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Pattern of pedestrian dissatisfaction on Heydarkhani Street, Narmak, Tehran

Original Article

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Abstract

The dominance of automobile-oriented approaches and the decline in the quality of urban micro-spaces, particularly in neighborhoods with a modernist design background such as Narmak, have weakened the walking experience and increased users' dissatisfaction with urban spaces. Walkability, as an effective approach in contemporary urban design, can play a significant role in improving the quality of urban environments. This study aims to identify patterns of users' dissatisfaction with pedestrian experiences and to prioritize physical interventions on Heydarkhani Street. Adjacent to the university and Elm-o-Sanat Metro Station, this street is one of the neighborhood's most heavily used corridors.

Using a descriptive-analytical research approach, the study was conducted based on data collected via a researcher-developed questionnaire featuring seven micro-spatial indicators, administered to 44 regular street users selected through convenience sampling. The collected data were analyzed through Spearman's correlation coefficient, K-means cluster analysis, multiple correspondence analysis (MCA), and decision-making models including the technique for order preference by similarity to ideal solution (TOPSIS) and importance-performance analysis (IPA).

The findings indicate significant positive correlations among all evaluated indicators (ranging from 0.48 to 0.72), suggesting a relatively integrated pattern in users' perception of dissatisfaction. Cluster analysis identified three user groups: highly dissatisfied users (32%), moderately dissatisfied users (54%), and slightly dissatisfied users (14%). Women were more prominent in the highly dissatisfied cluster. Furthermore, multiple correspondence analysis (MCA) revealed that the lack of shading elements and resting spaces represented the primary concerns among women, while inadequate cycling infrastructure was the major concern among young male users. TOPSIS and importance-performance analysis (IPA) identified access to cycling routes and the quality of resting spaces as immediate intervention priorities.

The findings show that improving walkability on Heydarkhani Street requires a systemic approach that considers users' perceptual differences and prioritizes the development of active mobility infrastructure and pedestrian resting spaces.

Keywords

Dissatisfaction pattern
Heydarkhani Street
Narmak
multiple correspondence analysis (MCA)
spatial prioritization
walkability

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1. Introduction

The excessive increase in automobiles in contemporary cities has not only reduced the quality of the urban environment but has also limited citizens' equal opportunities to benefit from public spaces (Southworth, 2005). In this context, walkability is recognized as a key element of sustainable urban development and public health promotion (Lee et al., 2019).

Heydarkhani Street in the Narmak neighborhood (District 4 of Tehran Municipality) is a prominent example of this challenge. Narmak, one of the areas developed upon modern plans in the 1960s and 1970s, initially had relatively appropriate standards in terms of access and green spaces. However, in recent decades, increased vehicular traffic, unsuitable urban furniture, reduced resting spaces, and inattention to climatic needs (especially in Tehran's hot and polluted conditions) have turned the walking experience on Heydarkhani Street—which daily hosts a high volume of students, university staff, and residents—into an unpleasant experience for many citizens. Hence, a systematic study of dissatisfaction across various aspects of this street and the identification of user dissatisfaction patterns can lead to effective and fair interventions.

Extensive international research has identified factors affecting walking satisfaction. These factors are generally summarized in six main dimensions: access and path continuity, safety and security, climatic and environmental comfort, quality and suitability of urban furniture, quality of resting spaces, and pollution conditions (Carmona et al., 2003; Ewing & Handy, 2009). Despite the diversity of dimensions in the literature, this study, focusing on the micro-spatial scale of the street and its objectives, selected only components that are directly measurable at the street scale and also have the potential for physical intervention by urban management. More recent studies have shown a significant correlation among various dimensions of walkability quality, and dissatisfaction with one component is often accompanied by dissatisfaction with other components; this indicates a relatively integrated perceptual pattern in user experience (Owais & Salah, 2026).

National-level research in Iranian cities, such as Tehran, Isfahan, and Shiraz, has primarily focused on prioritizing indicators from the perspective of citizens. A literature review shows limited use of cluster analysis methods, multiple correspondence analysis (MCA), and multi-criteria decision-making models (such as TOPSIS and IPA) in domestic studies, particularly when examining a single urban street.

Despite the expansion of walkability studies, several research gaps remain. First, most domestic research has been conducted at the regional or city scale and has paid less attention to micro-spatial analysis of a specific street. Second, perceptual differences among user groups, especially by gender and spatial usage patterns, have received less attention. Third, most studies have merely ranked indicators and have not combined multivariate analysis methods and decision-making models to explain dissatisfaction patterns and prioritize interventions.

The present study addresses these gaps by focusing on Heydarkhani Street in Narmak. The main objective of this research is to identify patterns of user dissatisfaction with pedestrian-oriented spaces on this street using multivariate analyses and to provide intervention priorities. The main question is whether user dissatisfaction with walkability quality on Heydarkhani Street results merely from weak independent physical components, or whether it is experienced as a relatively integrated perceptual pattern. Furthermore, which micro-spatial components should be prioritized in urban design interventions?

The innovation of this research can be explained in three dimensions:

1. Theoretical innovation: moving beyond the isolated view of spatial quality and providing preliminary evidence of a relatively integrated and cumulative perceptual pattern (spillover effect) in pedestrians' perception of dissatisfaction in Tehran's urban contexts.
2. Methodological innovation: The combined and simultaneous use of the exploratory power of geometric models (multiple correspondence analysis - MCA) to uncover hidden and gender-associated complaints, alongside matrix and decision-making models (TOPSIS algorithm and IPA quadrant analysis) for prioritizing physical interventions, which is considered a novel approach in the domestic literature of this field.
3. Practical innovation: formulating a roadmap for operational interventions based on micro-demographic differences (gender-sensitive design and movement patterns) instead of prescribing homogeneous solutions for all citizens.

Accordingly, the main hypothesis of the research is that dissatisfaction with walkability on Heydarkhani Street does not result merely from weak independent physical components, but is a reflection of the interaction among a set of micro-spatial indicators experienced as a relatively integrated perceptual pattern.

2. Literature review

Over the last two decades, the concept of walkability has moved beyond a purely physical indicator and become one of the most important interdisciplinary topics in urban design, transportation planning, public health, and environmental psychology. International studies show that the quality of pedestrian environments depends not only on physical infrastructure but also on complex interactions between physical characteristics, climatic conditions, user perception, quality of urban furniture, security, access, land use, and the social characteristics of the space. Therefore, walkability evaluation has shifted in recent years from one-dimensional approaches to multi-dimensional models based on user perception.

Early studies mainly focused on objective environmental dimensions, such as street network connectivity, density, land use mix, and access. However, recent research has shown that micro-spatial indicators such as the quality of resting spaces, climatic comfort, quality of urban furniture, perceived security, and active mobility facilities play a decisive role in shaping pedestrian satisfaction or dissatisfaction. Furthermore, recent studies emphasize perceptual differences among user groups, especially by gender and age, and have shown that the quality of the walking experience is not the same for all users and requires planning sensitive to social and demographic characteristics.

Accordingly, international research, in addition to developing walkability assessment indicators, has attempted to explain relationships among various components of the pedestrian environment, the pattern of user perception, and the prioritization of urban interventions. A review of these studies shows that while there is relative agreement on the dimensions of walkability, indicator selection depends on the research objective, study scale, and the physical characteristics of the study area.

Table 1. Findings from global studies

Author	Country	Research objective	Most important walkability indicators	Most important findings
Southworth (2005)	USA	Explaining the concept of walkability	Connectivity, safety, comfort, attractiveness	Walkability is a multidimensional concept.
Ewing & Handy (2009)	USA	Developing urban design indicators	Imageability, enclosure, human scale, transparency, complexity	Perceived environmental quality is more important than purely physical features.
Alfonzo (2005)	USA	Hierarchical model of walking decision	Access, safety, comfort, desirability	The decision to walk is a multi-stage process.
Frank et al. (2010)	Canada	Relationship between built environment and walking	Land use mix, density, connectivity	The physical environment directly affects the amount of walking.
Cerin et al. (2017)	14 World Cities	Comparing factors affecting walking	Security, aesthetics, services, access	User perception plays a decisive role in walking behavior.
Moura et al. (2017)	Portugal	Designing walkability indicators	Comfort, access, environmental quality	Micro-spatial indicators should be considered in evaluation.
Bivina et al. (2019)	India	Pedestrian satisfaction	Walkway quality, shade, furniture	Women are more sensitive to environmental quality.
Mazzulla et al.(2021)	Italy	Satisfaction with the pedestrian environment	Service quality, safety, comfort	Satisfaction is a function of both physical and perceptual factors.
Vale et al.(2022)	Portugal	Evaluating the pedestrian environment	Active transport, environmental quality	Developing active transport requires human-centered design.
Moura & Silva (2023)	Europe	Systematic review of walkability studies	Micro-spatial indicators, user perception	The new trend in studies emphasizes the quality of the perceptual indicators and walking experience.

In Iran, in recent years, along with increased attention to sustainable transport development and improved quality of public spaces, numerous studies have evaluated walkability and the quality of pedestrian environments. A major part of this research has focused on measuring physical indicators, evaluating sidewalk quality, analyzing user satisfaction, and prioritizing urban interventions. Despite their thematic diversity, most of these studies have used descriptive or indicator-based evaluation approaches and have rarely explored hidden relationships among walkability components or analyzed the perceptual pattern of user dissatisfaction.

Studies in Tehran, Tabriz, Ardabil, Shiraz, Mashhad, and Isfahan show that factors such as the quality of urban furniture, climatic comfort, safety, accessibility, continuity of pedestrian paths, quality of resting spaces, and environmental legibility are among the most important components affecting pedestrian satisfaction. These studies also indicate that weaknesses in micro-space design, lack of rest facilities, absence of shade, and inattention to the needs of different user groups are among the most important factors reducing the quality of the walking experience in Iran's urban spaces.

Despite their value, most studies are limited to the independent evaluation of indicators or ranking of factors and have rarely examined the internal structure of relationships among walkability indicators, users' perceptual differences, and the simultaneous prioritization of physical interventions within an integrated analytical framework.

Table 2. Findings from domestic studies

Research	Study area	Method	Most important finding
Abbaszadeh & Tamari (2013)	Tabriz	Analysis of walkability indicators	Environmental quality and urban furniture are the most important factors of user satisfaction.
Abizadeh (2023)	Ardabil	Walkability evaluation	Improving micro-space quality increases urban vitality.
Movahed et al.(2023)	Tehran	Analysis of sidewalk quality	Climatic comfort and furniture play an important role in environmental quality.
Habibi et al.(2018)	Tehran	Evaluating the pedestrian environment	Public space quality affects the level of citizen presence.
Hosseini et al.(2023)	Shiraz	Analysis of pedestrian satisfaction	Safety and accessibility are the most important factors of satisfaction.

