DANP model, and VIKOR model for BEV selection. Consumer priorities are identified via sentiment analysis. DEMATEL ranks dimensions: safety, technology, dynamics, comfort, and cost. DANP highlights price's impact. VIKOR selects Aion S, proposing optimization for BEV performance and customer satisfaction in China.
- **R. M. Zulqarnain et al. [18]** Application of TOPSIS Method for Decision Making. This paper discusses the TOPSIS method for decision-making. It outlines the TOPSIS algorithm and presents a graphical model. The method is applied to car selection using hypothetical data as an example.
- **Sagar V. Wankhede et al. [19]** MOORA and TOPSIS based selection of input parameter in solar powered absorption refrigeration system, In this work, MOORA and TOPSIS are used.
- **Sanjay Kumar et al. [20]** Supplier selection using fuzzy TOPSIS multi criteria model for a small scale steel manufacturing unit.

- **Won-Chol Yang et al. [21]** Materials selection method using TOPSIS with some popular normalization methods. This paper proposes a method for materials selection using TOPSIS and popular normalization methods. It aims to determine optimal material by combining individual TOPSIS results with various normalizations. In this paper, to evaluate performance of normalization method, entropy-based and variation coefficient-based performance scores are introduced. These methods have broad applicability in engineering materials selection.
- **Milad Moradian et al. [22]** Comparative analysis of multi criteria decision making techniques for material selection of brake booster valve body. The material selection for the valve body is very important and should satisfy the requirements. Explored MCDM techniques for brake booster valve body material selection. The weighting of criteria is carried out by entropy and AHP methods and a combination of these two techniques are used as the final weights. Employed MOORA, TOPSIS, VIKOR methods to rank alternative materials based on various criteria.
- **D. Diakoulaki et al. [23]** Determining objective weights in multiple criteria problems: The critic method.
- **Imad Hassan et al. [24]** A CRITIC–TOPSIS Multi-Criteria Decision-Making Approach for Optimum Site Selection for Solar PV Farm. This research work introduces CRITIC-TOPSIS hybrid approach for solar PV farm site selection by integrating two MCDM techniques, CRITIC sets factor weights, TOPSIS ranks alternatives based on various variables.
- **Debanan Bhadra et al. [25]** Sensitivity analysis of the integrated AHP-TOPSIS and CRITIC-TOPSIS method for selection of the natural fiber. Analyzes sensitivity in AHP-TOPSIS and CRITIC-TOPSIS methods for natural fiber selection as Weight variations affect results. Focuses on TOPSIS sensitivity via subjective (AHP) and objective (CRITIC) weights. Evaluates best natural fiber from twelve alternatives.
- **Godwin Odu [26]** Weighting methods for multi-criteria decision making technique**.** This paper reviews various weighting methods for multi-criteria decision making. Highlights their significance in achieving desirable properties and optimal performance across selected criteria. Emphasizes using these methods to establish preferences and identify best options.
- **Kumar et al. [27]** Prioritization of New Smartphones Using TOPSIS and MOORA. The aim of this study's methodology is to develop a useful and efficient approach for MCDM approach to evaluate different smart phone alternatives according to consumer preferences and to find out the best optimal smart phone. To prioritize smartphones effectively, the combination of the TOPSIS and MOORA methods is employed. For this methodology, five smartphone brands are selected and evaluated.
- **Prabina Kumar Patnaik et al. [28]** Composite material selection for structural applications based on AHP-MOORA approach. In this work, Utilizes AHP-MOORA hybrid MCDM for composite material selection in wear-resistant structural applications. Considers physical, mechanical, and wear properties of materials. Enhances selection process effectiveness.

A. Gap in the Literature

There is less evidence in literature that CRITIC method which is objective rating method is applied in combination with TOPSIS and MOORA for E-Vehicle selection.

B. Objectives of this Study

This study aims to choose the most suitable E-Scooter option. To achieve this, five different E-Scooters are assessed based on various factors like speed, range, power, battery capacity, charging time, and cost. The evaluation and ranking of the E-Scooters are carried out using a combination of the TOPSIS and MOORA methods, along with the CRITIC method.

III. ILLUSTRATIN OF PROPOSED METHODS

A. TOPSIS

➢ *Decision matrix*

The following decision matrix of 5 alternate EVs with 6 criteria is presented below.

Table 1: Decision Matrix

E-Vehicle	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Ola S1	95	128	8.5	3	5	1.3
TVS iQube	82	145	4.4	4.56	4.5	1.6
Ather 450 X	90	105	6.4	3.7	5.67	1.45
Bajaj Chetak	63	108	4.2	2.9	4	1.4
Ampere Magnus Ex	50	83	1.8	2.3	6.5	1.05

- *A2: Normalized decision matrix*
  The Normalized decision matrix is presented in Table-II.

