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Evaluation of Barriers and Facilitators to Smart Mobility and Logistics

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Abstract Smart mobility and logistics applications, an essential component for sustainable cities and communities, are a popular approach for both the industrial sector and the public's quality of life. Rapid population growth gradually increases the pace of urbanization, and various challenges arise in mobility and logistics activities due to social, environmental, technological, financial, etc. factors. The main purpose of this study is to systematically identify and evaluate the key barriers and facilitators impacting smart mobility and logistics. To achieve these goals, an extensive background is advanced, categorizing the factors into five main criteria: Governance, Social, Economic, Technology, Environment, and twenty-five sub-criteria. The Best-to-Worst Method (BWM) is used to calculate the weights of these factors, and the consistency of the findings is validated. By identifying and analyzing the critical factors, this paper aims to offer actionable insights for improving more sustainable cities and communities. The findings indicate that economic and technological criteria emerge as the most influential factors. These results offer a robust decision-support tool for governments, urban planners, and managers, helping to align smart mobility and logistics development with sustainability goals.

Keywords Smart mobility · Smart logistics · Multicriteria decision making · Barriers · Sustainability

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Evaluation of Barriers and Facilitators to Smart Mobility and Logistics

Introduction

The rapidly growing population makes it necessary to combine smart and sustainable urban planning with logistics activities (Paiva et al., 2021). It is expected that around 68 % of the population of the world will live in urban areas by 2050 (Y. Zhang et al., 2022). Urban ecosystems face various challenges due to the continuous growth of the urban population, increasing urbanization processes, uncertainties associated with climate change, and digital technology adaptation, etc. (Neirotti et al., 2014). As the population living in urban areas increases, urban mobility problems become more complex (Büyüközkan & Göçer, 2020). Smart mobility and logistics are a new approach that aims to connect transportation networks, industries, and commercial services (Sattar et al., 2025). These systems are indispensable for sustainable cities and communities. Smart mobility and logistics applications are becoming increasingly popular in industrial sectors, as well as at individual levels through micromobility solutions and intelligent autonomous systems (Sattar et al., 2025). However, the smart mobility discourse increases the potential for a transition to smarter and more sustainable cities while improving the quality of life (Savastano et al., 2023). These applications and strategies usually use technologies such as 5G internet services, cloud services, the internet of things, smart solutions, etc. Additionally, the Internet of Things (IoT), Big Data, and Artificial Intelligence will play an important role in new solutions (Paiva et al., 2021). This field is still in its early phases, and solutions need to be designed for unique challenges due to various needs (Sattar et al., 2025).

The logistics sector is one of the largest sources of carbon emissions and can be minimized through policies that support clean fuels (Hussain et al., 2025a). For example, 15% of global anthropogenic greenhouse gas emissions come from the transportation sector (Ferrer & Thomé, 2023). Smart logistics is a paradigm that reduces congestion in cities, optimizes movements, and includes more sustainable, safe, and environmentally friendly logistics activities (Büyüközkan & Göçer, 2020). Sustainable mobility provides important opportunities for urban economic development and quality of life, such as access to health, education, and other services (Lepitzki & Axsen, 2020). Smart logistics includes vital goals such as reducing carbon emissions, minimizing urban congestion, saving energy, and improving the overall quality of life in cities (Büyüközkan & Göçer, 2020). Various challenges arise in the face of these innovative approaches, and in this context, there is a need to understand the evolving mobility scenario to develop effective regulations and governance frameworks that maximize its social, environmental, and economic potential (Paiva et al., 2021). For example, Amsterdam, one of the cities where smart city strategies were implemented early, faces increasing mobility challenges as its population is expected to exceed 1 million by 2040 (Qonita et al., 2025). For more sustainable cities and communities, the challenges faced by smart mobility and logistics must be systematically identified, and sustainable solution approaches and strategies must be implemented by eliminating these barriers.

Thus, robust and systematic methods are needed, as the quality of sustainable smart mobility and logistics developments depends on a comprehensive evaluation. Additionally, urban planners and governments will face many challenges in developing and implementing smart mobility and logistics strategies and applications. In this background, effective management of transportation systems becomes critical, requiring robust decision-support tools capable of addressing barriers and facilitators. However, despite growing interest, systematic analyses of barriers and facilitators in smart mobility and logistics applications, particularly using advanced multi-criteria methods sensitive to uncertainties and varying participant preferences, remain limited.

The motivation behind this article is the need to identify and assess the challenges facing applications and developments in smart mobility and logistics for more sustainable cities and communities. The main goal of this study is to systematically identify and evaluate the key barriers and facilitators impacting smart mobility and logistics using a multi-criteria decision-making (MCDM) approach. By assessing these factors through expert evaluations and using

the Best-Worst Method (BWM), the study aims to offer actionable insights into the relative importance of various and significant barriers and facilitators in this field. This systematic method aims to inform the design and application of more practical and user-friendly solutions. Eventually, the study aims to improve the uptake of smart mobility and smart logistics strategies and activities, improving logistics management and urban planning under a sustainability framework.

