

Chapter 15

Assessing the Pedestrian Network Conditions in Two Cities: The Cases of Qazvin and Porto



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Abstract The quality of life in cities depends on the existence of suitable conditions to walk. The aim of this chapter is to assess the conditions provided to pedestrians in two cities with different urban morphologies: Qazvin (Iran) and Porto (Portugal). The assessment was performed through a model that combines multi-criteria analysis with street network connectivity to evaluate the pedestrian conditions. The multi-criteria analysis was carried out by using four criteria and nine sub-criteria that mostly influence walkability and by involving a group of experts from Qazvin and Porto. Street network connectivity was assessed by Space Syntax. Results showed that Qazvin provides better conditions and a network of pedestrian streets more connected than Porto. The model can be a useful tool for planning more walkable and sustainable cities in urban areas.

Keywords Walkability · Pedestrian network · Multi-criteria analysis · Street network connectivity analysis

15.1 Introduction

Walking is one of the least expensive and most broadly accessible modes of transportation. Walkability provides the opportunity for large numbers of people to walk together and experience the route or site (Dallman et al. 2013; Fernando et al. 2010; Jamei and Rajagopalan 2017; Socharoentum and Karimi 2016). This can be a powerful way to build a sense of community and to strengthen social networks. Pedestrian environments (sidewalks, paths and hallways) are a major portion of the

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public realm. Many beneficial activities (socialising, waiting, shopping and eating) occur in pedestrian environments (Buccolieri et al. 2015; Ferreira et al. 2016; Green and Klein 2011). Recent research shows that commercial activity, tourism, information technology and leisure economy are fostering economic growth (Evans 2001; Farrell 2000; Gospodini 2006). Walking supports this development and becomes conducive to create economic value and social vibrancy.

This chapter describes the result of the Pedestrian Network Assessment (PNA) developed for assessing the pedestrian conditions provided by the cities of Qazvin and Porto. The model was underpinned in a multi-criteria analysis and in street connectivity analysis. Through multi-criteria analysis, different weights were assigned to four criteria and nine sub-criteria with impact in walking. The weights were assigned considering the results of a survey where respondents evaluated the importance of such criterion in a scale ranging from 0 (minimal weight) to 1 (maximum weight). Street network connectivity (SNC) was evaluated through Space Syntax analysis. The scores obtained were introduced in a GIS software (ArcGIS) by using a weighted linear combination (WLC). The PNA was applied in two cities with different urban morphologies: Qazvin (Iran) and Porto (Portugal). The main structure of Qazvin is polycentric and space was created due to activities and the neighbourhood. Also, the city centre of Porto has a strong spatial articulation which is known as monocentric. These two cities were selected to show the impact that different urban structures may have on pedestrian conditions. It is hypothesised that ‘the more a space is integrated, the greater the chances that it will be cohesive pedestrian network’ (Jeong and Banyan 2016; Li et al. 2016). In other words, the chapter will study the impact of street configuration on the walking conditions provided to pedestrians. The results obtained with the implementation of the PNA model in both cities are compared by using a quadrant chart method.

The chapter starts with a literature review in Sect. 15.2, followed by descriptions of the two case studies in Sect. 15.3. The methodology is presented in Sect. 15.4, the results are described in Sects. 15.5 and 15.6 and the conclusions are presented in Sect. 15.7.

15.2 Literature Review

There has been a dramatic rise in the literature on factors affecting walking in the last two decades. Researchers have pointed out several criteria affecting pedestrian movement (Badland et al. 2013; Cervero and Kockelman 1997; Havard and Willis 2012). One of these criteria is to do with land use, which determines the trip destination (Bahrainy and Khosravi 2013; Lamíquiz and López-Domínguez 2015; Lerman and Omer 2016). In addition, the residential population density is an important criterion that shows the amount of movement and depends on daily demand (Grecu and Morar 2013; Lerman and Omer 2016). Many pedestrian studies found in literature are related with behavioural aspects associated with physical environment including human scale, visual dimension and the route slope

