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Research Article

Selection of EVs as Tourist and Logistic Means of Transportation in Bosnia and Herzegovina's Nature Protected Areas Using *Z*-Number and Rough Set Modeling

Adis Puška,[1] **Anđelka Štilić**,[2] **Darko Božanić**,[3] **Aleksandar Đurić**,[4] **and Dragan Marinkovic**[5]

[1]*Department of Public Safety, Government of Brčko District of Bosnia and Herzegovina, Bulevara Mira 1, Brčko 76100, Bosnia and Herzegovina*
[2]*Academy of Applied Studies Belgrade, The College of Tourism, Bulevar Zorana Đinđića 152a, Belgrade 11070, Serbia*
[3]*Military Academy, University of Defence in Belgrade, Veljka Lukica Kurjaka 33, Belgrade 11000, Serbia*
[4]*Faculty of Education, University of East Sarajevo, Semberskih Ratara 1E, Bijeljina 76300, Bosnia and Herzegovina*
[5]*Faculty of Mechanical Engineering and Transport Systems, Technische Universität Berlin, Straße des 17. Juni 135, Berlin 10623, Germany*

Correspondence should be addressed to Adis Puška; adispuska@yahoo.com

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This research focuses on the use of electric vehicles (EVs) to transport visitors and cargo within Bosnia and Herzegovina's Kozara National Park. Reduced air pollution and the preservation of natural resources are required to help protect this aerial spa. Together with the expert employees of this NP, the EV that would best suit their needs was chosen. The process of decision-making combines subjective and objective methods. Employees first chose the criteria and alternatives and then weighed their importance. On that occasion, *Z*-numbers were used to include uncertainty in the decision, because it is not always possible to make decisions with complete certainty. Furthermore, the weight of these criteria was determined using the fuzzy PIPRECIA (PIvot Pairwise Relative Criteria Importance Assessment) method. Range (*C*1) became the most important criterion, followed by vehicle cost (*C*2), and the technical specifications of these EVs were used to compare them. Because these specifications vary, a rough set was used in which the minimum and maximum EV characteristics were taken based on specific criteria. To rank the alternatives, the R-CRADIS (Rough Compromise Ranking of Alternatives with Distance to Ideal Solution) method was used. According to the research results, the Mercedes eVito Tourer 90 kWh is the highest ranked EV and the validation of the results confirmed these findings. According to the research results, the Mercedes eVito Tourer 90 kWh is the highest ranked EV and the validation of the results confirmed these findings. The sensitivity analysis revealed that if criterion *C*1 is not as important, the other EVs are ranked higher. This research`s methodology has demonstrated flexibility, therefore it is recommended for use in similar research.

1. Introduction

Protected nature areas and transportation are strongly interconnected in terms of tourism as transportation cannot be separated from the aspect of tourist ecological footprint. In addition to the carbon footprint, transportation has a significant influence on the quality of the tourist's experience [1], but rather than being solely driven by tourist demand, transportation in protected nature areas should be planned to meet clearly-defined management objectives on the matter. The transportation component ultimately makes up a major part of the calculation of the ecological footprint of tourism, and the energy consumption factored into the transportation calculation will likewise make up a sizable share [2]. The private vehicles cannot always be the principal means of transport after scenic spots and other natural resources are what attract visitors there, not the transportation system.

In terms of the impacts of transport in tourist areas, carbon pollution is one of the most important factors. It is claimed that tourism is directly responsible for 5% of global CO_2 emissions and that mobility accounts for three quarters of that amount, note that while worldwide emissions are beginning to decrease, those related to the tourism sector are increasing [3]. As a result, it is important to maintain a sufficient transportation infrastructure to decrease the distance factor with appropriate access quality and reduce journey time [4], as well as to encourage more sustainable solutions. There ought to be various systems of transportation, as well as the adoption of more environmentally friendly vehicles. This could be achieved with awareness-raising initiatives and the demystification of EVs as social status badges of individuals or businesses.

Despite the fact that during the past 40 years, sustainable transportation strategies have become more prevalent in many urban contexts, they have only lately been applied to natural environments [5]. This move toward ecological means of transportation is critical for nature-based locations as it helps reconcile tourism activities with protected nature area sustainability [6]. On the other hand, there are some setbacks. McGinlay et al. [7] reported that managing European protected natural areas in epidemic times was fraught with transportation and traffic challenges such as incidents of negligent parking and traffic volume as a result of the visitor's unwillingness to use organized shuttles or public transportation out of concern that a virus would be spread [5].

The most common means of transportation, the variables that affect tourist mobility, and an assessment of visitors' perceptions of the issues most significant to them when selecting a means of transportation must all be thoroughly examined in order to analyze tourist mobility [3]. Sustainable planning and managing must also take into account the "journey to destination" component in addition to minimizing the ecological footprint produced by the visitor's stay at the destination.

Regarding mobility in general and visitors' transfers, the highest ecological footprint values were noticed in transfers that are longer than 100 km, such as from an airport or harbors, especially when numerous pickups are required owing to visitors' individual arrival/departure schedules. On the other hand, a low-mobility ecological footprint was observed where public transportation was promoted over the use of private vehicles. The common idea is that transportation to and from a location has the highest ecological footprint and that the greatest carbon reduction may be accomplished by transitioning from air to ground travel, notably by train [8], as the least carbon-intensive mode of transportation.

This paper is focused on analyzing the mobility of tourists in protected natural areas. By doing so, we intend to determine the best environmental and economic sustainable alternative mode of transportation for tourist purposes in these areas. Decisions concerning the transportation industry are often riddled with disputes since they might result in both benefits and drawbacks for various stakeholders. To achieve sustainable transportation solutions, multiple viewpoints from various stakeholders must be included in the decision-making cycle [9]. Stakeholder engagement in decision making is critical as it assists in determining and assessing the objectives among many stakeholders, improving decision acceptance, and boosting the efficiency of decisions.

Based on the literature on alternative transportation, available electric vehicles, and protected natural areas policies, this research offers a selection of EVs as tourist and logistic means of transportation in Bosnia and Herzegovina's nature protected areas. When choosing an EV, the decision maker (DM) has at his disposal several alternatives that are observed through certain criteria. In this sense, selecting an EV falls within the scope of the multicriteria decision-making (MCDM) problem and applying the multicriteria analysis (MCDA) approach allows for this problem to be solved.

The following issue is that while selecting a vehicle, one faces client perception, because each customer has their own vision of how a vehicle should feel [10]. In this research, this problem will be addressed in such a way that the technological qualities of the EV will be taken into account. However, these technical parameters of EVs vary depending on charging time and method, vehicle model, and so forth. In order to perform a more comprehensive research, data will be obtained in the form of intervals. Furthermore, group decision-making will be utilized to determine the relevance of the weights of the criteria with uncertainty factored into the decision-making process. These problems serve as the foundation for the following research objectives:

(1) Applying a novel decision-making model based on Z-numbers and a rough approach.

(2) Performing EV selection for Kozara National Park needs.

(3) Contributing to environmental preservation by application of sustainable tourism.

(4) Providing a methodological framework for selecting EV.

To achieve these objectives, a hybrid MCDM model based on the PIvot Pairwise Relative Criteria Importance Assessment (Z-PIPRECIA) and Rough Compromise Ranking of Alternatives with Distance to Ideal Solution (R-CRADIS) methodologies will be utilized. The Z-PIPRECIA method is an upgrade to the standard PIPRECIA method that uses Z-numbers to help the reduction of uncertainty in decision-making. The R-CRADIS method is an upgrade to the classical CRADIS method in the rough set. Rough set is used here due to the alternatives' values being expressed as an interval. This interval is necessary to include all technical data regarding the observed EVs.

The paper is organized as follows. Section 2 reviews literature about grand narratives (GNs) for achieving sustainable mobility and offers a literature overview about different EV selection problems with listing various approaches and methods that were used by the authors. Section 3 consists of a research background that closely describes the subject of the conducted research, followed by EV selection methodology developed for NP Kozara's needs. In Section 4, the results of the ranking are presented and then validated by comparison with five other methods' ranking results. Results of the sensitivity analysis are presented in this section as well. Section 5 discusses the effect of more realistic decision-making on Z-number employment, and Section 6, as the conclusion to this research, summarizes the most important findings, limits, and recommendations for further research.

