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Assessment and Contrast the Sustainable Growth of Various Road Transport Systems using Intelligent Neutrosophic Multi-Criteria Decision-Making Model

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Abstract: This study analyses the elements and approaches to creating sustainable transport systems, with a focus on road travel. The study examines the environmental and economic aspects of sustainable road transport and stresses the need to curb carbon emissions, boost energy efficiency, clean the air, ensure everyone has easy access to transport, and think about societal goals as a whole. Important considerations including environmental effect, energy efficiency, legislative frameworks, and economic impact are highlighted in the study. The MCDM model is used as a complexity instrument to strike a balance between competing objectives and criteria. This research may help stakeholders use the MCDM method to better comprehend the existing condition of transport networks and to better plan for future sustainability actions. The primary goal of this article is to analyze and contrast how various present road transport systems have progressed toward a more sustainable future. Sustainability in road transport systems is discussed, and a framework procedure is presented based on the integrated single-valued neutrosophic set and DEMATEL approach. The factor relationship was built using the DEMATEL technique. There were 14 secondary criteria employed in addition to the four primary ones.

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1. Introduction

Modern society would not function without transport networks that facilitate the free flow of people and products. However, its long-term viability has been called into question due to road transport's negative effects on the environment, society, and the economy. For a more sustainable and resilient future, it is essential to address the sustainability of road transport as the demand for mobility increases [1], [2]. Many different aspects of the environmental, social, and economic efficiency of transport networks play into the concept of "road transport sustainability." Greenhouse gas emission reduction, energy efficiency improvement, cleaner air, and more widespread availability of transport services are all goals that must be considered. Furthermore, sustainable road transport solutions take larger social objectives into account, such as reducing congestion, improving public health, and bolstering economic growth [3], [4].

The purpose of this study is to examine the elements that contribute to the long-term viability of road transport. This research aims to identify and analyses the critical components of sustainable road transport systems by reviewing relevant literature, case studies, and best practices. The results of this study will aid in the assessment and implementation of sustainable road transport projects by providing a greater knowledge of essential issues that must be addressed.

Environmental impact, energy efficiency, alternative fuels and propulsion technologies, infrastructure design and planning, intelligent transportation systems, regulatory frameworks, and stakeholder involvement are just some of the areas researchers are looking into as part of this review. Modal transitions towards more sustainable modes of transportation are encouraged, and efforts are made to reduce greenhouse gas emissions, air pollution, and noise pollution by using cleaner and more efficient cars [5], [6].

The optimization of fuel usage and the reduction of energy waste by technology developments, human behavior, and infrastructural improvements make energy efficiency a critical component of sustainable road transport. Electric cars, hydrogen, and biofuels are only a few examples of the alternative fuels that should be investigated and used.

Sustainable road transport relies heavily on well-thought-out infrastructure, which includes things like smart traffic management systems, well-connected transportation networks, and paths well-suited to non-motorized modes of travel [7], [8].

The speed and trajectory of sustainable road transport are shaped by policy frameworks such as rules, incentives, and pricing systems. Sustainable practices and technology are promoted through effective policies, while polluting ones are discouraged. Sustainable road transport requires stakeholder involvement and public participation to ensure that communities' varying requirements and points of view are taken into account throughout the decision-making process[9], [10].

This research article seeks to give a holistic picture of the variables and methods that contribute to road transport sustainability by critically analyzing and synthesizing the current literature and case studies. The results will be helpful for anyone engaged in sustainable road transport projects, including politicians, transport planners, industry stakeholders, and academics. additional, the highlighted literature gaps and problems will lead future research paths and pave the way for additional improvements in sustainable road transport practices and policy. This paper used the DEMATEL method with the single valued neutrosophic set to evaluate and analysis factors of road transport sustainability [11], [12]. In final, environmental, social, and economic considerations must all be taken into account if we are to achieve sustainable vehicle transport. This study intends to add to the current body of knowledge by reviewing all the relevant aspects and approaches to sustainable road transport. The results of this research will aid in the formulation of well-informed decisions, the advancement of sustainable development, and the strengthening of the road transport system's capacity for sustainability and resilience.