This study makes some important contributions to this research field. It presents a comprehensive context by categorizing barriers and facilitators into five main criteria— Governance, Social, Economic, Technology, and Environment —providing a nuanced understanding of the factors influencing smart mobility and smart applications or activities. The use of the BWM to determine the relative importance of these key factors through expert assessments is a new approach, confirming that the weights reflect expert consensus and enhancing the consistency of the results. Furthermore, the study's focus on sub-criteria suggests a granular analysis of detailed challenges and facilitators, enabling targeted strategies or activities for logistic management under a sustainability framework. These insights have applied suggestions for designing and implementing user-centered smart mobility and smart logistics technologies/strategies.

This study aims to address the gap in the current literature on the evaluation of barriers and facilitators to smart mobility and smart logistics under a sustainability background. Consequently, this study focuses on two research questions:

RQ1: What are smart mobility and logistics challenges and how can they be assessed?

RQ2-How can the multi-criteria decision-making process evaluation of the barriers and facilitators to smart mobility and logistics applications/strategies be improved?

In light of these research questions and gaps, the main contributions of the study are as follows:

i. This study defines the barriers for smart mobility and logistics using the MCDM method.
ii. A comprehensive and critical set of barriers and facilitators was considered based on governance, social, economic, technology, and environment. A total of 25 sub-criteria were evaluated.
iii. Unlike the current studies in the literature, this paper employs the MCDM method: BWM to evaluate and prioritize barriers and facilitators for smart mobility and logistics.

The remainder of this paper is organized as follows: Section 2 presents the systematic literature review. Section 3 presents the proposed methodology. Section 4 presents the application, results, and sensitivity analysis, and the last section provides conclusion remarks and directions for future research.

Literature Review

This section provides an organized review of the current literature to establish a solid academic and theoretical foundation for the barriers and facilitators to smart mobility and logistics. The key intention is to contribute an expressive reference point for researchers working in this developing research area. In order to confirm academic rigor and significance, the SCOPUS database served as the main source for retrieving documents. This review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) background, which has gained extensive recognition for its methodical approach in recent academic surveys, as outlined by Moher et al. (2010). This approach includes four main steps: (i) setting the gathering parameters, (ii) conducting a comprehensive evaluation of the sources, (iii) filtering the most relevant documents, and (iv) gathering the important data components. Researchers use this method in the literature review process to minimize the risk of bias and conduct literature research with a more organized approach, as well as to guarantee the reliability and structure of the analysis (Santi & Putra, 2018).

We achieved a systematic literature search in the SCOPUS platform using a broad set of keywords related to smart mobility and logistics, evaluation, and MCDM methods, yielding 30 publications. After screening and applying PRISMA procedures, we identified a set of relevant publications for comprehensive review: *"smart mobility" OR "smart logistics"*

AND "assesment" OR "evaluation" AND "multi-criteria" OR "mcdm" OR "mcda" OR "madm" OR "Multi-Objective Decision Making" OR "Multi-Criteria Decision Analysis" OR ahp OR topsis OR vikor OR codas OR waspas OR edas OR bwm OR aras OR saw OR swara OR fucom OR anp OR electre OR promethee OR moora OR multimoora OR copras OR dematel OR critic OR cocoso OR mabac OR "entropy method" OR "Analytic Hierarchy Process" OR "Technique for Order of Preference by Similarity to Ideal Solution" OR "Vise Kriterijumska Optimizacija I Kompromisno Resenje" OR "entropy method" OR "Combinative Distance-Based Assessment" OR "Weighted Aggregated Sum Product Assessment" OR "Evaluation Based on Distance from Average Solution" OR "Best-Worst Method" OR "Additive Ratio Assessment" OR "Simple Additive Weighting" OR "Step-wise Weight Assessment Ratio Analysis" OR "Full Consistency Method" OR "Analytic Network Process" OR "Elimination et Choice Translating Reality" OR "Preference Ranking Organization Method for Enrichment Evaluations" OR "Multi-Objective Optimization on the Basis of Ratio Analysis" OR "Complex Proportional Assessment" OR "Decision-Making Trial and Evaluation Laboratory" OR "Criteria Importance Through Intercriteria Correlations".

Because of this search, 30 documents were found. Among them, only those focused on smart mobility and smart logistics assessment applications. Table 1 summarizes the most relevant studies in this field.

