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Application of the Analytic Hierarchy Process for Optimizing the Selection of Electric Vehicles in Urban Courier Services

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Abstract: The accelerating growth of urban populations, rapid city expansion, and inadequacies in transportation infrastructure have exacerbated traffic congestion and environmental burdens in metropolitan areas. These challenges have intensified the demand for sustainable mobility strategies, with electric vehicles emerging as a central component of urban decarbonization and efficiency initiatives. In this study, a structured multi-criteria decision-making framework was established to determine the most suitable electric vehicle for courier services. The framework was developed using the analytic hierarchy process (AHP), which enables the systematic evaluation of both criteria and sub-criteria and provides a robust mechanism for prioritizing alternatives. To enhance reliability, the model was implemented and validated using Expert Choice software, allowing for consistency testing and sensitivity analysis. Three categories of electric vehicles—electric cars, electric scooters, and electric bicycles—were assessed against a comprehensive set of decision factors encompassing economic, operational, environmental, and infrastructural dimensions. The resulting preference weights indicated that electric cars (0.387) represent the most suitable option for courier services under the evaluated conditions, followed closely by electric scooters (0.316) and electric bicycles (0.297). The ranking highlights the relative advantages of electric cars in balancing load capacity, operational flexibility, and environmental impact, while also reflecting the growing feasibility of scooters and bicycles for last-mile delivery. By offering a transparent and replicable approach to alternative vehicle selection, this research contributes to the optimization of courier logistics and the promotion of environmentally responsible transportation systems in congested urban environments. The methodological framework developed in this study may be adapted for broader applications in sustainable transport planning and fleet management, supporting policy-makers and practitioners in achieving urban sustainability objectives.

Keywords: Decision criteria; Electric vehicle selection; Analytic hierarchy process (AHP); Sustainable urban transport

1 Introduction

In Europe, more than half of the population lives in urban areas [1, 2] where 80% of the world's GDP and around 85% of the European Union's GDP are generated in urban environments [3]. Freight transport in urban areas, specifically the delivery of goods, is a fundamental prerequisite for the life and work of the population [3–5], as well as for activities [6] that contribute to the wealth and development of urban areas [3]. Cities, or urban areas, represent a 'complex' system because the city's area serves as both a surface for the transportation of goods and as an area for loading, transloading, and unloading goods [3, 5, 7, 8]. About 2/3 of all cargo flows either start or end in cities [3]. Most of the initial and final operations in supply chains are most often carried out by road transport and vehicles [3, 9] with a participation rate of 76% [3], while other modes of transport, including combined transport, have limited application [3]. Considering this, as well as the fact that road transport enables 'door-to-door' cargo delivery, it is not surprising that one ton of cargo is transported over a distance of up to 110 km by road [3]. More than 80% of freight transport by road is carried out in urban areas over a distance of up to 80 km [3, 7]. A study conducted by IVECO indicates that about 48% of vehicles operate within urban areas, while approximately 32% of vehicles operate within suburban zones [3, 7]. Light freight vehicles play a dominant role in deliveries, accounting for up to 42% of all deliveries. The use of light freight vehicles has been steadily increasing over the years [10]. The COVID-19 pandemic resulted in an impact on residents' lifestyles, threatened the sustainability of cities, caused disruptions in system functioning, and had a rapid and significant effect on population mobility [11]. Measures implemented to curb the spread of the COVID-19 virus, which involve restrictions on physical interaction [12], along with the fear of endangering life and health, have directed consumers towards online shopping [13]. The increase in online shopping has made the last mile of delivery more significant [4, 13], being the least efficient phase [14] and the most problematic part [3] of traffic and transport organization. The last and/or first mile of cargo delivery is often described as the most expensive, inefficient, and environmentally damaging part of the supply chain [14, 15]. According to the author Melo [16] the concept of transportation and traffic sustainability should address the question: 'How can a certain portion of cargo be transported efficiently and environmentally, moving goods over the shortest distances, without wasting time, with minimal costs, occupying the least amount of land, and causing minimal environmental pollution? '

Considering all of the above, special attention is directed towards the development of environmentally friendly systems, such as vehicles with alternative propulsion systems (electric vehicles, hybrid vehicles, vehicles running on natural gas, and cargo trams), with the aim of achieving sustainable transportation and traffic [3, 6]. Vehicles with alternative propulsion systems are still not widely used for either passenger or freight transport. It is estimated that in 2020 there were around 6.8 million electric vehicles worldwide, with 3 million (about 44%) coming into use that year [17, 18]. Electric vehicles are suitable for short-distance distribution and have the potential to achieve high speeds [3, 19]. Electric bicycles [3, 19] and electric scooters are used for last-mile delivery. For the sake of sustainability in urban distribution, some authors focus on the use of electric bicycles [3, 20, 21]. Estimated effects of using electric bicycles for courier deliveries in European and American cities vary significantly [3, 22] and show greater justification for use in urban environments with more spatial and infrastructural constraints [3, 23]. Research aimed at assessing the impact of improving vehicle energy efficiency through the use of cleaner fuels, including the application of electric carts and tricycles for delivery in urban areas, as well as the use of electric bicycles and scooters for courier deliveries, has indicated a reduction in harmful emissions and parking issues, while acceptance by cargo flow generators and citizens is significant [3].