2. Background

To ensure long-term viability and resilience, transport systems must be designed, operated, and managed in a sustainable way that reduces adverse effects on the environment, society, and economy. To guarantee that the transportation sector contributes to larger sustainability objectives, it is necessary to implement sustainable practices, technology, and regulations [13], [14]. Some of the contributing factors to sustainable transportation are:

Transport systems that are both efficient and kind to the environment need infrastructure that has been carefully planned and developed. Pedestrians, bicyclists, public transportation users, and truckers must all be taken into account. To maximize the efficiency of existing infrastructure, it is important to create and execute strategies such as universal design, barrier-free access, compact and mixed-use urban planning, and intelligent transportation systems [15], [16].

To ensure that everyone has access to resources like education, work, healthcare, and housing, sustainable transport projects attempt to make such services universally available. Social mobility for marginalized groups is prioritized and more accessible public transportation is created, all via this consideration. Strategies include including communities in transport planning and decision-making processes, adopting inexpensive and accessible transport choices, and improving public transportation networks.

Keeping transport systems viable economically is one of the main goals of sustainable transport, along with reducing costs and increasing efficiencies. Sustainable business models and finance methods must be promoted, as well as allocation optimization and infrastructure lifespan cost consideration. To finance sustainable transport initiatives, many strategies have been developed, such as value capture systems, public-private partnerships, and creative financing techniques [17], [18]. Promoting eco-friendlier travel habits is essential for maintaining a sustainable transportation system. In this respect, it is important to encourage people to ditch their cars in favor of eco-friendlier transportation options by spreading information about them and offering financial incentives to do so. Sustainable transport solutions and their advantages may be promoted via public education campaigns, financial incentives, and the dissemination of relevant information [19], [20]. Sustainability in transport can only be driven by strong governance and policy frameworks. Creating and enforcing rules, norms, and incentives for environmentally responsible transportation is a key part of this element. Methods include establishing emission regulations, introducing congestion pricing, incentivizing the use of low-carbon modes of transportation monetarily, and incorporating sustainability into transportation planning and decision-making [21], [22]. The sustainability of transport systems may be improved by taking them into account and incorporating them into their operations. Governments, transportation providers, corporations, communities, and people are just some of the groups that need to work together to make sustainable transportation a reality [23], [24].

3. Neutrosophic Model

To find an answer to the issue of evaluating road transport sustainability, the DEMATEL approach may be used to quantify the levels and interactions between different components. To create a direct connection matrix, the formal DEMATEL technique relies on expert

