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Selecting a bus terminal location in Uşak, Turkey, using a hybrid multicriteria decision-making model

The location of a bus terminal is crucial for efficient urban transportation and sustainable urban mobility. The location determines visitors' access to the city and safe, accessible, and economical transportation options. It also affects residents' access to employment, education, and health services and their efficiency, shaping the city's overall socioeconomic wellbeing. This study determines the optimal location for a new bus terminal in Uşak, Turkey, considering efficient operation of the city's transportation systems. The methodology employs a hybrid multicriteria decision-making model that evaluates twenty criteria, integrates the needs of residents and local authorities, and draws on urban transportation planning expertise for a comprehensive assessment of accessibility. The AHP method was used to assign weights to twenty evaluation criteria, and seven alternative areas were ranked using the MOOSRA, ARAS, and VIKOR methods. The findings revealed the most suitable location, demonstrating the robustness of the model and its applicability in urban planning.

Keywords: bus terminal, multicriteria analysis, location selection, MOOSRA, ARAS, VIKOR

1 Introduction

Bus terminals are key components of national, regional, and local transportation systems, where passengers transfer between services (Rodrigue, 2024). Their planning should reflect their critical importance in transportation networks and connectivity, as well as the added value they create as vital urban spaces. Bus terminals are more than just terminals for urban transportation (Sun et al., 2017).

These facilities are key points where passengers transfer between various types of bus lines (Curzel et al., 2019). They are important mobility points, where access for vehicles, pedestrians, and bicyclists is critical for the public transport network (Munir et al., 2024). Bus terminals have also emerged as integrated urban elements that influence spatial organization and social interaction. They function as catalysts for place-making and contribute to shaping the urban fabric (Vigneau, 2019).

In today's rapidly urbanizing cities, transportation and mobility policies have become integral to urban planning, alongside land uses such as housing, workplaces, education, and public facilities. The location of bus terminals is therefore a key planning decision that affects traffic performance, network efficiency, and the overall dynamics of urban development (Ayuningtyas et al., 2019).

Selecting an appropriate location for a bus terminal is a complex yet critical task. Although various approaches have been proposed, the application of multicriteria decision-making (MCDM) methods remains relatively limited. This is a significant gap because MCDM is particularly well suited for decisions involving multiple, often conflicting, criteria. As noted by Nedeljković (2023), location selection is influenced by both quantitative data and qualitative factors, which MCDM methods can effectively integrate. Similarly, Chakraborty et al. (2013) emphasize that MCDM provides a robust framework for addressing complex facility location problems that require balancing competing priorities.

Standard MCDM methods have inherent limitations in addressing complex and interrelated decision criteria, which often limit the accuracy and robustness of the results. Hybrid MCDM is an integrated decision-support approach combining two or more MCDM techniques to overcome the limitations of a single method, improving the accuracy, robustness, and interpretability of results (Poklepović & Babić, 2014). Adopting a hybrid MCDM framework provides a more comprehensive and reliable basis for evaluating bus terminal locations. Systematic integration of quantitative data and qualitative judgments ensures a data-driven, context-sensitive, and analytically balanced evaluation, allowing more precise weighting of criteria and consistent ranking of alternatives within a multidimensional context (Xu et al., 2024).

This study was conducted as part of the location selection project for the Uşak bus terminal together with the Uşak district. The study evaluates and determines the most appropriate site for Uşak's bus terminal using MCDM methods. It is postulated that integrating a hybrid MCDM approach will enhance analytical robustness and methodological reliability, thereby more effectively identifying the optimal terminal location.

Determining the optimal location of a vital infrastructure investment such as a bus terminal, together with assessing its interaction with the city's transportation axes, is highly complex. Such a decision cannot be made by depending solely on one person, decisionmaker, or method. Therefore, three different new and compromise solution methods are used.

Hybrid MCDM methods have proven effective in addressing various decision-making problems, but few studies improve existing techniques and integrate them. This article introduces a refined methodological framework that not only advances established MCDM approaches but also combines them into a coherent hybrid model. The framework is tested by selecting the location of the bus terminal, illustrating its practical applicability. The study contributes at two levels: methodologically, it enhances and integrates existing techniques into a novel hybrid approach, and empirically it demonstrates how this approach can be applied in a real-world case. Thus, this article is both an effort to extend the methodological toolkit and also a case-based demonstration of the effectiveness of hybrid MCDM applications.

Seven alternatives were evaluated to determine the optimal terminal location in Uşak's city centre. Results from three different methods were compared to select the best site. The Uşak district then reviewed the findings and started building the terminal. This study is significant and original because it moves beyond theoretical analysis to practical implementation.

Cities are systemic structures composed of many subsystems. Almost all urban subsystems (e.g., business, shopping, education, health, recreation, administration, industry, and residential) are linked and interact with each other. Their dynamic land-use typologies form a multidimensional and complex urban structure shaped by demographic, social, economic, administrative, natural, and spatial dynamics. Integrating these subsystems depends largely on the urban transportation network for accessibility. Because land use and transportation systems are mutually dependent, each land-use type generates specific travel needs. As transportation quality and accessibility improve, spatial value increases, leading to changes in land use. This interaction emphasizes the necessity for holistic and strategic spatial planning to achieve coherent and sustainable urban development (Oliveira & Hersperger, 2018; Hersperger et al., 2019).