Table 1

Literature Review

Ref.	Problem	Method	Criteria	Application area
(Brownrigg-gleeson et al., 2025)	Evaluation of challenges for smart mobility	Focus group analysis	Smart governance, living, environment, mobility, economy, and people—24 sub-criteria	Madrid, Antwerp, Turku
(Nathanail et al., 2021)	Assessment of smart logistics solutions	Life cycle sustainability analysis and multi-stakeholder multi-criteria decision making	Energy, development, benefits, costs, economics, and financial risks—36 sub-criteria	European Union Cities
(H. Zhang & Jin, 2021)	Building credit system for smart logistics public information platform	Machine learning algorithms	Customer domain, functional domain, physical domain, and process domain	China
(Choosakun & Yeom, 2021)	Developing an evaluation framework for smart logistics	Fuzzy analytical hierarchy process	Mobility, efficiency, reliability, accessibility, environment, and safety—21 sub-criteria	Bangkok Metropolitan Regions
(Zapolskytė et al., 2022)	Evaluation of smart mobility	Simple Additive Weighting (SAW), Complex Proportional Assessment (COPRAS), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), AHP	Traffic and pollution-based criteria—22 sub-criteria	Vilnius, Montreal, and Weimar
(Angarita-Lozano et al., 2025)	Evaluation of smart mobility	AHP	Social, governance, environmental, and economic—36 sub-criteria	Global South
(Liu & Zhao, 2024)	Evaluation of smart logistics	TOPSIS, driving force, pressure, state, impact, and response model, and smart logistics development index model	Driving force, pressure, state, impact, response—3 level indicators	China
(Stević et al., 2022)	Assessment of barriers to smart logistics and demand forecasting in COVID-19	Fuzzy FUll Consistency Method (FUCOM), interval rough evaluation based on Distance from Average Solution (EDAS)	Technological, economical, social, ecological, political, and legal risks—15 sub-criteria	Türkiye/Ordu
This study	*Evaluation of barriers and facilitators to smart mobility & logistics*	*BWM*	*Governance, Social, Economic, Technology, Environment, and 25 sub-criteria*	*Türkiye*

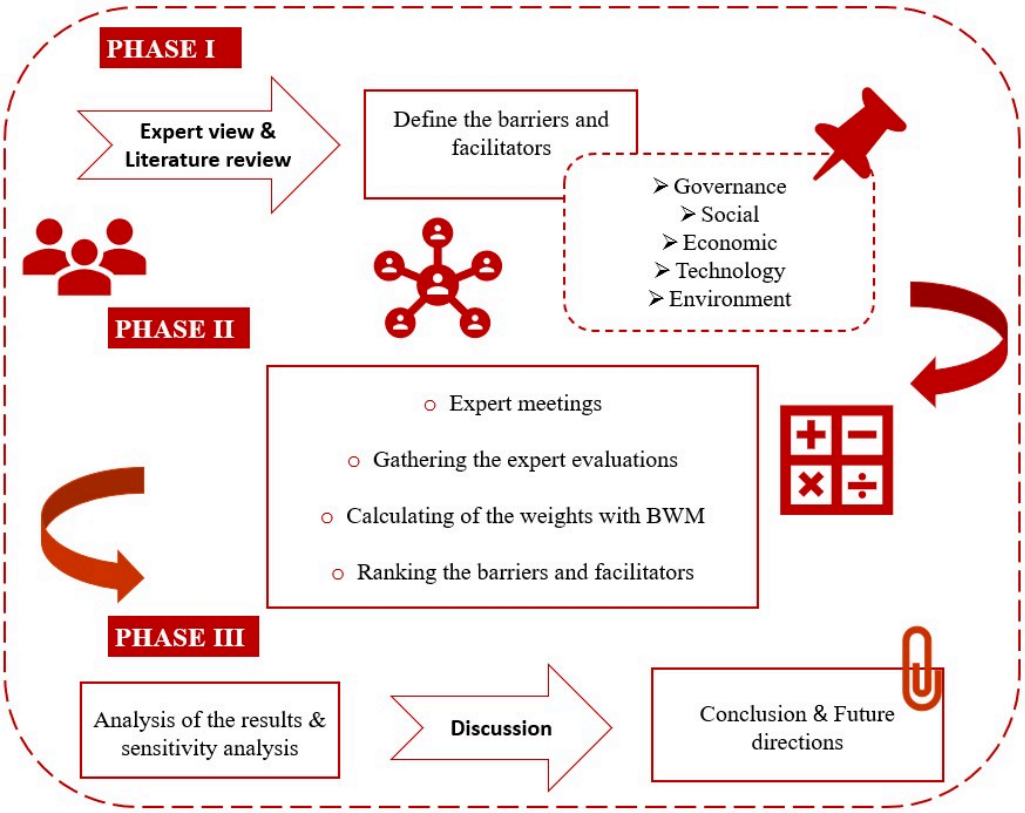
As observed in Table 1, most studies focused on analyzing strategies, solutions, and indicators. Evaluation of barriers and facilitators for smart mobility and logistics installations is not only a technical concern but also a sustainability-driven decision. However, MCDM approaches, which enable the simultaneous evaluation of multiple criteria and are frequently used in selection and evaluation problems, are not widely available in the literature. Approaches such as AHP and TOPSIS are generally used. Consequently, the evaluation process must consider numerous vital factors, including technology, environment, economic, and social factors. This study addresses the identified research gap in the current literature under the sustainable framework. It offers BWM, allowing flexible and realistic treatment of expert judgment. The most study similar to the one shown in Table 1 was conducted by Stević et al. (Stević et al., 2022). This study assesses the barriers to smart logistics and demand forecasting in COVID-19. However, our study is not specific to the pandemic; it covers general conditions. However, unlike studies in the literature (Brownrigg-gleeson et al., 2025; Stević et al., 2022), it evaluates barriers and facilitators.

