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Providing a Pattern and Planning Method for Footpaths and Sidewalks to Protect Deteriorated and Vulnerable Urban Contexts

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Abstract

This research seeks to answer this question to prevent the waste of capital in routes without potential and allocate facilities and facilities to routes with potential to encourage people to move on foot on short trips. Through what criteria and indicators can the existing potential of the roads be measured, and as a result, by finding the optimal routes for pedestrian traffic, one of the most important problems of the public's lack of acceptance of non-motorized transportation can be solved. At first, by using the descriptive-analytical research method, through library studies, the existing literature in this field and also the experiences of other countries of the world and Iran have been investigated. In this way, the theoretical framework of the research has been formed and effective criteria and indicators have been extracted in measuring the potential of roads for pedestrian movement. In this way, four criteria of land use, traffic safety, security, attractiveness, and comfort have been defined. The extracted criteria and sub-criteria are valued through the process of hierarchical analysis and the Delphi method. In the next step, by using the case-based research method, the data related to the sub-criteria at the level of the roads in the study area are collected through observation and interview entered into the geographic information system, and finally analyzed by the geographic information system and in some cases. The layout of the space (to measure the network continuity) is done and the routes with potential for pedestrian movement are extracted. Finally, from the summation of the weighted values obtained for each of the roads regarding land use criteria, traffic safety, security attractiveness, and comfort, the final score of each of the roads in the study area (intended statistical population) about the potential passages are obtained to create suitable routes for pedestrian traffic.

Keywords: footpaths, protection of degraded contexts, AHP, GIS, space layout.

Introduction

Walking compared to other types of vehicles has many advantages, such as not consuming non-renewable energy resources, not polluting the urban environment, low cost of providing related networks, reliability in terms of time, justice in accessing urban facilities, and help It is a part of personal and social health and vitality, mobility in urban spaces, creating social interaction, etc. On the other hand, a significant share of moving from place to place for short distances for shopping, work, recreation, meeting, spending leisure time, sports, and a combination of the above in the transportation system of the lively cities of the world is made by pedestrians. This issue in Iran due to the inefficiency of the public transportation system has forced the use of private vehicles and the general

preference for going somewhere on foot (with any purpose on foot from the origin to a destination) except In case of necessity, it is less important.

Nowadays, in modern urban planning, planning for the machine has come before planning for humans. As researchers and critics have pointed out, in contemporary urban planning, the pedestrian is a forgotten person. In fact, with the omnipresence of motor vehicles over the life of the city, the need for a person on foot has been ignored. The knowledge of traffic engineering and urban planning, despite all its progress, has only focused on guiding and facilitating the movement of riders and the safety of road riders. As a result of not considering an independent identity for pedestrians, as well as not paying attention to their needs and behavior patterns, the interaction between pedestrians and riders has been impaired.

In this regard, it should be said that the quality of life and moving around on foot in Tehran in the last few decades based on the rule of the car has been damaged like the big cities of the world and the needs of pedestrians in terms of physical issues such as connectivity, traffic volume, flooring And . . . And what about non-physical issues such as security, safety, and not noticed? As a result, one of the most important problems in this field is the lack of acceptance of walking due to the lack of adaptation of footpaths to the needs of pedestrians and the lack of suitable facilities for walking.

For this purpose, the upcoming research is looking for the answer to this question, through what criteria and indicators can the existing potential of the roads (at the level of the studied area) be measured, and as a result, finding the optimal routes for pedestrian traffic is one of the most important problems. It solved the public's lack of acceptance of non-motorized transportation. Walking is the oldest form of human movement in space, which can be considered the natural right of urban space users.

Until the last century, most of the cities were on the scale of pedestrian movement, and the pedestrian axes, especially in the city centers, which are the main places of shopping and circulation and passing of citizens, have been seriously neglected due to the conquest of the city by vehicles and its dominance over humans (Banerjee, 2023). This lack of attention to non-motorized movement in cities causes adverse consequences such as environmental pollution, difficulty and slowness of commuting, reduction of leisure facilities and the transformation of open spaces such as streets, squares, and alleys into channels for car movement, problems of daily shopping and access to Essential services.

Therefore, as long as the cities improve the quality of the environment to reduce fossil fuels, improve the physical and mental health of people, increase the mutual social relations between citizens, improve the social, cultural, and physical qualities of life in the city and help to humanize urban environments and . . . It depends on pedestrian movement, returning and re-approaching pedestrians and facilitating pedestrian movement seems an inevitable necessity.

As it was said earlier, one of the most important problems in this field is the lack of creating special pedestrian traffic routes in cities and the lack of compliance of the constructed routes with the needs of pedestrians. Perhaps the special routes for walking without scientific planning and spending a lot of money have low efficiency and reception, and in contrast to the routes that should be given special attention, they lack basic facilities in terms of the principles of route design.

As a result, to prevent the waste of capital on the routes without potential and to allocate facilities and facilities to the routes with potential to encourage people to move on foot in short trips, this research aims to find the routes by measuring the existing potential of the roads in the studied area. It is desirable to pay for pedestrian traffic and solve one of the most important problems of the public's lack of acceptance of walking.

In the formation of the desired topic and dealing with issues related to pedestrian movement, certain goals have been considered, which will be the guiding factor for the studies and finally the conclusion. The main goal of this research is "Pedestrian routing (at the level of the studied area of Yusuf Abad neighborhood) based on the existing potentials of the roads about the needs of pedestrians". Achieving the main goal of the research will be pursued through the following sub-goals. The main questions that this research seeks to answer are what criteria and indicators can be considered to measure the potential of roads for walking based on the public's desire to walk on these roads? Also, which axes in the studied area have the potential to create suitable pedestrian traffic routes and are welcomed according to the needs of pedestrians?