2. Literature Review

In comparison to a system based on the use of private vehicles, a sustainable transportation system based on public transportation could be more easily achieved. In order to maintain the ecological and cultural worth of nature tourist spots, public transportation is used to entice visitors to leave their private vehicles outside of these protected nature areas. To create tourist mobility sustainable, the majority of stakeholders in protected natural areas use a number of transportation strategies and policies, including private vehicle restrictions, park and ride initiatives, and public transportation support [9].

It is important to talk about sustainable mobility narratives [11] that include technological and social practices that reduce the need for driving, promote the use of shared transportation instead of private transportation, and support the widespread adoption of low-carbon transportation, especially electric vehicles (EVs) [12] in order to address these issues.

As electromobility, collective transport 2.0, and low-mobility society are proposed as the three GNs for achieving sustainable mobility [11], the transportation industry needs all stakeholders to act immediately and on a scale that has not existed before in order to coordinate and support each other. At all decision-making levels, solutions that recognize the assistance of experts, the developing market, and the support of citizens can function effectively.

2.1. GN 1: Electromobility. The term "electromobility" refers to the replacement of traditional ICE vehicles by EVs. EVs are available in a variety of forms, including battery (BEV), plug-in hybrid (PHEV), range-extended (REV), and fuel cell (FCEV) [13, 14] and including hydrogen hybrid options such as FCHEV or FCPHEV as well [15]. Electromobility, as the first grand narrative, is not just about replacing individual private internal combustion engine (ICE) vehicles, but all current fossil fuel-powered vans, buses, light and heavy-duty vehicles, trains, ships, and short-haul airplanes with equivalent EV drive [11]. It is worth mentioning that electromobility neither challenges nor demands that tourists travel less.

2.2. GN 2: Collective Transport 2.0. Public transportation has often been the solution to the problem of sustainable mobility. New categories of collective transportation are proposed by Collective transport 2.0, and this approach involves a change from owning to using a vehicle, which has also been referred to as shared or as "as a service" mobility [11, 16, 17]. For example, in Kruger National Park in South Africa, according to Brett [1], the present infrastructure's capacity is frequently surpassed and an increasing number of tourists require smart and organized transportation alternatives. The research presented that using shared vehicles, in this case open safari vehicles, had advantages as they could carry 5.9 tourists on average, compared to 2.4 tourists in private vehicles. The use of autonomous vehicles is also advocated as a transport service innovation in the second grand narrative: Collective Transport 2.0.

2.3. GN 3: Low-Mobility Societies. The numerous effects on the sustainability of private vehicle use could be observed through increased air and noise pollution, destroyed roadside vegetation, shortage of parking spots, visitor discomfort, growing traffic [9], and overall environmental degradation, and the transportation policy for protected natural areas is required. The third grand narrative, low-mobility societies, suggests car-free options through gradually reducing, and in the end, eliminating the use of private vehicles. In the process, it is suggested that low-mobility societies should travel on fewer and shorter trips and that the preferred choice of transportation, when needed, should be an EV alternative.

As an overview about different EV selection problems, various approaches and methods will be listed hereinafter (Table 1).

The fact that various approaches were utilized to obtain the selection of different EVs demonstrates a weakness to the decision-making process. Thus, this particular research proposes a novel decision-making model based on Z-numbers and a rough approach presented in the following section.

3. Methodology

3.1. Research Background. The amount of protected areas in Europe, both on land and at sea, has been steadily expanding since the turn of the 20th century. As of 2020, the 38 European Economic Area member nations have roughly 130,000 protected areas [42]. These locations span roughly 1.27 million km^2 (22.7%) of the land and approximately 570,000 km^2 (8%) of water, which ranks Europe as the continent with the highest protected area coverage rates. Moreover, the new EU Biodiversity Strategy 2030 [43] mandates EU member states to keep expanding conservation efforts to protect 30% of both land and water coverage by 2030, with 10% of them strictly protected [42–44]. On a global scale, the most popular NPs attract millions of visitors each year, which has economic advantages but also has environmental consequences [45].

In Bosnia and Herzegovina, 37 nature areas are classified as protected. The protected area covers 105,602.18 hectares or less than 3% of the entire land area of the country [46]. In Bosnia and Herzegovina, two areas have been designated as strict nature reserves (SNRs): SNR Prašuma Janj and SNR Prašuma Lom. Furthermore, the country is home to a total of four national parks, including National Park (NP) Kozara, NP Sutjeska, NP Una, and the most recently established NP

Table 1: EV selection problems, an overview of various approaches and methods.

Author	Objective	Method
Biswas and Das [18]	Selection of BEVs	Fuzzy AHP, MABAC
Biswas et al. [19]	EV evaluation under sustainable automotive environment	CoCoSo, CRITIC
Loganathan et al. [20]	Advanced battery technologies selection	MCDM-WPM
Babar et al. [21]	Viability of EV in the current market	Fuzzy SWOT, fuzzy LP
Büyüközkan and Uztürk [22]	Sustainable urban logistics	SAW, VIKOR
Hamurcu and Eren [23]	Electric bus selection	AHP, TOPSIS
Khan et al. [24]	HEV selection	TOPSIS
Ziemba [25]	EV selection for government use	PROSA-C, Monte Carlo
Ecer [26]	Comprehensively assessing BEV alternatives	SECA, MARCOS, MAIRCA, COCOSO, ARAS, COPRAS
Khan and Ali [27]	Smart waste management adoption framework	Fuzzy SWARA, fuzzy VIKTOR
Ren et al. [28]	Selection strategies for BEVs	LDA, DEMATEL, DANP, VIKTOR
Ziemba [29]	Selection of city and compact EVs	NEAT F-PROMETHEE
Ziemba [30]	Analysis and recommendation of the EV	Monte Carlo, fuzzy TOPSIS, fuzzy SAW, NEAT F-PROMETHEE II
Hamurcu and Eren [31]	EV selection for transportation in inner city	AHP, GP, TOPSIS
He [32]	Selection of battery electric bus	EWM
Oztaysi et al. [33]	EV selection problem	F-SMART
Ozdagoglu et al. [34]	Bus selection for intercity transportation	PIPRECIA, COPRAS-G
Stopka et al. [35]	Evaluation of selected passenger EVs	AHP
Štilić et al. [36]	Taxi service EV selection	SWARA, MSDM, MABAC
Wei and Zhou [37]	EV supplier selection	BWM, fuzzy VIKOR
Ziemba and Gago [38]	Selection and analysis of e-scooters	PROMETHEE GDSS, GAIA
Puška et al. [39]	EV selection	DNMEREC, DNCRADIS
Bączkiewicz and Wątróbski [40]	EV selection	Entropy, standard deviation (SD), CRITIC, Gini coefficient-based, MEREC, statistical variance, CILOS, IDOCRIW, VIKOR
Dwivedi and Sharma [41]	EV selection	Entropy, TOPSIS

Drina. In this research, the focus will be on creating a sustainable transportation system based on the selection of EVs for the needs of the NP Kozara. According to the 2013 Law on Nature Protection [47] and The Spatial Plan of the Special Purpose NP Kozara, the protected area of Mount Kozara is located within the municipalities and towns of Prijedor, Gradiška, and Kozarska Dubica [48, 49] (Figure 1). The majority of the karstic Kozara [50] falls under IUCN Category II, classifying it as a National Park [42].

In 1967, Kozara Mountain's center region was designated a national park in order to preserve its historical, cultural, and ecological qualities. The NP Kozara spans 3.907,54 acres and is situated in the heart of the aforementioned mountain. The park's territory is extended in a north-south direction, with a length of 7 km and a width that varies from 3 to 6 km. In NP Kozara, 865 plant species have been identified [51], which include 117 fungus species, 11 lichens, 80 mosses, and 657 species of vascular plants [52]. There are 19 rare and endangered plant species among the overall number, such as Northern white straw (*Galium boreale*), Holly (*Ilex aquifolium*), Cardamine (*Cardamine bulbifera*), Telekia (*Telekia speciosa*), and wild cyclamen (*Cyclamen purpurascens*). [51]. Even though detailed research on the fauna has not yet been conducted, we know that the NP Kozara is home to many autochthonous animal species, as well as many species that pass through it and stay for a short time. Roe deer (*Capreolus capreolus*), wild boar (*Sus scrofa*), wolf (*Canis lupus*), fox (*Canis vulpes*), badger (*Meles meles*) [51], and other autochthonous animal species may also be found in the park. Kozara also homes native bird species such as owls (*Strigidae*), magpies (*Pica pica*), finches (*Fringilla coelebs*), crested tits (*Parus cristatus*), and nightingales (*Luscinia luscinia*) [51].