Proposed Methodology

This study offers a structured MCDM approach to identify and evaluate the barriers and facilitators to smart mobility and logistics. Using the BWM, an inclusive context of criteria and sub-criteria was established and evaluated based on expert views. The analysis proposed calculates the relative importance of each criterion, confirming reliable and actionable insights. The flowchart of the study is shown in Figure 1.

Figure 1

Flowchart of the study



Best-Worst Method

BWM, one of the MCDM approaches, is a subjective weighting method advanced by Rezai (Rezaei, 2015, 2016). BWM was developed by addressing the shortcomings of the AHP technique. These shortcomings are that the AHP method requires a lot of pairwise comparisons, which frequently leads to inconsistencies. BWM assumes a straightforward

principle based on the use of reference objects for comparisons. Thus, BWM provides decision-makers with constant and reliable results, although it needs less comparison data. Also, there is a requirement for more experimental studies that validate the usefulness and efficiency of BWM compared to traditional methods like AHP and TOPSIS in varied applications (Yalcin Kavus et al., 2023). Additionally, compared to other methods, this technique yields more accurate weights (Motevali Haghighi & Torabi, 2018). These substances are considered most significant and least significant, and they are defined as best (C_b) and worst (C_w). In this approach, only comparisons with these reference objects are adequate. The steps of the BWM are as follows:

Step-1. Experts describe the set of n criteria $\{C_1, C_2, ..., C_N\}$ for the problem.

Step-2. Experts assess these criteria and consider the best (C_b) and the worst ().C_w).

Step-3. Each expert assesses the relative preference levels between the best and different factors in the set using a Likert scale. Let a_{bJ} signifies the preference level of the best over the factor C_j where $j \neq b$.The assessment proposals $A_b = (a_{b1},\ \dots,\ a_{bj}, ...,\ a_{bn})$ vector stated as best-to-others and $a_{bb} = 1$.

Step-4. Each expert labels the preference levels of the other factors (except the best) over the worst. This evaluation suggests others-to-worst vector, $A_b = (a_{1w},\ \dots,\ a_{jw}, ...,\ a_{nw})^T$ where a_{jw} signifies the preference level of criterion C_j over the worst where $j \neq b\ or\ j \neq w$.

Step-5. The criteria weights should be determined correspondingly to the preference scores of the best over the other criteria ($\frac{w_b}{w_j^1} = a_{bj}$). The preference scores of the other criteria over the worst ($\frac{w_j^1}{w_w} = a_{jw}$). This proposes determining the set of weights ($w_1^1, w_2^1, ..., w_n^1$) that minimizes the differences between $\left|\frac{w_b}{w_j^1} - a_{bj}\right|$ and $\left|\frac{w_j^1}{w_w} - a_{jw}\right|$. This minimization mathematical model is shown in Equation 1.

Subject to

$$\begin{gathered} \min \zeta \\ \left|\frac{w_b}{w_j^1} - a_{bj}\right| \leq \zeta,\ \forall_j \\ \left|\frac{w_j^1}{w_w} - a_{jw}\right| \leq \zeta,\ \forall_j \\ \sum_j w_j^1 = 1 \\ w_j \geq 0,\ \forall_j \end{gathered} \tag{1}$$

Barriers and Facilitators

In light of the literature review (Brownrigg-gleeson et al., 2025; Büyüközkan & Göçer, 2020; Hussain et al., 2025a; Paiva et al., 2021; Sattar et al., 2025; Setthachotsombut et al., 2024) and expert opinions, 25 barriers and facilitators are grouped under five main headings, as given in Table 2.