Vocabulary and concepts

Pedestrian. In the traffic laws of our country, a pedestrian is defined as "a person who walks without using any type of motorized or non-motorized vehicle" (Arulrajah, et al, 2018).

Sidewalk. A sidewalk is a pedestrian path parallel to the rider's path, but separate from it (). According to the definition of the traffic regulations of Iran, a sidewalk is "a part of the street that is located along it and is reserved for the passage of pedestrians" (Che, 2023).

Pedestrian crossing. The pedestrian crossing is a crossing that, due to the high volume of pedestrian traffic in city centers, is dedicated only to pedestrians. Pavements other than concrete, such as asphalt and cobblestones, are usually used in the construction of sidewalks. If vehicles pass parallel to this crossing, it is necessary to design a minimum distance of 1.5 meters between the pedestrian crossing and the vehicle crossing, and this distance is usually created by trees or water streams (Banerjee, 2023).

Walk. Sidewalks are enclosed streets where vehicular traffic is excluded. However, emergency vehicles have access to it, and service and cargo trucks are allowed to travel there during certain hours (Ibid, 2023).

Figure 1. An example of a sidewalk

Pedestrian needs. According to the Figure (2). The hierarchy of pedestrian crossing needs includes 5 main classifications:

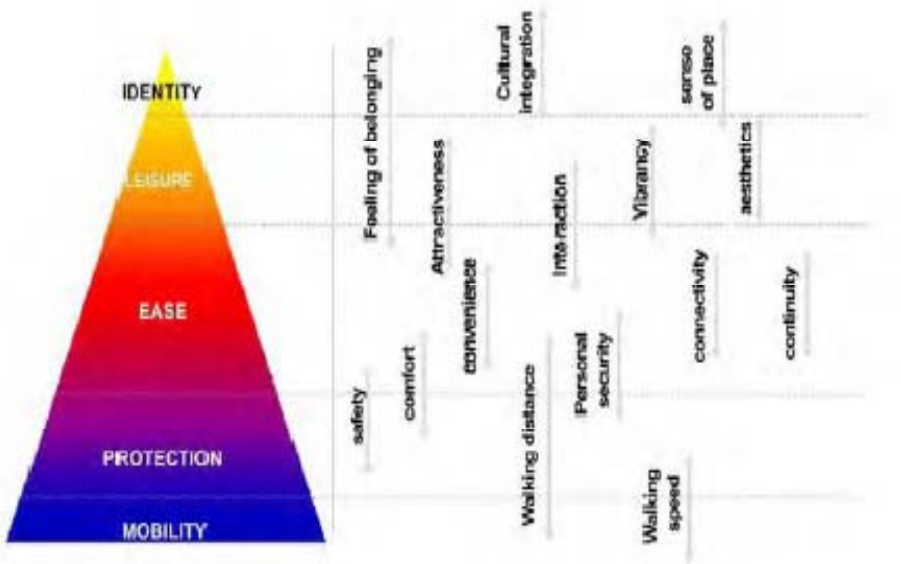

Figure 2. Hierarchy of pedestrian crossing needs

At the first level, the existence of specific beginning and end points in the pedestrian path and also providing pedestrian access along it is very important. At the second level, one of the needs of a pedestrian crossing is a feeling of protection, which means ensuring the safety and security of pedestrians along the pedestrian crossing. The third level includes providing the comfort and convenience of pedestrians on the pedestrian path, and the fourth level includes enjoying the space of the pedestrian crossing, which depends on several factors from the series of needs of a sustainable pedestrian crossing.

Such as the location and placement of pedestrian crossing facilities, the connection of the pedestrian network, and so on. . . Also, from the highest level of the needs of a pedestrian crossing, we can mention the degree of identification and recognition of the pedestrian crossing. This means the possibility of participation (establishing communication) with the facilities and facilities of the pedestrian crossing, one of the factors of which is the possibility of receiving environmental information from the pedestrian (Arulrajah, et al, 2018).

Theoretical

The discussion of pedestrians and pedestrians has been considered by the thinkers of this field throughout the history of urban planning. It may have faded in decades due to the peak power of motor vehicles, but they have not been oblivious to its importance (Chen et al., 2020). First, in this section, to achieve the criteria of a desirable urban space, the theories of thinkers called urbanism are examined. Examining these theories shows that all of them emphasize and pay attention to pedestrian movement and the creation of related spaces as one of the main indicators of improving environmental quality in cities.

Each of the theoreticians and promoters of the field of urban planning have looked at the phenomenon of the city and urbanization from a specific angle and have given a specific organization to the city. But the common point in all the presented theories is attention to man and his different needs in the environment. Among the experts whose theories have been used in this field, we can mention Jane Jacobs, Francis Tibbalds, Gordon Cullen, Louis Mumford, etc., whose opinions and theories are stated below. Then, different points of view related to pedestrians and pedestrian movement are discussed to reach a theory based on increasing the ability of pedestrians (Che, 2023).

Theories related to public spaces and sidewalks

Jane Jacobs (1916-2006). Analyzing the conditions that make the street lively, Jacobs points out three points: The first step to maintain the safety of the street is that there should be a clear boundary between public and private space. Second, constant control is needed. The eyes of those whom Jacobs considers the owners of the street must constantly watch the street. Third, the streets themselves, especially the sidewalks, should be used continuously (Banerjee, 2023). The street should connect two points that need to be connected, and there should be enough attractions that make people stop. An empty street has nothing to see, but watching a busy street will be enjoyable and this will make the street attractive and lively.