(Bahrainy and Khosravi 2013; Forsyth et al. 2009; Gilderbloom et al. 2015; Lamíquiz and López-Domínguez 2015; Marquet and Miralles-Guasch 2016; Mehta 2008; Nasir et al. 2014; Peiravian et al. 2014). Walking to public transport and having access to its information have been encouraged as an active living strategy in many countries (Cubukcu et al. 2015). However, accessibility is strongly linked with urban functions and physical environment (Gilderbloom et al. 2015; Lamíquiz and López-Domínguez 2015). The natural environment forms another criterion recognised for its effect on walkability thereby improving pedestrian movement (Lundberg and Weber 2014; Panagopoulos et al. 2016). Comfortable microclimatic conditions, including temperature, green space, sunlight shade and wind, are also important in supporting outdoor activities and walking (Koh and Wong 2013; Mehta 2008; Zadeh 1978). Finally, considerable research has focused on the relationship between walking and the above criteria, which contribute to an overall perception of walkability. Actually, these attributes are strongly associated with the decision to, and with the satisfaction of walking (Jabbari et al. 2017; Martinelli et al. 2015; Moura et al. 2017; Socharoentum and Karimi 2016).

On the other hand, the connectivity between pedestrian streets is another important attribute. Over the last years, street network connectivity analysis has contributed to a greater understanding of the spatial configuration of street networks and to the location of economic activities (Hillier and Hanson 1998; Hillier et al. 1993). Space Syntax is a tool often used for measuring the number of street intersections per line. A connection graph is defined depending on how each line connects to its surrounding lines (Jiang and Liu 2009; Penn et al. 1998).

Cities are clearly more complex than regularly structured systems; their geometry is variable and irregular. In turn, urban morphology is the primary generator of pedestrian movement patterns (Hillier et al. 1993). Peponis et al. (1989) presented some findings about morphology of Greek towns and their patterns of pedestrian movement. Some researchers have relied on general Graph theory to simulate the pedestrian network, which is detected in the conceptualisation of the patterns of urban morphology (Hillier and Iida 2005; Jayasinghe et al. 2016; Lerman et al. 2014; Li et al. 2016; McCahill and Garrick 2008; Önder and Gigi 2010). In this sense, urban morphology is another parameter for assessing the effects of urban form on walkability.

15.3 Case Studies: Porto and Qazvin

This study was developed comparing the Portuguese city of Porto and the Iranian city of Qazvin. These cities have different urban structures. The city centre of Porto has a strong spatial articulation with its urban morphology based on open space and urban tissues formed around it. In Porto, the urban structure has transformed during history, and finally organised around the Aliados Avenue. The main structure of Qazvin is different from Porto. The city is one of Silk Roads cities with each neighbourhood having boundaries defined by main streets. The urban structure of

Qazvin is comprised of several centres presenting a multinuclear morphology. Each neighbourhood centre was the local urban public space and consisted of a mosque, a water reservoir, a public bath and a flexible open space which was used for religious rituals as well as for daily social interactions (Pourjafar et al. 2014; Tavassoli 2016). Figure 15.1 shows the urban structures and the historical growth processes in of Porto and Qazvin.

The area selected in Porto for implementing the PNA comprises the historic centre of Porto and the neighbouring quarters. The area selected represents 7% of the city area, has about 2.6 km², and is defined by the streets of Santa Catarina, Bovista, Casa de Música Square, Júlio Dinis, Palácio de Cristal, and by the Douro river. The selected area includes open spaces, sloped terrains, riverfront, green areas and historical fabric. These spaces provide a variety of places, turning the places into a varied and multifunctional space for pedestrians. The area for implementing the PNA in Qazvin is limited by Bou Ali Sina Street, Molavi Street, Shahid Ansari Street, Hokm Abad Garden and Boulevard. The area of the framework corresponds to 15% of the Qazvin city, which is about 2.5 km². This area comprises historical urban tissue, a market, open spaces, and a park. This area of Qazvin also provides a variety of places, turning the places into a varied and multifunctional space for pedestrians.

The streets in the area selected in Porto sum 47 km, while in Qazvin sum 45 km. However, 64% of the streets in Qazvin has a length less than 120 m, while in Porto this percentage decreases to 46% (Fig. 15.2). These differences are directly related with the urban morphologies. Qazvin has a more polycentric structure defined by traditional neighbourhoods and main squares, containing many cul-de-sacs and small streets. The area selected in Porto is defined by only one centre ('Baixa') where the political, the religious and the main economic activities were installed.