Considering all of the above, this research aims to present a framework for identifying and analyzing criteria for selecting an appropriate electric vehicle (considering electric cars, electric bicycles, and electric scooters) for cargo delivery in urban areas by courier services.

2 Literature Review

2.1 Challenges in Organizing Road Traffic and Transport in Urban Areas

Today, online shopping is one of the most popular forms of shopping worldwide and is experiencing consistent growth [4]. In the United Kingdom, electronic shopping accounted for 59% of total shopping in 2004, compared to 49% in 2000 [4]. In the Republic of Serbia, 45.4% of all internet users have never made any purchases online [13, 24]. The percentage of online shoppers who make more than 10 purchases per month in Serbia is 5.6%, while in the European Union, this percentage is 15% [13, 24]. In 2018, in Serbia, users primarily purchased clothing and sports equipment through e-commerce (55.5%), followed by household products (22.6%), and electronic equipment (18.3%) [13, 24]. In the European Union, users purchased sports equipment (64%), vacation accommodations (53%), household products (46%), event tickets (38%), books, magazines, and newspapers (32%), movies and music (26%), electronic equipment (26%), food and groceries (26%), video games and software (23%), and telecommunications services (20%) [13, 24]. Online shopping gained special significance in the supply of food to the population. Specifically, during the COVID period, small, medium, and large food producers, as well as restaurants, delivered their products directly to consumers or the population [25]. It is estimated that 2 to 30% of goods ordered online must be delivered by specific delivery vehicles [3], which results in negative effects and consequences for traffic [26]. Increasing the intensity of traffic by delivery vehicles on the last and/or first mile leads to problems related to cargo delivery, parking issues, loading and unloading problems, insufficient loading factor, frequent trips, increased number of kilometers traveled, increased number of freight vehicles in urban areas, transportation with empty vehicles [27], road safety, environmental impact, as well as other undesirable effects and consequences [3–5, 26, 28, 29].

2.2 Impact of Road Traffic and Transport on the Environment and Quality of Life in Urban Areas

Road traffic creates both the greatest advantages and problems in urban areas. In addition to the many benefits provided by road traffic and transport, many authors point out and emphasize the numerous negative impacts of road traffic on the environment and quality of life, which are reflected in: emissions of harmful gases, noise, energy consumption, land use, climate change, traffic congestion, and disruption of natural habitats and species [6].

Emissions of harmful gases in urban areas are considered far more detrimental than the same number of emissions in uninhabited areas, given the density of the population exposed to the impact [3]. Research indicates that mortality is associated with air pollution [5], with mortality rates being 15 to 20% higher in polluted cities [3, 5]. In 2018, each resident of a European city experienced a social loss of 1,250 euros due to direct and indirect health losses caused by poor air quality, which accounts for 3.9% of the income earned in cities [30]. Road traffic is one of the main sources of harmful gas emissions in urban areas, with freight transport contributing about 40% to the problems associated with these emissions [3].

Every year, around 57 million people are disturbed by noise resulting from transportation, with 42% suffering serious consequences [3]. In Europe, at least one million years of life are 'lost' every year due to road traffic noise [3]. In the EU, about 40% of the population is exposed to noise from road traffic, with residents experiencing noise levels above 55 dB, while 20% are exposed to levels above 65 dB. During the night, more than 30% of the population is exposed to noise levels above 55 dB, which affects sleep and health [31]. In European cities with populations over 250,000, nearly 70 million people are exposed to long-term road traffic noise levels above 55 dB, which accounts for 62% of the population, while 15% are exposed to levels above 65 dB. In these cities, more than 48 million people are exposed to transport noise above 50 dB during the night, meaning 44% of the population is exposed to noise that is harmful to health while sleeping [32]. A noise level above 65 dB is considered unacceptable, noise at 80 dB can cause damage to the body, and prolonged exposure to noise levels of 70 dB can lead to irreversible hearing loss. The human tolerance threshold for noise is 154 dB. Factors influencing transport noise levels include: traffic intensity, movement patterns, type of vehicle, type of road surface, spatial planning, and green spaces [3].