In order to reach NP Kozara, visitors need to follow the main Banja Luka–Prijedor road, and then for the last 12 kilometers, the winding asphalt road will take them to the central parking on the Mrakovica plateau. The Mrakovica plateau, which sits at an elevation of 806 meters above sea level and dominates the center region of NP Kozara, is where many park visitors gather and where, as a result of its urban characteristics, cultural manifestations are frequently held. Every year, Kozara National Park's great biodiversity and ecological worth draw a large number of visitors, who may very well impact particular ecosystems [52].

3.2. Research Methodology. In all countries, environmental protection is becoming increasingly important. Bosnia and Herzegovina recognises this through undertaking the first steps of environmental protection. To preserve protected areas of nature, it is vital to reduce pollution and use environmentally friendly means of transportation. EVs have become the best alternative, and it is essential to adopt as many of them as possible for tourist and business transport. As a result, Kozara National Park initiated a campaign to deploy EVs for visitors and business transport in order to protect the NP`s environment. This research was conducted in collaboration with NP Kozara employees. The research methodology is presented in Figure 2.

The research was conducted in such a way that NP Kozara initially identified five of its employees as practice experts who dealt with this problem. These employees took part in group decision-making. The selection of the criteria came first. To prevent certain personal preferences of workers while selecting a vehicle, the technical parameters of the EVs were used to minimize subjectivity. Out of a total of 15 criteria that were initially identified as potential use cases, seven criteria, in the viewpoint of the employees, were chosen as the most crucial for the deployment of EVs at Kozara NP (Table 2). These criteria outline the fundamental criteria for EVs to meet the needs of NP Kozara.

The first criterion that was considered crucial is the EV range. The EV's range should be as long as possible in order to cover as many kilometers with a single battery charge. The range, however, varies depending on the temperature fluctuations [25]. Therefore, the range that a single vehicle can cover with a single battery charge is measured at both its maximum and minimum values. Vehicle cost is another significant criterion. The cost price of individual vehicle models was used to calculate the vehicle cost [31]. The cost of a vehicle varies depending on its size and equipment, and the values of two versions of the same EV are taken here as it is essential to keep expenses as low as possible in order to obtain a high-quality EV at the lowest possible cost. The following criterion is vehicle consumption or how much electricity is used for every 100 kilometers travelled. This consumption rises or decreases depending on the outside temperature and the driving mode used. According to Stopka et al. [35], the consumption rate is reduced as the temperature rises and the velocity decreases, and vice versa. To lower the cost of utilizing EVs, this consumption must be as low as feasible. As a result, the minimum and maximum consumption for each EV were calculated. Cargo volume was used as the fourth criterium. Given that each traveller has a set amount of luggage, the cargo volume of EVs is crucial for their usage [29, 30]. To be able to transport as many items as feasible with the EV, the cargo volume should be as large as possible. Because the vehicle comes in many configurations, the minimum and maximum volumes were taken. The carrying capacity is the sixth criterion. It should be as high as possible to accommodate as many passengers and belongings as necessary. When determining the carrying capacity, we must keep in mind that the weight of the battery is a challenge for all EVs, therefore the total carrying capacity varies [26]. This criterium depends on the performance of a certain EV, and the minimum and maximum carrying capacities of specific EVs were defined. The final two criteria address battery charging using home chargers and charging stations. Because no charging station has yet been established in NP Kozara, how long it takes to charge an EV using home chargers is of key importance. This charging cycle should be made as short as possible in order for the vehicles to be used. The charging time is also affected by the charger and its voltage [23], so as a result, charging using 220 v and 400 v chargers is taken into account here. Fast charging time makes up the final criterion. Charging stations are used for fast charging [26] and the installation of such stations is required for both the NP Kozara's vehicles and the private

Figure 1: Geographical position of NP Kozara.

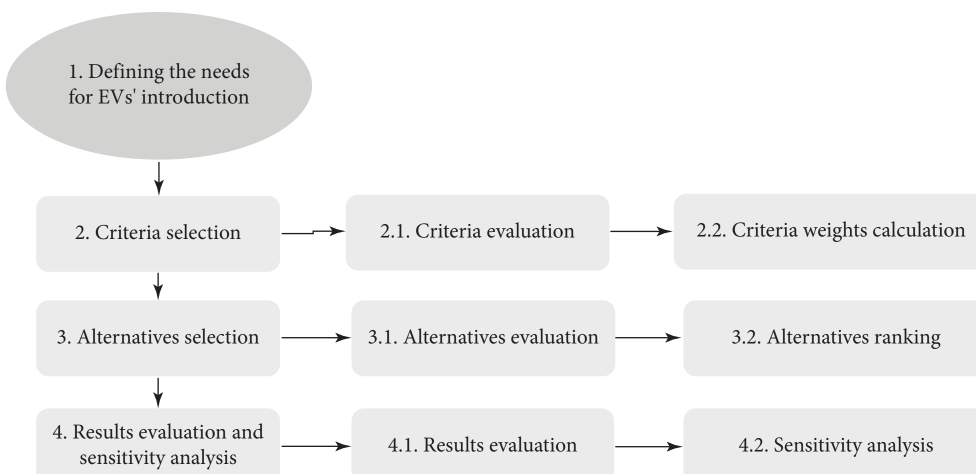

Figure 2: EV selection methodology for NP Kozara's needs.

visitors' vehicles. Due to the differing voltages of these charging stations, 50 kw and 100 kw, charging rates at these voltages were taken into account.

Once the criteria were defined, their relevance in the selection of EV had to be decided as the weight of the criterion defined as the significance of the individual criteria. The expert employees evaluated the criteria using linguistic values, comparing the significance of the criteria to the first and last criterion. They evaluated the importance of individual criteria regarding the first criterion, and then in relation to the last criterion. The value scale was used to calculate these parameters (Table 3). The value scale is determined for values when a specific criterion is more important than the first or final criterion (scale of 1-2) and when this criterion is less significant than the first and last criteria (scale of 0-1). The expert employees then decided the degree of certainty in their judgment after considering the value of the criteria and the level of certainty is assessed using a five-point scale ranging from very small (VS) to very high (VH). Using these scales, the *Z*-PIPRECIA method will be used to calculate the weight of the criteria.

The selection of alternatives, i.e., EVs, was initiated after the criteria were decided upon by the employees. Alternatives were chosen based on their capacity to transport a number of visitors and their cargo volume for transporting goods. The small van type of EVs, which have a minimum passenger capacity of 8, was used for this reason. Moreover, the availability of these vehicles on the Bosnia and Herzegovina`s market as well as the availability of authorized services for them was taken into consideration. This way, 13 alternatives were selected by the employees of NP Kozara, namely, Opel Vivaro-e M50 ($A1$), Citroen e-Jumpy ($A2$),

Table 2: Criteria for EV selection.

ID	Criterion	Unit	Reference	Criterion type
$C1$	Range	km	Biswas and Das [18]; Ziemba [25]; Ecer [26]; Ziemba [29, 30]; Hamurcu and Eren [31]; Stopka et al. [35]	Benefit
$C2$	Vehicle cost	Euro	Biswas and Das [18]; Ziemba [25]; Ecer [26]; Ziemba [29, 30]; Hamurcu and Eren [31]; Stopka et al. [35]	Cost
$C3$	Vehicle consumption	wh/km	Ziemba [25]; Ecer [26]; Ziemba [29, 30]; Hamurcu and Eren [31]; Stopka et al. [35]	Cost
$C4$	Cargo volume	l	Büyüközkan and Uztürk [22]; Ziemba [25]; Ziemba [29, 30]; Stopka et al. [35]	Benefit
$C5$	Max. Payload	kg	Ecer [26]; Kim and Cha [53]; Iwańkowicz [54]; Sagaria et al. [55]	Benefit
$C6$	Charge time	min	Hamurcu and Eren, [23]; Ziemba [25]; Ecer [26]; Ziemba [29, 30]; Hamurcu and Eren [31]	Cost
$C7$	Fast charge time	min	Loganathan, et al. [20]; Ziemba [25]; Ecer [26]; Ziemba [29, 30]; Hamurcu and Eren [31]	Cost

Table 3: Value scale.