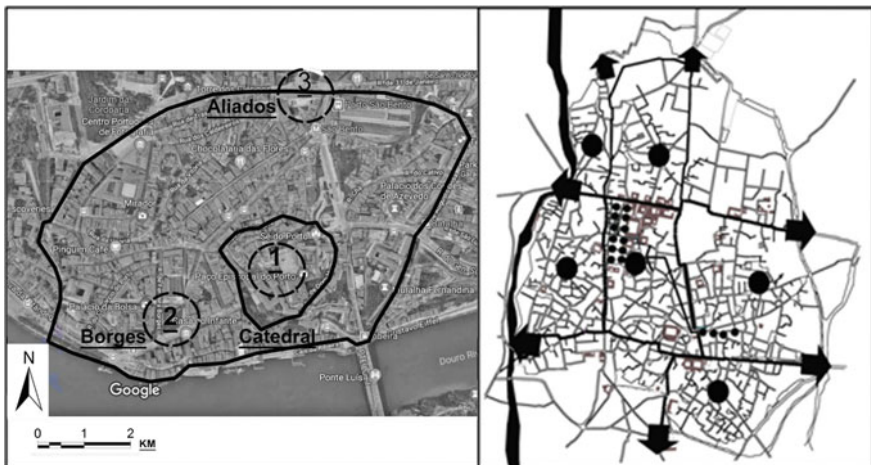


Fig. 15.1 Urban structure and process of urban growth between the 12th century and 16th century in Porto (left) and Qazvin (right). *Source* Google Map, 2019

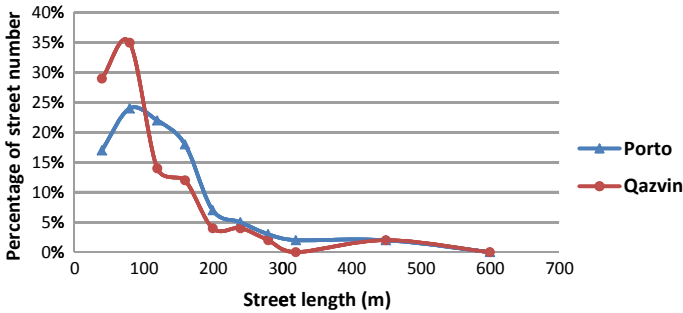


Fig. 15.2 Percentage of streets based on length (Porto and Qazvin). *Source* Authors

15.4 Methodology

The methodological procedures adopted in the study will be described according to the following order (Fig. 15.3): (i) Criteria selection; (ii) Description of the data collection; (iii) weights assignment and aggregation method; (iv) Connectivity Evaluation; (v) Assessment of the pedestrian network; and (vi) Obtain the cohesive pedestrian network.

As shown in Fig. 15.3, the first step of the work consisted of selecting the criteria with impact on walking. This work was done by making a literature review and by consulting a panel of experts. As described on Sect. 15.2, the criteria selected with impact on walking were the physical environment, urban functions, accessibility and natural environment. Each criteria was subdivided in sub-criteria as shown in Table 15.1.

The second step of the work was the validation of this initial list of criteria by a panel of experts in urban planning from Porto and Qazvin. Experts were involved in the study through surveys performed between July and September 2015. A total of 41 experts from Porto and 45 experts from Qazvin participated in the study. The first part of the survey consisted of selecting/validating the list of criteria and sub-criteria presented in Table 15.1. The survey was prepared to allowed the inclusion of new criteria/sub-criteria. Nonetheless, experts confirmed the options given in the list as only very few comments were made. For instance, safety was not highlighted as a critical criterion for walking demonstrating that this factor is not

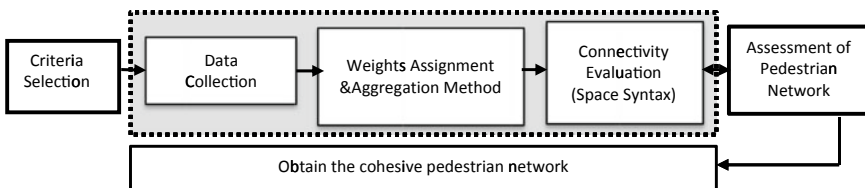


Fig. 15.3 Steps followed to define a pedestrian network assessment model. *Source* Authors

