Available online at www.sciencedirect.com

ScienceDirect

Transportation Research Procedia 45 (2020) 309–316

Transportation Research Procedia

www.elsevier.com/locate/procedia

AIIT 2nd International Congress on Transport Infrastructure and Systems in a changing world (TIS ROMA 2019), 23rd-24th September 2019, Rome, Italy

Designing walkable streets in congested touristic cities: the case of Cartagena de Indias, Colombia

Hannia Gonzalez-Urango[a,b], Michela Le Pira[c*], Giuseppe Inturri[d], Matteo Ignaccolo[c], Mónica García-Melón[a]

[a]*Ingenio (CSIC - UPV), Universitat Politècnica de València, Ciudad Politécnica de la 6 Innovación, Edif 8E 4°, Camino de Vera s/n, Valencia, Spain*

[b]*Universidad Simón Bolívar, Barranquilla, Colombia*

[c]*Department of Civil Engineering and Architecture, University of Catania, Via Santa Sofia 64, Catania 95125, Italy*

[d]*Department of Electric, Electronic and Computer Engineering, University of Catania, Via Santa Sofia 64, Catania 95125, Italy*

Abstract

This paper presents the case of Cartagena de Indias, a well-known international touristic destination in Colombia, which experiences serious problems of traffic congestion and accessibility to the city center. Promoting pedestrian mobility is one of the public administration's main goals, by enhancing and re-designing different pedestrian paths. Designing pedestrian zones is a context-specific multifaceted problem that involves multiple stakeholders and multiple criteria. A participatory multicriteria approach based on the Analytic Network Process (ANP) has been used to understand the most important characteristics affecting pedestrian mobility in Cartagena de Indias, thus deriving a useful decision-support tool for planning and designing pedestrian paths. In this respect, in this paper a set of streets in the city center has been evaluated, by combining the results of ANP with spatial data using Geographic Information Systems (GIS), producing thematic maps and an index of pedestrian priority to derive a priority of intervention. Some streets have been redesigned with the aim to increase their walking attractiveness. Results put the basis for discussion with local administration and stakeholders to validate them and propose further applications of the methodology.

Keywords: Multicriteria evaluation approach; Analytic Network Process; pedestrian street design; pedestrian mobility

* Corresponding author. Tel.: +39-095-738-2221.
E-mail address: mlepira@dica.unict.it

10.1016/j.trpro.2020.03.021

1. Introduction

Walking is at the basis of sustainable urban mobility, providing social, environmental and economic benefits, while limiting the increase in motorization (Banister, 2008; Caprì et al., 2016). Nevertheless, it has been in long-term decline, being considered as a secondary mode together with cycling (Tight et al., 2011). In Europe, it has been promoted via regional, national and local policies and projects for fostering better walking conditions and encouraging people to travel on foot, e.g. via several urban regeneration programs (TfL, 2005). In general, pedestrian-oriented policies should aim at increasing walkability (Southworth, 2005). The design of pedestrian routes and areas involves consideration of different technical, economic, environmental, and social factors (Sayyadi and Awasthi, 2013). Understanding the factors that influence walkability and pedestrians' perceptions enables planners to build more walkable and livable cities. Therefore, it should be a priority for local authorities.

This paper presents the case of Cartagena de Indias, a well-known international touristic destination in Colombia, which experiences serious problems of traffic congestion and accessibility to the city center. Local administration has proposed different plans and alternatives to improve mobility and rehabilitate spaces to make them available for citizens and tourists. Promoting pedestrian mobility is one of the main goals, by enhancing and re-designing different pedestrian paths through main historic and touristic places around the city center. However, these planning processes are under the pressure of stakeholders belonging to public and private sectors, but, mainly, of citizens, which demand actions that generate incomes and wellbeing for them.