Intercity transportation strengthens the interaction between different land uses by linking cities with surrounding towns and villages. Bus terminals are essential components of this system, acting as key nodes for intercity and intracity transportation. These terminals should be accessible, safe, flexible, and efficient. Ideally, they should be integrated with other transportation modes (e.g., air, rail, bicycle, and pedestrian) as well as green networks, creating a holistic urban mobility structure. As convergence points, bus terminals are vital for efficient transportation systems (Arifa & Sholahuddin, 2022). As key transit network hubs, their strategic location and design greatly influence urban development and economic growth in surrounding areas (Memon et al., 2023; Abdullah et al., 2019).

Because terminal areas drive the flow of people, goods, and traffic at urban and inter-urban scales, they have strong productive qualities. In addition to facilitating mobility, they are catalysts for economic and spatial integration, generating employment and jobs (Mello & Silva, 2021). Their spatial and functional characteristics influence surrounding land uses, reinforcing their capacity to attract or repel activities depending on their scale and structure.

As a general principle, terminals must be 1) places of movement providing urban access through effective planning and management; 2) associated with public spaces; 3) considered "good places" for the public; 4) places where people gather, serving as meeting points for public transport and pedestrian–vehicle interaction; 5) interactive for sectors such as industry, trade, and tourism; 6) connected with residential areas and pedestrian/bicycle spaces; 7) connected with other modes; 8) waiting and transition areas for passengers and vehicles; and 9) safe, secure, and comfortable.

In short, bus terminals are critical components of urban mobility and transportation infrastructure. They are dynamic and high-intensity nodes allowing the interaction of multiple transport modes, contributing significantly to the spatial organization and place-making of urban environments (Zhang et al., 2022; Lindberg et al., 2021).

2 Materials and methods

This study proposes an innovative hybrid MCDM model that combines the AHP (analytical hierarchy process), MOOSRA (multi-objective optimization by simple ratio analysis), ARAS (additive ratio assessment), and VIKOR (Srb. *višekriterijumska optimizacija i kompromisno rešenje* 'multicriteria optimization and compromise solution') methods to determine the most suitable location for the bus terminal. Because the number of examples in the literature with similar techniques used together is limited, this adds to this study's innovativeness. The goal of the hybrid model is to select the optimum location for the bus terminal (Figure 1). The hybrid MCDM model was chosen for its advantages and ability to combine multiple methods effectively.

In the first stage of the model, the AHP method is used to compare criteria in pairs to establish priorities, providing a logical basis for determining their weights (Iswari et al., 2019; Nguyen, 2023). Integrating AHP with other MCDM methods improves their reliability by providing a structured approach to weight determination. In land-suitability assessments, AHP makes possible nuanced pairwise comparisons that reduce bias and enhance result validity (Subiyanto et al., 2018). Its ability to convert qualitative judgments into quantitative weights allows a more comprehensive evaluation of alternatives (Yumoto, 2019). These weights, reflecting the relative importance of each criterion, serve as key inputs for the MOOSRA, ARAS, and VIKOR methods in MCDM to select the optimum bus terminal location.

A key feature of the MOOSRA method is its ability to address both beneficial and non-beneficial criteria through a direct ratio analysis (Ulutaş et al., 2021). This approach simplifies decision-making and reduces the influence of negative values that can skew the results in other MCDM methods. The MOOSRA method has been compared favourably with other MCDM techniques and has often yielded similar or superior results in ranking alternatives (Jagadish & Ray, 2014).

The ARAS method calculates a utility function value for each alternative that directly corresponds to the criteria's values and weights (Ecemiş & Coşkun, 2022). This feature is crucial because it maximizes the utility function while addressing the different measurement scales of the criteria, thus correcting for inconsistencies arising from varied measurement units (Zavadskas et al., 2023). When evaluating alternatives, ARAS simplifies complex decision-making scenarios, generating clear rankings by highlighting alternatives that perform better against established benchmarks (Liao et al., 2019). The ARAS method has proven effective in various applications, including mobile game selection based on user preferences and evaluating corporate social responsibility criteria (Meidelfi et al., 2022).