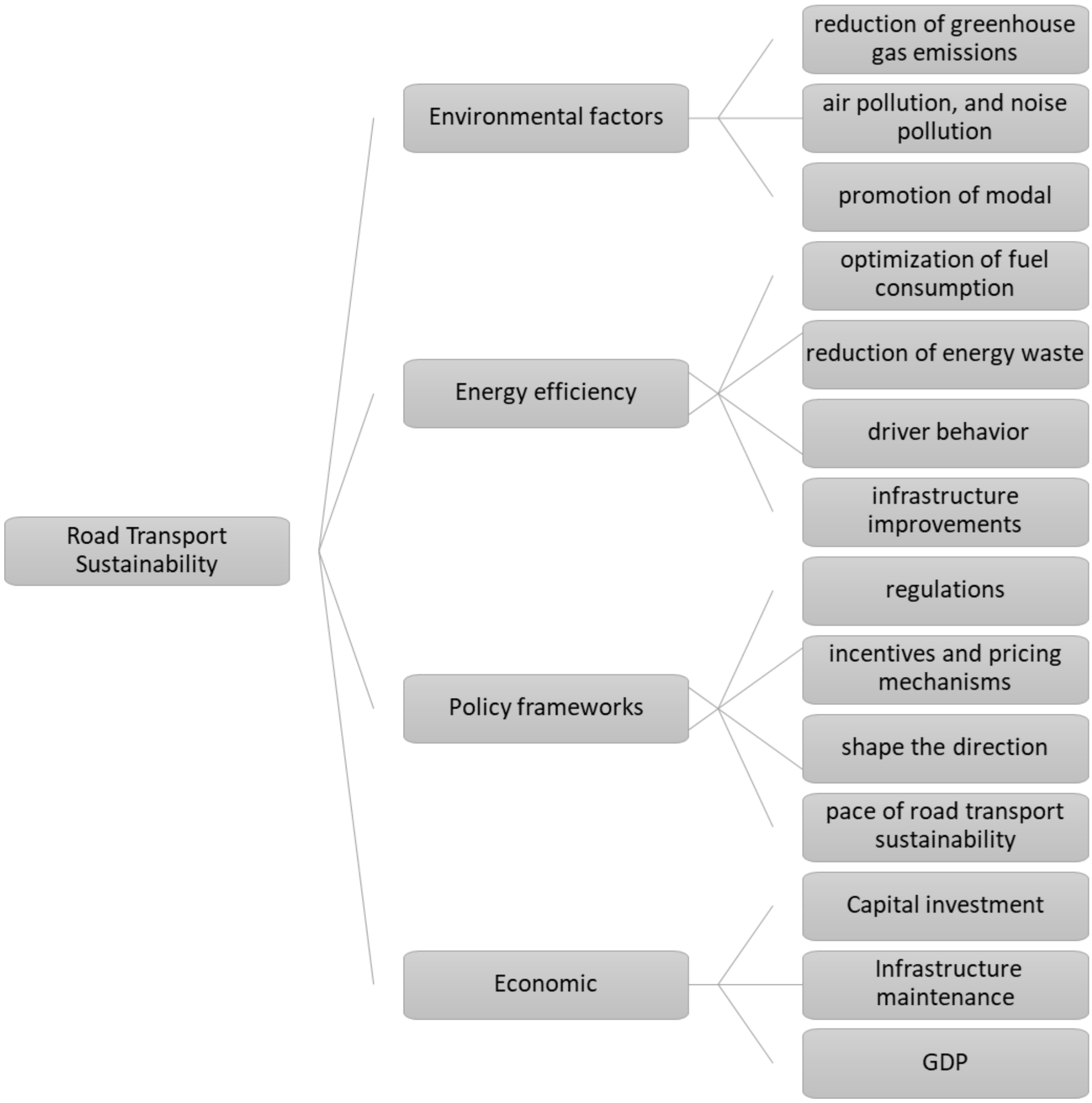

Figure 1. List of factors of road transport sustainability.

judgment. Data visualization is utilized to shed light on the situation in this methodical technique. verify the established connection structure and get an answer [25], [26]. The DEMATEL method integrated with the neutrosophic set to construct the relationship between factors. The neutrosophic set is used to deal with vague information.

3.1 Build the pairwise comparison matrix.

$$A = \begin{bmatrix} 1 & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{n1} & \cdots & 1 \end{bmatrix} \quad (1)$$

3.2 Normalize the pairwise comparison matrix.

$$D = \frac{a_{ij}}{\max a_{ij}} \quad (2)$$

3.3 Evaluate the cumulative association matrix

$$E = D(I - D)^{-1} \tag{3}$$

3.4 Design the relationship diagram

$$X_j = \sum_{i=1}^{n} e_{ij}, Y_j = \sum_{j=1}^{n} e_{ij} \tag{4}$$

4. Results and Discussions

This section introduces the analysis of results of applying the steps of the single valued neutrosophic DEMATEL method. This study used four main criteria and 14 sub criteria as shown in Figure 1. The ecological footprint of road transport is a major consideration in the issue of long-term viability. Greenhouse gas emissions must be lowered, the air quality must be enhanced, and noise must be kept to a minimum. Adopting cleaner and more efficient cars, encouraging modal shifts to public transport and non-motorized modes, and enacting rules that support sustainable practices are all strategies to deal with this problem. Improving energy efficiency is essential for long-term success in the field of sustainable road transport. Optimal fuel consumption is achieved by minimizing energy waste and encouraging the use of alternative fuels and propulsion systems. Increased investments in infrastructure that supports energy-efficient transport systems are among the strategies that may be implemented.