Several works have faced the problem of improving mobility in terms of pedestrian access using different approaches, to accessibility measurement based on infrastructure, activity or utility performances (Blečić et al. 2015, Talavera-Garcia and Soria-Lara 2015; Taleai and Taheri Amiri 2017). However, factors affecting walking differ according to many elements, such as pedestrian characteristics, walking purpose, urban context and other environmental and cultural aspects (Moura et al., 2017). Thus, designing pedestrian zones is a context-specific multifaceted problem that involves multiple stakeholders and multiple criteria. Our research is an attempt to build an index of pedestrian priority that takes into consideration some of these concerns from the stakeholders' perspective and considering the context. The problem has been faced with a participatory multicriteria approach using the Analytic Network Process (ANP) (Gonzalez-Urango et al., forthcoming). This methodology provided a useful decision-support tool for planning and designing pedestrian paths. In this paper, a set of streets in the city center has been evaluated, by combining the results of ANP with spatial data using Geographic Information Systems (GIS), producing thematic maps and an overall index of pedestrian priority that allows to support an adequate scheduling of interventions. Finally, some primary streets have been redesigned to increase their walking attractiveness.

The remainder of the paper is organized as follows. Section 2 will briefly introduce the methodological framework, based on four main pillars, i.e. (1) public participation, (2) stakeholder analysis, (3) MCDM methods, in particular ANP, and (4) spatial analysis for street evaluation and redesign. Section 3 will present the case study, together with the main results from participatory ANP (3.1), and will show the results of the spatial analysis (3.2). Section 4 will conclude the paper summarizing the main results and future research developments.

2. Methodological framework

The methodology is summarized in Fig. 1 and is based on the following pillars:

- Participatory approach. Planning and designing with stakeholders means involving them from the beginning of decision-making up to the final decision via a transparent process (Cascetta et al., 2015). In this respect, transport policies should be the results of technical evaluations and consensus building (Le Pira, 2018). Identifying stakeholders is the first important step. Interviews with them can help to set up the state of the art and provide relevant information about the important elements to consider. Besides, given the variety of stakeholders and interest and the difficulty to involve a large number of them in the evaluation process, it becomes important to perform appropriate *ex-ante* stakeholder analysis to have a clear insight of them (Le Pira et al., 2018).
- Stakeholder Analysis. One of the approaches that have been proposed to investigate the relationships among stakeholders is the Social Network Analysis (SNA) technique (Wasserman and Faust 2007), which allows to determine an individual value of the influence of each actor in a group of stakeholders based on graph theory. Through SNA, one can analyze interactions and flows of information in a network. The "position" of a participant

in the network (centrality) is the most commonly used index to analyze his/her influence (Ahmedi et al. 2017). This tool becomes useful to select a sub-group of stakeholders ("key stakeholders") that can be involved in the evaluation process. A detailed description regarding SNA can be found in Wasserman and Faust (2007), Reed et al. (2009), and Gonzalez-Urango and García-Melón (2018).

- Analytic Network Process. ANP (Saaty, 2001) is a well-known Multi Criteria Decision Method (MCDM), which provides a framework to address decision-making or problem assessment. It defines the prioritization model as a network composed of different elements (e.g. criteria, indicators, alternatives), grouped into clusters and connected to each other. It allows for complex, interdependent and feedback relationships between the elements (Sipahi and Timor, 2010). General information of the method can be found in Saaty (2001) and Ligardo-Herrera et al (2018). For what concerns pedestrian mobility, the important criteria to design walkable streets can be defined together with stakeholders, and evaluated by them via a questionnaire based on pairwise comparisons between couples of elements allowing to obtain their weights.
- Spatial analysis. Spatial data are needed to evaluate streets according to the chosen criteria and define a priority of intervention. Nowadays, with the diffusion of new technology, open data, e.g. Volunteered Geographic Information (VGI), their acquisition becomes easier and they can be managed and analyzed via GIS-based software. By combining the results of ANP with spatial data, i.e. by selecting the most weighted criteria from ANP and assessing them via appropriate measurement scales and data sources, it is possible to produce thematic maps and an overall index of pedestrian priority. This would allow to choose some streets to be redesigned so to become more pedestrian-friendly. Results of this analysis and design process should be discussed with policy-makers and stakeholders for their validation.