The transport sector's dependence on oil has become an increasingly prominent problem [3]. Energy for the transport sector is composed of 97% oil, 2% natural gas, 1% electricity, and less than 0.5% from renewable sources. In the European Union, 30% of total energy consumption is lost in transportation, with 43% of this used for freight transport [3, 5]. Fuel consumption and energy use in road transport account for over 80% of increased energy consumption, with road transport being the dominant consumer of oil, making up about 81% of total energy use in the transport sector. Half of the energy consumed in road transport is used in urban areas [3–5]. In 2008, China was the largest producer of vehicles and consumer of energy, with road transport accounting for about 85% or more of energy consumption in the transport sector [33].

Global warming currently represents the greatest problem and challenge for humanity. An increasing number of studies demonstrate that pollution resulting from human activities has led to the greenhouse effect, which causes rising average temperatures and climate change [3, 5]. Freight transport in road traffic is responsible for half of the greenhouse gas emissions [3, 5]. Transport in urban areas accounts for about 25% of harmful gas emissions responsible for climate change, with almost all of it resulting from road transport activities [3, 5].

It is estimated that the European Union loses about 100 billion euros annually, which is approximately 1% of GDP, due to traffic congestion. Passengers spend over 47 hours a year in traffic, an increase of 7 hours compared to 1993. The time spent traveling has increased by 7%, while the percentage of congested highways has risen from 51% to 60% [3, 5].

2.3 Criteria for Purchasing Electric Vehicles

Considering all of the above, with the aim of sustainable development, increasing attention is being given to the development of environmentally friendly systems and technologies for freight transport, such as electric vehicles, hybrid vehicles, natural gas vehicles, cargo trams, and other systems for railway and water transport in goods distribution [3]. In the past few years, annual sales of electric vehicles have increased from a few hundred thousand sold in 2010 to 500,000 in 2015, and 750,000 in 2016. Sales of electric vehicles have been steadily growing. In January 2017, the sales of electric vehicles amounted to around 2 million [34]. During 2017, one million electric vehicles were sold, representing a 54% increase compared to 2016. According to estimates from Bloomberg, it is expected that by 2035, half of all cars sold worldwide will be electric vehicles [17]. Alongside the emergence and development of electric vehicles, there has been advancement in internal combustion engines and mass production of cheaper gasoline vehicles. This situation has slowed the growth of electric cars. However, it is expected that at some point, electric vehicles will become dominant compared to fossil fuel-powered vehicles [17].

Most attention has been focused on electric vehicles, with the potential for electric vehicles in goods distribution being somewhat less explored [35]. Light electric commercial vehicles can serve transport over a distance of 2 km, so one such vehicle could replace up to 30% of commercial vans operating within that range [36]. Based on conducted research, it is estimated that 51% of all trips made by motor vehicles for goods transport in European cities could be replaced by bicycles or cargo bikes [37]. A survey conducted in Graz in 2009 indicates that 80% of goods from a sample of 1,600 deliveries could be transported in a bicycle basket, 14% of the goods would need to be transported in a bicycle trailer due to their quantity, and 6% of the deliveries would require a car for home transport. This approach highlights the importance of applying structured multi-criteria methods when evaluating alternative solutions in transport and logistics systems [38].

According to the "Market Analysis of E-Mobility in Montenegro" study (2019), the key motivations for purchasing an electric vehicle among dealers/distributors are: environmental awareness (85.71%), financial savings (71.43%), less vehicle maintenance concern (14.29%), and positive public perception of the company (marketing) (14.29%). As key motivations for purchasing an electric vehicle, vehicle service providers cite: financial savings (80%), positive public perception of the company (marketing) (40%), less vehicle maintenance concern (40%), and environmental awareness (20%). Meanwhile, financial institutions highlight: financial savings (75%), environmental awareness (75%), and positive public perception of the company (marketing) (50%) [39].

An analysis of respondents' attitudes in the Republic of Serbia identified key barriers to greater use of electric vehicles: high purchase prices (75.7%), lack of public charging infrastructure (61.7%), insufficient battery capacity (39%), inadequate subsidies for purchasing electric vehicles (38%), inadequate offerings from dealers (29%), insufficient bank services (17%), lithium shortages for battery production (10.8%), and other factors (3.2%) [40]. As benefits of using electric vehicles, Serbian citizens most commonly cite: reduced emissions of harmful gases (86.2%), lower long-term costs (electricity is cheaper than fuel, fewer repairs) (48%), reduced noise (45.7%), greater engine efficiency (16.8%), and 1% of respondents noted that there are no benefits [40]. The minimum acceptable range for an electric vehicle on a single charge, according to respondents in Serbia, is most commonly cited as 200-500 km (37.7%), followed by 100-200 km (27.2%), and then 500-800 km (15.2%) [40].

3 Methodology

3.1 AHP

The AHP is one of the popular methodologies used to estimate subjective judgment while making decisions or ranking factors and barriers [41]. Thus, methodologically speaking, the AHP method is a multi-criteria technique based on decomposing a complex model into a hierarchical structure. The goal is positioned at the top of the hierarchy, while criteria, sub-criteria, and alternatives are placed at lower levels [42–44]. The aim of this study was to identify, analyze, and rank the criteria for selecting an appropriate electric vehicle (electric car, electric bicycle, and electric scooter) for goods delivery in urban environments.