Francis Tibbalds (1941-1992). Tibbalds has confirmed the necessity of pedestrian paths in city centers. But at the same time, he considers the necessity of vehicles in cities as a solution to create harmony between pedestrians and cars. In any case, the priority for Tibalds is on foot. He emphasized the diversity of uses and activities.

Gordon Cullen (1914-1994). *Cullen*'s emphasis is on the "power of vision" by which the environment is fully understood, and he considered the importance of the landscape in recalling one's memories and experiences, and that each person should be able to express these experiences through the three ways that his sensory reactions will appear. To know the memories he considers these three ways visual observations, spatial observations, and content (Banerjee, 2023; Rahmati & Kashi, 2019, September; Iravani & Dehghan, 2022).

He says: "*People enjoy the city by moving and looking at it. Therefore, it is necessary to prepare the city for pedestrian movement by prioritizing the pedestrians and connecting them (Che et al., 2021). He considered the presence of citizens in the urban space to be necessary and a source of vitality. In his drawings, he always showed people in a real way and engaged in daily activities, not in an abstract life. He also tried in his articles and sketches to depict the extent and manner of the effect of urban details on people's sense of place and mood*".

Regen spray. One of the topics that Spray Regen refers to is pedestrian spaces. At the same time that he considers many streets without cars in the city to be soulless and dead, he reminds us that if the cars interfere with the movement of pedestrians, they will be a problem, and if the cars move at low speeds (Banerjee, 2023). And passing traffic should be reduced to the lowest possible level, both of them can be allowed to be present in crowded urban centers (Chen et al., 2020). Spray Regen considers the solution to the problem of crowded intersections in designing safe pedestrian islands, reducing traffic speed, increasing pedestrian crossings, and making them easier to use.

Louis Mumford (1895-1990). Mumford believes in paying attention to the individual and humans in the city and is against cars (Carthy et al., 2020; Rahmati & Kashi, 2019, September). He considers pedestrian paths important and mixed uses necessary. Mumford's emphasis is on the need to create open spaces, especially in neighborhoods, and he considers this necessary for all age groups. Regarding the pedestrian routes, he refers to the role of "architect, city planner" and the importance of these routes and believes that the designer should create these routes according to the performance and daily business in public areas and a variety of ways, both for residents and be accessible to visitors as well (Arulrajah, et al, 2018).

Kamilosite. Kamilosite believes that the pedestrian crossing is not only a crossing route but also its aesthetic aspects. So that the pedestrian can see his path and have a continuous effect on him. From his point of view, the street is an essential element of the city and a manifestation of the social life and vital function of the city, and not just a passageway (Loor & Evans, 2021). According to him, the issue of transportation should not substitute technical solutions for aesthetic values. He believes that it is possible to create a compromise between artistic vision and traffic.

Amos Rappaport (1929). Amos Rappaport negates the passive position of man in the urban space by discussing the interaction between man and the environment and considers movement in the environment to be the most important factor in knowing the environment and mental design. Also, another point of interest for Rappaport is orientation in the urban environment (Silva, 2019). According to him, special points, access, and use are the three factors that are effective in orientation. Pedestrians in their orientation use a set of special decision points that should be taken into consideration by designers, entrances and exits and special routes are important in the discussion of access, and users are also able to concentrate on activities (Che et al., 2021). Provide, they are usually effective and studyable in the orientation of people (Marshall, et al., 2019).

Rob Carrier (1938). Carrier, who considers the structure of the city to be composed of streets and squares, has classified them by studying many examples to create patterns for designing new forms in cities (Rahmati & Kashi, 2019, September). He has expressed his theories more specifically about pedestrian routes: the street space has a function only when it is a part of the formations in which the pedestrian crossing leads to the street (Loor & Evans, 2021). Commercial streets are among the most important streets and they should be designed differently from residential streets.

Sergey Chermayev (1900-1996). One of the first experts who paid attention to environmental issues in urban spaces was Sergey Chermaev). In his opinion, the personal car is the cause of the destruction of human life. Chermayev believed that people should be encouraged as much as possible not to use private cars, and he considered the best solution for this to be the provision of free public transportation. He even suggested the use of a rented bicycle for dense spaces in the cities (Marshall, et al., 2019; Rahmati & Kashi, 2019, September).

Michael A. Arth. His theory known as neo-pedestrianism, was presented in 1999, a new neighborhood or town that uses neo-pedestrianism is called a pedestrian village (Silva, 2019). Pedestrian villages can range from nearly car-free to rear access to nearly every home and workplace, but pedestrian crossings are always in front. By removing the front riding street and replacing it with a tree-planted crossing path, the pedestrian line has been emphasized on alternative trips with low impacts, such as walking and cycling.

Summary

According to the conducted studies, it seems that the main urban public space ideas makers can be divided into six groups based on their views, with environmental and sustainability considerations, with an emphasis on spatial and visual perception, with the approach of social interactions, with Emphasis on the expansion of pedestrian-oriented, with the approach of creating security and human-oriented in the urban space and with environmental-behavioral considerations. In the meantime, although each of the experts may have addressed the issue from several perspectives, according to the main axis of their thoughts, they have been placed in one group (Table 1).