The barriers and facilitators for smart mobility and logistics applications, strategies, or adaptation can be summarized into five key factors: governance, social, economic, technology, and environment. Governance criteria include facilitators, such as data management, strategic urban planning, smart mobility, and logistics policies for sustainable cities ((Brownrigg-gleeson et al., 2025; Setthachotsombut et al., 2024). Social criteria include potential barriers such as lack of public cooperation with practices and strategies, poor security in the area, or traffic congestion (Brownrigg-gleeson et al., 2025; Sattar et al., 2025; Setthachotsombut et al., 2024). Economic criteria express the costs or required investments that these applications and systems will cause (Brownrigg-gleeson et al., 2025; Hussain et al., 2025b; Paiva et al., 2021; Setthachotsombut et al., 2024). The technology criterion includes digitalization approaches that

smart applications must integrate with and considers barriers such as weak mobility services and weak IT integration (Brownrigg-gleeson et al., 2025; Büyüközkan & Göçer, 2020; Setthachotsombut et al., 2024). In addition, the environmental criteria include challenges such as the increase in CO_2 emissions, particularly for logistics applications, as well as urban structure. Furthermore, environmentally friendly innovative facilitators, including zero-emission vehicles and renewable energy integration, can significantly help reduce emissions (Setthachotsombut et al., 2024).

Table 2

Barriers and facilitators

Main criteria	Sub-criteria	References
Governance	C1.Policymaking *(facilitator)*	(Brownrigg-gleeson et al., 2025)
	C2.Data management *(facilitator)*	(Brownrigg-gleeson et al., 2025)
	C3. Strategic urban planning *(facilitator)*	(Brownrigg-gleeson et al., 2025)
	C4. Support for companies *(facilitator)*	(Setthachotsombut et al., 2024)
	C5. Monitoring systems *(facilitator)*	(Setthachotsombut et al., 2024)
Social	C6. Limited income rate *(barrier)*	Expert view
	C7.Lack of public participation *(barrier)*	(Brownrigg-gleeson et al., 2025; Setthachotsombut et al., 2024)
	C8. Weak safety *(barrier)*	(Brownrigg-gleeson et al., 2025)
	C9.Traffic congestion *(barrier)*	(Sattar et al., 2025)
	C10. Awareness *(facilitator)*	(Brownrigg-gleeson et al., 2025)
Economic	C11.Lack of funding and resources *(barrier)*	(Brownrigg-gleeson et al., 2025)
	C12.Limited investments *(barrier)*	Expert view
	C13. Operational cost *(barrier)*	Expert view
	C14.Logistic cost *(barrier)*	(Setthachotsombut et al., 2024)
	C15. Business opportunities *(facilitator)*	(Hussain et al., 2025a)
	C16. Innovation capability *(facilitator)*	(Büyüközkan & Göçer, 2020; Setthachotsombut et al., 2024)
Technology	C17. Weak mobility services *(barrier)*	(Brownrigg-gleeson et al., 2025)
	C18. Cybersecurity threats *(barriers)*	Expert view
	C19. Weak IT integration *(barrier)*	Expert view
	C20. Availability of skilled staff *(facilitator)*	Expert view
Environment	C21. Increasing CO_2 emission *(barrier)*	(Setthachotsombut et al., 2024)
	C22. Renewable energy integration *(facilitator)*	Expert view
	C23.Net-zero vehicle potential *(facilitator)*	Expert view
	C24. Urban infrastructure *(barrier)*	Expert view
	C25. Green innovation potential *(facilitator)*	(Setthachotsombut et al., 2024)

The main criteria and sub-criteria explained above are evaluated at this stage using the BWM method by a group of experts with different knowledge and experience in relevant fields such as industrial engineering, logistics, and supply chain management. Then, the criteria are listed by applying BWM step by step.

Results and Discussion

In this study, the expert group role is key for several details: i) determining barriers and facilitators and ii) determining the relative importance of these factors with BWM. The expert team formed to determine the weights of the barriers and facilitators for smart mobility and logistics consisted of 5 professionals with diverse expertise and

knowledge. These experts were selected from academics who have studied in similar fields to this study and have sufficient knowledge. Detailed information about the expert team is given in Table 3.

Table 3

Information about the expert team

	Experience	Education Degree	Job Title	Research area
E1	7	PhD in Industrial Engineering	Assistant Professor	Operation research, decision-making, and supply chain management
E2	12	PhD in Industrial Engineering	Associate Professor	Supply chain management, logistics, and decision-making
E3	5	Master's Degree in Industrial Engineering	Research Assistant	Operation research and decision-making
E4	20+	PhD in Industrial Engineering	Professor	Operation research, supply chain management, and logistics
E5	20+	PhD in Business Administration	Associate Professor	Logistics and supply chain management

In this phase, BWM is applied to evaluate barriers and facilitators. The outlined BWM steps are followed to calculate the factor's weights. Firstly, the weights of the criteria are calculated by classifying the most important *(best)* and least important *(worst)* factors, as determined by the experts and presented in Table 4.