Central to the VIKOR method is the capability to balance the trade-off between maximizing group benefits and minimizing individual regrets. This provides decisionmakers with

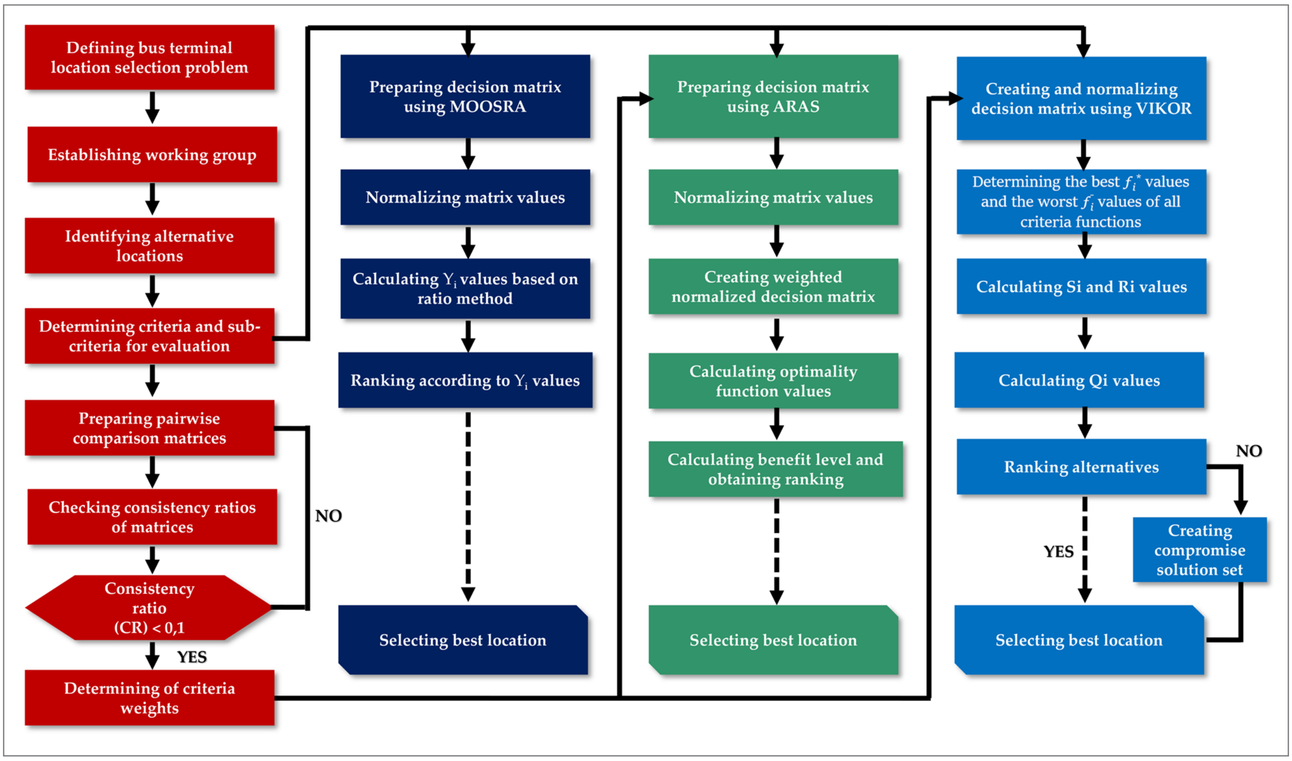

Figure 1: The basic network structure of the hybrid MCDM model used (source: authors).

compromise solutions that are more likely to be accepted by stakeholders (Elsotohy et al., 2023; Effatpanah et al., 2022). The VIKOR method has been effectively applied in diverse contexts, such as supplier selection in the nuclear power industry (Wu et al., 2016), vaccine selection during the COVID-19 pandemic (Öztürk et al., 2021), and optimization of welding parameters (Meikeerthy & Ethiraj, 2024). More information about each method can be found in the appendix (only available in the online version of the article).

2.1 Formation of the working group

A working group of managers and experts was formed to select the new bus terminal area. The primary objective was to ensure research-based and systematically organized decision making by combining the practical experience of city administrators with the academic expertise of specialists. The aim of including senior managers and department managers in the Uşak district was to increase the effectiveness of the decision-making. The group consisted of three senior managers, four department managers, and three expert academicians. The decisionmakers' work experience ranged from eight to thirty years, their ages ranged from thirty to fifty-two, and all had at least a bachelor's degree.

The district initially proposed several potential areas, including vacant land, public property, and other sites, which were examined by the working group. Its members conducted literature reviews and collected detailed data on successful bus terminal projects worldwide and in Turkey to guide the location selection. The information collected was evaluated within a framework compatible with the study's criteria. Based on the group's expertise and understanding of the city's spatial, infrastructural, and environmental characteristics, seven alternative locations were identified.

2.2 Determination of alternatives

Uşak is located in western Turkey, between Central Anatolia and the Aegean Region (Figure 2). The province of Uşak has six districts: Banaz, Eşme, Karahallı, Sivaslı, Ulubey, and Uşak. Uşak's city centre had a population of 236,366 in 2022 (Turkish Statistical Institute, 2023).

Field studies were carried out directly by the authors to determine the current land use and spatial structure of Uşak. The information collected then underwent a geographical information system (GIS) analysis, based on which the area' land use was updated in November 2023 (Figure 3). The study area covers 11,132 hectares and its boundaries are based on current zoning plans. Agricultural, water, and wooded areas constitute 44.52% of the area, and residential areas 14.41%. Roads comprise approximately 11.64%. The current bus terminal area is 2.32 hectares. Accordingly, the gross density of the city is 60 to 70 people per hectare, referring to the entire built-up urban area.