Table 1. Classification of opinions of experts about public spaces and pedestrian walkways

Theory	Approach	Year	Theorist	Row
• The presence of attractive and diverse uses in the body of the streets • Continuous use of the sidewalk • The constant presence of watchful eyes on the street • Keeping the street safe	Strengthening social interactions	(1916-2006)	Jane Jacobs	1
• Non-separation of pedestrians and riders,	Creating securi-	(1941-	Francis	2

Theory	Approach	Year	Theorist	Row
emphasizing the priority given to pedestrians • Emphasis on diversification of uses and activities	ty and humanity in the urban space	1992)	Tibbalds	
• Paying attention to successive views and the mental Figure of pedestrians in urban spaces • Emphasis on the continuity and continuity of the pedestrian network in the city • Emphasis on the existence of daily activities in the street that will lead to the presence of citizens in the urban space and thus vitality	Emphasis on spatial and visual perception	(1914-1994)	Gordon Cullen	3
• The presence of pedestrians and riders on the street with an emphasis on providing pedestrian traffic safety • Reducing traffic congestion, lowering traffic speed, and creating safe pedestrian islands for pedestrian traffic safety	Emphasis on movement in the urban space and the expansion of pedestrian traffic		Regen spray	4
• Mixed-use footpaths • Emphasizing the need to create private open spaces in neighborhoods • The city is the place where culture crystallizes and defends humans against cars	Creating security and humanity in the urban space	(1895-1990)	Louis Mumford	5
• Visual continuity in pedestrian movement • Creating peace and a sense of security in the urban environment	Emphasis on spatial and visual perception	-	Perfection	6
• Movement in the environment is the most important factor in knowing the environment and mental plan • Specific points, access, and use of three factors affecting orientation • The focus on activities is an effective factor in people's orientation	Emphasis on environmental-behavioral effects	(1929)	Amos Rapaport	7
• Paying attention again to the human and social concept of the street • The presence of pedestrians and riders on the street • Commercial use, the most important use of pedestrians	Emphasis on spatial and visual perception	(1938)	Rob Carrier	8
• Paying attention to environmental issues, personal cars are the cause of ruining human life • Providing free public transportation • Proposing the use of a rental bike for dense spaces in the cities	Emphasis on environmental considerations and sustainability	(1900-1996)	Sergey Chermayev	9
• Focus on reducing or eliminating cars in	Emphasis on	(1916-	Michael A.	10

Theory	Approach	Year	Theorist	Row
urban spaces • Pedestrian villages in an almost car-free range • Removing the front carriageway and replacing it with a tree-lined • Crosswalk • Low-impact alternative trips such as walking and cycling	movement in the urban space and the expansion of pedestrian traffic	2006)	Arth	

Source: Authors, 2024.

Conceptual Model of Research

In this part, to summarize and conclude the discussed topics, table (1), summarizes the effective criteria and indicators in measuring the potential of roads for pedestrian movement. Urbanization theories and external and internal experiences have been discussed. In Figure (3), the hierarchical structure of the effective criteria in measuring the potential of roads for pedestrian movement is given below:

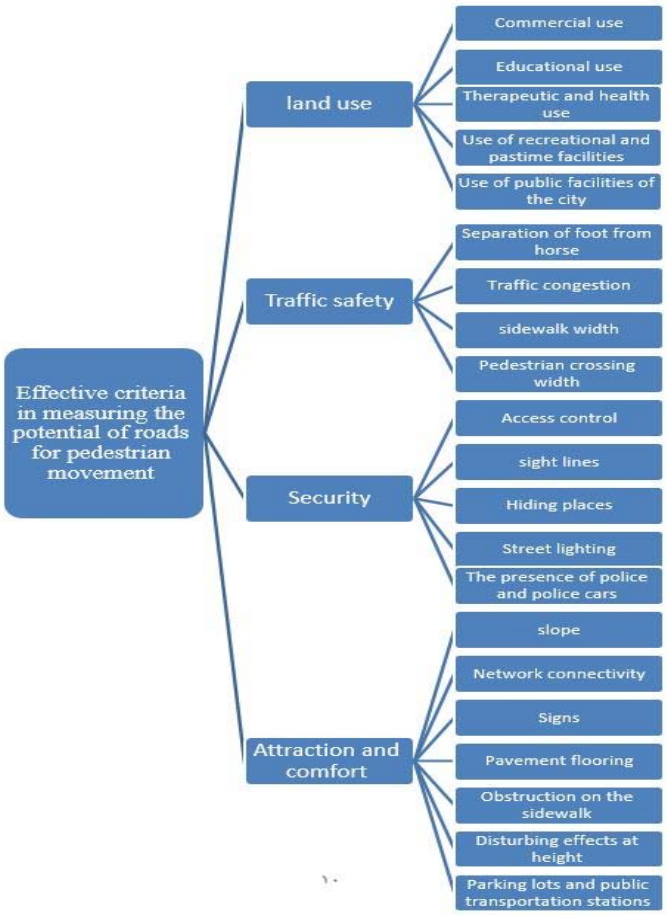

Figure 3. Hierarchical structure of the effective criteria in measuring the potential of roads for pedestrian movement (Source: Authors, 2024).

Methodology

Due to the location of District 12 and Ferdowsi and Baharestan neighborhoods, which are located in the center of Tehran. On the other hand, the presence of various and distinct functions at the neighborhood level, as well as proper access to the public transportation system, provides the possibility of proper access to other parts of the city using pedestrian movement in short trips. Therefore, a part of the Ferdowsi and Baharestan neighborhood has been considered as a study area to prevent the waste of capital on non-capable roads and encourage people to walk on short trips by finding routes with the ability to move on foot and strengthening the said roads. let's show

Introduction of Baharestan and Ferdowsi neighborhoods. As mentioned earlier, in this research, the Baharestan and Ferdowsi neighborhoods have been selected as a case study (Suksiri-pattanapong et al., 2022; Kahvand, et al., 2015). These neighborhoods are located in District 1 of the region. Based on the field observations, and according to the compiled final indicators, the three crossings of Serhang Sakhaei, Mujmar-Molla Nowrozi, and Gudarzi-Shahcheraghi were able to be evaluated and were selected as pilot crossings for evaluation. What is certain is the evaluation of this passage, which will be done in connection with other passages of the neighborhood and district. With this introduction, we will examine and analyze the mentioned localities.