Sustainability in road transport is mostly driven by policy frameworks. There are a variety of regulatory, incentive, and price structures in place to promote environmentally responsible practices and deter those that are destructive to the environment. Emission requirements, incentives for environmentally friendly automobiles, congestion pricing, and advocacy for eco-friendly city design are among the tactics that might be used. Involving Stakeholders and the Public in Decision-Making Processes Stakeholder engagement and public participation is essential to attaining sustainable road transport. Taking into account a wide range of stakeholder interests, focusing on issues of social fairness, and raising public knowledge and engagement all fall under this category. Consultations with stakeholders, community involvement in transportation planning, and the development of partnerships between government, industry, and civil society organizations are all part of the plan. Collectively addressing environmental, social, and economic concerns, these elements help ensure the long-term viability of the road transport sector. Taking them into account and incorporating them into transport planning and regulations may help build a road transport system that is sustainable and resilient enough to fulfill the demands of both current and future generations. The pairwise comparison matrix between criteria is built by Eq. (1) using single valued neutrosophic set. We used the linguistic terms of single valued neutrosophic set to evaluate the criteria. Then normalize the pairwise comparison matrix by using Eq. (3). We divide each value in pairwise comparison matrix by the maximum value in each column as shown in Table 1.

Table 1. The normalized pairwise comparison matrix between criteria.

	RTS_1	RTS_2	RTS_3	RTS_4	RTS_5	RTS_6	$RTS7_1$	RTS_8	RTS_9	RTS_{10}	RTS_{11}	RTS_{12}	RTS_{13}	RTS_{14}
RTS_1	0.2569	0.192205	0.34933	0.106658	0.235791	0.219136	0.246528	0.060549	0.185967	0.135361	0.094796	0.220138	0.29367	0.856
RTS_2	0.488125	0.3652	0.225526	0.123242	0.136161	0.17792	0.102272	0.150606	0.176491	0.163902	0.356159	0.162361	0.162744	0.5269
RTS_3	0.266218	0.586196	0.362	0.146188	0.194094	0.246528	0.134886	0.124185	0.124823	0.135361	0.136161	0.135361	0.380568	0.362
RTS_4	0.563377	0.693111	0.5792	0.2339	0.194426	0.094669	0.246528	0.124185	0.055411	0.06515	0.136161	0.178597	0.43137	0.415
RTS_5	0.402034	0.989702	0.688213	0.443917	0.369	0.094669	0.094464	0.123973	0.124823	0.179316	0.194094	0.094925	0.38186	0.526
RTS_6	0.300117	0.525468	0.375909	0.632504	0.997837	0.256	0.134886	0.060337	0.141666	0.179316	0.133578	0.135361	0.243314	0.369
RTS_7	0.266771	0.914143	0.687037	0.242887	1	0.485861	0.256	0.164512	0.228609	0.102246	0.094464	0.164159	0.284758	0.5269
RTS_8	1	0.571518	0.687037	0.443917	0.701521	1	0.366762	0.23569	0.165356	0.135361	0.08697	0.135361	0.201692	0.3698
RTS_9	0.327261	0.490201	0.687037	1	0.700323	0.428094	0.265285	0.337665	0.2369	0.247909	0.087416	0.101476	0.282975	0.38
RTS_{10}	0.487569	0.572414	0.687037	0.922319	0.528653	0.366762	0.643216	0.447314	0.245492	0.2569	0.094796	0.065998	0.234401	0.8963
RTS_{11}	1	0.378367	0.98103	0.633875	0.701521	0.707182	1	1	1	1	0.369	0.094796	0.282975	0.8796
RTS_{12}	0.299802	0.577848	0.687037	0.33645	0.998647	0.485861	0.400626	0.447314	0.599747	1	1	0.2569	0.114482	0.965
RTS_{13}	0.389833	1	0.423888	0.241632	0.430622	0.468864	0.400626	0.520747	0.373071	0.488403	0.581102	1	0.44563	0.44563
RTS_{14}	0.300117	0.693111	1	0.563614	0.701521	0.693767	0.485861	0.637345	0.623421	0.286623	0.419509	0.266218	1	1

Then evaluate the relation matrix by using Eq. (3) as shown in Table 2. Figure 2 shows the cause diagram between four main criteria. Figures 3-6 show the cause diagram between sub-criteria. Then build the pairwise comparison matrix between 14 sub-criteria to show the relationship between global criteria as shown in Figure 7.

Table 2. The total relation matrix.