Table 15.1 Criteria and sub-criteria used to assess the conditions provided to pedestrians

Criteria	Sub-criteria
Physical environment	Terrain slope
	Human scale
	Visual dimension
Urban function	Land use
	Population density
Accessibility	Public transportation service
	Intelligent transportation system(ITS)
Natural environment	Green space
	Microclimatic conditions (Temperature)

Source Authors

relevant in Porto and Qazvin. Based on this survey, the four criteria and the nine sub-criteria included in Table 15.1 were selected for making the PNA proposed in this study.

The survey addressed to experts was also used for defining the relative importance of the several criteria and sub-criteria. In this step of the work, experts were invited to assign weights to each criteria/sub-criteria according to their view. As criteria were valued differently, it was necessary to normalise the values. Criteria were normalised by using the sigmoidal function presented in Eq. 15.1.

$$f(x_i) = \begin{cases} x = x_{\min} = 0 \rightarrow f(x_i) = 0 \\ x_{\min} < x_i < x_{\max} \rightarrow f(x_i) = \frac{x-x_{\min}}{x_{\max}-x_{\min}} \\ x = x_{\max} \rightarrow f(x_i) = 1 \end{cases} \quad (15.1)$$

where,

X_i —Element of the network ($i = 1, 2, \dots, n$)

X — X_i of elements of the network

After normalising the sub-criteria, the next step was the aggregation of the relative values by using the weighted linear combination (WLC) method for sub-criteria (2) and criteria (3). Therefore, each standardised factor was multiplied by the respective weight. The process was adopted for obtaining the sub-criteria (Eq. 15.2) and the criteria (Eq. 15.3) weights.

$$j = 1, 2, \dots, 9 S_k(x_i) = \sum_{i=0}^n f_j^k(x_i)w_{kj} \quad (15.2)$$

$S_k(x_i)$ —Assessment of element X_i for all the sub-criteria j of criteria k

$$k = 1, 2, \dots, 4 T(x_i) = \sum_{i=0}^n S_k(x_i)w_k \quad (15.3)$$

Table 15.2 Weight of criteria and sub-criteria in Porto and Qazvin

Criterion	Weight	Sub criterion	Weight
<i>Porto</i>			
Physical environment	0.235	Terrain slope	0.290
		Human scale	0.295
		Visual dimension	0.415
Urban Function	0.253	Land use	0.875
		Population density	0.125
Accessibility	0.224	Public transportation service	0.50
		Intelligent transportation system (ITS)	0.50
Natural environment	0.288	Green space	0.667
		Microclimatic conditions (temperature)	0.333
<i>Qazvin</i>			
Physical environment	0.179	Terrain slope	0.273
		Human scale	0.228
		Visual dimension	0.497
Urban function	0.199	Land use	0.264
		Population density	0.736
Accessibility	0.310	Public transportation service	0.576
		Intelligent transportation system (ITS)	0.424
Natural environment	0.312	Green space	0.565
		Microclimatic conditions (temperature)	0.435

Source Authors

$T(x_i)$ —Assessment of all the criteria k for the element X_i of the network

Converting the experts’ opinions into values was done by using a pairwise comparison matrix. Therefore, the sum of all weights obtained using this method is equal to one. Table 15.2 presents the weights assigned by the experts of Porto and Qazvin. As shown in Table 15.2, the sub-criteria and criteria weights were calculated by performing different pairs of combinations. The criteria more valued by the experts from Porto were natural environment and urban function. In turn, the experts of Qazvin also ranked first the natural environment, followed by accessibility.

The next step was assessing the street network connectivity. Space syntax and more particularly the DepthmapX software was used to analyse street connectivity. Higher space syntax values correspond to streets with many connections (nodes) and vice versa. The analysis was performed by using the Eq. 15.4.

$$C_i = \sum_k R_{ik}, \tag{15.4}$$

where

R_{ik} presents the direct link between i and k .