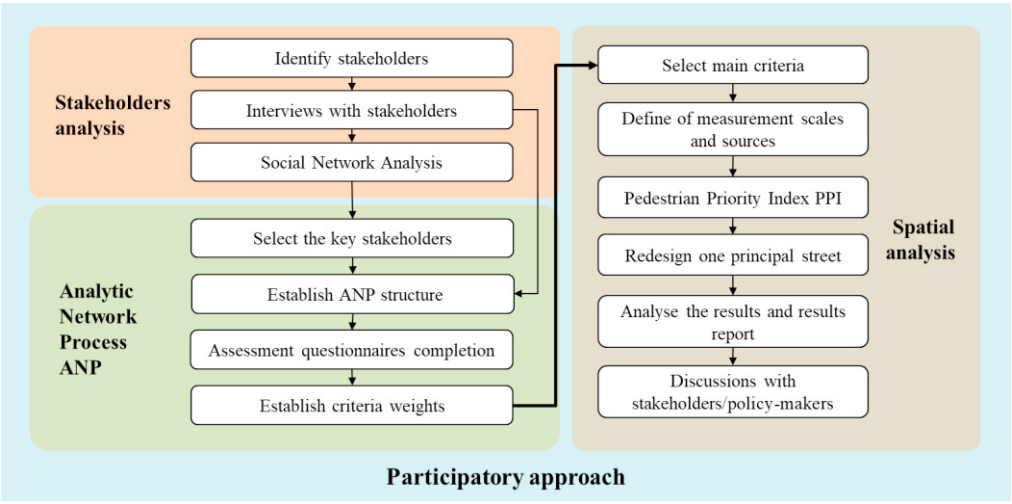


Fig. 1. Methodological framework

3. Case study

Cartagena de Indias, located in the Caribbean zone, is one of the most visited destinations in Colombia (Fig.2). The city stands out in different tourist segments due to its historical heritage; the most important one is the city center (a UNESCO World Heritage). It has different attractions that make it a vital point for the city with different actors and perceptions. The historical center of the city was chosen as a testbed for the spatial analysis. It consists of an area of about 0,5 km^2 characterized by a grid-like street network with many narrow streets. The area is developed as a shared space for vehicles, pedestrians and street-sellers due to the presence of the most of touristic attractions and several services (e.g. University), thus resulting in a congested zone with plenty of users where pedestrians are the least safe.

Fig. 2. Area of study: Cartagena de Indias, Colombia

The Local Administration has designed an intervention related to mobility to make the city center more livable for locals and tourists. One of the plans focuses on designing walkable streets. We have collected the opinions of the main stakeholders (public administration, academia, civil society, private sector, and informal commerce) to obtain their perceptions of the problem and establish the most important criteria for designing pedestrian spaces in the area. Using SNA and, in particular, evaluating betweenness centrality, we built the networks of information exchange and mobility projects and we found the most influential actors mostly belonging to the local and national Public Administration.

3.1. Evaluation of criteria for designing pedestrian routes through participatory ANP

At an early stage, a simplified evaluation of the criteria was developed by all the involved stakeholders (28 actors). Then, seven key stakeholders were selected via SNA, i.e. (1) Local Authority of Transit and Transportation, (2) City Centre Administration, (3) Local Public Space Administration Office, (4) The National Ministry of Culture, (5) Local Merchants, (6) Academia, and (7) Citizens. They evaluated each criterion through an ANP questionnaire based on pairwise comparisons using Saaty's 1-to-9 scale (1 = equally important; 9 = extremely more important). An importance index was obtained for each of them following the ANP procedure (Gonzalez-Urango et al., forthcoming). Mathematical foundations of ANP can be found in Saaty (2001). The main results are presented in Table 1:

Table 1. ANP results obtained for the criteria (four most weighted criteria in bold).