	RTS_1	RTS_2	RTS_3	RTS_4	RTS_5	RTS_6	$RTS7_1$	RTS_8	RTS_9	RTS_{10}	RTS_{11}	RTS_{12}	RTS_{13}	RTS_{14}
RTS_1	-0.37604	-0.37716	-0.1501	-0.18594	-0.10713	-0.0671	-0.03479	-0.09021	0.002616	-0.05775	-0.08151	0.043832	0.020367	0.142941
RTS_2	0.065611	-0.34697	-0.20074	-0.12168	-0.20083	-0.03304	-0.05565	-0.01298	0.026696	-0.05247	0.037893	-0.0756	-0.10912	0.048714
RTS_3	-0.08065	0.000635	-0.16394	-0.15884	-0.17822	-0.02221	-0.06501	-0.04966	-0.04574	0.00265	-0.00609	0.004063	0.006667	-0.10681
RTS_4	0.05378	-0.06593	-0.06573	-0.29572	-0.28989	-0.1756	0.014845	-0.07231	-0.09436	-0.06653	-0.00436	0.051601	0.013325	-0.07507

RTS_5	-0.02203	0.126451	-0.02889	-0.11927	-0.38483	-0.24443	-0.14739	-0.06903	-0.07527	-0.04392	0.006979	-0.05628	-0.00421	-0.03748
RTS_6	-0.06114	0.055878	-0.14361	0.129504	0.179788	-0.3087	-0.17045	-0.197	-0.12865	-0.05002	-0.02103	-0.03814	-0.03776	-0.10342
RTS_7	-0.18372	0.336063	-0.015	-0.25415	0.230659	-0.09051	-0.22722	-0.1802	-0.07779	-0.16848	-0.05227	-0.07556	-0.08507	-0.09738
RTS_8	0.324803	-0.06254	-0.07921	-0.12902	0.138016	0.293109	-0.17233	-0.31353	-0.22438	-0.22191	-0.15359	-0.04493	-0.09885	-0.1035
RTS_9	-0.00914	0.011652	0.03729	0.360426	-0.08709	-0.14006	-0.13114	-0.09919	-0.19301	-0.11323	-0.13362	-0.03203	-0.03331	-0.223
RTS_{10}	-0.13266	-0.05514	-0.07878	0.119003	-0.1857	-0.12617	0.094543	-0.05179	-0.21128	-0.29043	-0.2211	-0.10911	-0.04628	0.054578
RTS_{11}	0.149997	-0.38731	-0.00595	0.018529	-0.06912	0.003075	0.187968	0.045304	0.053677	-0.05018	-0.50355	-0.33144	-0.23043	-0.25747
RTS_{12}	-0.28005	-0.41655	-0.06734	0.007935	0.037609	-0.18203	-0.00644	-0.0464	-0.00473	0.222382	0.043569	-0.47912	-0.42698	-0.14609
RTS_{13}	-0.18692	-0.27189	-0.41741	-0.16712	-0.11685	-0.11609	0.039192	0.031636	-0.0613	0.206399	0.066543	0.189009	-0.56681	-0.44594
RTS_{14}	-0.42092	-0.3581	-0.19805	-0.11888	-0.14436	0.012487	-0.13822	0.052463	-0.00696	-0.15207	-0.07188	-0.04074	0.081382	-0.50285