In classical theory, C_i can positively quantify the permeability of i together with its aggregation degree; Based on the graph theory, the connectivity of a node can be defined as the number of other nodes directly connected to it. The analysis performed with space syntax shows a street connectivity ranging from 1 to 14 in Porto and from 1 to 21 in Qazvin. Higher space syntax values correspond to streets with many connections (nodes) and vice versa. These values were then normalised between 0.0 and 1.0 by fuzzy logic and inserted in the GIS database.

The last step of the work consisted of aggregating the street connectivity with the multi-criteria values. A WLC was calculated again to obtain the final scores by using a weight of 0.5 for the multi-criteria evaluation and 0.5 for street connectivity, as suggested by the experts. The result is a global assessment of the conditions provided to pedestrians (PNA), by considering characteristics of the physical and natural environment and street connectivity.

Finally, a quadrant chart method was proposed to compare the conditions provided by the two cities. As highlighted by Oh and Jeong (2007) and by Zhou et al. (2015), quadrant chart method is a useful tool for setting up items that shares common attributes by representing data in separate quadrants.

15.5 Results

This section presents the results obtained with the described method for Porto and Qazvin. In Porto, the sub-criteria assigned with higher values were population density, followed by the proximity to public transport and microclimatic conditions. In Qazvin, land use was the criterion more relevant for the experts, while the less important was population density. In turn, for the Porto experts, the less relevant criterion was human scale. In terms of criteria, which weights were aggregated by using a pairwise comparison matrix, the natural environment was the criterion more important for the experts of both cities. Such finding is in line with other studies demonstrating that the conditions of the natural environment (thermal comfort, shadow, natural light, etc.) are very important for pedestrians (Choi et al. 2016; Jayasinghe et al. 2016).

The ranking combining the four criteria was obtained by overlaying the four layers by using the weights presented in Table 15.2. This evaluation was implemented in GIS. Figure 15.4 shows the classification of the streets of the selected areas of Porto (4a) and Qazvin (4b) according to the four criteria. The highest classifications obtained were 0.71 in Porto and 0.75 in Qazvin. The average of the values obtained in both cities were also very similar: 0.387 in Porto and 0.393 in Qazvin. Results also showed that 52% of the streets in Porto and 56% of the streets in Qazvin ranked above the mentioned average values. In other words, more than half of the streets analysed in both cities score above average.



Fig. 15.4 Streets ranking considering the multi-criteria analysis in Porto (a) and in Qazvin (b). *Source* Authors

As described in the methodology, the street network connectivity analysis was applied by using Space Syntax and the results for both cities are presented in Fig. 15.5. The streets of Porto with higher levels of connectivity are in the central area especially in Bolhão and Avenida dos Aliados. The lowest levels of connectivity were found in the western area which includes the Boavista area, and also in some parts of the historical centre. Street connectivity in Porto obtained an average



Fig. 15.5 Streets ranking based on the street network connectivity in Porto (a) and in Qazvin (b). *Source* Authors

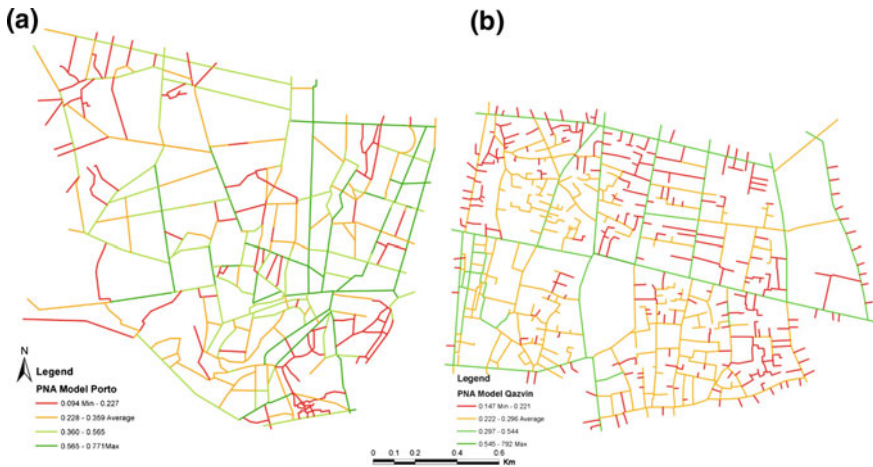


Fig. 15.6 Results of the PNA model in Porto (a) and in Qazvin (b). *Source* Authors