A review of domestic and international studies shows that previous research has confirmed the role of numerous factors, including safety, environmental quality, climatic comfort, accessibility, urban furniture, bicycle paths, and public space quality, in promoting walkability. However, four research gaps remain in the literature. First, most studies have examined each walkability indicator independently and paid less attention to the internal relationships among these indicators and the possibility of a common perceptual pattern in the formation of pedestrian dissatisfaction.

Second, a major part of the studies has focused on ranking indicators or measuring satisfaction levels, while perceptual differences among different user groups, especially in terms of gender and spatial usage patterns, have been less analyzed. Third, although various tools have been developed to evaluate the quality of pedestrian environments, the simultaneous use of multivariate analysis methods and multi-criteria decision-making models to discover patterns of dissatisfaction and prioritize physical interventions remains limited.

Fourth, in the domestic literature, no research has been observed that simultaneously examines the pattern of dissatisfaction, perceptual differences of users, and prioritization of interventions at the micro-spatial scale of an urban street. Accordingly, this study aims to identify patterns of dissatisfaction with walking and explain the priority of physical interventions on Heydarkhani Street in Narmak by combining correlation analysis, clustering, multiple correspondence analysis, and multi-criteria decision-making models.

3. Theoretical foundations

3.1. Physical-environmental approach to walkability and micro-spatial quality

In recent decades, walkability has evolved from a purely physical concept to a key pillar in new urban planning paradigms such as smart growth, new urbanism, and transit-oriented development (Forsyth, 2015). As the most fundamental form of active mobility, walkability plays a catalytic role in promoting public health, reducing diseases, and strengthening social capital (Sallis et al., 2016). Southworth (2005) argues that a walkable environment, beyond the existence of a sidewalk, requires connectivity, land use diversity, and spatial legibility; an approach crystallized in the idea of complete streets, which assumes the street to be a democratic space for all users (Speck, 2012; Pucher & Buehler, 2012). Classic models such as the 3Ds also recognize density, diversity, and design as the main drivers of walking behavior, to which access to micro-destinations has now been added (Cervero & Kockelman, 1997; Ewing & Handy, 2009).

However, citizens' perception of these qualities is strongly influenced by micro-scale variables. According to Alfonzo's hierarchy of walking needs model (2005), the choice of walking behavior is a step-by-step process that requires feasibility, accessibility, safety, comfort, and ultimately attractiveness; without safety and comfort, aesthetic features lose their function (Pikora et al., 2003). Jan Gehl (2010) also asserts that urban vitality depends on the formation of optional and social activities, which only occurs when micro-spaces are equipped with standard furniture and inviting resting spaces; otherwise, the street degrades from an urban place to a mere transit space (Carmona et al., 2010; Mehta, 2008). Besides physical space, in metropolises like Tehran, microclimatic and environmental variables also play a decisive role. The concept of thermal perception shows that the presence of shade and air movement significantly increases the time citizens spend in open spaces (Nikolopoulou & Steemers, 2003; Eliasson et al., 2007), and conversely, the lack of climatic comfort combined with pollution distorts the aesthetic perception of space by creating environmental stress (Lai et al., 2014).

3.2. Social dynamics, cumulative pattern of dissatisfaction, and evaluation framework

The perception of urban environmental quality is not a homogeneous phenomenon, and the intersection of gender, age, and social roles forms distinct patterns of needs. The feminist urbanism school has proven that, due to trip-chaining and caregiving responsibilities, women are much more dependent on path continuity, quality of resting spaces, and furniture suitability (Beebeejaun, 2017; Orellana et al., 2016), and that lighting and defensible spaces are an absolute priority for them (Loukaitou-Sideris, 2014). In contrast, men's behavioral patterns often indicate a tendency for high-speed mobility and the use of cycling routes (Adeel et al., 2013; Yavuz & Welch, 2010). Domestic studies have also emphasized the difference in behavioral patterns and the necessity of paying attention to gender and generational needs in furniture design, resting spaces, and ensuring access and safety in Iranian cities (Naderi Kia & Khaliji, 2022; Golmakani et al., 2014; Niknam, 2023; Panahi & Norouzi, 2025). Furthermore, the lack of resting and semi-public spaces has been identified as the main factor for weak user behavioral interaction and reduced place attachment (Haghani & Majidi Hatkehlouei, 2021), and the one-dimensional design of axes without considering all stakeholders leads to negative economic and traffic consequences (Abizadeh, 2023).

These spatial deficiencies and perceptual differences are not evaluated separately in users'minds; rather, environmental qualities have an accumulative nature (Marans, 2003; Fleury-Bahi et al., 2008). Based on the spillover effect, a severe physical defect reduces the individual's psychological tolerance threshold for other defects and leads to a unified negative evaluation (Fornara et al., 2010). This condition is known as a single-factor or systemic structure of dissatisfaction (Mouratidis, 2021). Research conducted in neighborhoods and streets of Iranian cities (such as Tehran, Isfahan, Mashhad, Gorgan, and Ilam) also confirms this systemic structure, such that there is a high correlation among perceptual, physical, climatic, and safety dimensions, and improving walkability quality depends on the simultaneous improvement of all these components (Rezaei & Sheikhi, 2017; Esmaeili & Karami, 2020; Karami & Abbasiyeh, 2021; Siami et al., 2022).

To accurately analyze this pattern of dissatisfaction and avoid common biases that assume society is homogeneous, advanced decision-making models are necessary. In this regard, multiple correspondence analysis (MCA) allows for discovering geometric patterns and co-occurrences between demographic variables and environmental complaints (Abdi & Valentin, 2007; Greenacre, 2017). K-means cluster analysis also divides respondents into distinct clusters based on dissatisfaction intensity (MacQueen, 1967; Birenboim et al., 2013). Finally, to translate perceptual findings into executive priorities, the combination of importance-performance analysis (IPA) with the TOPSIS algorithm measures options based on importance, performance, and distance from the ideal solution, providing the most accurate roadmap for physical interventions (Martilla & James, 1977; Hwang & Yoon, 1981; Awasthi et al., 2011; Mulyadi et al., 2023).

3.3. Systematic process of extracting and refining walkability indicators

Despite the diversity of indicators introduced in the literature, no complete consensus exists on a unified set of components constituting walkability. The reason for this is the dependence of indicators on the research objective, study scale, physical characteristics of the environment, and user type. Therefore, in this study, rather than simply selecting indicators, we implemented a systematic process to extract and refine components from existing literature.

First, we reviewed reputable domestic and international studies on walkability, urban design, and active transport, and extracted all the indicators used in these studies. More than 38 different indicators were identified in this stage. In the second step, we merged indicators with conceptual overlap. For example, indicators such as seating quality, bench comfort, resting spaces, and short-term stop facilities were classified under the comprehensive concept of quality of resting spaces. Likewise, indicators related to shade, ventilation, solar radiation, and protection from climatic factors were merged under climatic comfort. In the third step, we removed indicators defined at the metropolitan scale (such as density, land use mix, street network connectivity, and regional access) or that could not be measured at the scale of a single urban street. We also excluded indicators that did not directly connect with the research objective, i.e., examining micro-spatial quality and user perception of the pedestrian environment.

Table 3. Walkability indicator refinement process

Stage	Number of indicators	Process performed
Initial extraction from literature	38	Extraction of all indicators introduced in domestic and international studies
Removing duplicate indicators	27	Merging synonymous indicators and those with conceptual overlap
Removing macro-scale indicators	18	Removing indicators related to urban planning and street networks
Removing indicators not measurable in the field	11	Removing indicators that required secondary data or GIS analysis
Selecting final indicators	7	Selection based on theoretical support, micro-spatial scale, and perceptual measurability

Table 4. Matrix of indicator extraction from global studies

Indicator	Number of supporting studies	Sample references
Quality of resting spaces	18	Carmona, Ewing, Bivina, Mazzulla
Climatic comfort	16	Southworth, Moura, Cerin
Urban furniture	15	Ewing, Bivina, Gehl
Design quality of furniture	11	Carmona, Mazzulla
Bicycle path	13	Frank, Vale, Moura
Access	21	Alfonzo, Frank, Southworth
Environmental pollution	12	Cerin, Moura

Examining the frequency of indicator repetition in previous studies shows that although more than 30 different components have been proposed to evaluate walkability, the majority of research focuses on a limited set of micro-spatial indicators. In the present study, indicators' selection was based on frequency in the literature, field measurability at the street scale, and direct relevance to users' perceptual experience. Therefore, the seven final indicators represent the most important micro-spatial dimensions of walkability in the study area.

3.4. Rationale for excluding other walkability indicators

Despite the diversity of indicators introduced in the literature, not all of them were applicable to the present study. The reason for this is the difference in study scale, research objective, and the type of data required. For example, indicators such as population density, land use mix, street network connectivity, regional access, distance to public transport, and intersection density are mainly developed for urban analyses at the neighborhood or city scale and require GIS-based analyses or secondary data for their measurement.

On the other hand, the current study aimed to explore users' perceptions of the micro-spatial quality of an urban street and identify patterns of dissatisfaction. Therefore, we only selected indicators that citizens could directly experience and evaluate in the environment. For this reason, indicators representing the city's macro-structural characteristics, despite their theoretical importance, were excluded from the selection process. Also, some indicators such as the quality of urban facades, variety of commercial activities, visual attractiveness, and place identity, although used in various studies, were merged into more comprehensive dimensions due to their conceptual overlap with environmental quality indicators and the difficulty of independent measurement in a questionnaire.

Therefore, the selected indicators, in addition to having theoretical support, were compatible with the study scale, research objective, and users' perceptual measurability, and formed the basis for designing the research questionnaire.

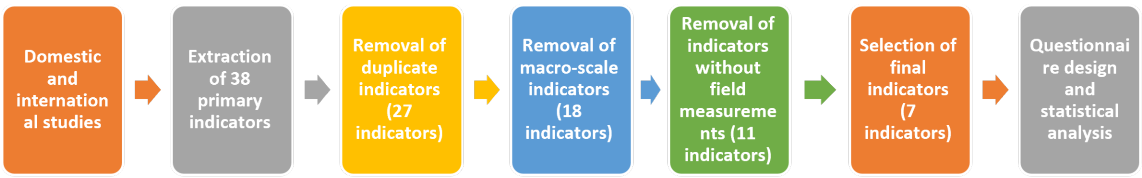


Figure 1. Flowchart of indicator extraction

3.5. Conceptual framework of the research

Based on the systematic and critical literature review and the process of refining walkability indicators described in the previous section, the conceptual framework of the research was developed. A review of previous studies shows that walkability is a multi-dimensional construct, and its quality results from the interaction of the environment's physical characteristics, the quality of urban micro-spaces, and the way users perceive the environment. Unlike traditional approaches that evaluate each indicator independently, the present research assumes that the various components of the pedestrian environment operate in a networked and interdependent manner, and the final user experience of walking is the result of the cumulative effect of these components.