Table 4

The most and least important main factors and decision vectors

	Best criterion	Worst criterion
E1	Technology	Social
E2	Governance	Social
E3	Governance	Social
E4	Economic	Environment
E5	Environment	Social

Two of the experts rated the Governance criterion as the most important criterion. Conversely, the social factor is commonly deemed the least significant. After gathering expert views, both Best-to-Others and Others-to-Worst vectors are created, as shown in Table 5.

Table 5

Decision vectors for the main factors

	Best-to-Others	Others-to-Worst
E1	5,8,4,1,3	4,1,4,8,4
E2	1,6,2,3,4	4,2,4,3,2
E3	1,9,5,3,7	9,1,5,7,3
E4	5,7,1,5,9	4,3,9,4,1
E5	5,9,5,5,1	5,1,5,5,9

For each expert, the mathematical models are established with the vectors given in Table 4, allowing for the calculation of the weights of the main factors. The weights of the criteria are presented in Table 6. Also, the consistency ratio for each expert is assessed. According to these values, all assessments are consistent. Table 6 shows that four out of five experts rated the social criterion as the least important criterion. This criterion's weighting is quite low compared to the other criteria. In contrast, there is no strong consensus on the most important main criterion.

Table 6
Main factor's weights

	E1	E2	E3	E4	E5
Governance	0.1162	0.2857	0.5246	0.1337	0.1329
Social	0.0508	0.0952	0.0460	0.0955	0.0490
Economic	0.1453	0.2857	0.1270	0.5820	0.1329
Technology	0.4939	0.1905	0.2117	0.1337	0.1329
Environment	0.1937	0.1429	0.0907	0.0551	0.5524

The same expert group concepted the Best-to-Others and Others-to-Worst vectors for the sub-criteria under each of the main criteria. Then, the experts' assessments are analyzed for consistency, and all are established as consistent. Then, the BWM steps are applied to calculate the sub-criteria weights for each expert, and these weights are given in Table 7. Also, the consistency ratio and associated threshold values are given in Table 7. The weights of the sub-criteria are calculated by multiplying each sub-criterion's weight by the consistent main factor's weight for each expert. The results in Table 7 support Tables 4 and 6. Accordingly, experts generally consider the sub-criteria related to the social criterion to be less important than the other sub-criteria. In addition, the weights of the C11.Lack of funding and resources and C16.Innovation capability sub-criteria are particularly high.

Table 7
Sub-criteria weights

		E1	E2	E3	E4	E5
Governance	C1. Policymaking	0.013	0.106	0.101	0.027	0.066
	C2. Data management	0.022	0.060	0.060	0.006	0.021
	C3. Strategic urban planning	0.053	0.060	0.263	0.068	0.021
	C4. Support for companies	0.006	0.040	0.076	0.016	0.021
	C5. Monitoring systems	0.022	0.018	0.025	0.016	0.005
	Consistency ratio	0.262	0.200	0.153	0.222	0.264
	Associated threshold	0.282	0.231	0.306	0.306	0.306
Social	C6. Limited income rate	0.003	0.023	0.006	0.012	0.008
	C7. Lack of public participation	0.006	0.011	0.010	0.019	0.011
	C8. Weak safety	0.025	0.015	0.005	0.048	0.011
	C9. Traffic congestion	0.007	0.040	0.024	0.004	0.008
	C10. Awareness	0.010	0.007	0.002	0.012	0.011
	Consistency ratio	0.190	0.200	0.222	0.222	0.292
	Associated threshold	0.282	0.231	0.306	0.306	0.306
Economic	C11.Lack of funding and resources	0.075	0.119	0.063	0.293	0.068
	C12.Limited investments	0.018	0.068	0.019	0.116	0.016
	C13.Operation cost	0.022	0.045	0.025	0.070	0.020
	C14.Logistic cost	0.022	0.034	0.013	0.070	0.020
	C15. Business opportunities	0.009	0.020	0.007	0.034	0.008
	Consistency ratio	0.214	0.100	0.178	0.190	0.214
	Associated threshold	0.282	0.264	0.296	0.282	0.282
Technology	C16.Innovation capability	0.273	0.070	0.109	0.022	0.073
	C17. Weak mobility services	0.064	0.039	0.026	0.058	0.017
	C18.Cybersecurity threats	0.064	0.039	0.044	0.022	0.017