value of 0.347 and 39% of the street length had a connectivity ranking above the average. In Qazvin, the streets with high connectivity were Naderi, Ferdowsi, Bazaar and Bu Ali Sina. Old neighbourhoods surround these streets. In turn, the streets with lower connectivity are located in Southern part of Qazvin, which is more recent. Street connectivity in Qazvin obtained an average value of 0.198, but 41% of the street length had a connectivity ranking above the average.

The last stage of PNA was combining the Multi-Criteria Analysis (MCA) with the street network connectivity. The results are presented in Fig. 15.6. The comparison with Fig. 15.4 shows that the inclusion of the connectivity increased the ranking obtained by the streets. In Fig. 15.6, the highest value increased from 0.71 to 0.77 in Porto; while in Qazvin, the highest value improved from 0.75 to 0.79. The percentage of streets ranking above the average values obtained decreased in Porto from 52% to 49%, while in Qazvin the values keep almost unalterable.

15.6 The Impact of Urban Morphology on the Pedestrian Network

As described in the methodology, a quadrant chart method was proposed to compare the conditions provided to pedestrians by the two cities. The quadrant method is considered a helpful decision making tool by representing data on two axes (X and Y).

In this study, the horizontal axis represents the MCA index, whereas the vertical axis shows the SNC index. In the chart, each point corresponds to the streets assessed in Porto and Qazvin (Fig. 15.7). In the quadrant chart, values of MCA and

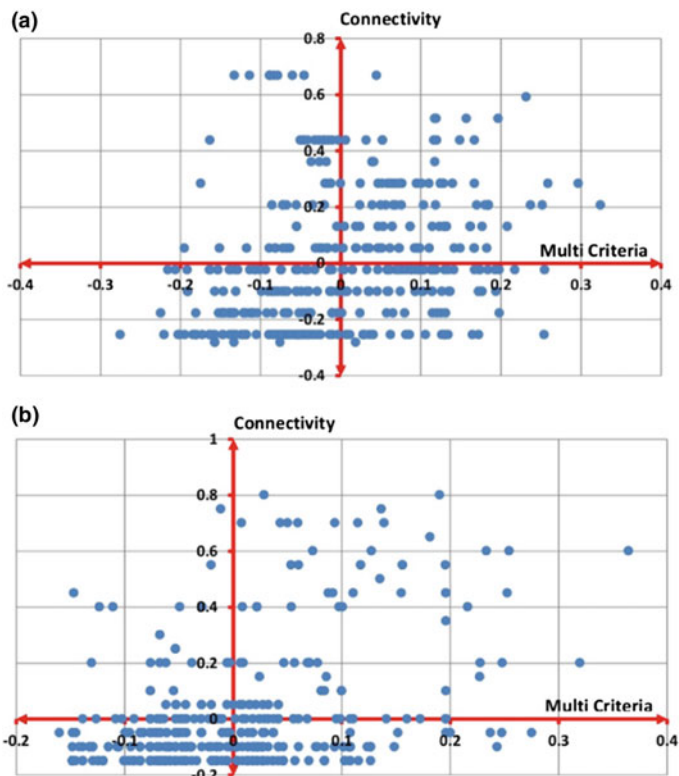


Fig. 15.7 Quadrant chart according to data average for Porto (a) and Qazvin (b). Source Authors

SNC can be greater or lesser than zero and the four following main situations can be found:

First quadrant (high MCA and SNC): streets located on this quadrant have positive values ($MCA > 0$ and $SNC > 0$) considering the criteria analysed and street connectivity. Streets located on this quadrant have the highest levels of walkability.

Second quadrant (low MCA and high SNC): streets located on this quadrant have positive values in terms of connectivity ($SNC > 0$) but negative values in terms of criteria ($MCA < 0$). The walkability of these streets could be enhanced by taking actions for improving the criteria with poor performance.