Since this research aims to evaluate walkability quality at the micro-spatial scale and at the level of an urban axis, only indicators were selected that had theoretical support, potential for direct measurement at the street scale, and a clear connection to users' perceptual experience. Therefore, macro-scale variables such as population density, land use mix, street network connectivity, and regional access, which require metropolitan analyses and secondary data (Ewing & Handy, 2009; Pikora et al., 2003; Alfonzo, 2005), were excluded from the selection process. Subsequently, by combining the results of the literature review, the frequency of indicator repetition in previous research, and the opinion of urban planning experts (through content validity assessment), seven final indicators, including access to bicycle paths, number of resting spaces, quality of resting spaces, variety of urban furniture, suitability of furniture design, climatic comfort, and environmental pollution status, were selected as representatives of the street's micro-spatial quality.

Based on this, the research assumes these seven indicators do not operate independently, but rather shape the quality of the walking experience as a common, intertwined perceptual pattern. As a result, a decline in the quality of any one of these components can be accompanied by increased dissatisfaction with others, ultimately leading to a relatively integrated pattern of dissatisfaction in the pedestrian environment. Furthermore, individual variables such as gender, age, and frequency of street use can influence the perception of these indicators; therefore, these variables were also examined in the analysis of users' perceptual patterns.

Based on this framework, the conceptual model of the research is built on three main pillars:

1) Physical-environmental inputs: including the seven selected indicators that explain the micro-spatial quality of the street.

2) Perceptual filters and social dynamics: indicating that users' perception of environmental quality is influenced by demographic characteristics and, based on the spillover effect theory, manifests in the form of a relatively integrated pattern of dissatisfaction.

3) Analysis and decision-making toolbox: in this stage, perceptual data are processed using K-means cluster analysis, multiple correspondence analysis (MCA), the TOPSIS model, and importance-performance analysis (IPA) to identify dissatisfaction patterns and extract priorities for physical interventions and a roadmap for improving walkability.

Figure 2 shows the research's conceptual framework and the relationship among theoretical dimensions, selected indicators, perceptual variables, and the analysis process schematically.

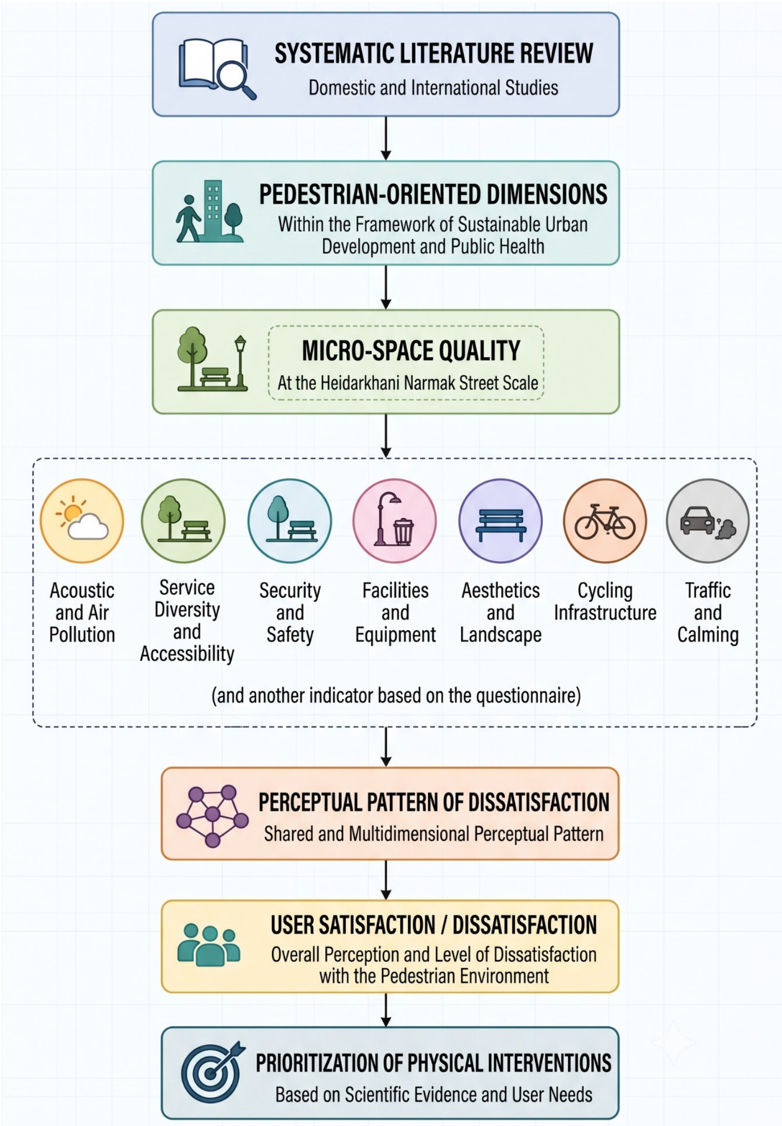


Figure 2. Conceptual framework of the research

3.6. Physical-environmental approach to walkability and micro-spatial quality

In recent decades, walkability has evolved from a purely physical concept to a key pillar of new urban planning paradigms such as smart growth, new urbanism, and transit-oriented development (Forsyth, 2015). As the most fundamental form of active mobility, it plays a catalytic role in promoting public health, reducing diseases, and strengthening social capital (Sallis et al., 2016). Southworth (2005) argues that a walkable environment, beyond the existence of a sidewalk, requires connectivity, land use diversity, and spatial legibility; an approach crystallized in the idea of complete streets, which assumes the street to be a democratic space for all users (Speck, 2012; Pucher & Buehler, 2012). Classic models such as the 3Ds recognize density, diversity, and design as the main drivers of walking behavior, to which access to micro-destinations has now been added (Cervero & Kockelman, 1997; Ewing & Handy, 2009).

However, citizens' perception of these qualities is strongly influenced by micro-scale variables. According to Alfonzo's hierarchy of walking needs model (2005), the choice of walking behavior is a step-by-step process that requires feasibility, accessibility, safety, comfort, and ultimately attractiveness; without safety and comfort, aesthetic features lose their function (Pikora et al., 2003).

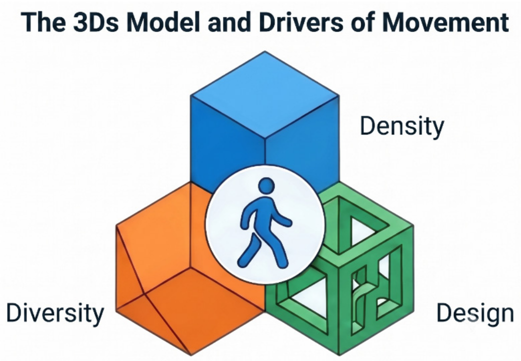


Figure 3. Focus on the 3 factors: density, diversity, and design as the main factors shaping pedestrian behavior

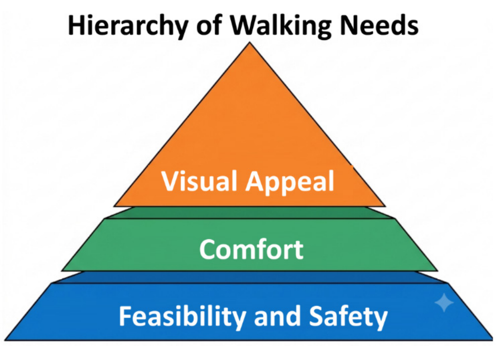


Figure 4. The choice of walking behavior is a step-by-step process requiring feasibility, safety, comfort, and ultimately attractiveness.

Jan Gehl (2010) also asserts that urban vitality depends on the formation of optional and social activities, which only occurs when micro-spaces are equipped with standard furniture and inviting resting spaces; otherwise, the street degrades from an urban place to a mere transit space (Carmona et al., 2010; Mehta, 2008). Besides physical space, in metropolises like Tehran, microclimatic and environmental variables also play a decisive role. The concept of thermal perception shows that the presence of shade and air movement significantly increases the time citizens spend in open spaces (Nikolopoulou & Steemers, 2003; Eliasson et al., 2007), and conversely, the lack of climatic comfort combined with pollution distorts the aesthetic perception of space by creating environmental stress (Lai et al., 2014).

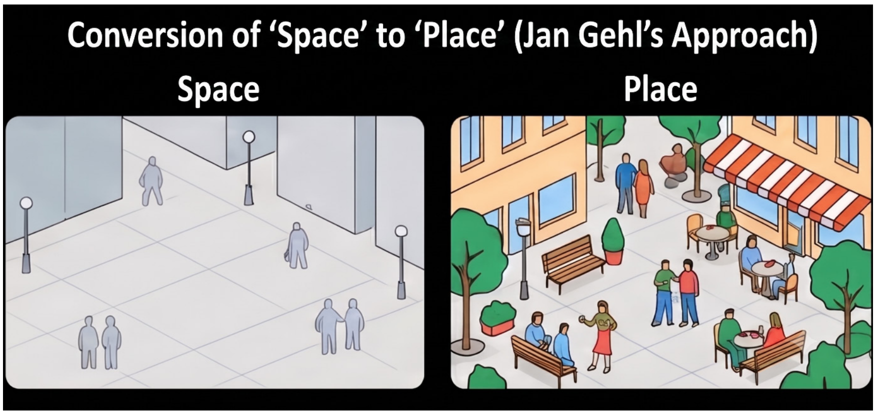


Figure 5. Enhancing urban vitality through equipping micro-spaces with standard furniture and resting spaces for social activities

3.7. Social dynamics, cumulative pattern of dissatisfaction, and evaluation framework

Perceptions of urban environmental quality are not homogeneous phenomena, and the intersection of gender, age, and social roles creates distinct patterns of needs. The feminist urbanism school has proven that due to trip-chaining and caregiving responsibilities, women are much more dependent on path continuity, quality of resting spaces, and furniture suitability (Beebeejaun, 2017; Orellana et al., 2016), and lighting and defensible spaces are an absolute priority for them (Loukaitou-Sideris, 2014). In contrast, men's behavioral patterns often indicate a tendency for high-speed mobility and the use of cycling routes (Adeel et al., 2013; Yavuz & Welch, 2010).

These spatial deficiencies and perceptual differences are not evaluated separately in the minds of users; rather, environmental qualities have an accumulative nature (Marans, 2003; Fleury-Bahi et al., 2008). Based on the spillover effect, a severe physical defect reduces the individual's psychological tolerance for other defects and leads to a unified negative evaluation (Fornara et al., 2010). This is known as a single-factor or systemic structure of dissatisfaction (Mouratidis, 2021). Research conducted in neighborhoods and streets of Iranian cities (such as Tehran, Isfahan, Mashhad, Gorgan, and Ilam) also confirms this systemic structure, such that there is a high correlation among perceptual, physical, climatic, and safety dimensions, and improving walkability quality depends on the simultaneous improvement of all these components (Rezaei & Sheikhi, 2017; Esmaeili & Karami, 2020; Karami & Abbasiyeh, 2021; Siami et al., 2022).