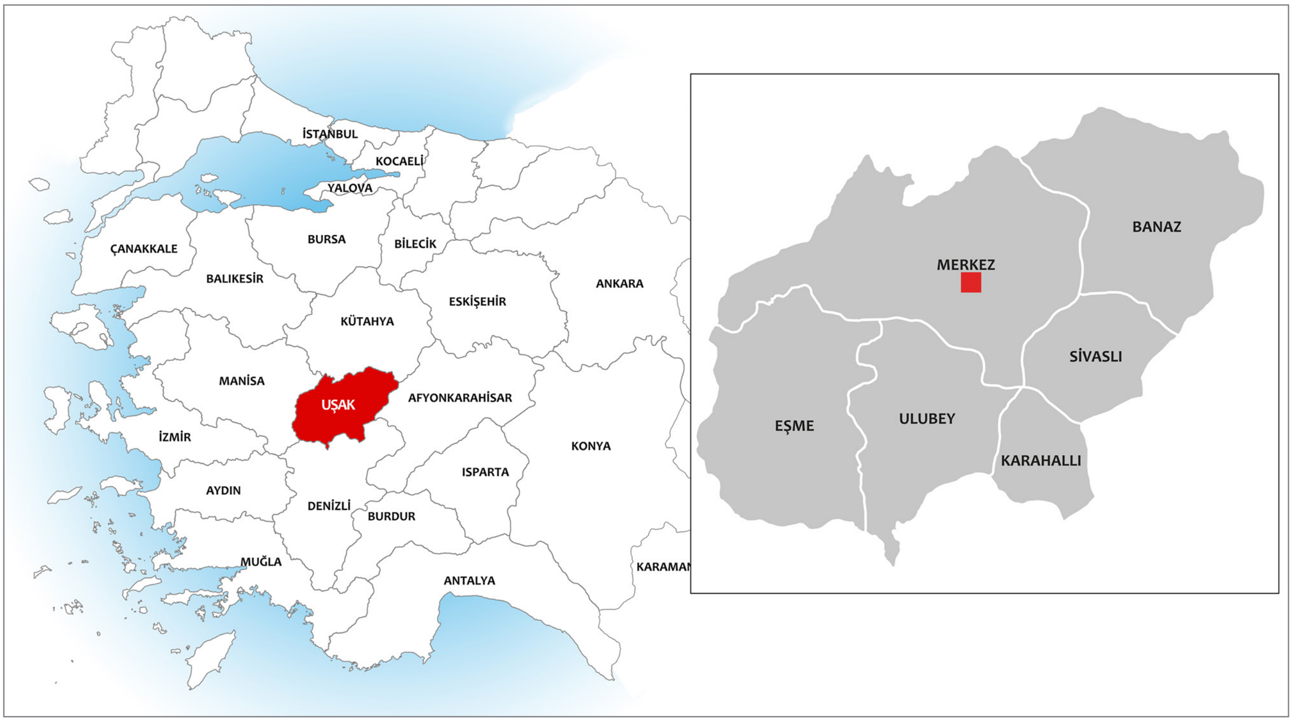

Figure 2: Location of Uşak (source: authors).

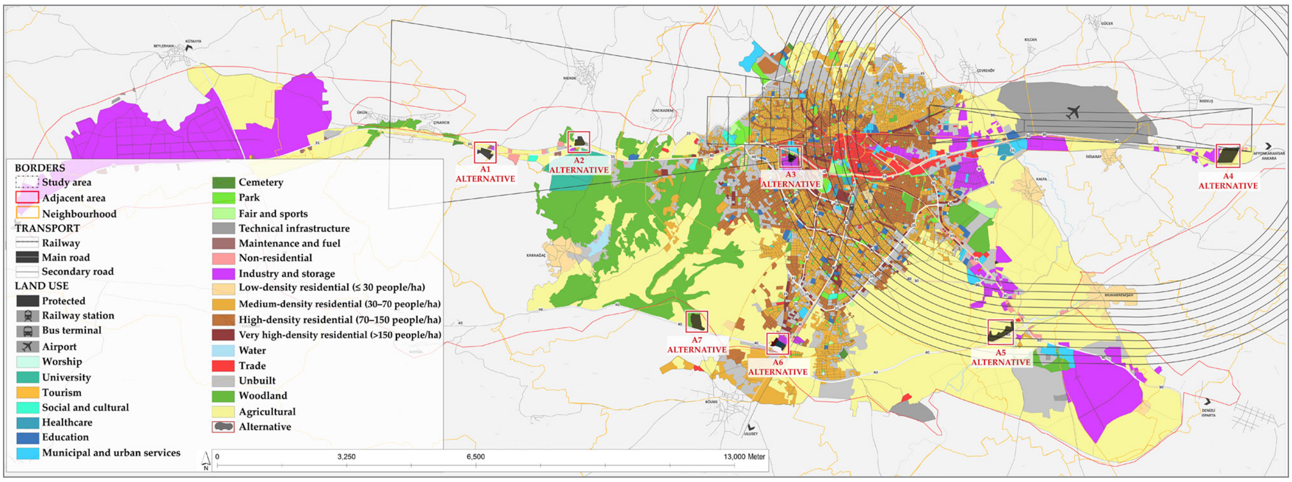

Figure 3: Land use in Uşak in November 2023 and possible bus terminal locations (illustration: authors, based on Uşak district GIS data and Google Maps).