The methodology of this research included several steps as shown in Figure 1:

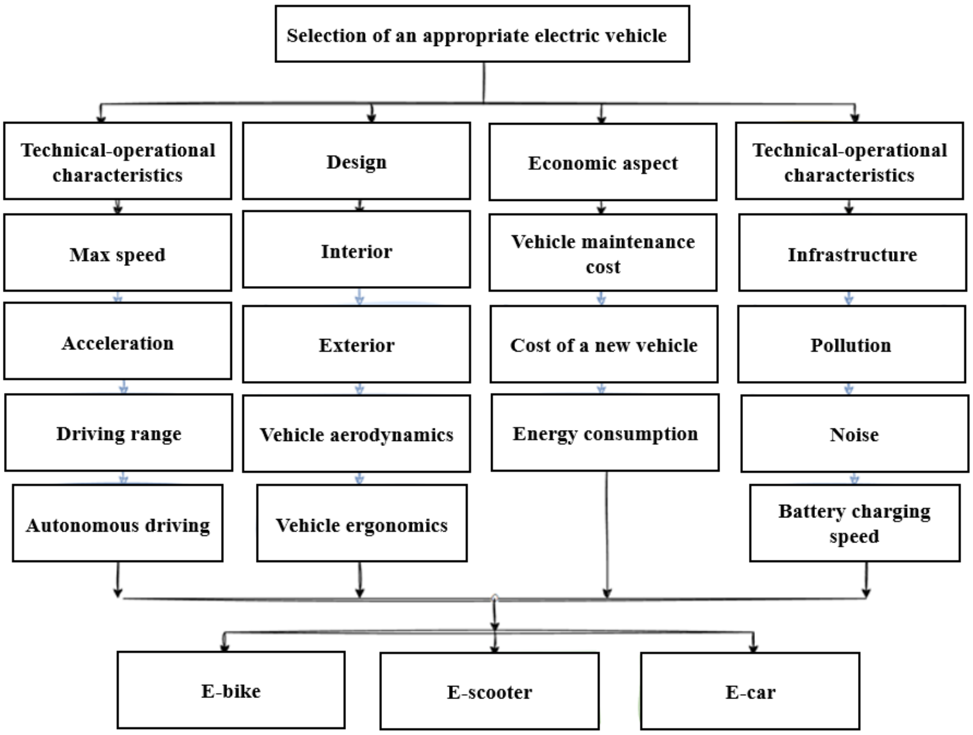

Figure 1. Hierarchical tree for ranking the criteria for selecting an appropriate electric vehicle

Note: This figure was prepared by the authors

1. Formation of a hierarchical structure for ranking the criteria for selecting an appropriate electric vehicle. The hierarchical model was defined using Expert Choice 11, based on previously conducted research [39–41, 45, 46].

2. Pairwise comparisons are conducted at all hierarchical levels, except at the highest (zero) level [42]. The pairwise comparison questionnaires were formulated in accordance with the research objectives and the defined criteria categories. Each comparison of two elements was performed using Saaty's scale, which ranges up to 9

points. Thus, the results of comparisons between elements at a given hierarchical level, as provided by the experts, were placed into the appropriate comparison matrices in the Expert Choice 11 software.

3. The procedure for calculating weight coefficients involves forming a comparative matrix based on expert assessments, and then calculating the eigenvector from the comparative matrix [41–44].

4. The weight coefficient for each indicator is calculated as the ratio of the sum of the rows, where the eigenvectors are located, to the number of indicators, based on the following formula [42]:

$$TK_i = \frac{1}{n} \cdot \sum_i V_i \tag{1}$$

5. The AHP method allows for the measurement of judgment errors by calculating the consistency index (CI) for the obtained comparison matrix, and then determining the degree of consistency [42]. To calculate the consistency ratio (CR), you first need to compute the CI using the formula [42]:

$$CI = \frac{\lambda \max - n}{n-1} \tag{2}$$

6. In this process, the closer $\lambda \max$ is to the number n, the smaller the inconsistency will be. To calculate $\lambda \max$, you first need to multiply the comparison matrix by the weight vector to determine vector b [42]:

$$\begin{bmatrix} \mathrm{a}_{11} & a_{12} & \cdots & \cdots & \cdots & a_{1n} \\ \mathrm{a}_{21} & a_{22} & \cdots & \cdots & \cdots & a_{2n} \\ \cdot & & & & & \cdot \\ \cdot & & & & & \cdot \\ \mathrm{a}_{n1} & a_{n2} & \cdots & \cdots & \cdots & a_{nn} \end{bmatrix} \cdot \begin{bmatrix} w_1 \\ w_2 \\ \cdot \\ \cdot \\ w_n \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ \cdot \\ \cdot \\ b_n \end{bmatrix} \tag{3}$$