To accurately analyze this pattern of dissatisfaction and avoid common biases that assume society is homogeneous, advanced decision-making models are necessary. In this regard, multiple correspondence analysis (MCA) helps identify geometric patterns and co-occurrences between demographic variables and environmental complaints (Abdi & Valentin, 2007; Greenacre, 2017). K-means cluster analysis also divides respondents into distinct clusters based on dissatisfaction intensity (MacQueen, 1967; Birenboim et al., 2013). Finally, to translate perceptual findings into executive priorities, the combination of importance-performance analysis (IPA) with the TOPSIS algorithm measures options based on importance, performance, and distance from the ideal solution, providing the most accurate roadmap for physical interventions (Martilla & James, 1977; Hwang & Yoon, 1981; Awasthi et al., 2011; Mulyadi et al., 2023).

4. Research method

The present research is applied in terms of objective, quantitative in terms of data nature, and descriptive-analytical and survey-based in terms of implementation method. This cross-sectional study was conducted in winter 2025 to analyze patterns of dissatisfaction with walking and prioritize physical interventions on Heydarkhani Street in the Narmak neighborhood. The statistical population included citizens aged 18 to 60 who were residents, employees, or regular users of this street. The sampling used a non-probability convenience method with an inclusion criterion of using this street at least twice a week. A total of 68 questionnaires were collected. After the data collection, we assessed the quality of the responses based on predefined criteria. This quality control was conducted to ensure the completeness and validity of the responses. The removal of questionnaires was not based on improved statistical results or the significance of relationships. The criteria for exclusion included: 1) incompleteness of the main sections of the questionnaire, 2) the presence of a uniform and logically non-diverse response pattern, such as selecting the same option for all questions, 3) the presence of inconsistent or contradictory responses in different sections of the questionnaire, and 4) not meeting the study inclusion criterion, i.e., using Heydarkhani Street at least twice a week. Accordingly, 24 questionnaires were ineligible for analysis and were excluded, and 44 valid questionnaires were used in the final analysis. Given the exploratory nature of the research and the use of convenience sampling, the findings are interpreted with caution, avoiding direct generalization to the entire statistical population. To check the normality assumption and justify the use of non-parametric tests, the Shapiro-Wilk test was performed on the indicators. The results showed that the distribution of all indicators deviates significantly from normal ($p < 0.05$); therefore, non-parametric tests (Spearman and Friedman) are justified.

The data collection tool was a researcher-developed questionnaire designed in three parts: 1) demographic information, 2) evaluation of walkability indicators, and 3) recording user complaints and priorities.

Walkability indicators were first extracted through a targeted literature review, then refined using a Delphi panel of five urban planning experts and two statistics experts. After removing duplicate, macro-scale, and context-inappropriate indicators and confirming the content validity ratio (CVR > 0.79), seven final indicators, including access to bicycle paths, number of resting spaces, quality of resting spaces, variety of urban furniture, suitability of furniture design, climatic comfort, and environmental pollution status, were selected and measured using a five-point Likert scale.

The face and content validity of the questionnaire were confirmed based on the expert panel's opinion, and reliability was evaluated using Cronbach's alpha coefficient (0.87). A Cronbach's alpha value above 0.70 indicates acceptable tool reliability; therefore, a value of 0.87 indicates good internal consistency. Data were analyzed using SPSS 26 and Excel 2019 software. First, descriptive statistics were calculated to describe the sample characteristics. Then, Spearman's correlation coefficient was used to examine relationships among indicators, and the Friedman test was used to compare indicators'ranks. K-means cluster analysis identified different user groups based on dissatisfaction intensity; multiple correspondence analysis (MCA) examined perceptual patterns and the relationship between individual characteristics and walkability indicators, and TOPSIS and IPA decision-making models prioritized physical interventions. The choice of analytical methods was based on the research questions and each method's distinct role in addressing the various aspects of the problem. Given the limited sample size (n=44), these methods were employed in an exploratory and complementary manner to provide preliminary evidence of perceptual patterns, relationships between indicators, and intervention priorities in the study area, not to create predictive models or generalize results to the entire user population. Therefore, the findings from the K-means, MCA, regression, TOPSIS, and IPA analyses are interpreted with caution and considered evidence dependent on the sample studied. This research complied with research ethics principles; participation was voluntary, and information was collected anonymously. Respondents were informed about the purpose of the research and the confidentiality of their information before completing the questionnaire.

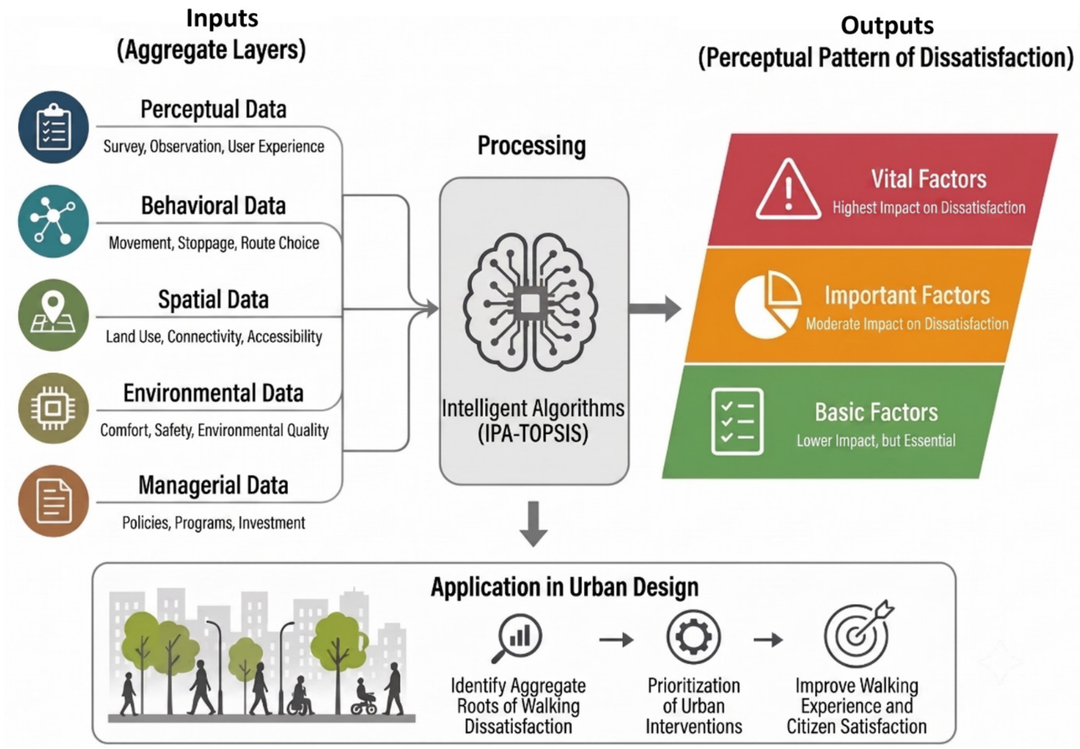


Figure 6. Research analytical process and sequence of applying statistical and decision-making methods

4.1. Evaluation of validity and reliability of the research tool

To ensure the measurement tool's validity, the questionnaire was designed based on indicators extracted from a systematic literature review, and its initial version was reviewed by a specialized panel of five faculty members in urban planning and two experts in statistics and research methodology. To measure content validity, the Content Validity Ratio (CVR) was calculated for all items based on the Lawshe method. Experts assessed each item at three levels: necessary, useful but not necessary, and not necessary. The results showed that all items obtained at least the acceptable CVR value corresponding to seven experts; therefore, none of the items were eliminated, and all were used in the final version of the questionnaire. In this stage, the suitability of items with the research objectives, writing clarity, comprehensibility, and coverage of the intended dimensions were evaluated, and the experts' suggested modifications were applied in the final version of the questionnaire. Thus, the face and content validity of the tool were confirmed through expert opinion. To evaluate the tool's reliability, Cronbach's alpha coefficient was used, which was 0.87. This value indicates good internal consistency of the questionnaire and adequate reliability of the tool for statistical analyses.

Table 5. Research analytical framework and the role of each method in answering research questions

Row	Statistical method/decision model	Role of the method in the research analysis
1	Spearman's correlation coefficient and Friedman test	Given the ordinal nature of the data from the five-point Likert scale and the limited sample size, rank-based Spearman and Friedman methods were used. Spearman's correlation coefficient examined the strength and direction of relationships among walkability indicators, and the Friedman test compared the ranks of indicators among respondents.
2	Cluster analysis (K-means)	Most urban studies analyze citizens as a homogeneous mass and rely on overall averages (mean-centered analysis). This algorithm was chosen to identify hidden heterogeneities in society and segment users by dissatisfaction intensity to identify highly vulnerable groups (e.g., the highly dissatisfied cluster).

Row	Statistical method/decision model	Role of the method in the research analysis
3	Multiple correspondence analysis (MCA)	This method was used due to the categorical and multi-response nature of the variables in this section. Since the objective of MCA was to examine co-occurrence patterns between demographic characteristics and the options selected by users, the data for this section were entered as categorical categories, and the five-point Likert items were not used in this analysis. Also, MCA was used in this research with an exploratory aim to display co-occurrence patterns and relative proximity among categories; therefore, the results are interpreted based on the relative position of points in the factor space, and this analysis was not used to test statistical significance of relationships or infer causal relationships.
4	TOPSIS analysis	The indicators were ranked using the TOPSIS model by normalizing the data, applying equal weights to all indicators, calculating distances from the positive and negative ideal solutions, and determining the closeness coefficient to prioritize interventions.
5	Importance-performance analysis (IPA)	This model's advantage is transforming purely descriptive data into a strategic roadmap. IPA was chosen to combine the relative importance weight of indicators with users' perceived performance in a four-quadrant matrix to determine the relative priority of urban design interventions.

The statistical methods in this research were chosen based on the nature of the variables, the research questions, and the objectives of each part of the analysis. Given the exploratory nature of the research, the sample size, and the measurement scale of the data, the analytical methods were used in a complementary, not confirmatory, manner. Thus, Spearman's correlation coefficient and the Friedman test were used to examine relationships and compare indicators; K-means cluster analysis was used to identify user groups based on dissatisfaction intensity; multiple correspondence analysis (MCA) was used to explain perceptual patterns and relationships among categorical variables; and TOPSIS and IPA models were used to prioritize physical interventions. Each method answered one research question, and the results were interpreted complementarily alongside each other; therefore, the findings are presented with an exploratory approach and without claiming causal inference or extensive generalizability. The integrated use of these methods enabled simultaneous analysis of relationships among variables, user heterogeneity, and intervention priorities, and collectively provided a comprehensive picture of walkability quality and the pattern of user dissatisfaction. Given the limited sample size, these analyses are interpreted mainly at a descriptive-exploratory level, and inferences beyond the sample or generalizable claims have been avoided.