Table 2: Normalized Decision Matrix

E-Vehicle	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Ola S1	0.5456	0.4946	0.6862	0.3967	0.4293	0.4237
TVS iQube	0.4709	0.5602	0.3552	0.6030	0.3864	0.5214
Ather 450 X	0.5169	0.4057	0.5167	0.4893	0.4868	0.4726
Bajaj Chetak	0.3618	0.4173	0.3391	0.3835	0.3434	0.4563
Ampere Magnus Ex	0.2872	0.3207	0.1453	0.3042	0.5581	0.3422

- *A3: Weighted normalized decision matrix*
  CRITIC method is employed to determine the relative weights of the variables. Results of the CRITIC method are presented below.

- *Standard deviation*: Standard deviation of the input and out variables are determined as discussed in the CRITIC methodology is presented below.

Table 3: Standard Deviation

Variable	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
STEDEV	0.1089	0.0913	0.2036	0.1145	0.0843	0.0666

- Standard deviation: Standard deviation of the input and out variables are determined as discussed in the CRITIC methodology is presented below.

Table 4: Correlations

Criteria	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Speed km/hr	1.0000	0.6750	0.9209	0.9209	-0.2634	0.5872
Range km	0.6750	1.0000	0.5112	0.7899	-0.6665	0.7847
max power (kW)	0.9209	0.5112	1.0000	0.2607	-0.2829	0.3552
Battery (kWh)	0.9209	0.7899	0.2607	1.0000	-0.4283	0.9193
Charging Time (hr)	-0.2634	-0.6665	-0.2829	-0.4283	1.0000	-0.7034
Cost (lacs)	0.5872	0.7847	0.3552	0.9193	-0.7034	1.0000

- *Standard deviation*: Standard deviation of the input and out variables are determined as discussed in the CRITIC methodology is presented below.

Table 5: Conflict among the variable (1-correlation)

Criteria	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Speed km/hr	0.0000	0.3250	0.0791	0.0791	1.2634	0.4128
Range km	0.3250	0.0000	0.4888	0.2101	1.6665	0.2153
max power (kW)	0.0791	0.4888	0.0000	0.7393	1.2829	0.6448
Battery (kWh)	0.0791	0.2101	0.7393	0.0000	1.4283	0.0807
Charging Time (hr)	1.2634	1.6665	1.2829	1.4283	0.0000	1.7034
Cost (lacs)	0.4128	0.2153	0.6448	0.0807	1.7034	0.0000

- *Measurement of conflict of the variables:* The values are presented in the following table.

Table 6: Measure of Conflict

Criteria	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Measure of conflict	2.159	2.9606	3.235	2.537	7.344	3.057

- Measurement of conflict of the variables: The values are presented in the following table.

Table 7: Information Content

Criteria	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Information content	0.235	0.265	0.658	0.290	0.619	0.204

- Relative weights of the criteria: Relative weights of the criteria/variables are determined and the values are presented below.

Table 8: Relative Weight of Inputs/Outputs

Criteria	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Relative weight	0.1035	0.1168	0.2898	0.1278	0.2726	0.0896

- *Weight normalized decision matrix*:
The weighted normalized decision matrix is presented in Table-IX.

Table 9: Weighted Normalized Decision Matrix

E-Vehicle	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Ola S1	0.0565	0.0578	0.1988	0.0507	0.1170	0.0380
TVS iQube	0.0487	0.0654	0.1029	0.0771	0.1053	0.0467
Ather 450 X	0.0535	0.0474	0.1497	0.0625	0.1327	0.0423
Bajaj Chetak	0.0374	0.0487	0.0982	0.0490	0.0936	0.0409
Ampere Magnus Ex	0.0297	0.0374	0.0421	0.0389	0.1521	0.0307

- *Ideal solutions*: Positive and negative ideal solutions are developed and are presented in Table-X.

Table 10: Positive and Negative Ideal Solutions

Ideal solutions	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Positive ideal solution	0.0565	0.0578	0.1988	0.0507	0.1170	0.0380
Negative ideal solution	0.0487	0.0654	0.1029	0.0771	0.1053	0.0467

- *Separation measures*: Separation measures from Positive and negative ideal solutions are developed and are presented in Table-XI.

Table 11: Separation Measures from Positive and Negative Ideal Solutions

E-Vehicle	Separation measure from positive solution	Separation measure from negative solution
Ola S1	0.04516	0.16265
TVS iQube	0.10820	0.08025
Ather 450 X	0.05893	0.11979
Bajaj Chetak	0.12277	0.05895
Ampere Magnus Ex	0.16589	0.06067

- *Closeness coefficient*: Closeness coefficients of each alternative are determined .Ranking of alternatives are made in the descending order of closeness coefficient .The closeness coefficients and ranking of alternative Electric Vehicles are presented in Table-XII.

Table 12: Ranking of Electric Vehicles according to TOPSIS

E-Vehicle	Closeness coefficient	Rank
Ola S1	0.78267	1
TVS iQube	0.42584	3
Ather 450 X	0.67026	2
Bajaj Chetak	0.32442	4
Ampere Magnus Ex	0.26779	5

B. MOORA

➢ *Normalized decision matrix*
The normalized decision matrix is presented in Table-II.

➢ *Weighted normalized decision matrix*
Weighted normalized decision matrix is already presented in Table-IX.