		E1	E2	E3	E4	E5
	C19. Weak IT integration	0.064	0.016	0.022	0.022	0.017
	C20. Availability of skilled staff	0.028	0.026	0.010	0.010	0.008
	Consistency ratio	0.214	0.167	0.222	0.200	0.214
	Associated threshold	0.296	0.190	0.306	0.231	0.296
Environment	C21.Increasing CO_2 emission	0.032	0.023	0.048	0.003	0.091
	C22. Renewable energy integration	0.048	0.017	0.019	0.028	0.136
	C23.Net-zero vehicle potential	0.024	0.035	0.012	0.007	0.068
	C24.Urban infrastructure	0.009	0.059	0.008	0.011	0.027
	C25. Green innovation potential	0.081	0.008	0.004	0.007	0.230
	Consistency ratio	0.214	0.200	0.222	0.190	0.214
	Associated threshold	0.282	0.264	0.306	0.282	0.282

In this step, these weights are aggregated, assuming equal effect from each expert. The final criteria weights and rankings are proposed in Table 8.

Table 8

Final weights and rankings of the factors

Barriers and Facilitators	Final weight	Rank
C1. Policymaking	0.0626	5
C2. Data management	0.0338	12
C3. Strategic urban planning	0.0930	**3**
C4. Support for companies	0.0318	13
C5. Monitoring systems	0.0172	19
C6. Limited income rate	0.0103	24
C7. Lack of public participation	0.0115	23
C8. Weak safety	0.0209	18
C9. Traffic congestion	0.0167	20
C10. Awareness	0.0083	25
C11.Lack of funding and resources	0.1236	**1**
C12.Limited investments	0.0474	7
C13.Operation cost	0.0364	11
C14.Logistic cost	0.0318	13
C15. Business opportunities	0.0156	22
C16.Innovation capability	0.1094	**2**
C17. Weak mobility services	0.0408	8
C18.Cybersecurity threats	0.0372	10
C19. Weak IT integration	0.0282	16
C20. Availability of skilled staff	0.0164	21
C21.Increasing CO_2 emission	0.0394	9
C22. Renewable energy integration	0.0496	6
C23.Net-zero vehicle potential	0.0292	15
C24.Urban infrastructure	0.0228	17
C25. Green innovation potential	0.0660	4

According to the findings in Table 8, the most critical barriers and facilitators in this decision-making process are C11. Lack of funding and resources, C16. Innovation capability, and C3. Strategic urban planning with weights of 0.1236, 0.1094, and 0.0930. Thus, the most important barrier in practice for smart mobility and logistics activities is the lack of funding and resources under the economic criterion. In other words, governments, managers, or other decision-makers for smart mobility and logistics should focus on the funding and resources problem in the construction of sustainable smart cities. The results also emphasize the necessity of innovation-oriented approaches or capabilities. Additionally, Brownrigg et al. evaluated the biggest challenges in smart mobility. They emphasized that one of the key factors is the problem of financing and resources and the importance of strategic planning (Brownrigg-gleeson et al., 2025). Moreover, various innovative approaches are being designed to improve smart mobility and logistics, such as IoT-based dynamic traffic management, mobility in degraded vision, and electric vehicles. (Paiva et al., 2021). In contrast, awareness was determined to be the least important factor for this evaluation process. In general, it can be said that social-based factors are considered less important than other factors. This is because smart mobility and logistics investments, applications, and strategies require certain costs and technological decisions. Environmental factors are also important. Compared to these factors, social factors are human-related and can present relatively easier challenges to overcome. Angarita et al. ((Angarita-Lozano et al., 2025) in their smart urban evaluation study demonstrate that the results obtained from their model place significant emphasis on social criteria. However, this study combines objective measurements with subjective citizen perceptions. Thus, the criteria considered under the social factor include the availability of public spaces, length of public transportation roads, and length of bike lanes.

Overall, the results indicate that the most substantial barriers to smart mobility and logistic adoption, activities, or applications are economic and technological challenges. Social factors are perceived as less important in comparison. Consequently, to address the challenges, it is vital to address these barriers first. This context can be used as a tool by governments, urban planners, or other decision-makers to assess their strategies and applications under similar uncertainty and sustainability conditions. Governments can focus their efforts on finding resources or enhancing their capabilities in this area through innovation-focused training and investments. Furthermore, urban planning strategies and policies that prioritize these factors can be developed and implemented.

Sensitivity Analysis

To evaluate the robustness of the results, we conducted a sensitivity analysis by defining several expert decision weighting scenarios. Normally, when calculating criteria weights using the BWM method, the arithmetic mean of the expert evaluation results is taken. Since there are five experts in total, in the first scenario (S1), the first expert is given a weight of 0.5, and the others are given a weight of 0.125. The other scenarios continue similarly. This sensitivity analysis evaluates the results obtained by assigning different weights to experts. The results of the criteria weights for all scenarios are presented in Table 9. This analysis validates the robustness of the recommended weights.