5. Introduction to the study area

The Narmak neighborhood is located in the northeast of Tehran, within Districts 4 and 8 of Tehran Municipality. This neighborhood, situated north of Tehran-e-No and south and east of Shemiran-e-No, was built by the French in the 1950s, before Tehranpars. The area was once known for its many pomegranate orchards, and its pomegranates were famous for their taste and juiciness. The word Narmak itself means sucking a pomegranate. Narmak means a place where large pomegranates grow. Narmak is known as the neighborhood of a hundred squares due to its 100 squares of various sizes.

Within this regular urban fabric, Heydarkhani Street is one of the region's main thoroughfares. This street is situated in District 4 of Tehran and passes through the Narmak and Elm-o-Sanat neighborhoods. Access to this street is possible via the Resalat Expressway (from the south) and Ghadir Square (from the north), and its proximity to the Iran University of Science and Technology has influenced its use by students and employees. Research by Motieyan & Esmaeili (2026), using pedestrian route data in central Tehran, has shown that areas with mixed land use and retail and food centers are more attractive to pedestrians. Heydarkhani Street, with its mixed use and proximity to commercial and university centers, is one such area, which doubles the importance of studying its walkability.

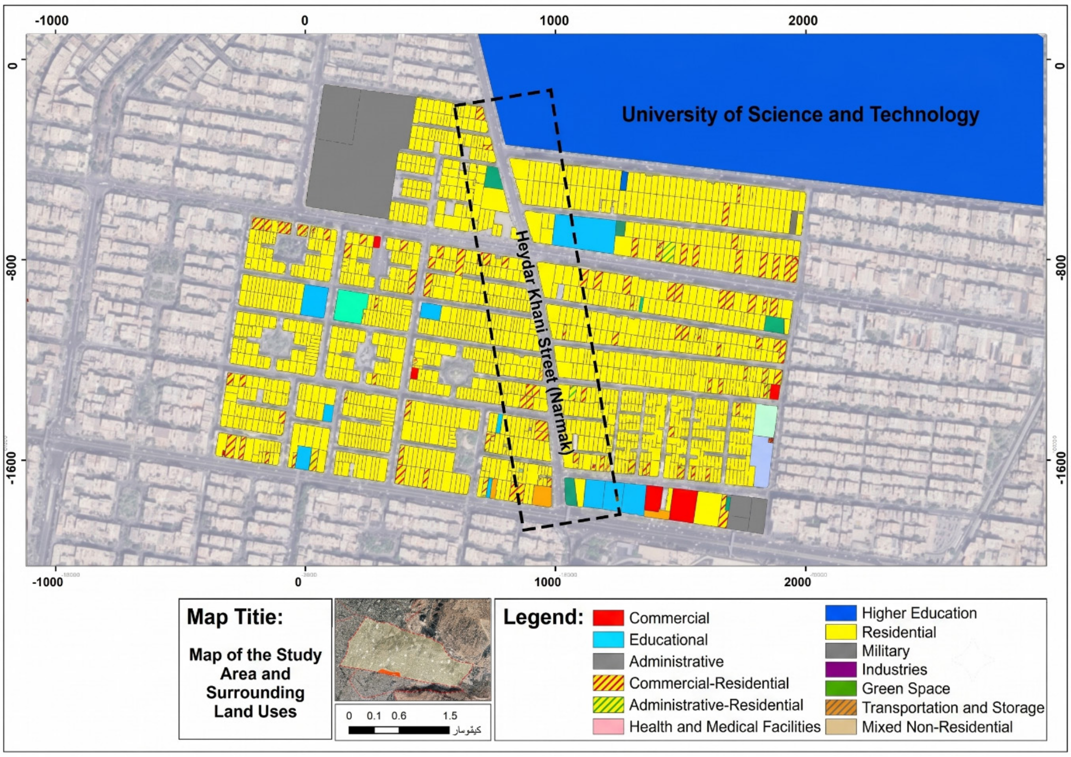


Figure 7. Introduction of the study area

6. Findings

6.1. Examining the correlation pattern of indicators and preliminary evidence of a common pattern of dissatisfaction

To investigate the internal relationship among the seven walkability indicators, the Spearman correlation matrix was calculated (Table 6). This matrix shows whether dissatisfactions are independent or form an interconnected pattern.

Table 6. Spearman correlation matrix among walkability indicators (n=44)

Indicator	C1	C2	C3	C4	C5	C6	C7
C1: Access to bicycle path	1.00	0.65	0.54	0.50	0.55	0.48	0.52
C2: Number of resting spaces		1.00	0.70	0.62	0.60	0.55	0.50
C3: Quality of resting spaces			1.00	0.68	0.65	0.60	0.55
C4: Variety of urban furniture				1.00	0.72	0.58	0.50
C5: Suitability of furniture design					1.00	0.62	0.53
C6: Climatic comfort						1.00	0.60
C7: Environmental pollution status							1.00

All correlation coefficients are positive and significant at the 0.01 level. The coefficients vary from 0.48 (between C1 and C6) to 0.72 (between C4 and C5). Correlations above 0.6 are mainly observed among indicators related to resting spaces and furniture (C2 to C5), as well as between C2 and C3 (0.70). This pattern indicates that dissatisfaction with one dimension is systematically accompanied by dissatisfaction with other dimensions. In other words, a citizen dissatisfied with the furniture situation is very likely also dissatisfied with climatic comfort, the bicycle path, and the quality of resting spaces. This pattern suggests an overall negative attitude that encompasses all components of the space.

6.2. Friedman test: Ranking comparison of indicators

To examine statistically significant differences in the ranking of the seven indicators from the perspective of the entire sample, the Friedman test was performed (Table 7), and its results were also visualized as a bar chart (Figure 8).

Table 7. Results of the Friedman test for comparing the rankings of seven walkability indicators (n=44)

Indicator	Mean rank
C1: Access to bicycle path	3.67
C2: Number of resting spaces	4.18
C3: Quality of resting spaces	3.73
C4: Variety of urban furniture	3.91
C5: Suitability of furniture design	3.72
C6: Climatic comfort	4.51
C7: Environmental pollution status	4.28
Statistic	**Value**
Number (n)	44
Degrees of Freedom (df)	6
Chi-Square (χ^2)	6.10
p-value	0.412

Given the p-value = 0.412 (much greater than 0.05), no significant difference exists in the ranking of the indicators. Although some indicators had slightly higher mean ranks than others, the Friedman test showed that these differences are not statistically significant ($p > 0.05$). Therefore, the observed differences are only descriptive, and the statistical superiority of any indicator cannot be inferred. The mean ranks range from 3.67 (lowest rank, related to bicycle access) to 4.51 (highest rank, related to climatic comfort), but these differences are statistically negligible. Nevertheless, a definitive inference regarding the existence of a common dissatisfaction pattern requires exploratory factor analysis (EFA) or confirmatory factor analysis (CFA). Because of the limited sample size (44 people), the statistical requirements for a valid factor analysis were not met; the Spearman correlation and Friedman test results should not be interpreted as definitive proof of a latent factor. Rather, these results merely show preliminary evidence of a common, intertwined, and cumulative pattern of user dissatisfaction, and its final confirmation is subject to larger future studies.

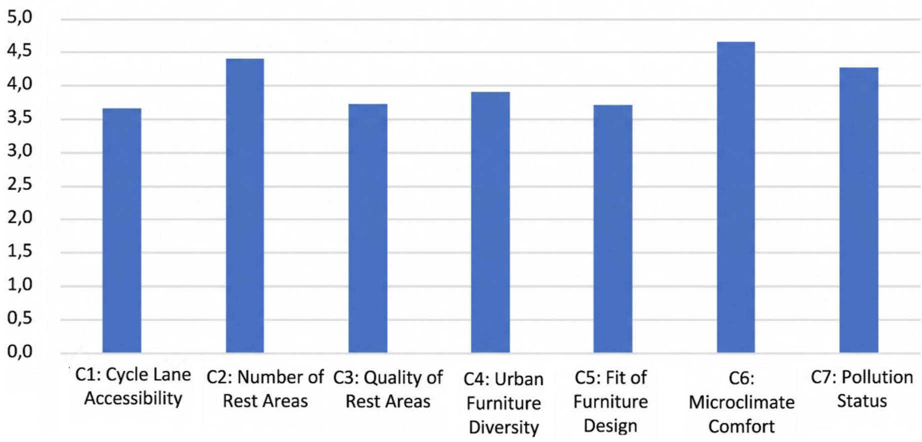


Figure 8. Results of the Friedman test for comparing the rankings of seven walkability indicators

6.3. Linear regression analysis

For an exploratory investigation of the simultaneous relationship between gender and traffic frequency and overall satisfaction, a multiple linear regression model was fitted (Table 8). In this analysis, overall satisfaction was calculated as the dependent variable as the average of the scores of the seven walkability indicators for each respondent; each respondent received an overall score ranging from 1 to 5. Gender and traffic frequency variables were also entered into the model as independent variables.

Before interpreting the model, the main assumptions of multiple linear regression were checked. Independence of errors using the Durbin-Watson statistic (DW value = 1.82, which is within the acceptable range of 1.5 to 2.5), absence of severe multicollinearity among independent variables with VIF (less than 1.5) and Tolerance (above 0.7) indices, and normality of residuals were assessed. No serious violation of the main assumptions was observed. Also, the homogeneity of error variances was evaluated by examining the scatterplot of standardized residuals against predicted values. The results indicated no serious violation of the main assumptions, and the model is interpretable in this regard. Given the limited sample size, this analysis was conducted solely for preliminary exploration of possible relationships, and its results are not definitive or generalizable.

Table 8. Results of linear regression: predicting overall satisfaction based on gender and traffic frequency

Variable	Coefficient B	Std. Error	t-statistic	p-value
Intercept (Men, lowest traffic)	2.205	0.292	7.55	<0.001
Gender (Female = 1)	-0.302	0.194	-1.56	0.127
Traffic frequency (1 to 4)	-0.074	0.086	-0.86	0.392
R^2	0.042			
F(2,42)	0.93			0.404

The multiple regression model showed that gender and traffic frequency variables alone are not significant predictors of overall satisfaction ($p > 0.05$), and the overall model is also not statistically significant ($R^2 = 0.042$, $F = 0.93$, $p = 0.404$). Similarly, in the simple regression model with gender entered, the estimated coefficient ($B = -0.320$, $p = 0.097$) was not significant. Therefore, the demographic variables under study do not explain users' overall satisfaction in this sample. Given the low coefficient of determination and the limited sample size, the results are interpretable only as preliminary and exploratory evidence, and causal or generalizable inferences are avoided.

