Investigate Walkability: An Assessment Model to Support Urban Development Processes

Green Energy and Technology

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Smart and Sustainable Planning for Cities and Regions

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Contents

Investigate Walkability: An Assessment Model to Support Urban Development Processes

Francesca Abastante, Marika Gaballo, and Luigi La Riccia

Abstract This chapter is about defining and testing a multi-methodological framework able to measure the "walkability" in the urban practice perspective, based on assessment indicators and Geographic Information Systems (GIS). Nowadays, cities are facing a complex challenge concerning sustainability, which is fueling the search for new development solutions. Among others, one of the most important problems is how to make cities sustainable and resilient, as stressed by the Sustainable Development Goal 11 (SDG11) highlighted by the United Nations through the 2030 Agenda. The topic of "walkability" appears in this framework: Walking has ecological, social, economic and political benefits. Moreover, designing walkable networks is important to create a functional and multi-modal city with transport choices and makes urban settlements sustainable and inclusive from the perspective that a sustainable city is also a walkable city. However, despite the positive impact of walkability on public space, it is still difficult to fully include it in governmental strategies because of its novelty in the scientific debate. The ongoing research proposed here aims at: (i) describing the problem, related to what trends and strategies have been implemented to face it; (ii) investigating walkability, understanding its definition in the scientific panorama, and how it is evaluated; (iii) understanding the current evaluation methods to assess the walkability of spaces; (iv) proposing a new multi-methodological framework based on existing methods that are able to measure the walkability degree from the perspective of better planning of cities. The multi-methodological framework has been tested through a case study: the Politecnico di Torino Campus (Torino, Italy).

Keywords Walkability · Sustainable urban mobility · Walkability evaluation index · Evaluation model

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1 Introduction

Nowadays, cities are characterized by a large number of walking paths, whose design is often underestimated in urban transformation processes and budgets. However, designing walkable networks is not only important to create a functional and multi-modal city with transport choices, but also to make urban settlements sustainable and inclusive. We can call this particular intention "walkability" (Rogers et al. 2013), understood as the easiest, cheapest and socially equable form of "soft-mobility" (La Rocca 2010). This does not mean that other transport modalities are not also recognized, but that they must be integrated in a sustainable way, improving the liveability of the city (Blečić 2015). This appears in line with the objectives of the 2030 Agenda for Sustainable Development with particular reference to the Sustainable Development Goals 11 (SDG11: Make cities and other human settlements inclusive, safe, resilient and sustainable) SDG13 (Take urgent action to combat climate change and its impacts).

In this panorama, the ongoing research, here presented, aims at defining and testing a multi-methodological framework based on assessment indicators and Geographic Information Systems (GIS) (Yin 2017; Lombardi et al. 2017; Chiantera et al. 2018) that are able to measure the "walkability" in the urban practice perspective.

The multi-methodological framework is structured in some interactive and iterative phases. First, we provided a literature review considering a span-time of ten years (2010–2019) in order to understand which indices and indicators should be used to measure "walkability."

Second, we applied a qualitative method based on questionnaires in order to verify the sensibility on the indices and indicators identified.

Third, the results obtained by the questionnaires have been aggregated and analyzed according to statistical models (Eliou and Galanis 2011; Shatu and Yigitcanlar 2018). This step turned out to be fundamental since it enables us to identify the final weights to be assigned to each index and indicator considering both quantitative and qualitative aspects.

In parallel, we explored the possibility of using visualization tools as assessment tools by mapping the indices and indicators identified using the QGIS software.

The multi-methodological framework here proposed has been tested in the walkability assessment of the Politecnico di Torino Campus (Turin, Italy).

The chapter is organized as follows: Sect. 2 provides an overview of the "walkability" issue and the main assessment methods to evaluate it; Sect. 3 reports the multi-methodological framework proposed through the application to a case study, while Sect. 4 concludes the chapter with a discussion of the future development of the research.

2 Walkability and Assessment

The increasing level of unsustainability that gradually affected every city at the global level requires an alternate international path related to urban mobility and accessibility. Among the urgent calls defined by the United Nations SDGs, "walkability" has a fundamental role. In fact, under the SDGs, this concept is explored and analyzed according to various perspectives, such as economic, political, social, ecological, and health (Rogers et al. 2013).

Accordingly, the "walkability" topic is increasingly becoming central in the research field of urban mobility and sustainability (Jensen 2013; Rogers et al. 2013; Urry 2016), and it is understood to be one of the factors that make cities "inclusive, safe, resilient and sustainable" (United Nation General Assembly 2017). It is demonstrated that improving "walkability" could lead to significant results in terms of money and time saved, the reduction of noise and air pollution, democratization of mobility, social cohesion and reduction of obesity, and prevention of cardiovascular diseases (Kaczynski 2012). This means that planning "walkable" cities could produce smart cities and communities as stressed by the SDG11.