➢ *Normalized assessment index*
Normalized assessment index is determined. Ranking of alternate are determined in the descending order of normalized assessment index values. Normalized assessment index values and ranking of the alternate Electric vehicles are presented in Table-XIII.

Table 13: Normalized Index Values and Ranking

E-Vehicle	Assessment index of benefit criteria	Assessment index of cost criteria	Normalized assessment index	Rank
Ola S1	0.3638	0.1550	0.2088	1
TVS iQube	0.2942	0.1520	0.1421	2
Ather 450 X	0.3131	0.1750	0.1381	3
Bajaj Chetak	0.2334	0.1345	0.0990	4
Ampere Magnus Ex	0.1481	0.1828	-0.0346	5

C. MOORA Reference Point Method

➢ *Reference point*
Highest values of the criteria are considered for benefit attributes and minimum values are considered for cost type criteria. The reference points of the criteria are presented in Table-XIV.

Table 14: Reference Point of the Criteria

Criteria	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)
Ref. point	0.5456	0.5602	0.6862	0.6030	0.5581	0.3422

➢ *Maximum distance of alternatives*
Maximum distance values of each alternative to the reference points under all criteria are determined and then from these values minimum one is chosen as the best alternative. Final ranking of the alternatives is obtained by ranking the maximum distance values in increasing order. Maximum distance and ranking of alternatives are presented in Table-XV.

Table 15: Maximum Distance and Ranking of Alternatives

E-Vehicle	Speed (km/hr)	Range (km)	max power (kW)	Battery (kWh)	Charging Time (hr)	Cost (lacs)	Max.	Rank
Ola S1	0.0000	0.0077	0.0000	0.0264	0.0351	0.0073	0.0351	1
TVS iQube	0.0077	0.0000	0.0959	0.0000	0.0468	0.0161	0.0959	3
Ather 450 X	0.0030	0.0180	0.0491	0.0145	0.0194	0.0117	0.0491	2
Bajaj Chetak	0.0190	0.0167	0.1006	0.0281	0.0585	0.0102	0.1006	4
Ampere Magnus Ex	0.0267	0.0280	0.1567	0.0382	0.0000	0.0000	0.1567	5

IV. RESULTS AND DISCUSSION

A. Results and Discussion
The results are given and compared in Table-XVI. Same ranking pattern is obtained with the proposed TOPSIS and MOORA ref point method. Similar ranking pattern is obtained with MOORA ratio method. The proposed methods are consistent in ranking Ola S1, Bajaj Chetak and Ampere Magnus Ex alternatives.

Table 16: Comparison of Rankings

E-Vehicle	Ranking			Avg Rank
	TOPSIS Method	MOORA_Ratio Method	MOORA_Ref Point Method	
Ola S1	1	1	1	1
TVS iQube	3	2	3	3
Ather 450 X	2	3	2	2
Bajaj Chetak	4	4	4	4
Ampere Magnus Ex	5	5	5	5

The results of the proposed methods were compared using examples of E-Vehicles. In real situations, the findings match those in Table-XVI. MOORA and TOPSIS are methods that use a simple way to rank choices by measuring how close they are to a certain point. These methods were used to rank the alternatives, and they have clear benefits:

they are easy to use and give a definite order for choosing between options.

Ola S1 is ranked first followed by Ather 450X, TVS iQube ranked third, Bajaj Chetak ranked fourth and Ampere Magnus Ex ranked fifth. The most preference E-Scooters are (Ola S1 > Ather 450 X > TVS iQube > Bajaj Chetak and Ampere Magnus Ex) that are found in result of this study under average perspective.

V. CONCLUSION AND FUTURE SCOPE

B. Concluding Remarks

Based on research in the field, people's liking and adoption of EVs are influenced by how EVs are designed. As technology improves, the specifications of EVs differ among the various options available in the growing vehicle market. This situation calls for a careful analysis to make the best choice. In this study, three analytical decision-making processes were employed. Although there are some variations in the outcomes due to the specific procedures of these methods, all three methods yield similar results.

Electric vehicles are assessed and chosen based on 6 specific criteria. To ensure fairness in the decision-making process, the TOPSIS and MOORA methods are used. It's observed that the MOORA method, which is quick and straightforward in its calculations, is a suitable approach for vehicle selection problems. As shown by the literature review, this method effectively fills the gap in applying the CRITIC method alongside TOPSIS and MOORA for selecting EVs.

C. Future Scope of Study

Assigning weights to different factors in multi-criteria problems is a crucial step because changes in these weights impact outcomes. Both subjective and objective weighting methods can be combined with Multi-Criteria Decision Making (MCDM) techniques. Hybrid models like AHP-TOPSIS, ANP-TOPSIS, AHP-MOORA, or ANP-MOORA can also address the preferences in purchasing E-Vehicles. Additionally, criteria such as Battery Life, Battery Cost, Battery Safety, Appearance, Climb Capability, Torque, Charging Speed, and Vehicle Size can be used for evaluation. With minor adjustments, this model can also be applied to other decision-making scenarios.

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