Third quadrant (low MCA and SNC): streets located on this quadrant have negative values ($MCA < 0$ and $SNC < 0$) considering the criteria analysed and street connectivity. Streets located on this quadrant have the lowest levels of walkability.

Fourth quadrant (high MCA and low SNC): streets located on this quadrant have positive values in terms of criteria evaluation ($MCA > 0$) but negative values in

terms of street connectivity ($SNC < 0$). The walkability of these streets could be enhanced by taking actions for improving street connectivity.

The aforementioned classification provided by the quadrant chart was used for ranking the streets according to their potential to define a network of pedestrian streets. Thus, the streets were organised in the following three-level scale:

- The first level refers to the streets that have the highest potential to make a pedestrian network. This includes the streets included in the first quadrant.
- The second level includes streets that have the potential to make part of a pedestrian network. These streets require actions to improve their connectivity or specific conditions provided to pedestrians. This level includes the streets located in the second and in the fourth quadrants.
- The third level includes the streets that have the lowest potential to make a pedestrian network. This includes the streets located in the third quadrant.

For a better comparison of the conditions provided by the streets of Porto and Qazvin, the total length of the streets located in each quadrant was measured. Results of this assessment are presented in Table 15.3. The length of the streets analysed in the two cities was similar: about 47 km in Porto and 45 km in Qazvin. Considering the street length, Qazvin had 41% of the streets located in the first quadrant, 32% in the second and fourth quadrants and 28% in the third quadrant. In turn, Porto had 27% of the streets in the first quadrant, 36% in the second and fourth quadrants and 37% in the third quadrant. As the first quadrant comprises the streets providing better conditions for pedestrians and the highest potential to make a

Table 15.3 Multi-criteria (X) and street network connectivity (Y) in Porto and Qazvin from quadrant chart

Porto city	Quadrant	Street length (m)	Percentage
$MCA > 0.387$ and $SNC > 0.330$	1 ($X > 0$ and $Y > 0$)	12558.10	27
$MCA \leq 0.387$ and $SNC > 0.330$	2 ($X < 0$ and $Y > 0$)	11137.34	24
$MCA \leq 0.387$ and $SNC \leq 0.330$	3 ($X < 0$ and $Y < 0$)	17355.02	37
$MCA > 0.387$ and $SNC \leq 0.330$	4 ($X > 0$ and $Y < 0$)	5882.26	12
Total length of Porto		46932.74	100
Qazvin city	Quadrant	Street length (m)	Percentage
$X > 0.392$ and $Y > 0.198$	1 ($X > 0$ and $Y > 0$)	18087.20	41
$X \leq 0.392$ and $Y > 0.198$	2 ($X < 0$ and $Y > 0$)	7019.98	16
$X \leq 0.392$ and $Y \leq 0.198$	3 ($X < 0$ and $Y < 0$)	12400.02	28
$X > 0.392$ and $Y \leq 0.198$	4 ($X > 0$ and $Y < 0$)	7042.90	16
Total length of Qazvin		44544.32	100

Source Authors

pedestrian network, it can be concluded that Qazvin exhibits general better conditions to pedestrians than Porto. In this last city, the length of streets included in the worst quadrant (3) and in the intermediate quadrants (2 and 4) is much more representative.

A global overview of the streets ranked in the first level (streets on the first quadrant) as well as in the second level (streets on the second and fourth quadrants) are respectively presented in Figs. 15.8 and 15.9. In Porto, the streets classified in the first level are mainly located around Praça da Liberdade, Avenida dos Aliados, S. Bento station, Mouzinho da Silveira. They broadly define the central area of the city called 'Baixa' which corresponds to the oldest main centrality of the city. In Qazvin the situation is different, it is evident that there are not only more streets classified in this level, but also a higher distribution among several centres. Figure 15.8b shown the streets of Qazvin have with higher levels of connectivity includes the main streets named to Nadri, Ferdowsi, Bazar and Bu Ali Sina streets. Also, those streets have surrounded the ancient neighbourhoods as the boundary. Regarding the streets classified in the second level, the conclusions are identical. In Qazvin, the streets are arranged around in three neighbourhoods that named Drab-Kooshek, Bolaghi, Sar-kocheh reyhan and tradition market (Bazaar). In the case of Porto, there are much more streets classified in the second level and they are more widespread by the selected area. The Western (more recent) part of the city, as well as part of Ribeira, characterised by narrowed and hilly streets, are the areas of Porto providing less walkable conditions.