Based on previous district assessments and the evaluations by the working group, seven alternative locations were identified. The locations considered are close to the city centre of Uşak (Figure 4).

The first university location (Figure 4a) has an area of 5.6 hectares and is 9.3 km from the city centre. It is on the road to the university and 2.5 km from it. The location is public property in a rural area surrounded by agricultural land and lacks developed infrastructure, but it includes reserve areas suitable for future development. It only provides a connection to the city centre. There is currently no public transportation to the area.

The second university location (Figure 4b) has an area of 4.9 hectares and is 7.0 km from the city centre. It is located on the road to the university, directly across from the campus, and has adequate infrastructure. There are no residential areas nearby, but the location is surrounded by developable reserve land. The land is privately owned and has access to the public transportation line serving the university campus.

The current terminal location (Figure 4c) has an area of 2.3 hectares. The terminal is in the city centre, with high traffic density and inefficient intersections. The terminal faces significant challenges for manoeuvring vehicles, and it is outdated

Figure 4: Alternative locations: a) university (Alternative 1); b) university (Alternative 2); c) current bus terminal (Alternative 3); d) airport (Alternative 4); e) Çanlı Bridge (Alternative 5); f) Ulubey Road (Alternative 6); g) west of the Ulubey junction (Alternative 7; illustration: authors, based on Google Maps).

and insufficient. Although reconstructing a new terminal at the exact location might seem cost effective, this would require resolving major infrastructure issues, realigning key roads, and expropriating nearby small industrial units to expand the area. A significant drawback is that incoming bus traffic must pass through the city centre to reach the terminal, exacerbating traffic congestion on main corridors and straining transportation. The location lacks direct integration with the railway network, but it remains a critical transportation hub with robust public transit connections. It is publicly owned.

The airport location (Figure 4d) has an area of 14.6 hectares and is 9.4 km from the city centre. There are industrial and storage facilities nearby, and the open sides of the area are surrounded by reserve areas suitable for development. The area is currently used as agricultural land. It is located on Ankara Road at the intersection with the southern ring road, which is under construction. The area, which is directly adjacent to the railway and the airport, is zoned for commercial activity is expected to become an industrialized region (Uşak District, 2021). The area is publicly owned and cannot be accessed by public transportation.

The Çanlı Bridge location (Figure 4e) has an area of 10.8 hectares and is 7.1 km from the city centre. It is opposite the Çanlı Bridge, at the junction with Sivaslı Road. It is an undeveloped area surrounded by agricultural land. This strategic transportation node is on the route from Isparta to Denizli and directly adjacent to the southern ring road. The area's sloping topography would make construction of the bus terminal relatively costly, requiring additional excavation, grading, and stabilization. The area is mainly publicly owned and is accessible by public transportation.

Table 1: Evaluation criteria for location selection.

Category, code, and criterion	Method, data source
Land use and environmental impact	
C1: Spatial plan compliance	Examination of zoning plans (Uşak District, 2021)
C2: Usable area	Land-use analysis
C3: Distance to centre	GIS point density analysis
C4: Topography	Slope analysis to assess terrain suitability
C5: Disaster risk	Analysis using AFAD (2021) data
Economic and social factors	
C6: Project costs, infrastructure constraints	Project cost estimate (land acquisition, technical/environmental factors)
C7: Investment attraction potential	Current/potential investment review; local government interviews
Transportation and mobility	
C8: Road width	Analysis based on land-use data
C9: Daily access route traffic volume	Vehicle counts for all vehicle types
C10: Daily access route bus volume	Counts and route data from existing bus terminal
C11: Road safety	Analysis of accident hotspot map
C12: Distance to closest intersection	Measured from land-use data using GIS
C13: Distance to rail	Shortest network travel distance calculated using land-use data
C14: Distance to high-speed train	Closest distance to the high-speed train project
C15: Distance to airport	Shortest network travel distance calculated using land-use data
C16: Distance to public transport	GIS analysis using data from Uşak Directorate of Transportation Services
C17: Pedestrian/bicycle accessibility	Analysed using accessibility data from land-use and transportation studies
C18: Distance to university	Analysed using GIS point density
C19: Distance to industrial zone	Shortest network distance calculated using land-use data
C20: Proximity to residential area	Analysed using GIS point density

The Ulubey Road location (Figure 4f) has an area of 4.9 hectares and is 4.7 km from the city centre. It is directly adjacent to the Ulubey junction on the road to the Ulubey district and the southern ring road. This is an important transportation node with the potential for access to the city from all directions. Currently, the area is a commercial area, district service area, and unbuilt area, suitable for development to the east. This area has advanced infrastructure facilities, and it has been zoned as a cultural facility and urban service area (Uşak District, 2021). The area is also close to planned dense residential development areas to the south and southeast. The area is publicly owned and well connected to public transportation. Adjacency to the railway from the east would allow the bus terminal to operate as an integrated transfer station with an additional railway line.