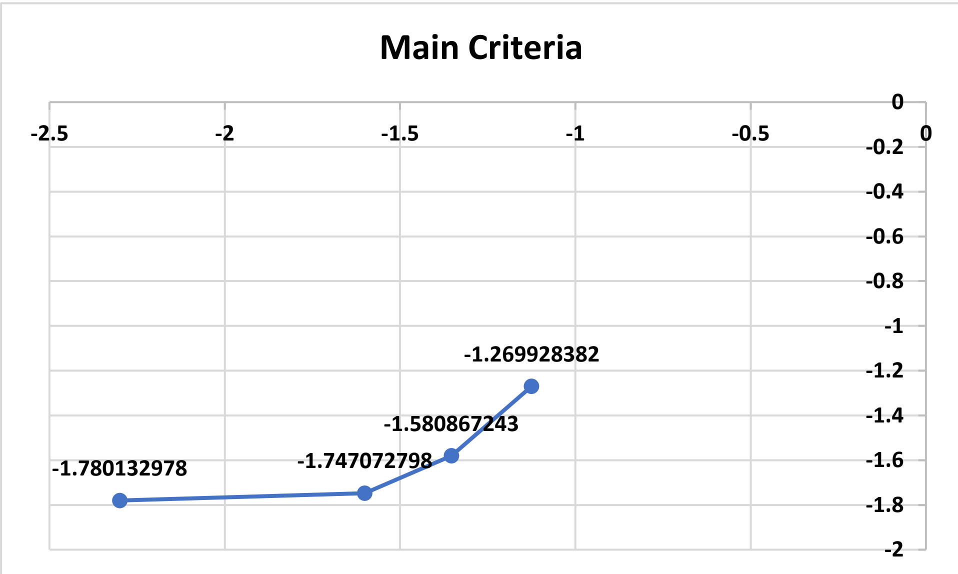

Figure 2. The Cause diagram between main criteria.

Then we design the relationship diagram between criteria by using Eqs. (4 and 5)

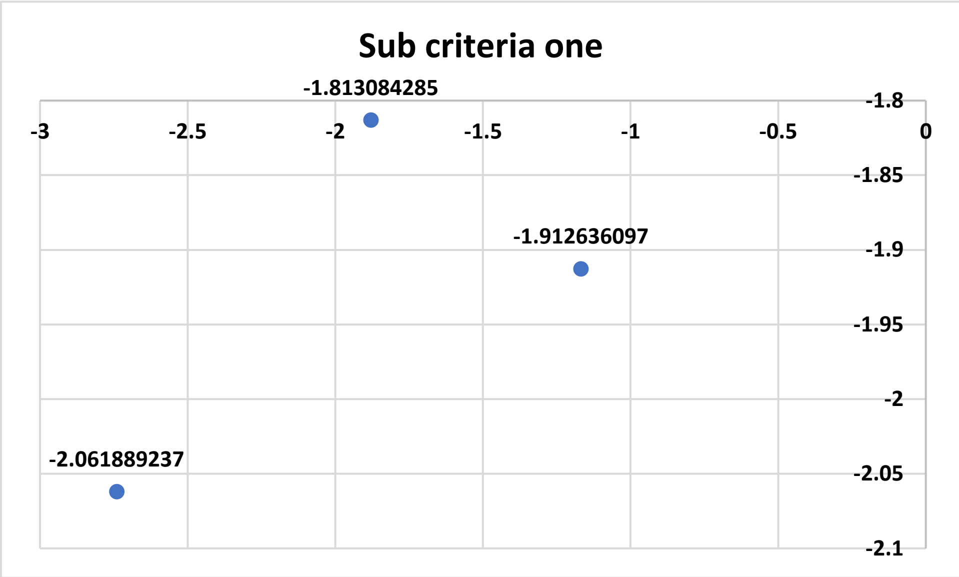

Figure 3. The Cause diagram between sub criteria one.