Criteria	Weights	Criteria	Weights	Criteria	Weights
1. Presence of Public Transport	0,080	6. Parking Areas	0,047	11. Aesthetic	0,033
2. Access to destination	0,082	**7. Cultural elements**	**0,117**	12. Feeling/Perception	0,011
3. Street connectivity	**0,122**	**8. Street vitality**	**0,218**	13. Personal security	0,063
4. Pathway continuity	0,010	9. Path performance	0,039		
5. Path directness	0,023	**10. Street traffic**	**0,154**		

3.2. Street evaluation and redesign

The first four most weighted criteria from ANP, i.e. street vitality (V), street traffic (T), street connectivity (C) and cultural elements (CE) were chosen for data search. Taking advantage of open data and maps from OpenStreetMap (https://www.openstreetmap.org), in particular GPS track data and points of interests (POI), and traffic data from Google Traffic (https://www.drivingdirectionsandmaps.com/traffic-conditions-on-google-map/), it was possible to

assign scores to each link of the network. A numerical scale (from 1 to 3) was chosen for each criterion and thematic maps were created (see Table 2 and Fig. 3).

Table 2. Definition of measurement scale for the criteria for the spatial analysis.

Criteria	Definition	Evaluation standard	Source	Measurement scale
Street vitality (V)	The liveliness that a space can transmit	More is better	GPS track data OpenStreetMap	(1) low (2) medium (3) high
Street traffic (T)	Vehicular traffic conditions	Less is better	Traffic data from Google Traffic – Wednesday h 12:00:00	(1) high (2) medium (3) low
Street connectivity (C)	Related to the number of connection with other links	More is better	Street network from OpenStreetMap	(1) connected with just 1 link (2) connected with 2 links (3) connected with more than 2 links
Cultural elements (CE)	Presence of cultural elements or convivial points	More is better	Points of interests (POIs) from OpenStreetMap	(1) few: 0-5 POI (2) medium: 6-20 POI (3) many: 21-83

In particular, V and T scores derive from qualitative values (from low to high) assigned by simply looking at the different spatial maps (e.g. street vitality from the density of trajectories recorded by GPS). C was evaluated according to the number of link connections. In this specific case, since we have a grid-like network, all the streets have the highest connectivity[1]. CE were evaluated by creating a regular 1m x 1m grid and assigning POI to each square (see Fig. 3d). By doing this, it was possible to assign a score to each link related to "cultural elements" according to the intensity of POI in the square they were located.

(a) Street vitality (b) Street traffic

[1]As future research, one could change the measurement scale, e.g. by considering the mean distance between intersections.

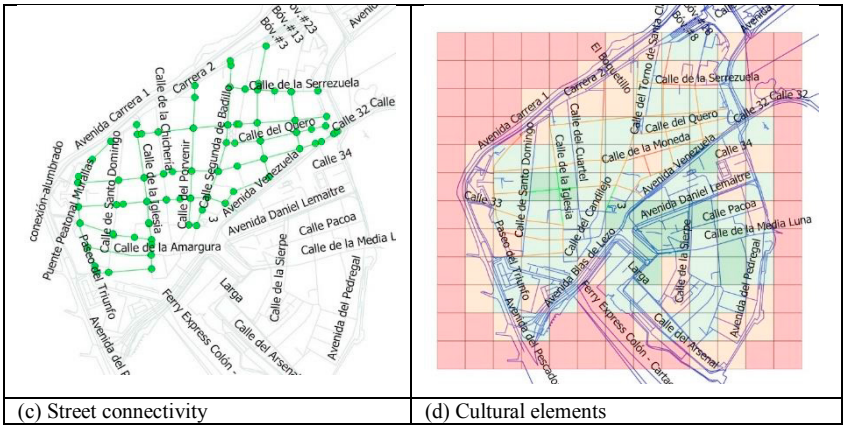


Fig. 3. Thematic maps of the main criteria (link colours: red = score 1; yellow = score 2; green = score 3).