Table 9. Results of simple linear regression: predicting overall satisfaction based on gender only

Variable	Coefficient B	Std. Error	t-statistic	p-value
Intercept (Men)	1.980	0.131	15.12	<0.001
Gender (Female = 1)	-0.320	0.188	-1.70	0.097
R^2	0.063			
F(1,43)	2.88			0.097

The non-significance of the traffic frequency variable may indicate that high-frequency and low-frequency users in this sample group probably have a relatively similar image of the street's condition, and the different sensitivities observed in the descriptive sections could not be proved as a direct linear relationship.

6.4. Cluster analysis (k-means)

To identify homogeneous groups in terms of dissatisfaction intensity, K-means cluster analysis was performed on the seven walkability indicators. Before running the algorithm, the seven indicators'scores were converted to standardized scores (Z-scores) to scale the variables. To determine the optimal number of clusters, different K-means solutions for k=2 to k=5 were examined, and the Elbow Method and Silhouette Width were calculated. The results showed that the three-cluster solution, with the highest average Silhouette Width (0.34) and at the elbow curve's breakpoint, provides the most suitable separation. Also, comparing the K-means results with hierarchical clustering using Ward's method showed over 90% consistency in assigning individuals to clusters. Based on this, three clusters were selected as the final structure. Given the limited sample size, the clustering results in this research are exploratory and are interpreted solely for identifying different patterns of dissatisfaction in the studied sample (Table 10). Table 11 presents cluster centers, mean overall satisfaction, and the demographic characteristics of each cluster, and Figure 9 shows the graphical distribution of mean scores.

Table 10. Evaluation of different K-means solutions based on clustering validation indices

Number of clusters (k)	Within-cluster sum of squares (WCSS)	Average Silhouette Width	Interpretation of clustering structure
2	184.2	0.29	Overall separation with lower quality
3	112.5	0.34	Best separability and the breakpoint of the elbow curve
4	98.1	0.27	Decreased separation quality and creation of minor sub-clusters
5	82.4	0.22	Further decrease in separation quality in the limited sample

Table 11. Cluster centers and demographic characteristics of the three extracted clusters

Characteristic	Cluster 1: Highly dissatisfied	Cluster 2: Moderately dissatisfied	Cluster 3: Slightly dissatisfied
Cluster size (n)	14 (32.6%)	23 (53.5%)	6 (14.0%)
Cluster centers (standardized scores)			
C1: Access to bicycle	1.14	1.91	3.17
C2: Number of resting spaces	1.21	2.04	3.17
C3: Quality of resting spaces	1.29	1.78	2.83
C4: Variety of furniture	1.50	1.83	2.67
C5: Suitability of Furniture design	1.14	1.87	3.17
C6: Climatic comfort	1.43	2.13	3.83
C7: Environmental pollution	1.64	2.00	3.83
Mean overall satisfaction	1.24	1.99	2.95
Demographic characteristics			
Women share (%)	50.0	34.8	16.7
Daily traffic share (%)	57.1	47.8	33.3
Age 18-30 share (%)	78.6	91.3	100.0
Student/employee share (%)	92.9	95.7	83.3

Cluster 1 (33% of the sample) was labeled "Highly dissatisfied." Members of this cluster mainly gave scores of 1 or 2 to the indicators, with a mean overall satisfaction of 1.24. In this cluster, 50% of members are women and 57% have daily traffic. This distribution shows that in the studied sample, a higher share of women was found in the "Highly dissatisfied" cluster. However, the Chi-square test indicated that the relationship between gender and clustering was not statistically significant (χ^2=2.12, p=0.347). Therefore, this finding is reported merely as a descriptive trend in the sample and is not generalizable to the statistical population.

Cluster 2 (54% of the sample) was labeled "Moderately dissatisfied." This group's values are mainly concentrated around 2, with a mean overall satisfaction of 1.99. This cluster comprises over half of the sample, and its gender composition and traffic frequency are largely consistent with the overall sample distribution. Cluster 3 (14% of the sample) was labeled "Slightly dissatisfied." This group's mean overall satisfaction is 2.95, and its members mainly recorded scores between 2 and 5. In this cluster, 17% of members are women, and 33% have daily traffic. This pattern may indicate differences in the characteristics of individuals in this cluster, including the frequency of street use or their expectation levels; however, given the non-significance of the Chi-square test, these differences are interpretable only as a descriptive observation in the current sample, and definitive or generalizable conclusions cannot be drawn from them.

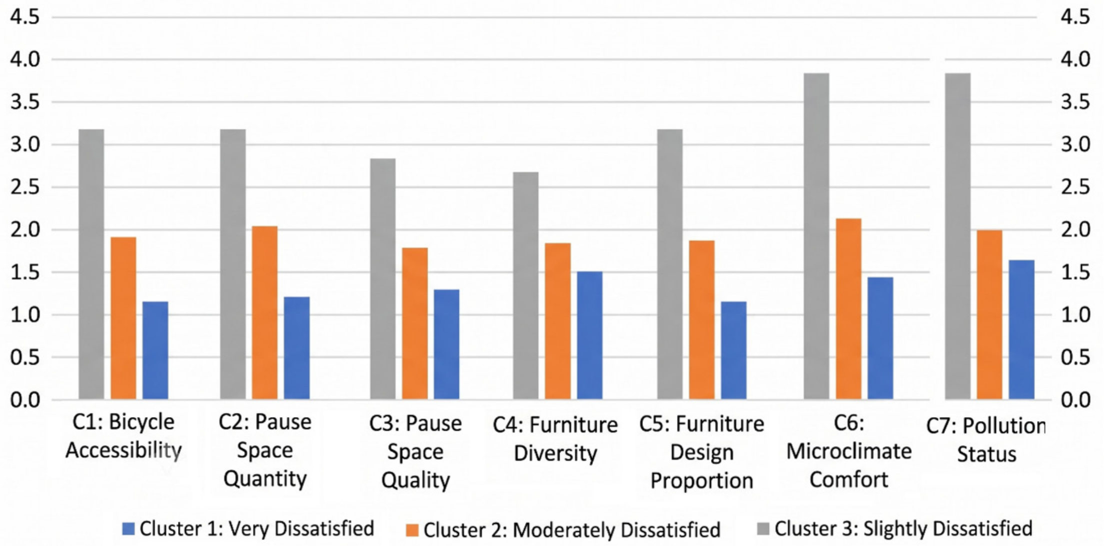


Figure 9. Cluster centers and demographic characteristics of the three extracted clusters

6.5. Multiple correspondence analysis (MCA)

To identify association patterns between demographic characteristics and multi-response options related to user dissatisfaction, Multiple correspondence analysis (MCA) was performed. In this analysis, data from the five-point Likert items were not entered directly into the model, nor did they need to be transformed or categorized. The MCA used categorical variables, including responses to four multi-response questions, gender, age group, and user traffic frequency. Based on this, a Burt matrix with 25 categories was formed, and the MCA analysis was conducted based on the co-occurrence frequency of these categories. The first two dimensions together explained 28.4% of the total inertia (Dimension 1: 16.1% and Dimension 2: 12.3%). The Chi-square test for the co-occurrence matrix of categories was significant at $\alpha=0.01$ ($\chi^2 = 312.4$, $p < 0.001$), indicating non-random relationships among categories in the factor space. The contribution share of key categories in the extracted dimensions is reported in Tables 12 and 13, and the perceptual map from the analysis is presented in Figure 10.

Table 12. Contribution share of key categories in the first dimension of MCA (comfort & rest vs. bicycle infrastructure axis)

Negative pole (left): Comfort & rest concerns	Contribution (%)	Positive pole (right): Bicycle infrastructure concerns	Contribution (%)
Lack of shade (lack of resting spaces)	9.2	Lack of dedicated bicycle path	8.7
Inappropriate design of resting spaces	7.5	Lack of bicycle parking	6.1
Need for Canopies	8.1	Other bicycle obstacles	4.8
Need for Benches	6.4	Women	5.3
Low number of resting spaces	5.9	Age group 18-30	3.2

Table 13. Contribution share of key categories in the second dimension of MCA (quality & maintenance vs. access axis)

Negative pole (bottom): Complaints about quality & maintenance	Contribution (%)	Positive pole (top): Access barriers & low-traffic users	Contribution (%)
Inappropriate design for specific groups	10.3	Difficult access to resting spaces	8.9
Lack of furniture maintenance	8.6	Other deficiencies of resting spaces	6.2
Daily traffic	6.9	Rare traffic	5.7
Dissatisfaction with furniture suitability	5.4	Residents	4.9

The MCA analysis reveals a subtle pattern of differences in concerns. In the first dimension, women are positioned near the categories "Lack of shade," "Canopy, bench, and inappropriate design of resting spaces." This perceptual map indicates that in the studied sample, women's complaints were more frequently observed in proximity to these categories. However, given the exploratory nature of the MCA analysis and the non-significance of gender differences in inferential tests, this pattern is interpreted merely as a descriptive trend; it should not be considered a significant or generalizable relationship. Men and the 18-30 age group are on the opposite side, near the categories "Lack of dedicated bicycle path" and "Lack of bicycle parking," indicating the co-occurrence of these categories in the factor space. Also, high-traffic users (daily) in the second dimension are closer to the categories "Inappropriate design for specific groups" and "Lack of maintenance," while low-traffic users and residents are situated near the "Difficult access" category. These proximities reveal observed patterns in the factor space and should not be interpreted as evidence of statistically significant or causal relationships among variables.