The location west of the Ulubey junction (Figure 4g) has an area of 7.8 hectares and is 7.0 km from the city centre. It is 2.5 km west of the Ulubey junction and faces the southern ring road. This is a critical transportation node with the potential for access to the city from all directions with the completion of the southern ring road. It is currently an agricultural area with slopes on three sides. If a bus terminal is built in the area, infrastructure will need to be built. In addition, effective operation would require a north–south primary connection between the highway from Ankara to İzmir and the southern ring road close to the city centre. The district partially owns the area, which currently does not have a connection to public transportation lines.

2.3 Determination of criteria

A comprehensive literature review was first conducted to identify the relevant criteria for selecting the location of the bus terminal. Its findings are summarized below.

One essential criterion is spatial proximity to population centres and other transport facilities. Roquel et al. (2021) underscore the importance of evaluating the distance between bus terminals and high-demand areas such as residential zones, commercial centres, and transit routes. Proximity facilitates access for passengers and promotes reliance on public transport. Koblar and Mladenovič (2020) stress approaches that encourage compact, mixed-use urban areas, improving efficiency and user experiences. Bus terminals should ensure effective multimodal integration by providing seamless connections to rail, pedestrian, and cycling networks (Abdullah et al., 2019). This connectivity enhances mobility and accessibility (Taghavi et al., 2021).

The location of bus terminals has significant implications for land use and the surrounding environment. Integrating environmental sustainability into planning has become an indispensable aspect of urban planning. Studies emphasize the need to consider both ecological and economic dimensions when selecting a terminal location (Tuames & Widyastuti, 2020; Memon et al., 2023). Bus terminals exert influence beyond the transportation sector, serving as economic and social hubs. Integrating terminals with commercial areas increases their value as nodes of trade and tourism while also transforming surrounding public spaces into "good places" for social interactions (Abdullah et al., 2019). Bus terminals should not be regarded merely as mobility and transport infrastructure. Rather, they must be understood as vibrant, dense, and continuously utilized urban nodes – key elements in the interaction of urban modes and the creation of "good places."

Like previous research, which has systematically examined a wide range of spatial, environmental, economic, and social factors, this study also sought to establish an extensive set of potential criteria. Initially, sixty criteria were identified, and detailed evaluations by the working group refined the list to twenty criteria most essential for decision-making. This participatory approach enhanced the contextual relevance of the criteria and strengthened the practical applicability of the location selection approach.

The twenty finalized criteria were classified into three main categories: 1) land use and environmental impact, 2) economic and social factors, and 3) transportation and mobility. This reflects not only the theoretical foundations of the criteria but also their practical significance.

The methodological framework adopted in this study is a multistage elimination process by the working group, integrating a literature review and expert evaluation. Table 1 presents a detailed list of the criteria along with the data sources.

3 Results

3.1 Criteria weights determined by AHP

In applying the AHP method, the twenty criteria were evaluated through pairwise comparison, based on which a comparison matrix was created. Then the matrix was normalized and the criteria weights were calculated. The weights obtained express the general priority levels of the criteria. The consistency rate was calculated to evaluate the reliability of the analysis, and it was determined that the consistency rate was below 10% (0.092377). Therefore, the study was valid and reliable. Table 2 presents the criterion weights determined by the AHP, along with the twenty criteria and their values used in the decision matrices of the ARAS, MOOSRA, and VIKOR methods.

Based on the weights assigned, the category Transportation and Mobility ranked first with 0.542 points, and the category Land Use and Environmental Impact ranked second with 0.339 points. The criteria that received the highest weight in the AHP analysis were Disaster Risk, Usable Area, Distance to Residential Area, Project Cost and Infrastructure Constraints, and Distance to Public Transport. These factors were considered the most critical.

3.2 MOOSRA selection

To apply the MOOSRA method, the data in Table 2 were normalized by first calculating the sum of squares for each column, taking their square roots, and then dividing each value by the corresponding column's square root. Next, the AHP weights were multiplied by the normalized values to form the weighted normalized decision matrix. Beneficial and non-beneficial criteria were then separated (the criteria marked † in Table 2 representing non-beneficial ones) and their sums calculated. This categorization produced the results shown in Table 3.

Finally, alternatives were ranked by performance values, with higher values indicating better suitability. The ranking revealed that Alternative 6 (Ulubey Road) ranked first, followed by Alternative 3 (current bus terminal) and Alternative 2 (second university location; Table 3).

Table 2: Criterion weights determined by AHP and the decision matrix.