Then, an overall index of pedestrian priority for each link i (PPI_i) was defined combining scores for each criterion with the normalized weights derived from ANP:

$$PPI_i = w_V * V + w_T * T + w_C * C + w_{CE} * CE \quad (1)$$

Finally, the index was normalized with the maximum and the minimum[2] so to have values between 0 and 1.The PPI map is visible in Fig. 4.

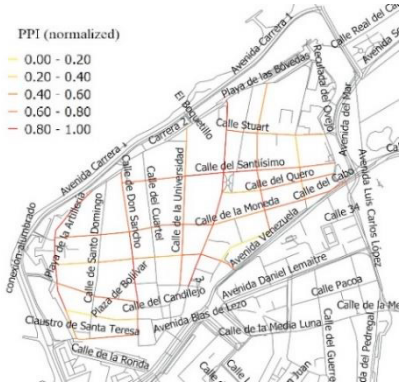
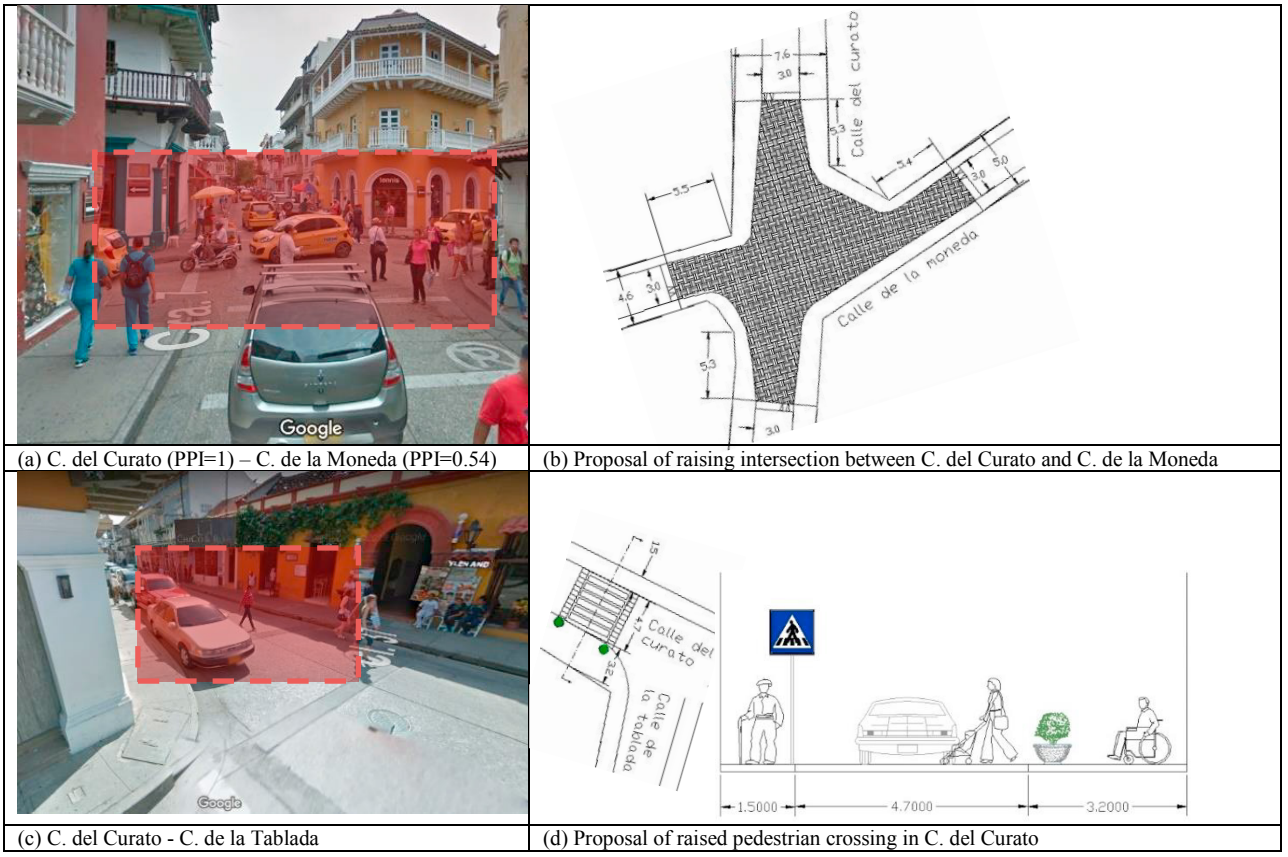