Linguistic scale	Scale	l	m	u	DFV
Almost equal value (AEV)	Scale 1-2	1.000	1.000	1.050	1.008
Slightly more significant (SMS)		1.100	1.150	1.200	1.150
Moderately more significant (MMS)		1.200	1.300	1.350	1.292
More significant (MS)		1.300	1.450	1.500	1.433
Much more significant (MSI)		1.400	1.600	1.650	1.575
Dominantly more significant (DMS)		1.500	1.750	1.800	1.717
Absolutely more significant (AMS)		1.600	1.900	1.950	1.858
Neutral (NO)		1.000	1.000	1.000	1.000
Weakly less significant (WLS)	Scale 0-1	0.667	1.000	1.000	0.944
Moderately less significant (MLS)		0.500	0.667	1.000	0.694
Less significant (LS)		0.400	0.500	0.667	0.511
Really less significant (RLS)		0.333	0.400	0.500	0.406
Much less significant (MSI)		0.286	0.333	0.400	0.337
Dominantly less significant (DLS)		0.250	0.286	0.333	0.288
Absolutely less significant (ALS)		0.222	0.250	0.286	0.251

Peugeot e-Expert ($A3$), Toyota PROACE Shuttle ($A4$), Fiat E-Ulysse 50 kWh ($A5$), Mercedes eVito Tourer 60 kWh ($A6$), Opel Vivaro-e M75 ($A7$), Peugeot e-Traveller ($A8$), Toyota PROACE Shuttle M ($A9$), Citroen e-Space Tourer ($A10$), Fiat E-Ulysse 75 kWh ($A11$), Mercedes eVito Tourer 90 kWh ($A12$), and Mercedes EQV 300 ($A13$). The values assigned to these alternatives were determined by their technical characteristics in accordance with the observed criteria (Table 4). These values are presented in the form of intervals, and a rough set was used to rank these alternatives and select the one that best meets NP Kozar's needs. To rank the alternatives, the CRADIS method will be applied.

After determining the weights and ranking of the alternatives, the results are evaluated in such a way that the ranking of the alternatives is tested using 5 other methods. These methods are Rough SAW (simple additive weighting), Rough ARAS (additive ratio assessment), Rough MABAC (multiattributive border approximation area comparison), Rough MARCOS (measurement of alternatives and ranking according to the compromise solution) and Rough TOPSIS (technique for order performance by similarity to ideal solution). The aim of the evaluation of the results is to compare the results obtained with different methods in order to confirm the results obtained with the rough CRADIS method as each of the methods has its own specifics by which it ranks the alternatives. The Rough SAW method determines the ranking based on the value of the weighted normalized decision matrix [53]. The Rough ARAS method ranks alternatives based on the degree of usefulness in relation to the optimal alternative and Rough MABAC ranks the alternatives based on the average value of the alternatives. Rough MARCOS ranks alternatives using a utility function in relation to ideal and anti-ideal solutions and Rough TOPSIS ranks alternatives in relation to ideal and "anti-ideal" solutions. Therefore, it is important to evaluate how these method's characteristics influence the alternatives' ranking and determine whether this ranking differs significantly from the offered CRADIS method ranking.

The research results will be followed by a sensitivity analysis with the main objective to determine how much each criterion affects the final ranking of the alternatives. The weights of the alternatives are altered based on the scenarios, the ranking of the alternatives is established, and how sensitive the alternatives are to particular criteria will be shown by the sensitivity analysis's results.

3.3. Z-PIPRECIA Method. Z-numbers represent an extension of the fuzzy number when there is uncertainty in the decision-making. When compared to fuzzy numbers, Z-numbers have the benefit of using uncertain information [56]. When decision-making includes uncertainty, Z-numbers may be applied in all MCDA approaches.

Table 4: Alternatives' values.

ID	Range (km)		Vehicle cost (€)		Vehicle consumption (wh/km)		Cargo volume (l)		Max. Payload (kg)		Charge (kw)		Fast charge (kw)	
	Min	Max	From	To	Min	Max	From	To	From	To	400 v	220 v	100 k	50 k
$A1$	125	270	50992	51825	167	360	507	912	1051	1056	300	435	26	41
$A2$	125	270	50190	50980	167	360	507	912	1116	1121	300	435	26	41
$A3$	125	265	50190	50980	170	360	603	989	1094	1108	300	435	26	41
$A4$	120	260	49695	50895	173	375	550	980	1003	1035	300	435	26	41
$A5$	125	270	55990	56990	167	360	450	800	1006	1011	300	435	27	50
$A6$	145	310	60678	61571	194	414	990	1390	716	741	390	585	31	59
$A7$	185	395	56942	57775	172	368	507	912	1008	1035	450	660	38	61
$A8$	185	395	69160	69950	172	368	603	989	1014	1044	450	660	38	61
$A9$	180	385	64530	65385	177	378	603	989	1008	1035	450	660	38	61
$A10$	185	390	57890	58680	174	368	507	912	1008	1035	450	660	38	61
$A11$	185	395	61990	62990	172	368	450	800	973	995	450	660	38	61
$A12$	215	450	64248	65140	200	419	990	1390	1020	1045	585	870	41	80
$A13$	215	445	71388	72281	202	419	1030	1410	915	940	585	870	41	80

Z-number represents an ordered pair of fuzzy numbers $Z=(A, B)$, where A is a fuzzy number that represents the limitation of the variable X, while B is a fuzzy number that represents the reliability of the fuzzy number A [57]. In general, Z-numbers could be presented as $\widetilde{Z} = \{(a_1, a_2, a_3; w_A), (b_1, b_2, b_3; w_B)\}$. The transformation of the Z-number into a classical fuzzy number is performed by applying the following steps [58]:

Step 1. Converting a B fuzzy number to a crisp number,

$$\alpha = \frac{a_1 + a_2 + a_3}{3}. \tag{1}$$

Step 2. Adding the weight of B fuzzy number to A fuzzy number,

$$\widetilde{Z}^{\alpha} = \left\{\langle x, \mu_{A^{\alpha}}(x)\rangle \middle| \mu_{A^{\alpha}}(x) = \alpha\mu_A(x)\right\}. \tag{2}$$

Step 3. Converting the Z-number weights to an ordinary fuzzy number,

$$\begin{aligned} \widetilde{Z}' &= \left\{\langle x, \mu_{Z'}(x)\rangle \middle| \mu_{Z'}(x) = \mu_A\left(\frac{x}{\sqrt{\alpha}}\right)\right\}, \\ \widetilde{Z}' &= \sqrt{a} \bullet \widetilde{A} = \left(\sqrt{a} \bullet a_1, \sqrt{a} \bullet a_2. \right. \end{aligned} \tag{3}$$

By using these steps, the Z-number will be converted into an ordinary fuzzy number and the other operations will be performed as with ordinary fuzzy numbers.

The PIPRECIA method was developed by Stanujkić et al. [59]. This method enables the ability to evaluate criteria without first ranking them in terms of importance; instead, the value is compared to the first and final criteria. The fuzzy PIPRECIA method is applied as follows:

Step 1. Forming a set of criteria for comparison.

Step 2. Decision makers initially evaluate the criteria by comparing them to the first criterion and determining the relevance of those other criteria in relation to the first criterion. They next compare the other criteria to the last criterion and determine their relevance in relation to the last criterion. The value scale shown in Table 3 is used on this occasion as follows:

$$\overline{s_j^r} = \begin{cases} >\overline{1} \text{ if } C_j > C_{j-1}, \\ =\overline{1} \text{ if } C_j = C_{j-1}, \\ <\overline{1} \text{ if } C_j < C_{j-1}, \end{cases} \tag{4}$$

where $\overline{s_j^r}$ represents the evaluation of the criteria by the r-th decision maker.