By dividing the corresponding elements of vectors b and w, you obtain [42]:

$$\begin{bmatrix} \frac{b_1}{w_1} \\ \frac{b_2}{w_2} \\ \cdot \\ \cdot \\ \frac{b_n}{w_n} \end{bmatrix} = \begin{bmatrix} \lambda_1 \\ \lambda_2 \\ \cdot \\ \cdot \\ \lambda_n \end{bmatrix} \tag{4}$$

And finally, it is obtained that [42]:

$$\lambda \max = \frac{1}{n} \sum_{i=1}^{n} \lambda_i \tag{5}$$

7. By substituting the value of $\lambda \max$ from relation (5) into relation (2), the CI is determined. Finally, the CR represents the ratio of the CI to the random index (RI) [42]:

$$\mathrm{CR} = \frac{CI}{RI} \tag{6}$$

8. The RI depends on the size of the matrix and represents a tabulated value. The values of random indices are shown in Table 1, where the first row represents the matrix order (matrix size), and the second row shows the RI values [42].

Table 1. RI values (Wind and Saaty [44])

1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	...
0.0	0.0	0.58	0.9	1.12	1.24	1.32	1.41	1.45	...

9. If the CR is less than 0.10, the result is considered sufficiently accurate, and there is no need for corrections in the comparisons or recalculations. However, if the CR is greater than 0.10, the results should be reanalyzed to identify the causes of inconsistency, address them through partial repetition of pairwise comparisons, and if repeating the procedure in several steps does not reduce the CR to the acceptable limit of 0.10, all results should be discarded, and the entire process should be restarted from the beginning [42].

3.2 Survey and Data

The research was conducted in 2024 with experts employed in various courier services in the Republic of Serbia. The respondents from courier services were selected for this study due to the specific demands and characteristics of their job, which involves constant driving in urban environments, often under conditions of heavy traffic and in city centers. Courier services have a pronounced need for environmentally friendly vehicles that enable efficient navigation through dense traffic, reduce harmful gas emissions, and lower maintenance and energy costs. For these reasons, experts from courier services are ideal candidates for assessing the suitability of electric vehicles, as their experiences and needs directly reflect the challenges they face in their daily operations, making them relevant participants for this study. The study involved 20 experts. Using Expert Choice 11, 24 complete and consistent datasets were obtained, along with 22 inconsistent datasets. The experts were selected randomly and were not obligated to participate in the research [47]. The respondents did not receive any compensation for their participation [48]. During the research, all ethical standards were observed. The flowchart of the research is shown in Figure 2.