Fig. 4. Overall pedestrian priority index (PPI)

According to these results, there are some streets where there is more urgency to intervene. In particular, one of the streets with the maximum values (PPI=1), i.e. Calle del Curato, was selected and redesigned (Fig. 5). It is about 650 m long and it has many services, shops, and touristic attractions. There is a high concentration of pedestrians, but pedestrian facilities (i.e. sidewalks) are not sufficient for adequate and safe pedestrian flows. Besides, there is high promiscuity with private traffic, and parking is allowed in some parts (see fig. Fig. 5a and Fig. 5c). In order to improve the walkability of this street, it should be redesigned first by widening the sidewalks in both side (at least 1,50 m to guarantee good walking conditions, e.g. for disabled people), and by limiting or prohibiting car parking. Besides, to

[2]Despite this normalization scale does not allow maintaining proportionalities of judgments, it allows creating a clear separation between similar values. In this respect, we decided to use it to obtain a priority of streets since values were not substantially different from each other.

guarantee continuity of paths and protection from car traffic, car lanes can be raised at the level of sidewalks, both with raised pedestrian crossing and by raising the level of the overall intersections (Fig. 5b and Fig. 5d). Attention should be paid to adapt street travel direction and frame these interventions into a general local traffic calming scheme.



(a) C. del Curato (PPI=1) – C. de la Moneda (PPI=0.54)

(b) Proposal of raising intersection between C. del Curato and C. de la Moneda

(c) C. del Curato - C. de la Tablada

(d) Proposal of raised pedestrian crossing in C. del Curato

Fig. 5. Examples of street redesign

This preliminary spatial analysis could be extended to the entire city center, also by including the other less-weighted criteria of evaluation. The next step would be to discuss the results of the analysis and the proposed interventions with the Public Administration and stakeholders, in order to validate them. In this respect, both thematic and PPI maps can be useful to have an overall idea of the actual conditions of pedestrian paths from different points of view. Finally, these maps could be made available to all citizens, so to raise their awareness and involve them directly by asking them to complete them with user-generated information (in terms of VGI) so to create an open database and help locals and tourists to walk safely and pleasantly in the city center, and administrators to understand how and where to improve street walkability.

4. Conclusion

Promoting walking in cities is fundamental to make them more livable, and to relieve them from the burden of car traffic. In order to do so, one should understand the most important factors that influence walkability and pedestrians' perception, and provide spatial evidence of the current condition of walkability, so to define priority of interventions. This paper presented the case of Cartagena de Indias, a well-known international touristic destination in Colombia, which experiences serious problems of traffic congestion and accessibility to the city center and where local administration is focusing on improving pedestrian mobility for citizens and tourists. This problem was approached

with a participatory multicriteria approach, using ANP and involving stakeholders in criteria identification and evaluation. This allowed understanding the most important characteristics affecting pedestrian mobility. In this paper, according to the results of ANP, a spatial analysis using GIS was performed, by selecting and evaluating a set of streets in the city center, deriving thematic maps and an overall index of pedestrian priority. Finally, some critical streets have been redesigned to increase their walking attractiveness. These results should be shared with Public Administrations and stakeholders, both to validate them, and as the first step of a wider participatory planning process aimed at improving walkability in Cartagena de Indias.

Acknowledgements

Authors would like to thank the 'Bolivar Gana Con Ciencia' project from the Gobernación de Bolívar (Colombia) for financial support.

References

Ahmedi, L., Rrmoku, K., Sylejmani, K., and Shabani, D., 2017. A bimodal social network analysis to recommend points of interest to tourists. Social Network Analysis and Mining, Springer Vienna, 7(1), 14.