Table 9

Results of the sensitivity analysis

Barriers and Facilitators	S1 weight	S2 weight	S3 weight	S4 weight	S5 weight
C1. Policymaking	0.0440	0.0789	0.0770	0.0493	0.0639
C2. Data management	0.0294	0.0436	0.0436	0.0234	0.0290
C3. Strategic urban planning	0.0780	0.0806	0.1568	0.0836	0.0660
C4. Support for companies	0.0221	0.0349	0.0484	0.0259	0.0278
C5. Monitoring systems	0.0190	0.0175	0.0201	0.0168	0.0126
C6. Limited income rate	0.0076	0.0151	0.0087	0.0108	0.0095
C7. Lack of public participation	0.0094	0.0113	0.0109	0.0145	0.0113
C8. Weak safety	0.0224	0.0187	0.0149	0.0312	0.0172

Barriers and Facilitators	S1 weight	S2 weight	S3 weight	S4 weight	S5 weight
C9. Traffic congestion	0.0130	0.0254	0.0194	0.0120	0.0134
C10. Awareness	0.0090	0.0078	0.0060	0.0096	0.0093
C11.Lack of funding and resources	0.1054	0.1219	0.1009	0.1871	0.1028
C12.Limited investments	0.0364	0.0551	0.0368	0.0731	0.0356
C13.Operation cost	0.0310	0.0396	0.0321	0.0490	0.0303
C14.Logistic cost	0.0281	0.0326	0.0248	0.0461	0.0274
C15. Business opportunities	0.0131	0.0173	0.0124	0.0225	0.0128
C16.Innovation capability	0.1708	0.0946	0.1093	0.0766	0.0958
C17. Weak mobility services	0.0495	0.0401	0.0353	0.0473	0.0319
C18.Cybersecurity threats	0.0473	0.0379	0.0398	0.0315	0.0296
C19. Weak IT integration	0.0416	0.0236	0.0259	0.0259	0.0240
C20. Availability of skilled staff	0.0208	0.0200	0.0140	0.0140	0.0133
C21.Increasing CO_2 emission	0.0366	0.0333	0.0426	0.0258	0.0588
C22. Renewable energy integration	0.0490	0.0374	0.0381	0.0415	0.0820
C23.Net-zero vehicle potential	0.0273	0.0314	0.0228	0.0209	0.0438
C24.Urban infrastructure	0.0176	0.0364	0.0173	0.0184	0.0244
C25. Green innovation potential	0.0716	0.0443	0.0428	0.0439	0.1275

According to the sensitivity analysis results, in the current and equal weights scenarios and in S2 and S4 C11.Lack of funding and resources hold the top position. This criterion is also seen as the second most important criterion in other strategies. Furthermore, C16. Innovation capability, currently the second most important factor, has also been considered a significant factor in other scenarios. Overall, these findings underscore the critical role of funding and resources in shaping urban mobility and logistics planning.

Conclusion Remarks and Future Directions

This study presents a systematic approach to identify and evaluate the key barriers and facilitators for smart mobility and logistics. By identifying and analyzing these criteria, this study aims to provide actionable visions for more sustainable cities and communities. To achieve this purpose, BWM is employed to systematically evaluate the importance of numerous and significant barriers and facilitators in this field.

The findings highlight that the most critical factor in this decision-making process is the lack of funding and resources under the economic criterion. Governments, managers, urban planners, or other decision-makers for smart mobility and logistics should focus on the funding and resources barrier in the construction of sustainable smart cities. Additionally, the results highlight the necessity of innovation-oriented approaches or capabilities. Consequently, this context can be used as a tool by governments, urban planners, etc. to evaluate their strategies and investors under similar uncertainty and sustainability conditions. In addition, governments can focus their efforts on finding resources or enhancing their capabilities for innovation-focused training and investments.

Although this study contributes meaningfully to the literature on decision-making and evaluation of smart mobility and logistics barriers and facilitators, there are some limitations. For instance, the evaluation process was based only on expert opinions, which may affect the objectivity of the results. Also, this expert group may affect the robustness and generalizability of the results to many socioeconomic or local circumstances. Moreover, expanding the expert team and choosing from different research areas could also strengthen the assessment process. Additionally, growing the set of criteria would further progress the context and support a more holistic assessment.

This study includes significant directions for future studies. Future research could explore the use of other MCDM approaches and expand the criteria set to contain a broader range of factors, possibly including empirical data to improve the robustness of the results. This condition will provide a more comprehensive background for evaluation and the decision-making process. The suggested methodology can be extended to other related research areas, such as smart mobility and logistics applications, or strategies evaluation and selection process. These directions will further develop the pertinency and strength of the methodology and contribute to reaching more sustainable cities and communities.

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