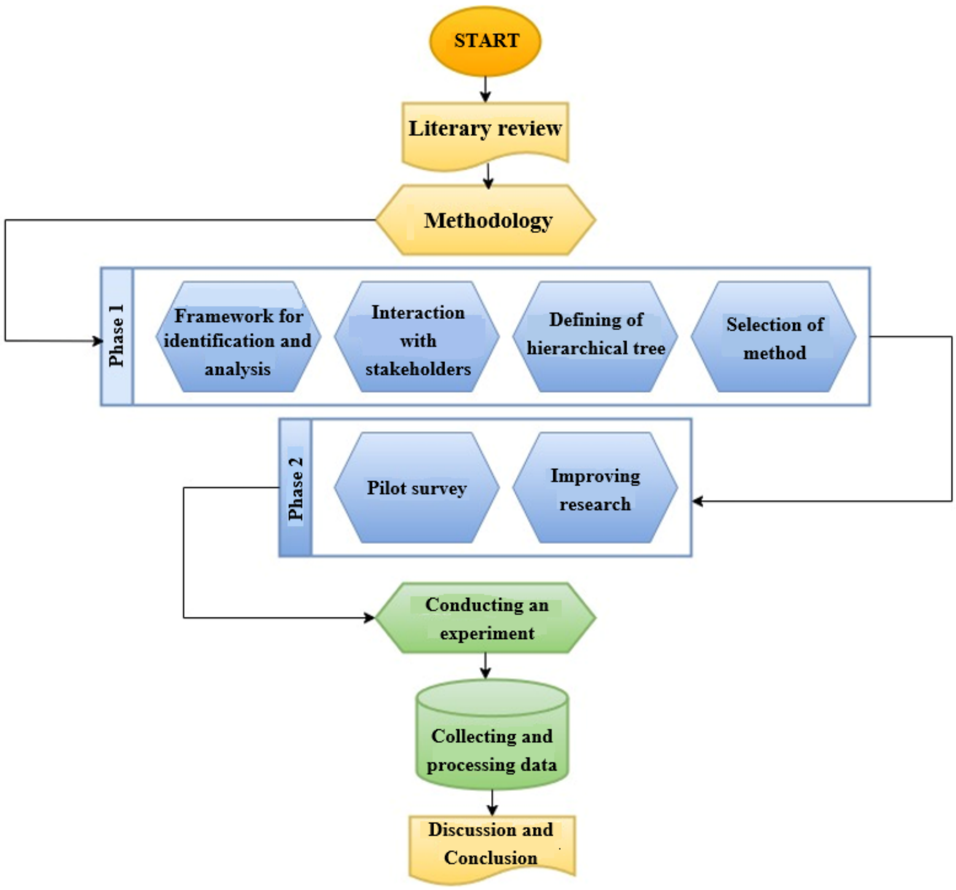

Figure 2. Overall research methodology flowchart

Note: This figure was prepared by the authors

4 Results

The results of the AHP estimation are shown in Table 2. When examining the defined criteria in relation to the goal, the results indicate that the most significant criterion for selecting an appropriate electric vehicle is "technical-operational characteristics" (47.6%), followed by the "economic aspect" (32.4%), then "other characteristics of electric vehicles" (12.3%), and "design of electric vehicles" (7.7%).

4.1 Analysis of the Sub-criteria Results in Relation to the Criteria

Table 3 shows the group decisions for the sub-criteria: Maximum speed, acceleration, driving range, and autonomous driving, in relation to the criterion of technical-operational characteristics. Driving range is the most significant sub-criterion for selecting an appropriate electric vehicle (60.5%). Following driving range are autonomous driving (driving assistance - driverless driving) (18.6%), maximum speed (11.7%), and finally vehicle acceleration (9.1%).

Table 2. Weight and ranking vectors according to decision-makers and group context

Criteria	Priority Weight	Priority Weight (%)	Rank
Technical-operational characteristics	0.476	47.6%	1
Design	0.077	7.7%	4
Economic aspect	0.324	32.4%	2
Other	0.123	12.3%	3

Table 3. Weight and ranking vectors of the sub-criteria in relation to the criterion "technical-operational characteristics"

Sub-criteria	Priority Weight	Priority Weight (%)	Rank
Max speed	0.117	11.7%	3
Acceleration	0.091	9.1%	4
Driving range	0.605	60.5%	1
Autonomous driving	0.186	18.6%	2

For decision-makers, according to the group decision shown in Table 4, vehicle ergonomics is the most significant sub-criterion in relation to the criterion "design" for selecting an appropriate electric vehicle (33.5%). Following vehicle ergonomics are vehicle aerodynamics (27.6%), exterior (23.1%), and interior (15.8%) of the vehicle.

Table 4. Weight and ranking vectors of the sub-criteria in relation to the criterion "design"

Sub-criteria	Priority Weight	Priority Weight (%)	Rank
Interior	0.158	15.8%	4
Exterior	0.231	23.1%	3
Vehicle aerodynamics	0.276	27.6%	2
Vehicle ergonomics	0.335	33.5%	1

Table 5 shows the group decision on the sub-criteria: Vehicle maintenance cost, cost of a new vehicle, and energy consumption, in relation to the criterion "economic aspect". For decision-makers, according to the group decision, vehicle maintenance cost is the most significant sub-criterion for selecting an appropriate electric vehicle (44.6%). Following vehicle maintenance cost are the costs of a new vehicle (30.9%) and the vehicle's energy consumption (24.5%).

Table 5. Weight and ranking vectors of the sub-criteria in relation to the criterion "economic aspect"

Sub-criteria	Priority Weight	Priority Weight (%)	Rank
Vehicle maintenance cost	0.446	44.6%	1
Cost of a new vehicle	0.309	30.9%	2
Energy consumption	0.245	24.5%	3

Table 6 presents the group decision results for the sub-criteria: Infrastructure, pollution, noise, and battery charging speed, in relation to the criterion "other characteristics". For decision-makers, according to the group decision (Table 5), infrastructure (charging stations) is the most significant sub-criterion for selecting an appropriate electric vehicle (42.5%). Following infrastructure (charging stations) are battery charging speed (32.1%), pollution (19.5%), and noise (6%).

Table 6. Weight and ranking vectors of the sub-criteria in relation to the criterion "other characteristics"

Sub-criteria	Priority Weight	Priority Weight (%)	Rank
Infrastructure	0.425	42.5%	1
Pollution	0.195	19.5%	3
Noise	0.060	6%	4
Battery charging speed	0.321	32.1%	2

4.2 Analysis of the Results of Alternatives in Relation to the Sub-criteria

Table 7 presents the group decision for the alternatives: e-bike, e-scooter, and e-car, in relation to the sub-criteria. For decision-makers, according to the group decision, the electric car is the most significant alternative for selecting an appropriate electric vehicle based on the following sub-criteria: maximum speed (78.6%), acceleration (81.5%), driving range (81.8%), autonomous driving (81.8%), interior (81.4%), exterior (77.4%), and ergonomics (76.2%). On the other hand, the electric scooter is the most significant alternative for the following sub-criteria: vehicle aerodynamics (58.8%), vehicle maintenance cost (50.1%), cost of a new vehicle (58.8%), infrastructure (42.2%), pollution (44.8%), and battery charging speed (58.8%). The electric bike is the most significant alternative for the sub-criteria: energy consumption (58.8%), infrastructure (42.2%), pollution (44.8%), and noise (39.8%).