Baharestan Neighborhood

The neighborhood known today as Baharestan is bounded from the north by Revolution Street, from the east by Ibn Sina Street, from the south by Amir Kabir Street (from Sarcheshmeh to Saadi), and from the west by Saadi Street. The area of the neighborhood is 649,762 square meters, of which 101,950 square meters (equivalent to 15.7%) are allocated to residential uses. In this neighborhood, Mujmar-Molla Nowrozi and Gudarzi-Shahcheraghi roads have been analyzed and investigated for evaluation.

A) Mujmar-Molla Nowrozi road: with a variable width of 9 to 10 meters and a length of approximately 300 meters, in the hierarchy of the existing communication network, it has the local role of collector and distributor, which connects Saadi, Lalezar, and Ferdowsi streets.

B) Gudarzi-Shahcheraghi crossing: this crossing with a width of 10 meters and a length of approximately 320 meters has a local gathering and spreading role in the hierarchy of the existing communication network, which connects Saadi, Lalezar, and Ferdowsi streets.

Figure 4. Mejmar Street from three perspectives (Source: Authors, 2024).

Refining criteria

In this part, according to factors such as possibilities and goals of the research, limitations, the situation of the case sample about the existing indicators that have been investigated in the initial recognition stage, and also the sameness of the axes in the index to the refinement and final selection of the index. We will pay the desired. It should be noted that in this research, an attempt was made to use as many indicators as possible for the validity of the results, so the number of indicators that will be removed after refining is limited.

The final list of indicators. After refining the indicators and their final selection, the indicators that will be used to evaluate the axes are described in the following table 2, and their objective or subjective nature is also specified.

Table 2. The final list of (objective) evaluation indicators in the studied axes

Indices	Indicator	Criterion
Number of breakpoints per 120 meters	There are pauses	Physical characteristics
The percentage of the route with suitable flooring	Floor Covering	
Number per 50 meters	Urban furniture and facilities	
The percentage of the path with the right width	sidewalk width	
Connectivity value extracted from Space Syntax analysis	Connectivity in the road network	
Negative average number of obstacles per 50 meters	No obstacles	
The percentage of the route with the possibility of use by physically challenged people	Facilities for disabled people to pass	
The age range of users in question	The age range of users	Variety of users
female to male ratio	Sexual diversity	
Number of trees per 50 meters	planting trees	Route desirability
The percentage of the path with proper cleaning	The state of cleaning the track	
The percentage of the route with a favorable view	Favorable scenery and visual values along the way	
List check (based on proper signs and speed of cars)	Traffic safety at intersections	safety and security
The percentage of the path with proper lighting	Lighting	
Total number/number of user activity mode	Variety of activities	Variety of activities
The number of users on the route	Number of users	

Source: Authors, 2024.

Results

Evaluation and potential measurement of the roads in the studied area for pedestrian movement about the criteria and indicators extracted from the theoretical framework of the research and

evaluation of the effective criteria and indicators in the potential measurement of roads for pedestrian movement using the Analytical Hierarchy Process (AHP).