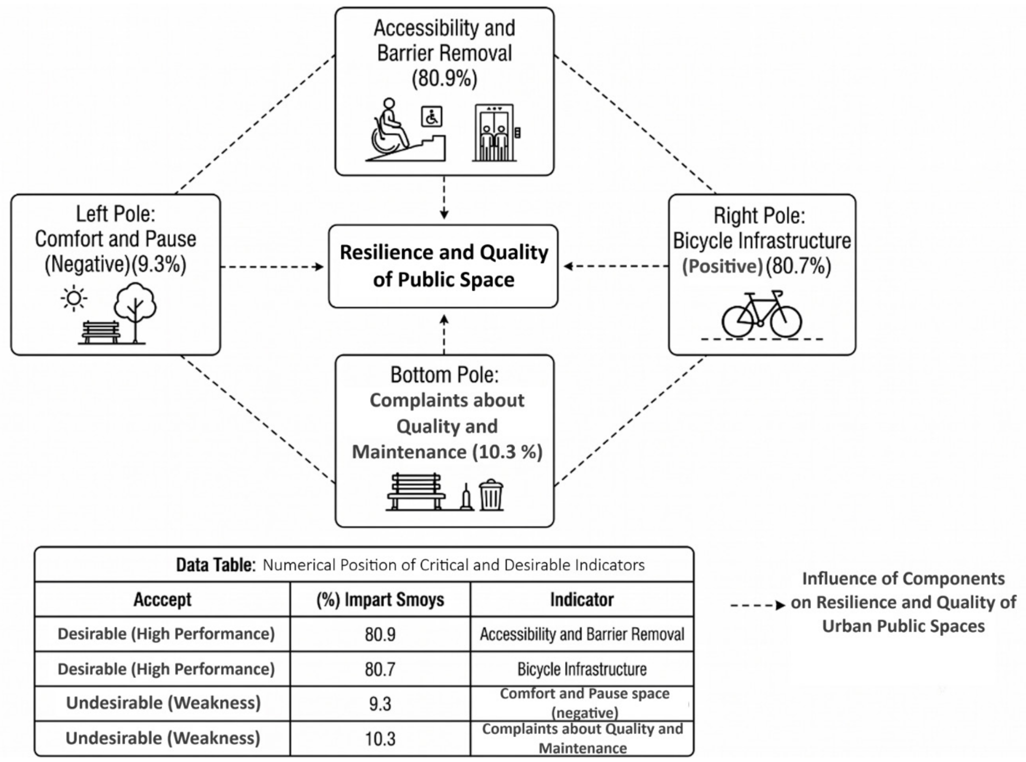


Figure 10. Four-dimensional analysis of urban space and infrastructure challenges

6.6. Prioritizing interventions: From diagnosis to treatment

In implementing the TOPSIS model, since the research objective was to compare the status of the seven selected indicators from the users' perspective and there was insufficient theoretical or empirical basis for preferring one indicator over another in determining weights, the equal weighting method was used. Consequently, the weight of each of the seven indicators was set to 1/7 (0.143), and the sum of weights was set to 1. The use of equal weights ensured that the final ranking of indicators was not influenced by subjective weighting, and the difference in ranks was determined solely based on the observed performance of the indicators in the decision matrix and their distance from the ideal solution. The distances from the ideal and anti-ideal solutions and the closeness coefficient (C) for each indicator were calculated, and the final ranking is presented in Table 15 and Figure 11.

Table 14. Weights of criteria used in the TOPSIS model

Row	Indicator	Weight
1	Active land uses variety	0.142857
2	Pedestrian access and pavement quality	0.142857
3	Access to bicycle path	0.142857
4	Number and quality of resting spaces	0.142857
5	Visual quality of facades	0.142857
6	Skyline continuity and enclosure	0.142857
7	Suitability and variety of urban furniture	0.142857
Total	-	1.000

Table 15. Results of TOPSIS analysis: distances and closeness coefficients of indicators

Rank	Indicator	Distance from ideal (d^+)	Distance from anti-ideal (d^-)	Closeness coefficient (C)
1 (Worst)	C3: Quality of resting spaces	5.264	1.018	0.162
2	C1: Access to bicycle path	5.351	1.083	0.168
3	C5: Suitability of furniture design	5.265	1.260	0.193
4	C4: Variety of urban furniture	5.123	1.258	0.197
5	C2: Number of resting spaces	5.147	1.383	0.212
6	C6: Climatic comfort	4.996	1.672	0.251
7 (Best relative)	C7: Environmental pollution status	4.957	1.879	0.275

The closeness coefficients for the quality of resting spaces (0.162) and access to bicycle paths (0.168) are the lowest, indicating the worst status among the seven indicators. These two areas should receive the highest priority in interventions. However, even the best indicator (pollution status) has a closeness coefficient of 0.275, which is still very low, indicating that no indicator is close to the desired status. The final ranking is calculated based on the normalized matrix and equal weights.

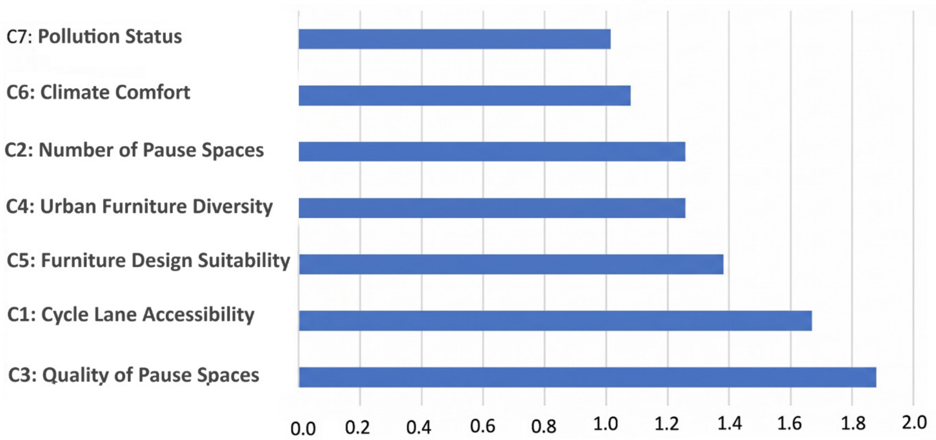


Figure 11. Results of TOPSIS analysis: distances and closeness coefficients of indicators

6.7. Importance-performance analysis (IPA)

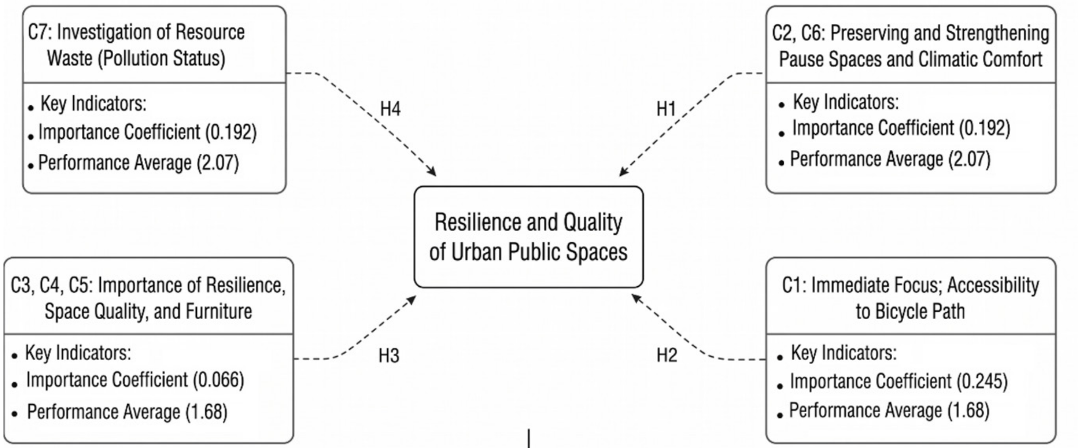
The IPA analysis used the relative importance weights of each indicator as the horizontal axis and the mean performance as the vertical axis. The importance weights for the seven indicators were normalized, and their sum was set to one; therefore, the mean importance weight of 0.143 was set as the cutoff line for the importance axis. The mean performance was also calculated based on the average user evaluation scores for each indicator, and 1.85 was used as the cutoff for the performance axis. The position of the indicators in the four quadrants of the importance-performance analysis matrix (Figure 12) is as follows:

Concentrate here quadrant (high importance, low performance): C1: access to bicycle path, with an importance of 0.245 and performance of 1.68, falls into this quadrant. This indicator has the highest importance and one of the lowest performances, requiring the most urgent attention.

Keep up the good work quadrant (high importance, performance above average): C2: number of resting spaces (performance 1.89, importance 0.215) and C6: climatic comfort (performance 2.07, importance 0.192) are located in this quadrant. These two indicators perform slightly above the overall mean (1.85) but are still very weak (below 2.1) and require maintenance and strengthening. This position should not be mistakenly interpreted as sufficient.

Low priority quadrant (low importance, low performance): C3: quality of resting spaces (1.68, 0.086), C4: variety of furniture (1.75, 0.129), and C5: suitability of furniture design (1.68, 0.066) are located in this quadrant. The lower priority of these indicators compared to others does not mean they are unimportant; rather, they can be placed in the second wave of interventions if resources are limited.

Possible overkill quadrant (low importance, performance higher): C7: environmental pollution status (performance 2.07, importance 0.066) is located in this quadrant. Its performance is slightly better relative to its importance, but it still needs improvement.



Data Table: Numerical Standing of Critical and Desirable Indicators

Status in Matrix	Performance Average	Importance Coefficient	Urban Indicator
Focus Here (Critical)	1.68	0.245	C1: Bicycle Path
Performance Preservation (Desirable)	2.07	0.192	C6: Climatic Comfort
Low Priority	1.68	0.066	C5: Furniture Design

Figure 12. Importance-performance analysis (IPA)

7. Discussion

The research findings provide preliminary evidence of a relatively integrated pattern in user dissatisfaction, and spatial concerns differ by gender and traffic frequency variables. Furthermore, the prioritizations indicate an urgent need to develop bicycle infrastructure and improve resting spaces.

Preliminary evidence of a common and systemic perceptual pattern of dissatisfaction (through high indicator correlations and the Friedman test) is consistent with the findings of Owais & Salah (2026) and Esmaeili & Karami (2020). This similarity may be attributed to the perceptual spillover effect. In environments such as Heydarkhani Street, which suffer from integrated decay and the long-standing dominance of car-oriented design, this finding may be because users evaluate space quality as a set of interconnected experiences; a weakness in one component affects the evaluation of other components. The low explanatory power of the regression model in the present study indicates that gender and traffic frequency alone cannot explain a significant portion of the variance in overall satisfaction. Given the limited sample size and the exploratory nature of the analysis, this result should be interpreted with caution, and definitive inferences about the determinants of user satisfaction cannot be made.

In examining perceptual differences, MCA analysis showed that women's complaints were more concentrated around the lack of shade and resting spaces, while young men were more concerned about the lack of bicycle infrastructure. This finding is consistent with studies by Campisi et al. (2020) and Mazzulla et al. (2024) in Europe, which emphasized gender differences. However, there is a subtle difference in the cause. In Western studies, women's primary concern is usually reported as safety at night and lighting, while in this study, women focused on shade and resting furniture. A possible explanation for this difference could be Tehran's climatic conditions (heat islands) and social travel patterns, as well as differences in spatial use patterns and users' functional needs; however, this hypothesis requires further investigation in future research. Men's priority for bicycle paths is influenced by the street's adjacency to Iran University of Science and Technology and the young demographic's tendency to use active and economical transport modes. This pattern may be associated with the functional characteristics of the axis and the significant presence of students in the area.