Table 7. Weight and ranking vectors of the sub-criteria in relation to the criterion economic aspect

Criteria	**Sub-criteria**	**E-bike**			**E-scooter**			**E-car**		
		Priority Weight	**Priority Weight (%)**	**Rank**	**Priority Weight**	**Priority Weight (%)**	**Rank**	**Priority Weight**	**Priority Weight (%)**	**Rank**
Technical exploration characteristics	Max speed	0.167	16.7%	2	0.047	4.7%	3	0.786	78.6%	1
	Acceleration	0.111	11.1%	2	0.074	7.4%	3	0.815	81.5%	1
	Driving range	0.092	9.2%	2	0.090	9%	3	0.818	81.8%	1
	Autonomous driving	0.091	9.1%	2	0.091	9.1%	3	0.818	81.8%	1
Design	Interior	0.115	11.5%	2	0.071	7.1%	3	0.814	81.4%	1
	Exterior	0.113	11.3%	2	0.113	11.3%	3	0.774	77.4%	1
	Vehicle aerodynamics	0.361	36.1%	2	0.588	58.8%	1	0.051	5.1%	3
	Vehicle ergonomics	0.162	16.2%	2	0.076	7.6%	3	0.762	76.2%	1
Economic aspect	Vehicle maintenance cost	0.447	44.7%	2	0.501	50.1%	1	0.053	5.3%	3
	Cost of a new vehicle	0.361	36.1%	2	0.588	58.8%	1	0.051	5.1%	3
	Energy consumption	0.588	58.8%	1	0.361	36.1%	2	0.051	5.1%	3
Other	Infrastructure	0.422	42.2%	2	0.422	42.2%	1	0.155	15.5%	3
	Pollution	0.448	44.8%	2	0.448	44.8%	1	0.104	10.4%	3
	Noise	0.398	39.8%	1	0.244	24.4%	3	0.357	35.7%	2
	Battery charging speed	0.361	36.1%	2	0.588	58.8%	1	0.051	5.1%	3

In the conducted research, based on the group decision of all experts who participated, a ranking list of suitable electric vehicles was obtained in relation to the set goal, considering all evaluations of criteria and sub-criteria. Table 8 presents that the electric car ranks first, considering all evaluations of criteria and sub-criteria (38.7%), followed by the electric scooter in second place (31.6%), and the electric bicycle in third place (29.7%) .

Table 8. Weight and ranking vectors of alternatives for selecting an appropriate electric vehicle in relation to the set goal, considering all evaluations of criteria and sub-criteria

Sub-criteria	**Priority Weight**	**Priority Weight (%)**	**Rank**
E-car	0.387	38.7%	1
E-scooter	0.316	31.6%	2
E-bike	0.297	29.7%	3

5 Discussion

This study examines the selection of an appropriate electric vehicle for urban transport needs using the AHP multi-criteria decision-making method. Given the increasing issues of pollution, traffic congestion, and energy challenges in urban environments, the results of this study provide significant practical and theoretical contributions.

By using data collected from experts in courier services, insights have been obtained that are directly related to the real needs of a sector that deals daily with these issues.

The results show that ”technical-operational characteristics” are the most important criterion in selecting an electric vehicle, with a particular emphasis on driving range. These findings are not surprising, given that courier services operate in dynamic and unpredictable urban environments where battery longevity and vehicle reliability are crucial factors. Furthermore, the vehicle's economic efficiency, particularly regarding maintenance costs, is the second most important criterion, aligning with the goal of reducing operational costs in the highly competitive courier service.

However, it is important to note that focusing on courier services, while a logical choice due to their specific needs, is also one of the main limitations of this study. The exclusive focus on this sector may limit the applicability of the results to other industries and broader urban contexts. For example, the needs of public transportation or individual electric vehicle users may differ significantly in terms of priorities such as comfort, design, or even charging infrastructure.

This research also shows that experts from courier services have recognized the importance of ”design” as a criterion, but with a smaller share in the overall evaluation compared to technical and economic aspects. This suggests that, although aesthetic and functional characteristics play a role, practicality and efficiency remain the dominant factors in choosing a vehicle for business needs. This finding can also be interpreted as an indicator of the need for further development of vehicles that combine top-notch technical features with user-friendly design tailored to urban environments.