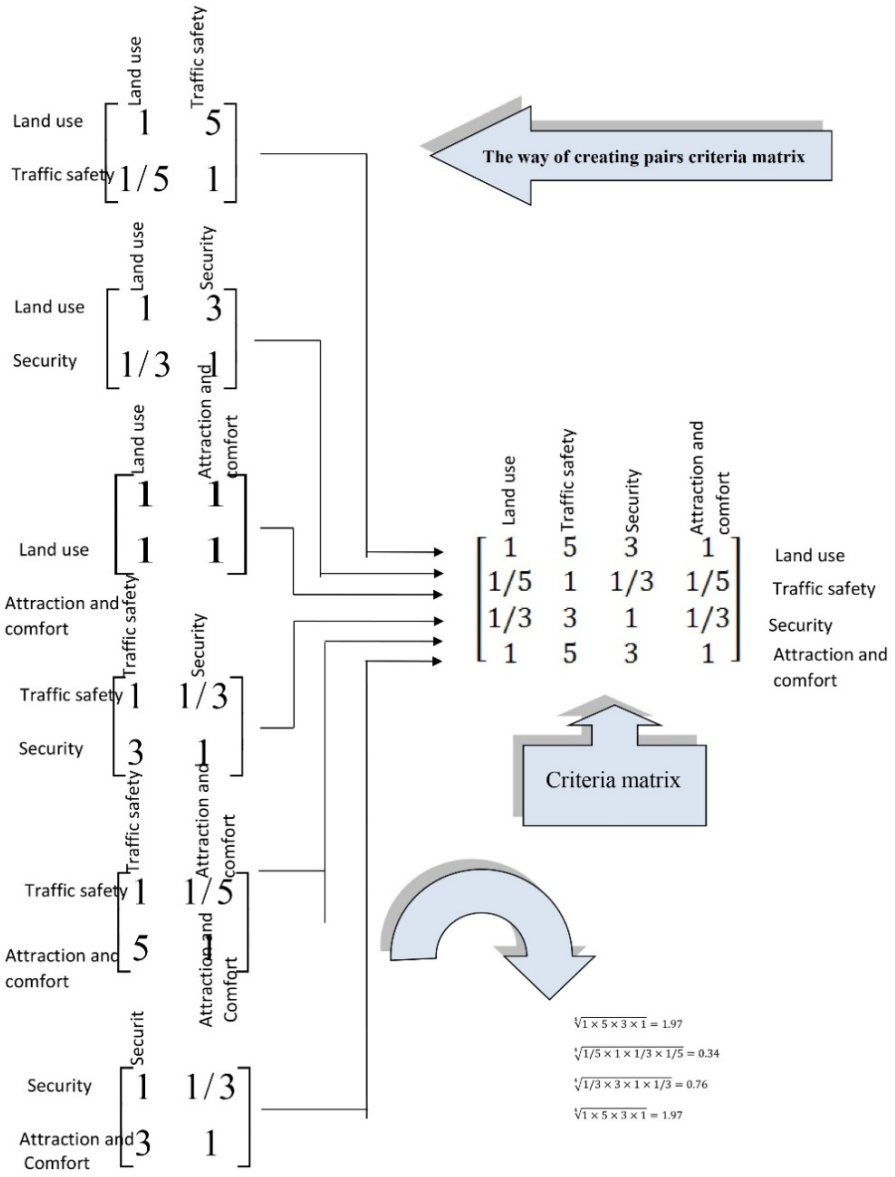

Figure 5. Calculations of AHP Model (Source: Authors, 2024).

As can be seen, the sum of the importance coefficients of the mentioned four criteria (the second level of the hierarchy) is equal to one, and this indicates the relative importance of the criteria (GM et al., 2021, October). To obtain the importance coefficient (weight) of the sub-criteria, we perform the same steps as above to obtain the importance coefficient (weight) of the criteria. In this research, Expert Choice software, which is one of the AHP application software, was used to calculate the importance coefficient (weight), and the weight of all criteria and sub-criteria was calculated

using the aforementioned method. In Table (3), the weight calculated for all criteria and sub-criteria is given (Cirianni et al., 2022).

Table 3. Weight calculated for criteria and sub-criteria

Weight below criteria (fourth level)	Weight below the criteria (third level)	Criteria weight (second level)
Suitable = 0.73	Commercial use = 0.54	Land use = 0.39
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Educational use = 0.10	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Therapeutic and health use = 0.03	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Use of recreational facilities and spending time = 0.27	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Usage of public facilities of the city = 0.06	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Separation of the pedestrian from the rider = 0.53	Traffic safety = 0.07
Fairly suitable = 0.21		
Inappropriate = 0.06		
Low density = 0.73	Traffic density = 0.18	
Average density = 0.21		
High density = 0.06		
Suitable = 0.73	Sidewalk width = 0.20	
Fairly suitable = 0.21		
Inappropriate = 0.06		
The same value = 1	Pedestrian crossing width = 0.09	
The same value = 1	Access control = 0.13	Security = 0.15
The same value = 1	Long sight lines = 0.06	
Suitable = 0.73	Hiding places = 0.06	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable brightness = 0.9	Illumination of passages = 0.43	
Inappropriate lighting = 0.1		
Suitable = 0.9	Presence of police and police car = 0.32	
Inappropriate = 0.1		
Weight below criteria (fourth level)	Weight below the criteria (third level)	Criteria weight (second level)
Appropriate slope = 0.78	Slope = 0.27	Attractiveness and comfort = 0.39 Criteria weight
Relatively inappropriate slope = 0.15		

Weight below criteria (fourth level)	Weight below the criteria (third level)	Criteria weight (second level)
Inappropriate slope = 0.07		(second level) Land use = 0.39 Traffic safety = 0.07
Suitable = 0.73	Network connectivity = 0.18	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Signs = 0.05	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.73	Paving = 0.07	
Fairly suitable = 0.21		
Inappropriate = 0.06		
Suitable = 0.65	Long obstructions on the sidewalk = 0.05	
Fairly suitable = 0.20		
Relatively inappropriate = 0.10		
Inappropriate = 0.05		
Suitable = 0.65	Disturbing effects at height = 0.03	
Fairly suitable = 0.20		
Relatively inappropriate = 0.10		
Inappropriate = 0.05		
Suitable = 0.73	Parking lots and public transportation stations = 0.35	
Fairly suitable = 0.21		
Inappropriate = 0.06	Weight below the criteria (third level) Commercial use = 0.54	

Source: Authors, 2024.

Discussion and Conclusion

Explanation of a merit index for choosing passages with potential for pedestrian movement a merit index for measuring the potential of passages for pedestrian movement is determined by the agreement of the relative weights (preferences) of RIWs factors at each level of the hierarchical structure. The suitable index for all the roads of the study area (the desired statistical population) is determined simultaneously using the algebraic operations of maps in the GIS environment (Wong, 2020; Iravani & Ahd, 2021-a). This index is derived from the weighted summation method in the Thomas Al-Saati matrix, but it is applied to layers in the GIS environment and is calculated as follows:

This index is calculated by multiplying the relative weight of the RIWs criteria of the value of the passages (the lowest level of the structure) by the relative weight of the RIWs criteria of the higher level of the previous criteria in the hierarchical structure (Rodway-Dyer & Ellis, 2018). They are in the previous stage, in the weight of the factors of higher levels of RIWs, and repeat until reaching the second level of the hierarchical structure. The equation related to the four-level structure is calculated as follows:

$$SI = \sum_{i}^{N2} \left[RIW_i^2 \times \sum_{j}^{N3\,i} RIW_{ij}^3 \times RIW_{ijk}^4 \right]$$

SI = Merit index

N_2 = Number of second-level criteria

N_{3i} = The number of sub-criteria of the third level that is directly related to the i-th criterion of the second level

RIW_i^2 = The relative weight of the i-th criterion of the second level

RIW_{ij}^3 = The relative weight of the j sub-criteria of the third level from the i-th sub-criteria of the second level

RIW_{ijk}^4 = The relative weight of sub-criteria k of the fourth level (descriptive information of passages) from sub-criterion j of the third level from sub-criterion i of the second level

Table 4 shows the weighted values of the last level of criteria entered as the values of the cells of the information layers in GIS.