The Friedman test, TOPSIS, and IPA models pursue different analytical objectives. The Friedman test merely examines the presence or absence of a statistical difference among the indicators' ranks, while the TOPSIS and IPA models prioritize intervention options within a multi-criteria decision-making framework. Therefore, the priorities from these two models do not imply a statistically significant difference among the indicators, but rather indicate the relative priority of interventions from a decision-making perspective. From an intervention prioritization perspective, both IPA and TOPSIS methods identified the bicycle path and the quality of resting spaces as the most critical indicators. However, a noteworthy point was that in the IPA quadrant analysis, the quality of resting spaces indicator fell into the low priority quadrant (low perceived importance), while the mathematical TOPSIS algorithm identified it as the worst indicator. This apparent paradox, also observed in research by Mulyadi et al. (2023) in developing countries, may be attributed to the phenomenon of normalization of spatial deprivation. For years, pedestrians on Heydarkhani Street have dealt with a lack of quality resting spaces. As a result, their expectations have diminished. In direct evaluations, where they assign a weight of 100 points, they have assigned it less importance.

Overall, the comparative analysis of findings shows that the quality crisis on Heydarkhani Street is not merely a physical issue, but a consequence of historical inattention to climatic and gender needs in micro-spatial planning. Future interventions must move beyond a homogenizing view of citizens and focus on the fair distribution of space (allocating safe bicycle paths for the young and designing shaded resting spaces for women and the elderly).

In a critical analysis of the results, we argue that the critical state of walkability on Heydarkhani Street is not merely the result of temporal physical decay, but rather a reflection of the inefficiency of urban development policies and the dominance of a macro-oriented, car-centric view in the urban planning system in previous periods. Unlike developed Western studies that often regard walkability improvement as dependent on aesthetic interventions and smart technologies, this study's results show that on this local axis, basic needs (such as a safe bicycle path and simple shade for stopping) remain in a critical stage. This deep gap is likely rooted in top-down planning processes, in which the street is mainly reduced to a vehicle transit corridor and the concept of spatial justice and differences in various user groups' needs (especially women) are ignored at the micro-spatial scale. The continuation of planning patterns based on vehicular movement in micro-space management has caused the urban environment to become a tense space instead of a platform for interaction; a phenomenon that underscores the necessity of changing the urban management paradigm from purely physical-traffic approaches to people-oriented and behavior-based design.

From a theoretical perspective, the findings of this research indicate that walkability quality cannot be considered merely the result of the independent performance of each physical component, but rather these components are experienced as an interconnected perceptual system. This result is consistent with contemporary human-centered design approaches and environmental experience theory, suggesting that improving a single component alone, without paying attention to other micro-spatial dimensions, will likely have a limited effect on overall user satisfaction. The findings of this research are interpreted in light of the study's exploratory nature, and the use of multiple analytical methods was aimed at examining the issue from different angles and increasing the richness of the analysis, not at providing definitive evidence for generalization to other urban contexts.

8. Conclusion

The present study aimed to identify patterns of user dissatisfaction with pedestrian spaces on Heydarkhani Street in Narmak. The results showed that evidence of a relatively integrated pattern in users' perceptions of dissatisfaction is observable. In this regard, all walkability indicators showed positive and significant correlations with each other, and no significant difference was observed in their ranking. The identified patterns are interpreted based on the observed relationships among variables and the results of exploratory analyses, especially multiple correspondence analysis (MCA), and are not considered proof of a latent construct or hidden factor. Therefore, the research findings should be interpreted within the framework of the exploratory nature of the study and the limitation of sample size. In examining descriptive trends, we observed differences in user dissatisfaction patterns; for example, in the studied sample, women more frequently mentioned the lack of shade and resting spaces, while men and young people more frequently pointed to the lack of bicycle infrastructure. However, these differences were not statistically significant in inferential tests and merely indicate descriptive trends in the studied sample. Furthermore, high-traffic users, due to continuous exposure to the space, showed greater sensitivity to design details and maintenance issues. Finally, the TOPSIS and IPA analyses identified the quality of resting spaces and access to bicycle paths as relative priorities for intervention within the framework of multi-criteria decision-making models. These priorities do not indicate statistically significant differences among the indicators but rather provide a basis for guiding urban planning and design decisions in the study area.

In response to the research questions, the results showed a positive and significant correlation among the investigated indicators, but no significant difference in their ranking. Gender and traffic frequency variables had limited explanatory power in predicting overall satisfaction, and the regression model was not statistically significant; therefore, its results are interpreted only as preliminary and exploratory evidence. Cluster analysis identified three groups: highly dissatisfied, moderately dissatisfied, and slightly dissatisfied, and exploratory analyses indicated that in the studied sample, women were more associated with the lack of shade and resting spaces, men and young people with the lack of bicycle paths, and high-traffic users with inappropriate design and poor maintenance of urban furniture. Accordingly, the TOPSIS and IPA multi-criteria decision-making models indicated that access to bicycle paths and the quality of resting spaces have a relatively higher priority for intervention compared to other indicators. However, given the non-significant results of the Friedman test, these priorities should be interpreted within the framework of multi-criteria decision-making models, not as a definitive statistical difference among indicators.

This research is significant in three dimensions: theoretical, methodological, and practical. From a theoretical perspective, this study showed that evidence of a relatively integrated pattern is observable in users' perception of dissatisfaction with pedestrian space, and dissatisfaction with various dimensions of the pedestrian-oriented environment is experienced simultaneously and interdependently. Methodologically, combining multivariate statistical analyses (including K-means clustering and multiple correspondence analysis) with multi-criteria decision-making methods (TOPSIS and IPA) provided an exploratory framework for translating perceptual data into urban planning and design priorities, which can be utilized in similar studies. From a practical perspective, the findings indicate that one-dimensional interventions alone will not adequately address the existing issues, and improving the quality of this axis requires simultaneous attention to the various dimensions of environmental quality. In the study area, the results suggest that greater attention to developing safe bicycle infrastructure, improving the quality of resting spaces, and enhancing environmental comfort conditions could reduce user dissatisfaction. Accordingly, future research should incorporate greater demographic diversity in samples by increasing sample size and using probabilistic sampling methods. Furthermore, combining perceptual data with objective environmental measurements and pedestrian behavior observation, conducting longitudinal studies in different seasons, and applying more advanced methods such as structural equation modeling can help validate and develop the findings of this research. Additionally, comparative studies in different neighborhoods, evaluating interventions' effectiveness after implementation, and examining the role of new technologies and spatial data in analyzing satisfaction with pedestrian spaces will open new horizons for future research.

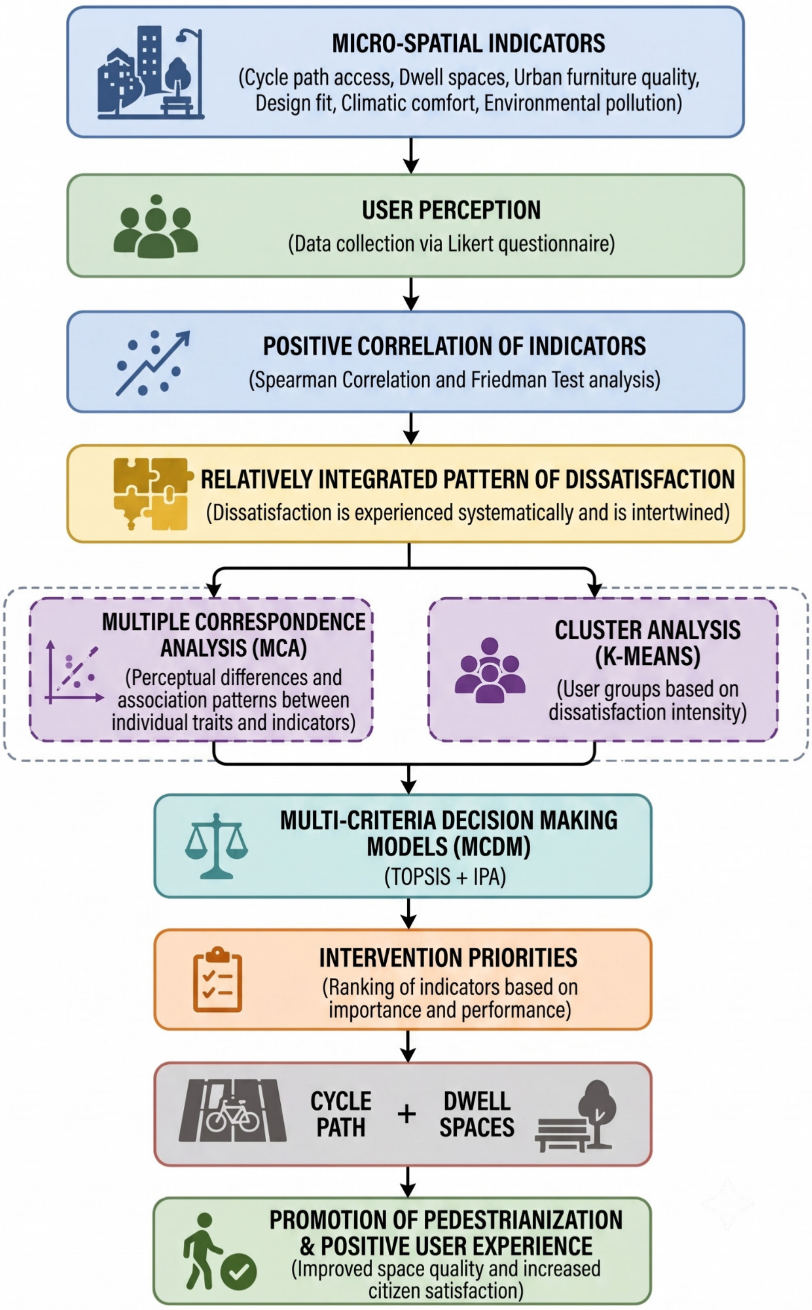


Figure 13. Final research model

The present study also had limitations that should be considered when interpreting the findings. The most important limitation was the relatively small sample size (44 people) and the use of non-probability convenience sampling, which limits the generalizability of the results to other urban areas. Therefore, the findings represent only the perceptions of the users surveyed on Heydarkhani Street and should not be interpreted as a definitive pattern for other urban spaces. Also, due to the sample size, the results of multivariate and regression analyses should be considered preliminary and exploratory evidence, and their validation in future studies with larger samples is necessary.

Other limitations include reliance on self-reported questionnaire data, the study's cross-sectional nature, and the lack of investigation into certain contextual variables such as income level, education, and physical health status. Therefore, future studies should be conducted with larger samples, both objective and subjective data, longitudinal studies, and more advanced analytical methods to allow for a more precise evaluation of factors affecting satisfaction with pedestrian spaces. A summary of the achievements and a roadmap of intervention priorities are also presented in the form of the final research model (Figure 13).

Authors' Contributions

The contribution and role of all authors were equal.

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Conflict of Interest

The authors declare that they have no conflicts of interest regarding the authorship or publication of this article.

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