In order to generate matrix $\overline{s_j^r}$, it is necessary to calculate the average matrix $\overline{s_j^r}$ using the geometric mean.

Step 3. Determining the coefficient $\overline{k_j}$.

$$\overline{k_j} = \begin{cases} =1 \text{ if } j = 1, \\ 2 - \overline{s_j} \text{ if } j > 1, \end{cases} \tag{5}$$

Step 4. Determining the fuzzy weight $\overline{q_j}$.

$$\overline{q_j} = \begin{cases} =\overline{1} \text{ if } j = 1, \\ \dfrac{\overline{q_{j-1}}}{\overline{k_j}} \text{ if } j > 1. \end{cases} \tag{6}$$

Step 5. Determining the relative weight of the criterion $\overline{w_j}$.

$$\overline{w_j} = \frac{\overline{q_j}}{\sum_{j=1}^{n} \overline{q_j}}. \tag{7}$$

This method is used for both grading regarding the first criterion and grading in relation to the last criterion. The final weight of the criteria is calculated by averaging the weights determined with respect to the first and last criteria.

3.4. Rough CRADIS Method. The CRADIS method was developed by Puška et al. [60], whereas the Rough CRADIS method was developed by Dordevic et al. [61]. The CRADIS method calculates the deviation of the alternatives from the ideal and anti-ideal alternatives, as well as the deviation of the alternatives from the optimal alternative. The steps of the Rough CRADIS approach are as follows:

Step 1. Formation of initial rough decision matrix.

$$\xi = \begin{bmatrix} \left[\xi_{11}^L.\xi_{11}^U\right] & \left[\xi_{12}^L.\xi_{12}^U\right] & \cdots & \left[\xi_{1n}^L.\xi_{1n}^U\right] \\ \left[\xi_{21}^L.\xi_{21}^U\right] & \left[\xi_{22}^L.\xi_{22}^U\right] & \cdots & \left[\xi_{2n}^L.\xi_{2n}^U\right] \\ \vdots & \vdots & \ddots & \vdots \\ \left[\xi_{m1}^L.\xi_{m1}^U\right] & \left[\xi_{m2}^L.\xi_{m2}^U\right] & \cdots & \left[\xi_{mn}^L.\xi_{mn}^U\right] \end{bmatrix}. \tag{8}$$

Step 2. Normalization of the initial rough decision matrix.

$$\begin{aligned} \varsigma_{ij} &= \frac{\xi_{ij}}{\max \xi_{ij}} = \left[\frac{\xi_{ij}^L}{\max \xi_{ij}^U}.\frac{\xi_{ij}^U}{\max \xi_{ij}^L}\right].\ j \in B, \\ \varsigma_{ij} &= \frac{\min \xi_{ij}}{\xi_{ij}} = \left[\frac{\min \xi_{ij}^L}{\xi_{ij}^U}.\frac{\min \xi_{ij}^U}{\xi_{ij}^L}\right].\ j \in C. \end{aligned} \tag{9}$$

Step 3. Weighting of normalized decision matrix.

$$v_{ij} = \varsigma_{ij} \times w_j = \left[\varsigma_{ij}^L \times w_j^L.\varsigma_{ij}^U \times w_j^U\right]. \tag{10}$$

Step 4. Identification of ideal τ_{id} (highest value) and anti-ideal solutions τ_{aid} (lowest value).

$$\begin{aligned} \tau_{\text{id}} &= \left[\tau_{\text{id}}^L.\tau_{\text{id}}^U\right] = \max v_{ij}, \\ \tau_{\text{aid}} &= \left[\tau_{\text{aid}}^L.\tau_{\text{aid}}^U\right] = \min v_{ij.} \end{aligned} \tag{11}$$

Step 5. Calculation of ideal and anti-ideal solutions' deviations.

$$\delta_{ij}^{+} = \left[\delta_{ij}^{+L}.\delta_{ij}^{+U}\right]_{\text{mxn}} = \tau_{id} - \upsilon_{ij} = \left[\tau_{id}^{L} - \nu_{ij}^{U}.\tau_{id}^{U} - \nu_{ij}^{L}.\right],$$
$$\delta_{ij}^{-} = \left[\delta_{ij}^{-L}.\delta_{ij}^{-U}\right]_{\text{mxn}} = \upsilon_{ij} - \tau_{\text{aid}} = \left[\nu_{ij}^{L} - \tau_{\text{aid}}^{U}.\nu_{ij}^{U} - \tau_{\text{aid}}^{L}\right]. \quad (12)$$

Step 6. Calculation of individual alternatives' deviations from ideal and anti-ideal solutions.

$$\vartheta_i^{+} = \left[\vartheta_i^{+L}.\vartheta_i^{+U}\right]_{1xm} = \sum_{j=1}^{n} \delta_{ij}^{+},$$
$$\vartheta_i^{-} = \left[\vartheta_i^{-L}.\vartheta_i^{-U}\right]_{1xm} = \sum_{j=1}^{n} \delta_{ij}^{-}. \quad (13)$$

Step 7. The utility function calculation in relation to deviations from optimal alternatives.

$$\varrho_i^{+} = \left[\varrho_i^{+L}.\varrho_i^{+U}\right]_{1xm} = \left[\frac{\vartheta_0^{+}}{\vartheta_i^{+}}\right] = \left[\frac{\vartheta_0^{+L}}{\vartheta_i^{+U}}.\frac{\vartheta_0^{+U}}{\vartheta_i^{+L}}\right], \quad (14)$$

where $\vartheta_0^{+} = \min \vartheta_i^{+}$.

$$\varrho_i^{-} = \left[\varrho_i^{-L}.\varrho_i^{-U}\right]_{1xm} = \left[\frac{\vartheta_i^{-}}{\vartheta_0^{-}}\right] = \left[\frac{\vartheta_0^{-L}}{\vartheta_i^{-U}}.\frac{\vartheta_0^{-U}}{\vartheta_i^{-L}}.\right], \quad (15)$$

where $\vartheta_0^{-} = \min \vartheta_i^{-}$.

Step 8. Calculation of the values of the CRADIS method.

$$\chi_i = \left[\chi_i^{L}.\chi_i^{U}\right]_{1xm} = \left[\frac{\varrho_i^{+} + \varrho_i^{-}}{2}\right] = \left[\frac{\varrho_i^{+L} + \varrho_i^{-L}}{2}.\frac{\varrho_i^{+U} + \varrho_i^{-U}}{2}\right]. \quad (16)$$

Highest value represents the highest ranked alternative.

4. Results

In order to determine which EV best meets the objectives of NP Kozara, EVs were ranked based on their technical characteristics and using selected criteria. These criteria were evaluated by expert employees of NP Kozara in such a way that they assessed which criteria were more and which were less important. They based their evaluations in accordance with the scale (Table 3). Firstly, criterion $C1$ was given a neutral value (NO), and the other criteria were given a value in relation to this first criterion, as well as the values for other criteria. At the same time, they expressed their level of confidence in their assessment. Uncertainty was included in decision-making in this manner. Following that, they gave the last criterion a neutral rating, while the other criteria were rated in relation to criterion $C7$. In this case, uncertainty is included (Table 5). The Z-PIPRECIA method's steps are then carried out. To begin, the linguistic values are transformed into fuzzy numbers, with A representing fuzzy number A and B representing fuzzy number B. To accomplish this, linguistic values must be transformed into fuzzy numbers through the membership function (Table 3 and Table 6).

The fuzzy number B is defuzzified once the linguistic values are transformed into fuzzy numbers A and B. The number is then rooted and that value is multiplied by the value of the fuzzy number A [55]. The average value of the fuzzy number A was calculated to account for each employee's opinion when determining the weight of the criteria. The initial decision matrix for the fuzzy PIPRECIA method is thus formed in this manner.

When multiplying the fuzzy number A by the value of number B, a table is generated for calculating the PIPRECIA method. Initially, the value s_j is computed, representing the starting point for calculating the criteria weights. This value is then subtracted from two (2) to derive the value k_j. The value q_j is obtained by reusing the value of k_j, for the first criterion. For criterion $C2$, q_j is calculated by dividing the previous criterion's ($C1$) q_j value by its corresponding k_j value. Similarly, this process is applied to all criteria to obtain q_j values, which are subsequently summed up. The weight value w_j is determined by dividing the individual q_j values by the total sum of these values. This same procedure is also conducted in reverse for the second part of Table 7. Here, criterion $C7$ serves as the primary criterion, and the remaining criteria are calculated based on it.