Table 4. The value of information layers in GIS

The value of information layers	Criteria (second level)	Criteria (second level)
Suitable = 0.1537	land use	land use
Relatively suitable = 0.0442		
Inappropriate = 0.0126		
Suitable = 0.0284		
Fairly suitable = 0.00819		
Inappropriate = 0.00234		
Suitable = 0.00854		
Fairly suitable = 0.00245		
Inappropriate = 0.0007		
Suitable = 0.0768		
Fairly suitable = 0.0221		
Inappropriate = 0.0063		
Suitable = 0.0170		
Relatively suitable = 0.0049		
Inappropriate = 0.0014		
Suitable = 0.0270	Traffic safety	Traffic safety
Fairly suitable = 0.0077	Criteria (second level)	Criteria (second level)
Inappropriate = 0.0022	land use	land use

Source: Authors, 2024.

Table 5. Details of analyses

The value of information layers	Sub-criteria (third level)	Criteria (second level)
Low density = 0.0091	Traffic density	Traffic safety
Average density = 0.0026		
High density = 0.0007		

The value of information layers	Sub-criteria (third level)	Criteria (second level)
Suitable = 0.0102	Sidewalk width	
Fairly suitable = 0.0029		
Inappropriate = 0.0008		
The same value = 0.0063	Pedestrian crossing width	
The same value = 0.0195	Access control	security
The same value = 0.0090	Long sight lines	
Suitable = 0.0065	Hiding places	
Fairly suitable = 0.0018		
Inappropriate = 0.0005		
Suitable = 0.0580	Street lighting	
Inappropriate = 0.00645		
Suitable = 0.0432	The presence of police and police cars	
Inappropriate = 0.0048		
Suitable = 0.0821	Slope	Attraction and comfort
Relatively inappropriate = 0.0157		
Inappropriate = 0.0073		
Suitable = 0.0512	Network connection	
Relatively suitable = 0.0147		
Inappropriate = 0.0042		
Suitable = 0.0142	Signs	
Relatively suitable = 0.0040		
Inappropriate = 0.0011		
Suitable = 0.0199	Flooring	
Fairly suitable = 0.0057		
Inappropriate = 0.0016		
Suitable = 0.0126	Long obstructions on the sidewalk	
Fairly suitable = 0.0039		
Relatively inappropriate = 0.0019		
Inappropriate = 0.0009		
The value of information layers	Sub-criteria (third level)	Criteria (second level)
Suitable = 0.0076	Disturbing effects at height	Attraction and comfort Criteria (second level) Traffic safety
Fairly suitable = 0.0023		
Relatively inappropriate = 0.0011		
Inappropriate = 0.0005		
Suitable = 0.0996	Parking lots and public transport stations Sub-criteria (third level) Traffic density	
Fairly suitable = 0.0286		
Inappropriate = 0.0081		

Source: Authors, 2024.

The weights extracted from the hierarchical analysis process are assigned to the information layers. Then, for each layer, the corresponding weight was calculated using the merit index formula up to the second level and assigned to the layers. The result of the operation is the layers, each of which weights pedestrian movement potential, and the sum of all these layers shows the sum of merit weights for selecting pedestrian movement potential. The higher this number is, the more potential the road has for pedestrian movement.

Summarizing the potential measurement of the roads in the studied area for pedestrian movement about the criteria and indicators extracted from the theoretical framework of the research (Foster & Newell, 2019; Iravani & Ahd, 2021-b). The model resulting from the combined method of AHP and GIS in the current research, which was called the spatial AHP model, is a valuable weighted map of the roads with the potential for pedestrian movement in the area under study (target statistical population). In this layer, larger numbers indicate the greater potential of the passages for pedestrian movement. For better understanding, the weight values of this layer were scored on a scale of 0 to 100. This type of scoring shows both the percentage of points and the priority of points.

Potential measurement of the roads of the studied area for pedestrian movement in connection with land use criteria

From the summation of the weighted values obtained for each of the roads about the indicators of commercial use, educational use, medical and health use, recreational and pastime facility use, and urban public facility use, the final score of each of the roads in the study area (the desired statistical population) is obtained in connection with the land use criterion (Habibi & Haghi, 2018). Asadabadi Street, the distance between Asadabadi Square and Panzham Street, due to the presence of various commercial uses (retail shops, banks, restaurants, etc.) Adjacent and also the presence of recreational and windy uses, and especially the presence of Shafaq Park within a 4-5 minute radius of its access, has the highest score and, as a result, the highest potential for pedestrian movement about the land use criteria (Ghadarjani, et al., 2013).

Measuring the potential of the roads in the studied area for pedestrian movement in connection with the traffic safety criteria (Habibi & Haghi, 2018; Gheitarany et al., 2013). From the summation of the weighted values obtained for each of the roads about the indicators of the separation of the sidewalk from the pedestrian surface, traffic density, the useful width of the sidewalk, and the width of pedestrians, the final score of each of the roads in the study area (community the desired statistics) d) the relationship with the traffic safety criterion is obtained. It has been given the lowest score and is in bad condition, and the 38th collector street is useful due to the proper separation of the sidewalk from the pedestrian surface (water and green spaces), the low volume of passing traffic, and the appropriate width. The sidewalk with the volume of pedestrians has the highest score and, as a result, the highest potential for pedestrian movement to traffic safety criteria (Khanian, et al., 2019).