Banister, D., 2008. The sustainable mobility paradigm. Transport policy, 15(2), 73-80.

Blečić, I., Cecchini, A., Congiu, T., Fancello, G., and Trunfio, G. A., 2015. Evaluating walkability: a capability-wise planning and design support system. International Journal of Geographical Information Science, 29(8), 1350–1374.

Caprì, S., Ignaccolo, M., Inturri, G., Le Pira, M., 2016. Green walking networks for climate change adaptation. Transportation Research Part D 45, 84–95.

Cascetta, E., Cartenì, A., Pagliara, F., Montanino, M., 2015. A new look at planning and designing transportation systems: A decision-making model based on cognitive rationality, stakeholder engagement and quantitative methods. Transport Policy, 38, 27–39.

Gonzalez-Urango, H., García-Melón, M., 2018. Stakeholder engagement to evaluate tourist development plans with a sustainable approach. Sustainable Development, (January), 1–12.

Gonzalez-Urango, H., Inturri, G., Le Pira, M., García-Melón, M., forthcoming. Planning for pedestrians: a participatory multicriteria approach using Analytic Network Process (ANP) in Cartagena de Indias (Colombia). Journal of Urban Planning and Development. 10.1061/(ASCE)UP.1943-5444.0000585

Le Pira, M., 2018. Transport Planning with Stakeholders: An Agent-Based Modeling Approach. International Journal of Transport Economics, 45(1).

Le Pira, M., Inturri, G., Ignaccolo, M., Pluchino, A., 2018. Dealing with the complexity of stakeholder interaction in participatory transport planning. In Advanced Concepts, Methodologies and Technologies for Transportation and Logistics (pp. 54-72). Springer, Cham.

Ligardo-Herrera, I., Gómez-Navarro, T., Gonzalez-Urango, H., 2018. Application of the ANP to the prioritization of project stakeholders in the context of responsible research and innovation. Central European Journal of Operations Research, Springer Berlin Heidelberg.

Moura, F., Cambra, P., Gonçalves, A. B., 2017. Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. Landscape and Urban Planning, 157, 282–296.

Parajuli, A., Pojani, D., 2017. Barriers to the pedestrianization of city centres: perspectives from the Global North and the Global South. Journal of Urban Design, 23(1), 142-160.

Reed, M. S., Graves, A., Dandy, N., Posthumus, H., Hubacek, K., Morris, J., Prell, C., Quinn, C. H., and Stringer, L. c., 2009. Who's in and why? A typology of stakeholder analysis methods for natural resource management. Journal of Environmental Management, 90(5), 1933–1949.

Saaty, T. L., 2001. The Analytic Network Process: Decision Making with Dependence and Feedback. RWS Publications.

Sayyadi, G., Awasthi, A., 2013. AHP-Based Approach for Location Planning of Pedestrian Zones: Application in Montreal, Canada. Journal of Transportation Engineering, 139(2), 239-246.

Sipahi, S., Timor, M., 2010. The analytic hierarchy process and analytic network process: an overview of applications. Management Decision, 48(5–6), 775–808.

Southworth, M., 2005. Designing the walkable city. Journal of urban planning and development, 131(4), 246-257.

Talavera-Garcia, R., Soria-Lara, J. A., 2015. Q-PLOS, developing an alternative walking index. A method based on urban design quality. Cities 45, 7–17.

Taleai, M., and Taheri Amiri, E., 2017. Spatial multi-criteria and multi-scale evaluation of walkability potential at street segment level: A case study of Tehran. Sustainable Cities and Society, Elsevier B.V., 31, 37–50.

Tight, M., Timms, P., Banister, D., Bowmaker, J., Copas, J., Day, A., ..., Watling, D., 2011. Visions for a walking and cycling focussed urban transport system. Journal of Transport Geography, 19(6), 1580-1589.

TfL, 2005. Improving walkability. Good practice guidance on improving pedestrian conditions as part of development opportunities.

Wasserman, S., and Faust, K., 2007. *Social Network Analysis*. Cambridge University Press, New York.