Weight values for individual criteria were obtained by transforming fuzzy numbers into crisp numbers using the defuzzification process (Table 8). According to NP Kozara employee opinion, the most important criterion for selecting an EV is range ($C1$), followed by vehicle cost ($C2$), while the fast charge time ($C7$) criterion has the least importance. These results indicate that, in this case, it is of key importance that the vehicle can travel as many kilometers on a single charge as possible while also being as inexpensive as possible. In terms of charging, the employees believe that vehicles will be charged overnight while visitors are not visiting NP Kozara, thus these criteria are not of great importance.

After determining the weights of the criteria, the alternatives are ranked using the Rough CRADIS method. After determining the weights of the criteria, the alternatives are ranked using the Rough CRADIS method. The rough CRADIS method begins with the creation of a rough decision matrix (Table 4). The rough decision matrix is then normalized as the following step (Table 9). When performing normalization, the type of criteria, whether benefit or cost, must be taken into account.

Furthermore, the normalized rough decision matrix is weighted. In this step, the elements of the normalized rough decision matrix are multiplied by the appropriate weights. The next step is to determine the ideal and anti-ideal solutions. This involves selecting the ideal value, which corresponds to the maximum value among all alternatives based on all criteria, and the anti-ideal value, which represents the minimum value among alternatives when considering all criteria (expressions 13 and 14). Following this, the deviation from these solutions is calculated by subtracting the values of the weighted normalized decision matrix from the maximum value, i.e., the anti-ideal solution subtracted from the weighted normalized decision matrix (expressions 15 and 16). Subsequently, values are computed, optimal alternatives

Table 5: Criteria's importance evaluation.

DM	C1		C2		C3		C4		C5		C6		C7	
	A	*B*	*A*	*B*	*A*	*A*	*A*	*B*	*B*	*B*	*A*	*B*	*A*	*B*
DM1	NO	VH	WLS	VH	AVE	VH	MSI	VH	MMS	VH	SMS	VH	MS	VH
DM2	NO	H	MLS	H	WLS	VH	MMS	H	AVE	H	SMS	H	MS	H
DM3	NO	VH	AVE	VH	SMS	VH	MSI	VH	MMS	VH	MS	VH	DMS	VH
DM4	NO	H	WLS	H	AVE	H	MS	H	MSI	H	SMS	H	DMS	H
DM5	NO	M	LS	VH	RLS	VH	SMS	H	WLS	H	NO	H	AVE	H
	C7		C6		C5		C4		C3		C2		C1	
DM1	NO	VH	MLS	VH	WLS	VH	AVE	VH	LS	VH	MSI	VH	RLS	VH
DM2	NO	H	MLS	H	LS	H	WLS	H	MSI	VH	DLS	H	RLS	H
DM3	NO	VH	MLS	VH	LS	VH	WLS	VH	RLS	VH	MSI	VH	DLS	VH
DM4	NO	H	MLS	H	SMS	H	AVE	H	MLS	H	RLS	H	LS	H
DM5	NO	H	WLS	H	MLS	H	AVE	H	MSI	VH	RLS	VH	WLS	M

Table 6: Fuzzy number *B* membership function.

Linguistic value	Fuzzy number
Very small (VS)	0, 0, 0.2
Small (S)	0.1, 0.25, 0.4
Medium (M)	0.3, 0.5, 0.7
High (H)	0.55, 0.75, 0.95
Very high (VH)	0.8, 1, 1

Table 7: Calculation of the Z-PIPRECIA method.

	s_j			k_j			q_j			w_j		
*C*1	0.869	0.869	0.869	1.131	1.131	1.131	1.131	1.131	1.131	0.279	0.227	0.196
*C*2	0.884	1.002	1.038	1.116	0.998	0.962	1.014	1.134	1.176	0.250	0.228	0.204
*C*3	0.737	0.939	1.035	1.263	1.061	0.965	0.803	1.068	1.219	0.198	0.215	0.212
*C*4	0.319	0.390	0.503	1.681	1.610	1.497	0.478	0.663	0.815	0.118	0.133	0.141
*C*5	0.450	0.550	0.647	1.550	1.450	1.353	0.308	0.458	0.602	0.076	0.092	0.105
*C*6	0.479	0.591	0.788	1.521	1.409	1.212	0.203	0.325	0.497	0.050	0.065	0.086
*C*7	0.309	0.380	0.442	1.691	1.620	1.558	0.120	0.200	0.319	0.030	0.040	0.055
							4.057	4.980	5.759			
*C*1	1.130	1.237	1.283	0.870	0.763	0.717	1.179	2.838	4.115	0.194	0.293	0.330
*C*2	1.274	1.448	1.478	0.726	0.552	0.522	1.026	2.164	2.949	0.169	0.223	0.237
*C*3	1.205	1.332	1.379	0.795	0.668	0.621	0.744	1.194	1.540	0.122	0.123	0.124
*C*4	0.710	0.905	0.923	1.290	1.095	1.077	0.592	0.798	0.956	0.097	0.082	0.077
*C*5	0.864	0.953	1.068	1.136	1.047	0.932	0.764	0.874	1.030	0.126	0.090	0.083
*C*6	0.958	1.012	1.057	1.042	0.988	0.943	0.868	0.916	0.960	0.143	0.094	0.077
*C*7	0.905	0.905	0.905	1.095	1.095	1.095	0.905	0.905	0.905	0.149	0.093	0.073
							6.079	9.690	12.454			

Table 8: Criteria weight values.

Criteria	Fuzzy number			*w*
Range (*C*1)	0.236	0.260	0.263	0.257
Vehicle cost (*C*2)	0.209	0.226	0.221	0.222
Vehicle consumption (*C*3)	0.160	0.169	0.168	0.167
Cargo volume (*C*4)	0.108	0.108	0.109	0.108
Max. payload (*C*5)	0.101	0.091	0.094	0.093
Charge time (*C*6)	0.096	0.080	0.082	0.083
Fast charge time (*C*7)	0.089	0.067	0.064	0.070

are determined, and these derived values are summed for all alternatives, including the optimal ones (expressions 17 and 18). This leads to the calculation of the utility function (expressions 19 and 20), and the average values of these functions are subsequently computed (Table 10).

The final results of the Rough CRADIS method are obtained by calculating the average value of the rough numbers (Table 11). The results revealed that alternative *A*12-Mercedes eVito Tourer, a 90 kWh model, best satisfies the specific objectives of the research, while alternative *A*6-Mercedes eVito Tourer 60 kWh received the lowest ranking. In order to validate these results, they will be examined using other rough methods.

In order to minimize the impact of data normalization on the ranking order, the same normalization process was used in all methods. This is because the original form of the MABAC, ARAS, and TOPSIS methods has a different

Table 9: Normalized rough decision matrix.

	$C1$	$C2$	$C3$	$C4$	$C5$	$C6$	$C7$
$A1$	[0.28 1.26]	[0.96 1.00]	[0.46 2.16]	[0.36 0.89]	[0.94 0.95]	[0.69 1.45]	[0.63 1.58]
$A2$	[0.28 1.26]	[0.97 1.01]	[0.46 2.16]	[0.36 0.89]	[1.00 1.00]	[0.69 1.45]	[0.63 1.58]
$A3$	[0.28 1.23]	[0.97 1.01]	[0.46 2.12]	[0.43 0.96]	[0.98 0.99]	[0.69 1.45]	[0.63 1.58]
$A4$	[0.27 1.21]	[0.98 1.02]	[0.45 2.08]	[0.39 0.95]	[0.89 0.93]	[0.69 1.45]	[0.63 1.58]
$A5$	[0.28 1.26]	[0.87 0.91]	[0.46 2.12]	[0.32 0.78]	[0.90 0.91]	[0.69 1.45]	[0.52 1.52]
$A6$	[0.32 1.44]	[0.81 0.84]	[0.40 1.86]	[0.70 1.35]	[0.64 0.66]	[0.51 1.12]	[0.44 1.32]
$A7$	[0.41 1.84]	[0.86 0.89]	[0.45 2.09]	[0.36 0.89]	[0.90 0.93]	[0.45 0.97]	[0.43 1.08]
$A8$	[0.41 1.84]	[0.71 0.74]	[0.45 2.09]	[0.43 0.96]	[0.90 0.94]	[0.45 0.97]	[0.43 1.08]
$A9$	[0.40 1.79]	[0.76 0.79]	[0.44 2.03]	[0.43 0.96]	[0.90 0.93]	[0.45 0.97]	[0.43 1.08]
$A10$	[0.41 1.81]	[0.85 0.88]	[0.45 2.07]	[0.36 0.89]	[0.90 0.93]	[0.45 0.97]	[0.43 1.08]
$A11$	[0.41 1.84]	[0.79 0.82]	[0.45 2.09]	[0.32 0.78]	[0.87 0.89]	[0.45 0.97]	[0.43 1.08]
$A12$	[0.48 2.09]	[0.76 0.79]	[0.40 1.80]	[0.70 1.35]	[0.91 0.94]	[0.34 0.74]	[0.33 1.00]
$A13$	[0.48 2.07]	[0.69 0.71]	[0.40 1.78]	[0.73 1.37]	[0.82 0.84]	[0.34 0.74]	[0.33 1.00]