After that, Jahan Ara Street was placed in second place due to the proper separation of the sidewalk from the riding surface (water and green space) and the proportion of the useful width of the sidewalk to the volume of pedestrians, despite the high volume of passing traffic. Measuring the potential of the roads in the studied area for pedestrian movement in connection with the security criterion. From the summation of the weighted values obtained for each of the roads about the access control indicators, long sight lines, hiding places, lighting of the roads, and the presence of police and police cars, the final score of each of the roads in the study area (community the desired statistic) is obtained in connection with the security criterion.

Jahan Ara street due to the provision of 2 to 5 lux lighting in it and the presence of two police shelters in certain places on the said street and the high relative weight of this index among the

security indicators, despite the existence of places with the potential to hide in Along the route, the said street has the highest score and thus the highest potential for pedestrian movement about the security criterion (Maleki et al., 2023). Measuring the potential of the roads in the studied area for pedestrian movement about the criterion of attractiveness and comfort. From the summation of the weighted values obtained for each of the roads about the slope indicators, network continuity, signs, sidewalk flooring, obstructions on the sidewalk, and disturbing effects in height and parking.

For public transport stations, the final score of each of the roads in the study area (target statistical population) is obtained about the criteria of attractiveness and comfort. Fifteenth Street, due to its location within the access radius of the existing public parking lot at the intersection of Asadabadi and 17th streets, as well as the appropriate slope of this intersection and the high relative weight of these two indicators, among the indicators of attractiveness and convenience, it has the highest score and, as a result, the highest potential for direction. Pedestrian movement is related to the criteria of attraction and comfort. After that, Fathi Shaghaghi Street about the proper access to public transport stations and the proper slope of the crossing and Asadabadi Street between Asadabadi Square and Farhang Square according to the accessibility and connection (network continuity) of this crossing which is the most accessible The road is at the level of Yusuf Abad neighborhood, and convenient access to public transportation stations are placed next.

Matching research findings with research questions

To achieve the general goal of the research, which was "Pedestrian movement routing (at the level of the studied area of Yusuf Abad neighborhood) based on the existing potentials of the roads about the needs of pedestrians", two questions were asked. which was compiled by studying various documents and documents, the theoretical framework of the research, and from the summation of the studies obtained from the opinions of theorists (theories of thinkers and theories of urban development) and external and internal experiences, the first question of the research is "what criteria and indicators can be used for measuring potential Did you consider the paths for walking on foot based on the public's desire to walk on these paths?

Then, to answer the second question of the research, "Which axes at the level of the Yousef Abad neighborhood have the potential to create suitable pedestrian traffic routes and are welcomed according to the needs of pedestrians?" From the summation of the weighted values obtained for each of the roads about the criteria of land use, traffic safety, security and attractiveness, and comfort, the final score of each of the roads in the study area (intended statistical population) about the potential of the roads Creation of suitable foot traffic routes is achieved.

Asadabadi Street, between Asadabadi Square and Farhang Square, has the highest score and therefore the greatest potential for pedestrian movement. And after that, Asadabadi Street, between Farhang Square and 15th Street, is in second place (Habibi & Haghi, 2018). As a result, by identifying the roads with the potential for pedestrian movement, the main problem of the research, which is to prevent the creation of pedestrian routes without scientific planning and spending a lot of money, which has low efficiency and reception, has been solved, and suitable routes for pedestrian traffic that should be It has been determined that special attention should be paid to them and the necessary facilities should be allocated to them.

Measuring the potential of the roads in the studied area to create a sidewalk. According to the definition of sidewalks, which are enclosed streets where vehicular traffic is excluded. However, emergency vehicles have access to it, and service and cargo trucks are allowed to travel there during certain hours. As a result, due to the elimination of horse traffic on the sidewalks to measure the potential of the roads to create a sidewalk, the traffic safety criterion has been removed. From the summation of the weighted values obtained for each of the roads in connection with the criteria of

land use, security, attractiveness, and comfort, the final score of each of the roads in the study area (statistical population of the case opinion) is obtained in connection with the potential of the roads to create a sidewalk. Asadabadi Street, the border between Asadabadi Square and Farhang Square, has the highest score and therefore the greatest potential for creating a pedestrian walkway. And after that, Asadabadi Street, between Farhang Square and 15th Street, is in the second place.

Explaining the general process of evaluating and measuring the potential of pedestrian crossings

To generalize the results of the research to other similar cases and to use the research process in other projects to evaluate and measure the existing potential of roads to find the optimal routes for pedestrian traffic in this part to explain the overall process of evaluating and measuring the potential of roads for pedestrian traffic been paid (Mitra et al., 2020). At first, we value the extracted criteria and sub-criteria effective in measuring the potential of pedestrian crossings using the process of hierarchical analysis. To determine the importance of the criteria, the Minister of Standards uses the Delphi method to compare the criteria and sub-criteria two by two and form the matrix of criteria and sub-criteria, then obtain the geometric mean of the rows of the matrix and normalized.

In this research, Expert Choice software was used to estimate the importance coefficients (Mohammadinia, 2019). In the next stage, to evaluate the passages based on the criteria and sub-criteria, the data related to the criteria and sub-criteria in the desired passages were collected using the documents, field observation, and survey and entered into the GIS software and using the GIS software and Space Syntax is evaluated (Nir et al, 2022). Then, using the weighted sum method (the product of the relative weight of the criteria and sub-criteria in the hierarchical structure), the value of the information layers in GIS is determined.

Finally, the final score of the roads is calculated from the summation of the weighted values using the algebraic operation of the maps in the GIS environment. From summarizing the weighted values obtained for each road about land use criteria, traffic safety, security, attraction, and comfort, the final score of each of the desired roads (target statistical population) about the potential of the roads to create routes it is suitable for pedestrian traffic. It should be said that the larger numbers indicate the greater potential of the passages for pedestrian movement.

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