The different performance obtained in both cities can be attributed to the different urban morphologies. Qazvin has a more polycentric structure due to the traditional neighbourhoods arranged around centres (mosque, bazaar). In Porto, the urban morphology is more concentrated around 'Baixa', the traditional political and

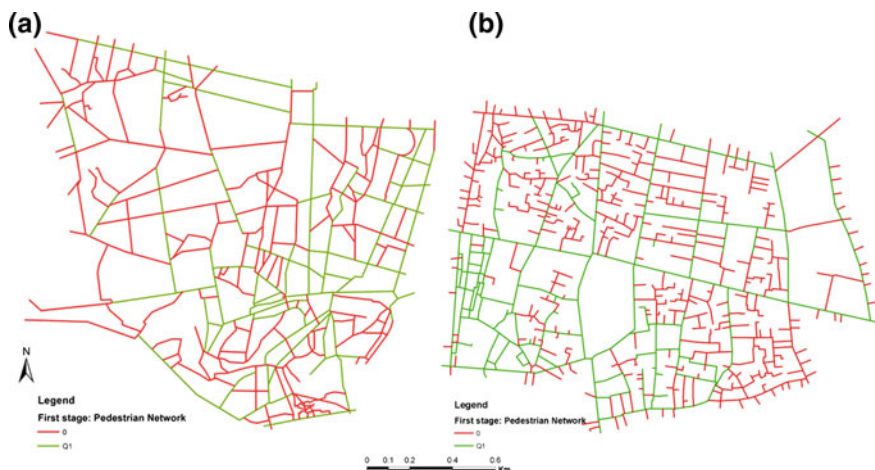


Fig. 15.8 Streets classified in the first level in Porto (a) and in Qazvin (b). *Source* Authors



Fig. 15.9 Streets classified in the second level in Porto (a) and in Qazvin (b). *Source* Authors

economic centre. The PNA model also shows that a network of pedestrian streets is particularly missing in Porto, where streets providing good conditions are well-connected only cover a small area. The PNA model was also useful for identifying a group of streets with potential to improve the pedestrian network—the second level streets. By defining actions to improve the walkability and/or connectivity of these streets, these findings could be fundamental for obtaining a broader and well-connected network of pedestrian streets. Therefore, the model described in this paper as potential to support urban planning decisions aiming at improving walkability and sustainability in cities.

15.7 Conclusion

The main aim of this research was to compare the conditions provided to pedestrians in two cities with different urban morphologies: Qazvin (Iran) and Porto (Portugal). It proposed a pedestrian network assessment (PNA) model considering multi-criteria and street connectivity analyses. A quadrant chart method was also proposed to analyse and compare the results obtained in the two cities. Results show that Qazvin provides more walkable streets considering the criteria analysed and street connectivity. Moreover, the pedestrian streets are more organised and connected in a network in Qazvin than in Porto. By identifying the problems affecting walkability and the level of connectivity, the PNA model has a potential to help planners and decision-makers in designing more walkable cities. The described

model can also potentially be replicated in other cities in terms of improving walkability and in promoting sustainable urban mobility.

In addition, the urban structure determines how serviceable and flexible an urban area is and how well it integrates into its surroundings. The urban structure contributes to both the function and feel of an area and creates a sense of place. A well-functioning urban structure connects neighbourhoods, where activity centres are within a convenient walking distance. Regarding type of urban spatial structures, the polycentric urban structure is an effective way to reduce pressure on transport to the city centre and influences the possibility of walking. Research results are attributed to the polycentric structure of Qazvin, causing a strong network of walkable streets in Qazvin.

Nonetheless, some aspects could be improved in future works. It will be particularly important to support the weighting process in a larger and representative sample. A combined system involving not only a group of experts but also the residents' opinions could be useful to strengthen the robustness of the approach. Finally, the model will present a more accurate assessment from the walkable streets in a central area of a city to identify the potential for a pedestrian network and to improve mobility.

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