Table 10: Ideal and anti-ideal solution and utility function.

	ϑ_i^+	ϑ_i^-	ϱ_i^+	ϱ_i^-
$A1$	[2.44 3.17]	[2.01 3.01]	[0.68 1.26]	[0.58 1.45]
$A2$	[2.43 3.16]	[2.00 3.00]	[0.68 1.26]	[0.58 1.45]
$A3$	[2.44 3.16]	[2.01 3.00]	[0.69 1.26]	[0.58 1.45]
$A4$	[2.45 3.17]	[2.02 3.01]	[0.68 1.25]	[0.57 1.44]
$A5$	[2.48 3.21]	[2.05 3.05]	[0.67 1.24]	[0.57 1.42]
$A6$	[2.50 3.22]	[2.07 3.06]	[0.67 1.23]	[0.57 1.41]
$A7$	[2.40 3.20]	[1.97 3.04]	[0.68 1.28]	[0.57 1.48]
$A8$	[2.43 3.22]	[2.00 3.06]	[0.67 1.26]	[0.57 1.46]
$A9$	[2.44 3.22]	[2.01 3.06]	[0.67 1.26]	[0.57 1.45]
$A10$	[2.42 3.20]	[1.98 3.04]	[0.68 1.27]	[0.57 1.47]
$A11$	[2.43 3.22]	[2.00 3.06]	[0.67 1.26]	[0.57 1.45]
$A12$	[2.38 3.19]	[1.95 3.03]	[0.68 1.29]	[0.57 1.49]
$A13$	[2.41 3.21]	[1.98 3.05]	[0.67 1.27]	[0.57 1.47]
$\vartheta_0^\pm$	[2.16 3.07]	[1.73 2.91]		

Table 11: Final ranking of the alternatives.

	χ_i^L	χ_i^U	χ_i	Rank
Opel Vivaro-e M50	0.63	1.35	0.99	7
Citroen e-Jumpy	0.63	1.36	0.99	5
Peugeot e-Expert	0.63	1.36	0.99	6
Toyota PROACE Shuttle	0.63	1.34	0.99	11
Fiat E-Ulysse 50 kWh	0.62	1.33	0.98	12
Mercedes eVito Tourer 60 kWh	0.62	1.32	0.97	13
Opel Vivaro-e M75	0.62	1.38	1.00	2
Peugeot e-Traveller	0.62	1.36	0.99	8
Toyota PROACE Shuttle M	0.62	1.35	0.99	10
Citroen e-Space Tourer	0.62	1.37	1.00	3
Fiat E-Ulysse 75 kWh	0.62	1.36	0.99	9
Mercedes eVito Tourer 90 kWh	0.62	1.39	1.01	1
Mercedes EQV 300	0.62	1.37	0.99	4

normalization process than the CRADIS and MARCOS methods. The validation conclusions on the results obtained by these rough techniques demonstrated that the ranking orders are almost identical, except for the ranking order obtained by the rough TOPSIS method based on Song et al.'s [62] research, which had a large deviation (Figure 3). The ranking order for alternatives $A1$ and $A10$ was different when using the rough ARAS technique, but only the rank order has been changed for these alternatives. The obtained validation results demonstrated that the rough CRADIS ranking did not differ from those of other methods, thus the ranking obtained by this method was confirmed.

Following the validation of the research results, a sensitivity analysis was carried out by developing and executing scenarios. Many recent research studies have used this form of sensitivity analysis, i.e., Durmić et al. [63], Božanić et al. [64], Aytekin [65], Jokić et al. [66], Bakir et al. [67], Alosta et al. [68], Pamučar et al. [69], Tešić et al. [70], Đukić et al. [71], and Stojanović, et al.'s [72] studies. The scenarios were designed in such a manner that the individual criterium's value decreased by 15% while the weights of the other criteria grew to compensate for the reduction of these individual criteria. As a result, 42 scenarios were developed, along with scenario $S0$, which represents the rank order of the rough CRADIS method with specified initial weights. In this manner, the extent to which a certain criterion influences the ranking of alternatives was tested. The sensitivity analysis revealed that none of the alternatives are immune to the conducted analysis (Figure 4). The sensitivity analysis results revealed that the $A12$ alternative achieved the best results with the highest number of scenarios where it was ranked first, and as such, it is the preferred option for EV in NP Kozara`s case. This alternative demonstrates how the ranking order changed noticeably when the range criterion's weight was changed. As a result, in the $S4$–$S6$ scenarios, $A12$ was ranked 12th. Thus, it was proven that this alternative would not be selected as the best if the maximum required EV range was between 300 and 400 km. Moreover, worth mentioning is the fact that among all alternatives, alternative $A7$ has the most consistent ranking. Its poorest rank was sixth, but in two of the scenarios, it was ranked first.

5. Discussion

Despite having a wealth of biodiversity and countless natural attractions, Bosnia and Herzegovina treats its environment and natural resources improperly [73]. For the benefit of future generations, the environment must be protected [74]. Since NP Kozara is also an air spa, it is important to protect the air in the area. Internal combustion engines contribute to air pollution by emitting greenhouse gasses and other harmful gasses [75]. This must be avoided, hence vehicles

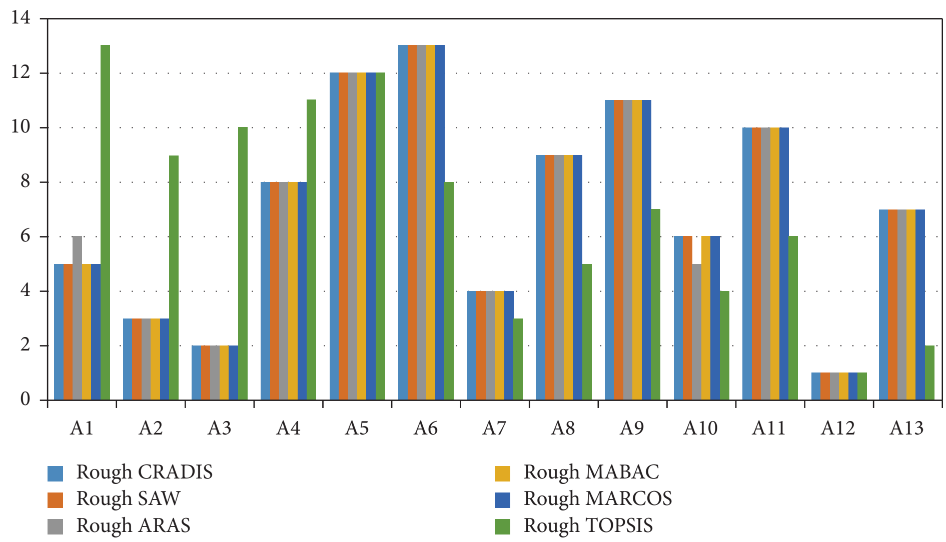

Figure 3: Validation of the results.