Category, code, and criterion	Alternatives							Weight
	1	2	3	4	5	6	7	
Land use and environmental impact								
C1: Spatial plan compliance (Likert)	2	3	5	2	3	3	1	0.035
C2: Usable area (ha)	5.6	6.4	2.3	14.6	10.8	4.9	6.4	0.121
C3†: Distance to centre (km)	10.7	8.3	3.3	10.0	6.8	7.7	8.2	0.013
C4: Topography (Likert)	3	5	1	3	2	5	3	0.048
C5: Disaster risk (Likert)	5	5	1	2	3	5	5	0.122
Economic and social factors								
C6†: Project costs (Likert)	5	3	3	5	3	2	5	0.106
C7: Investment attraction potential (Likert)	1	5	1	2	3	5	2	0.014
Transportation and mobility								
C8: Road width (m)	35	35	50	30	40	30	40	0.027
C9†: Traffic volume (daily number of vehicles)	30,568	30,568	33,176	17,667	2,052	16,146	3,250	0.041
C10: Bus volume (daily number)	264	264	800	543	30	80	20	0.042
C11: Road safety (Likert)	5	5	1	5	3	3	5	0.013
C12†: Distance to intersection (km)	4.6	2.3	0.1	2.8	0.5	0.2	2.0	0.031
C13†: Distance to rail (km)	12.0	7.5	2.2	0.2	6.7	0.2	2.1	0.062
C14†: Distance to high-speed train (km)	22.0	17.4	14.0	17.0	11.0	8.0	9.5	0.044
C15†: Distance to airport (km)	16.0	13.6	8.4	3.6	10.0	11.0	13.3	0.015
C16†: Distance to public transport (km)	9.5	7.1	2.9	9.4	7.1	4.7	7.7	0.080
C17: Pedestrian/bicycle access (Likert)	1	2	5	1	2	3	1	0.053
C18†: Distance to university (km)	5.1	0.5	6	17.5	18.7	10.2	8.6	0.011
C19†: Distance to industrial zone (km)	6.0	8.5	13.8	24.7	21.4	15.6	13.6	0.007
C20†: Distance to residential area (km)	10.1	7.6	2.6	9.7	8.2	5.8	8.2	0.116

Note: A five-point Likert scale was used (1 = very low, 5 = very high). Criteria marked † were used in the minimization / cost case phase, and the others were used in the maximization / benefit case phase (for calculating Y_i values).

3.3 ARAS selection

The ARAS analysis evaluated the scores for the alternatives based on the criteria. Because the optimal values were not fully represented, the benefit or cost nature of each criterion was defined to calculate optimal values. To ensure comparability and eliminate unit effects, normalization was performed considering the benefit–cost characteristics of the criteria, producing the normalized decision matrix. The AHP weights were then multiplied by these normalized values to obtain the weighted normalized decision matrix.

Table 3: Ranking of alternatives according to MOOSRA.

Alternative	Y_i	Ranking
1	0.533607	7
2	0.924436	3
3	1.079570	2
4	0.848516	5
5	0.922459	4
6	1.612323	1
7	0.810362	6

Table 4: Optimality function values and alternative rankings.

Alternative	S_i	K_i	$\%K_i$
Optimal	0.241804892		
1	0.080000154	0.330845888	33.08
2	0.093320829	0.385934414	38.59
3	0.133164547	0.550710725	55.07
4	0.096110390	0.397470827	39.75
5	0.100526268	0.415732980	41.57
6	0.168023970	0.694874154	69.49
7	0.08804895	0.36413221	36.41

Table 5: The best f_i^* and the worst f_i^- values.

Code	f_i^*	f_i^-
C1	5	1
C2	491	56
C3	10	107
C4	5	1
C5	5	1
C6	2	5
C7	5	1
C8	50	30
C9	2052	33176
C10	800	20
C11	5	1
C12	2	46
C13	2	75
C14	8	174
C15	10	136
C16	29	95
C17	5	1
C18	5	187
C19	6	247
C20	26	101

Table 6: *S*, *R*, and *Q* values and ranking.

Alternative	S_i	R_i	Q_i
6	0.212373937	0.049493333	0.000000000
3	0.443452258	0.122000000	0.737771710
5	0.585031914	0.106535632	0.776811340
2	0.574150026	0.118774713	0.850013938
7	0.621309110	0.118774713	0.898539027
4	0.698298696	0.109813333	0.915961751
1	0.686624490	0.121000000	0.981091723

Table 7: Comparison of MOOSRA, ARAS, and VIKOR results.

Alternative	MOOSRA	ARAS	VIKOR	General ranking
1	7	7	7	Weak
2	3	5	4	Medium
3	2	2	2	Strong
4	5	4	6	Weak
5	4	3	3	Medium
6	1	1	1	Most suitable
7	6	6	5	Weak

Subsequently, optimality function values for each alternative were computed and converted into S_i and K_i scores, presented with rankings in Table 4. According to the ARAS analysis results, the most suitable area for the bus terminal location was Alternative 6 (Ulubey Road), which was close to optimal. Alternative 3 (current bus terminal) was in second place and Alternative 5 (Çanlı Bridge) in third.

3.4 VIKOR selection

In the VIKOR method, the decision matrix (Table 2) was normalized to ensure comparability among criteria, resulting in a weighted normalized matrix. Ideal (best f_i^*) and anti-ideal (worst f_i^-) values were determined for each evaluation criterion (Table 5), after which S_i and R_i values were calculated for the seven alternatives. The weight values from the AHP calculations in the previous stage were used at this stage. After obtaining S_i and R_i values, the Q_i values were calculated. The v value in the equation was 0.5, as in the study by Opricović and Tzeng (2004). The best alternative in the VIKOR method rankings has the smallest numerical value. The final rankings after obtaining the *S*, *R*, and *Q* values are presented in Table 6.