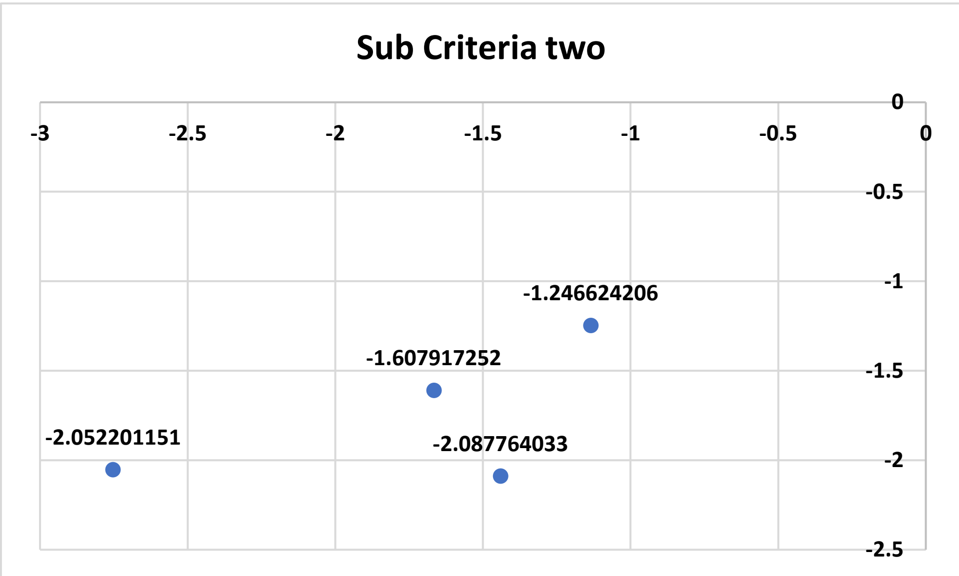

Figure 4. The Cause diagram between sub criteria two..

5. Conclusion

In conclusion, achieving long-term sustainability in the road transport sector is an urgent and complex task that calls for an integrative strategy. The environmental impact, energy efficiency, alternative fuels and propulsion technologies, infrastructure design and planning, intelligent transport systems, policy frameworks, and stakeholder engagement are just some of the topics this paper covers in its comprehensive review of the factors and strategies related to road transport sustainability. Sustainable practices may be put into place if the negative effects of road

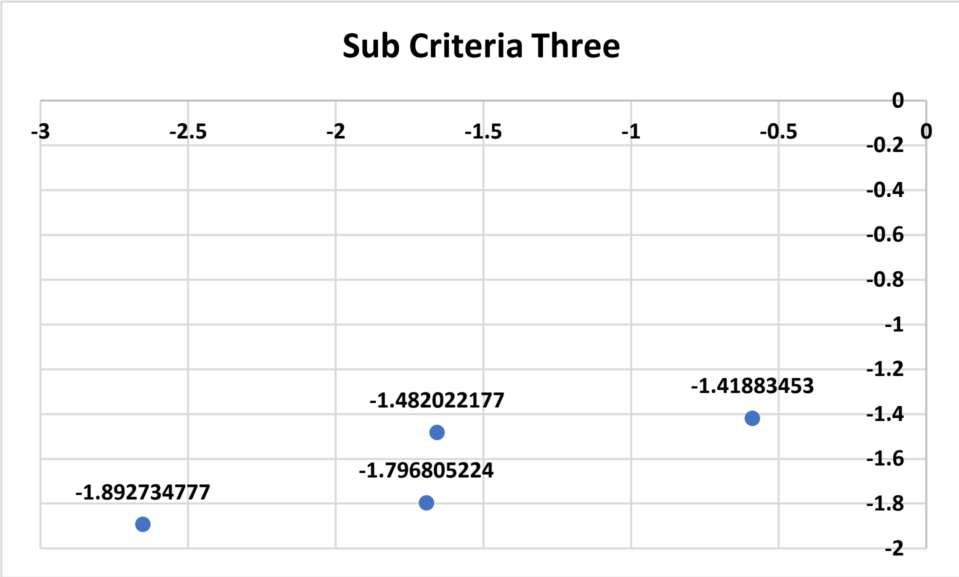

Figure 5. The Cause diagram between sub criteria three.