Future research should encompass a broader range of participants from various industries and regions to enable generalization of the results. Including participants from sectors such as public transportation, logistics, and private users could provide new insights and expand the applicability of the findings. Additionally, extending the research to an international level would allow for comparison of preferences across different cultural and economic contexts, offering a global perspective on the challenges and opportunities in the implementation of electric vehicles.

In conclusion, this study provides an important contribution to understanding the criteria and priorities for selecting electric vehicles for urban conditions, with a specific focus on the needs of courier services. While there are limitations regarding the sample's breadth, the results offer a solid foundation for further research and the development of policies that support the transition to sustainable urban transport.

6 Conclusions

This study provides a comprehensive approach to evaluating alternative electric vehicles using the AHP multi-criteria decision-making method, based on data collected from experts in courier services in Serbia. The research results show that the electric car is the most suitable option among the considered alternatives, with ”technical-operational characteristics” recognized as the most significant criterion. These results may offer guidance for further development of sustainable transport solutions in urban environments. Based on the data collected and analyzed in the conducted research, the following conclusions can be drawn:

1. Based on the results of the calculations when considering the criteria relative to the goal, it can be concluded that the most significant influence on the criterion for selecting an adequate electric vehicle is “technical-operational characteristics” (0.476), followed by the “economic aspect” (0.324). This is followed by “other characteristics of electric vehicles” (0.123) and “design of electric vehicles” (0.077);

2. For all decision-makers, driving range represents the most significant sub-criterion for selecting an adequate electric vehicle (0.605) when considering the “technical-operational characteristics” criterion. Following driving range, the next most important sub-criteria are autonomous driving (assistance or driverless driving) (0.186), maximum speed (0.117), and finally, vehicle acceleration (0.091);

3. For decision-makers, based on the group decision, vehicle ergonomics is the most significant sub-criterion for selecting an adequate electric vehicle (0.335) when considering the ”vehicle design” criterion. Following ergonomics, the next most important sub-criteria are vehicle aerodynamics (0.276), exterior (0.231), and interior (0.158) of the vehicle;

4. Vehicle maintenance cost is the most significant sub-criterion for selecting an adequate electric vehicle (0.446) when considering the “economic aspect” criterion. Following maintenance cost, the next most important sub-criteria are the cost of a new vehicle (0.309) and the vehicle's energy consumption (0.245);

5. Infrastructure (charging stations) is the most significant sub-criterion for selecting an adequate electric vehicle (0.425) when considering the “other characteristics” criterion. Following infrastructure (charging stations), the next most important sub-criteria are battery charging speed (0.321), pollution (0.195), and noise (0.060);

6. The electric car represents the most significant alternative for selecting an adequate electric vehicle according to the following sub-criteria: maximum speed (78.6%), acceleration (81.5%), driving range (81.8%), autonomous driving (81.8%), interior (81.4%), exterior (77.4%), and ergonomics (76.2%);

7. The electric scooter represents the most significant alternative according to the following sub-criteria: aerodynamics (58.8%), maintenance cost (50.1%), purchase price (58.8%), infrastructure (42.2%), pollution (44.8%), and battery charging speed (58.8%);

8. The electric bicycle represents the most significant alternative according to the following sub-criteria: energy consumption (58.8%), infrastructure (42.2%), pollution (44.8%), and noise (39.8%);

9. Considering all the evaluations of criteria and sub-criteria, the synthesis of solutions resulted in the following "ranking list" of alternatives for selecting the most suitable electric vehicle based on the set objective: electric car (0.387), electric scooter (0.316), and electric bicycle (0.297).

The obtained results can be used to make informed decisions regarding the acquisition of electric vehicles in courier services and other sectors, as well as for developing strategies to promote environmentally friendly transportation solutions in urban areas. Additionally, the results can serve as a foundation for formulating policies that support the broader adoption of electric vehicles through subsidies and the development of appropriate infrastructure.

Aside from the limitations related to the sample, where experts were exclusively from courier services, which might affect the specificity of the results, another significant limitation of the study is the geographical concentration of the research within the Republic of Serbia. This focus may restrict the applicability of the results to other regions with different traffic, economic, and cultural characteristics. Additionally, focusing on only one industry sector may lead to a narrow view of the electric vehicle issue. Future research should include a broader range of participants from various industries and regions to enhance the generalizability of the results. Moreover, exploring other sustainable transportation alternatives, such as hydrogen-powered vehicles or hybrid systems, would provide a more comprehensive approach to sustainable urban transport.

Author Contributions

Conceptualization, T.I. and J.Š.; methodology, T.I.; software, S.S.; validation, A.T.; formal analysis, T.I.; investigation, T.I.; resources, J.Š.; data curation, S.S.; writing—original draft preparation, T.I.; writing—review and editing, A.T.; visualization, S.S.; supervision, J.Š.; project administration, S.S.; funding acquisition, S.S. All authors have read and agreed to the published version of the manuscript.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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