After obtaining the rankings, Condition 1 (acceptable advantage) and Condition 2 (acceptable stability in decision making) were tested to obtain a compromise solution. To test Condition 1, the inequality $Q(a'') - Q(a') \geq DQ$ must be checked. The DQ value in this equation is 0.16. If the value is greater than 0.16, alternative a' satisfies Condition 1. To test Condition 2, the best alternative based on the *Q* value (Alternative 6) must also hold the top *R* or *S* rankings. Because Alternative 6 ranks first in both *R* and *S* rankings, Condition 2 is met.

3.5 Comparison of results

To provide a more systematic overview, the results obtained from three different methods were compared (Table 7).

As seen in the table, all three methods consistently identified Alternative 6 (Ulubey Road) as the optimal site. This strong convergence indicates the robustness of the hybrid model and its ability to generate reliable, replicable results. Moreover, the outcome is reinforced by case-based evidence: Alternative 6 is strategically positioned near the southern ring road, directly adjacent to the railway line, and supported by the Uşak district's ongoing infrastructure investments. This integration of model-based results with practical planning realities confirms the validity of the findings.

4 Discussion

The hybrid MCDM model proposed in this study offers a systematic and analytical framework that assists decisionmakers in addressing complex, real-world problems. Incorporating stakeholders' diverse perspectives ensures that decisions are balanced and rational. The model's applicability is illustrated by the selection of the bus terminal location. The hybrid MCDM model selected Alternative 6 (Ulubey Road) as most suitable. This location is in an industrial zone between the Uşak railway line and the future Uşak ring road. The location can be connected to nearby main roads and junctions. Although the land is currently unused, zoning plans would change depending on future land-use decisions. Compared to other locations, Alternative 6 is the least sensitive regarding social and environmental issues. In addition, investment costs would be more affordable than in other locations.

The hybrid model employed in this study proved effective in handling complex decision-making by integrating both quantitative and qualitative dimensions. The findings indicate that Alternative 6 consistently achieved the highest ranking across all three methods. This outcome is primarily attributed to the site's advantageous accessibility, its compatibility with existing and planned land uses, and its strong potential for integration with future transportation corridors.

This study was carried out as part of the project for selecting the location of the Uşak bus terminal in cooperation with the Uşak district. When the project was completed, Alternative 6 was selected as a suitable location based on evaluations by the Uşak district. In line with this selection, construction of the new bus terminal in this area was started in 2024. This is an important indication that the research is not merely theoretical but also has practical applicability. In addition, the project's transformation into concrete implementation proves the validity and potential of the location selection model.

The study makes contributions to both theory and practice. From a theoretical perspective, it enriches MCDM literature by presenting a hybrid model that combines four methods in a complementary way. Although individual applications of AHP, MOOSRA, ARAS, and VIKOR are common, integrating them into a coherent framework for selecting a terminal location is a methodological innovation. The study also empirically validates the argument that hybrid models enhance decision robustness compared to single-method approaches. From a practical perspective, the research demonstrates the applicability of hybrid MCDM tools in real-world urban planning. The fact that district authorities relied on the results for policy implementation illustrates the potential of such models to bridge the gap between academic analysis and urban governance.

Nevertheless, the study has certain limitations. The analysis was restricted to seven possible locations and twenty criteria, which, although comprehensive, did not capture all qualitative aspects, such as passenger satisfaction, community acceptance, and user experience. Rather than adopting a static perspective, the study was conducted in line with existing upper- and lower-scale urban development plans. Accordingly, the analysis was bounded by Uşak's spatial and policy framework, which meant that long-term demographic shifts, future urban expansion, and climate-related risks were not explicitly modelled but were indirectly reflected through the planning framework.

Future research may overcome these limitations by enhancing stakeholder participation through structured approaches such as Delphi, SWOT, TOWS, or SOAR analyses (Cole et al., 2022; Ju & Kim, 2023; Lee et al., 2025). Incorporating dynamic weighting schemes that capture the varying influence of different actors would also improve the robustness of decision outcomes. In addition, integrating the hybrid MCDM framework with complementary tools – such as simulation modelling, network analysis, and GIS – could increase its capacity to address allocation and optimization problems involving multiple intermodal terminals. These methodological extensions would broaden the model's applicability and reinforce its relevance for contemporary issues in transportation and mobility planning, including intermodal network design, technology assessment, distribution management, and transport policy formulation.

5 Conclusion

The study identifies the Ulubey Road site as the optimal location for the bus terminal and makes a methodological contribution by refining hybrid MCDM models as well as a practical contribution by influencing city decision-making. By synthesizing empirical findings with theoretical insights and applied implications, the research demonstrates the potential of hybrid decision-support tools to promote integrated, sustainable, and forward-looking urban transportation planning.

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