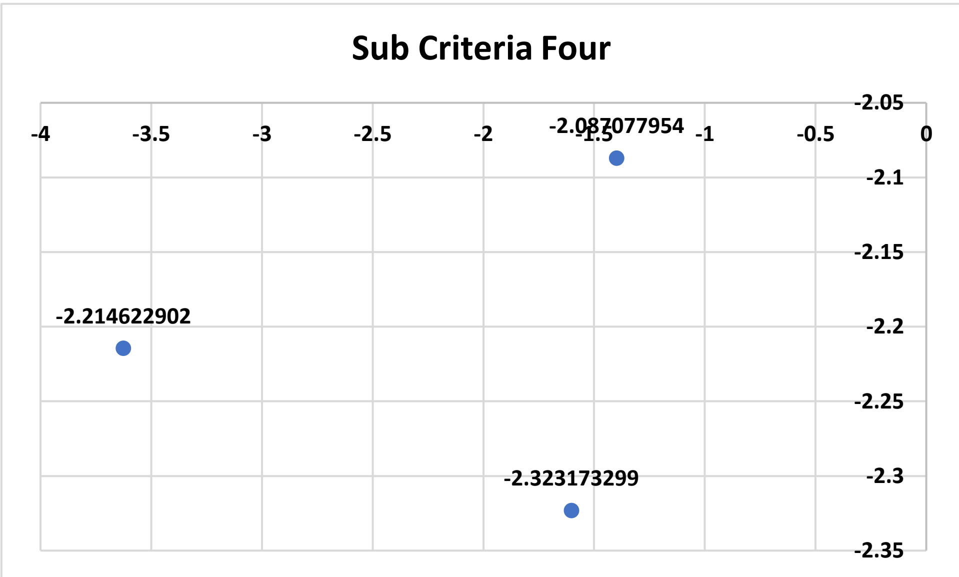

Figure 6. The Cause diagram between sub criteria four.

travel on the environment, such as emissions of greenhouse gases, air pollution, and noise pollution, are mitigated. Improving energy efficiency via innovation, changed driving habits, and new infrastructure is essential. Reducing reliance on fossil fuels is aided by the investigation and implementation of alternative fuels and propulsion technologies like electric cars and biofuels.

The speed and direction of sustainable road transport are shaped by policy frameworks such as rules, incentives, and pricing systems. Engaging stakeholders and inviting the public to weigh in are essential steps towards attaining sustainable road transport. This paper's conclusions are helpful for policymakers and practitioners who are tasked with developing, launching, and maintaining sustainable road transport programs. Stakeholders may help build a more

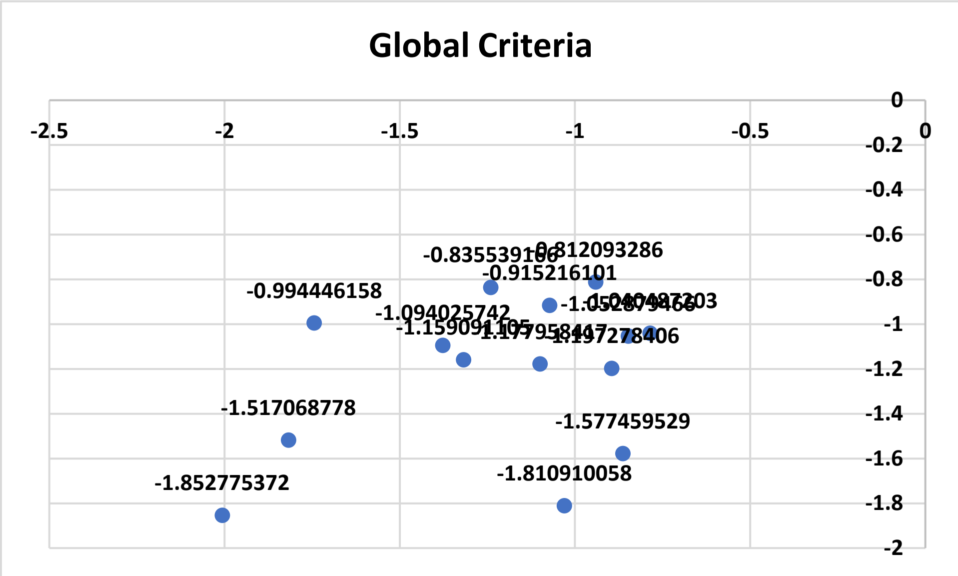

Figure 7. The Cause diagram between global criteria.

sustainable and resilient road transport system by incorporating the identified elements and methods into policies and practices. However, there are still open questions and areas for improvement that need to be explored. Researchers need to look at ways to improve the integration of intelligent transportation systems into existing infrastructure, as well as ways to evaluate the long-term consequences of alternative fuels and propulsion technologies. Overall, achieving sustainability in road transport is a difficult task that calls for cooperation among many parties and the persistent search for novel solutions. Prioritizing sustainability in road transport will help us create a transport system that is better for the environment, the economy, and society as a whole. This paper used the DEMATEL method as a MCDM method to show the relationship between factors. The DEMATEL method integrated with the single valued neutrosophic set to deal with vague data.

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This research paper does not contain any supplementary materials.

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

Conflicts of Interest

The authors declare that there is no conflict of interest in the research.

Institutional Review Board Statement

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Not applicable.

Data Availability Statement

All data generated or analyzed during this study are included in this article.

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