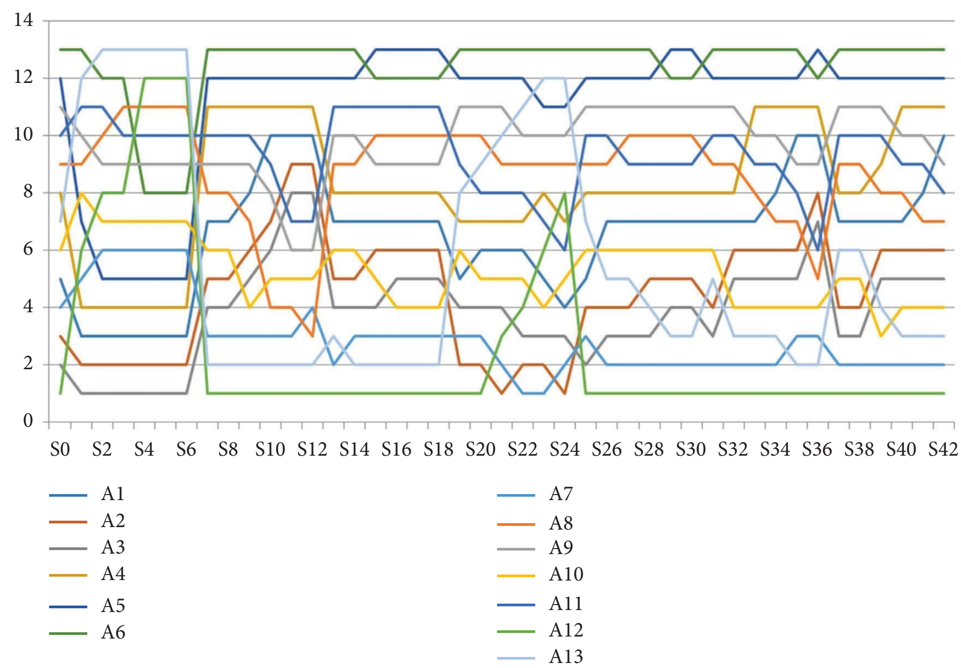

Figure 4: Sensitivity analysis results.

that are ecologically friendly, i.e., electric vehicles, hydrogen-powered vehicles, compressed air-powered vehicles, and so forth, should be used to serve visitors and NP Kozara employees.

This research aimed at determining the most appropriate EV for the needs of NP Kozara. Even though it is important to encourage the electric vehicle purchase decision in Bosnia and Herzegovina, EVs are not yet widely available in BiH, thus only about 50 EVs were imported in 2021 [36]. For selection of EV NP, Kozara appointed five expert employees in order to determine the most important criteria for this selection. They decided on 7 criteria and defined limitations for possible EV purchases. These limitations were in terms of a minimum carrying capacity of 8 people and that they are suitable for carrying cargo as well. As a consequence, only small van types of vehicles were considered and 13 alternatives that are available on Bosnia and Herzegovina`s market were examined.

To avoid absolute subjectivity in selecting an EV, the technical values of these vehicles were combined with NP Kozara employees` evaluation of the criteria. In decision-making, Z-numbers are intended to include uncertainty [56], thus Z-numbers are utilized in the combination of these subjective evaluations of the criteria. Integrating uncertainty into the decision-making process is imperative, given the inherent difficulty in achieving absolute certainty in one's decisions. This strategy fosters a more pragmatic approach to decision-making. Decision makers may be doubtful about the criterium's evaluation, whether it is accurate, or whether it should be different. It is therefore necessary to include additional evaluations that will indicate how certain one is of his/her decision [76]. Employees must first determine the significance of each criterion in relation to the first and last criterion, as well as their level of certainty. For the mutual relationship and decision-making certainty, they provided two gradings in the form of linguistic scales.

To calculate the weight of the criteria, i.e., the importance of individual criteria for decision makers, the Z-PIPRECIA method was used, that is, the classic fuzzy PIPRECIA method was extended with Z-numbers. The PIPRECIA method was used in this case because, unlike the FUCOM (full consistency method), it is not necessary to sort the criteria by importance beforehand [77]. This contrasts with the FUCOM method, where it is necessary to rank the criteria in order of importance during the first step. While employing the PIPRECIA method, employees were instructed to compare all criteria with the first criterion and the last criterion. The weight value of the criteria was then calculated by averaging these two comparisons [78]. The fact that every employee was given the same importance in decision-making must be emphasized.

The results obtained based on employees' opinions showed that the most important criterion for them is range ($C1$), followed by vehicle cost ($C2$), while the least important criterion is fast charge time ($C7$). However, with EVs, these two most important criteria are in conflict. To have a longer range, EVs need larger capacity batteries, which cost more and raise the total vehicle's price. In order to select an EV that best meets all criteria, these conflicting criteria must be balanced. Furthermore, the EV criteria values also vary, particularly when considering the range criterion. The outside temperature affects the range of electric vehicles, so when it is colder outside, their range is also shorter, and vice versa [18]. Likewise, the vehicle consumption criterion is affected by the outside temperature. Since the minimum and maximum values are provided, these criteria are set in the form of an interval. In addition, it is necessary to develop new innovative methods for energy production [79], while the focus should be on renewable energy sources to power these EVs.

Using the Rough CRADIS method, the results indicated that the EV Mercedes eVito Tourer 90 kWh ($A12$) ranked first. This was due to the fact that this vehicle has the largest battery capacity and thus the longest range, which was the most important criterion. The validation of the results, which used other rough methods, also confirmed these research results. The sensitivity analysis, however, revealed that if a lower value of the rank criterion is assigned, alternative $A12$ is not the best, but it did finish second to last in three scenarios. This analysis revealed that depending on the weight of the criteria, other alternatives can be selected as the best. Consequently, in order to choose the best alternative as objectively as possible, it is necessary to consider which criteria are used and how important they are.

6. Conclusion

Creating a sustainable transportation system based on electromobility, collective transport 2.0, and low-mobility society is not a myth, but the limitations lie in the fact that the majority of stakeholders in protected areas, such as NP Kozara, must develop a number of strategies and policies that would restrict private vehicle usage and public vehicles support to create a sustainable tourist mobility environment and to reduce the ecological footprint of tourism.

Following the grand narrative, this research offered a contribution to environmental preservation by the application of sustainable tourism through a methodological framework for selecting EVs for the needs of NP Kozara. As in the process of vehicle selection, decision makers could have their own vision on how a vehicle should feel, this research addressed the problem by taking into account technical and measurable parameters. The objectives of the research were achieved by using a hybrid MCDM model based on Z-PIPRECIA and R-CRADIS, with the goal of reduction of uncertainty in decision-making and by using the interval sets to express the alternative values needed to present EVs technical data.

The results showed that alternative $A12$, Mercedes eVito Tourer, a 90 kWh model, was the best ranked among the thirteen alternatives, owing primarily to the battery capacity, therefore this alternative's range was the greatest when compared to others. As a result of the outcomes of the analysis carried out using Z-PIPRECIA, the highest weight was given to this criterion. With the notion that the sensitivity analysis revealed that if this criterion is not the most important, then alternative $A12$ is also not the best in terms of ranking. The criteria that were used are where this study's limitations lie. However, these criteria were chosen by NP Kozara employees because they are the most important to them. In future research, other criteria should be used to see how they affect the final decision. Furthermore, the research was limited to only 13 alternatives as only those met the expert employees' set limitations. Future research must expand the number of these alternatives, especially as the number of EVs on the market grows by day. Additionally, there are limitations in terms of the number of criteria utilized in the study. For future research, it is essential to incorporate subjective evaluations from experts to assess these electric vehicles. However, in order to fully exploit the advantages of EVs in tourist transportation, future research papers should also delve into researching chargers that generate electric energy from renewable sources. This approach would serve to mitigate the adverse environmental impact, preserving nature for forthcoming generations.

This research presented a novel EV selection methodology. The methodology demonstrated great flexibility, therefore it is recommended for use in similar decision-making problems. Moreover, the obtained results demonstrated that the R-CRADIS method results do not differ from the results obtained by other methods, implying that it can be used in future research. During the validation process, it was also discovered that the rough TOPSIS method's ranking order deviates the most from the other ways utilized in this research; thus, future research could address the cause for this discrepancy and attempt to make the outcomes of this method closer to the results of other methods.

Data Availability

The data used to support the findings of this study are included in the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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