According to the literature (Cambra 2012; Moayedi et al. 2013; Blečić et al. 2015), "walkability" is first of all a tool to measure the degree of pedestrian uses of a certain area (Abastante and Gaballo 2020; Abastante et al. 2020b). Despite this shared vision, a proper widespread definition of this concept is still missing: Some researchers define walkability as "the safety, security, economy, and convenience of traveling by foot" (Krambeck 2006), while others highlight a qualitative perspective linking "walkability" with the "quality of a place" (Ewing and Handy 2009). Those differences are probably due to several factors: (i) The ambiguity of the action of "walking" makes it tricky to catalogue "walkability," since people walk in an urban context for many reasons (Solnit 2005); and (ii) "Walkability" impacts different spheres of reality such as planning, transport, economy, and society. Therefore, we can affirm that the variables of "walkability" are many, making this concept subjective and making its definition dependent on those who deal with it (Lo 2009).

Moreover, despite that "walkability" is a consolidated field of analysis in the international context (D'Alessandro et al. 2016; Keat et al. 2016), in Italy this topic is little explored and considered by academics and Public Administrations (PAs).

In addition, while the socio-demographic impacts of "walkability" have been widely probed in the scientific literature (Saelens et al. 2003), studies about its physical and environmental variables linked to the built environment are scarce. This could be due to the fact that the act of walking in an urban context is wrongly often taken for granted. On the contrary, it actually requires proper design and be included in the planning of sustainable cities as a crucial mode of transport from the perspective that good "walkability" planning controls the way people move and determines the way they will move in the future (Jacobs 1961). Furthermore, "walkability" is a way of looking beyond the presence, distribution and accessibility of urban facilities: The spatial quality and the ability to accommodate and promote pedestrian mobility

Table 1 Main methods to assess walkability

Methods		Purpose
Quantitative	Statistical models	Provide an objective state of art
	Weighing indexes and indicators	Needed to obtain a global index structured on the basis of the indices considered, divided into indicators
Qualitative	Surveys	Outline users' perception of nonphysical and objectively measurable characteristics
	Empirical investigation	Provide scientific robustness for analysis

within the urban environment influence the way in which people perceive and use the entire city (Leslie et al. 2005).

In this panorama, a question emerges: How can we assess walkability in a city planning perspective?

According to the literature (D'Alessandro et al. 2016; Keat et al. 2016), properly understanding and measuring the complexity of walkability is extremely challenging. This is due to the jointly interrelated presence of two "souls": tangible/objectives elements (i.e., pavement height) and intangible/subjective aspects (i.e., the comfortable sensation felt when walking through a space). While the first are easily measurable and quantifiable, the second are not.

Many methods have been proposed in the scientific literature to assess "walkability" (Table 1).

From Table 1, it emerges that: (i) the most widespread quantitative methods are statistical models and weighting of indices and indicators, in the perspective of analysing the current state of a territory; and (ii) the most used qualitative methods are surveys and empirical investigations to identify nonphysical aspects and verify the robustness of previous analysis.

It is important to notice that the two "souls" of walkability, tangible/objectives elements and intangible/subjective aspects, are separately addressed by current methods proposed in the literature.

In our opinion, this could risk leading the city projects in diametrically opposite directions, complicating the decision-making processes and producing ineffective results.

The research presented in this paper aims at contributing to the current scientific debate by proposing a multi-methodological framework based on the main current assessment methods found in the literature and integrated within a spatial evaluation.

2.1 The Multi-methodological Framework

The multi-methodological framework here proposed is structured into three main phases (Fig. 1):

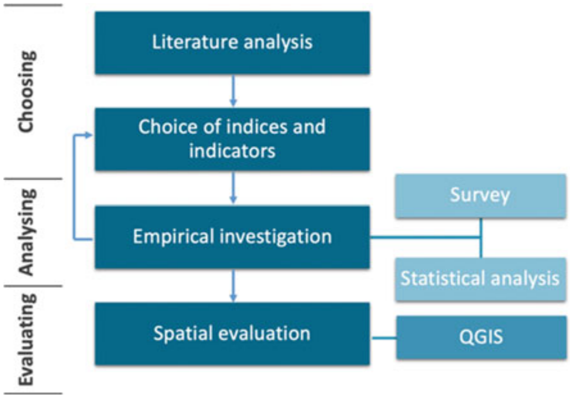

Fig. 1 Multi-methodological framework structure

(i) Choosing, related to the choice of indices, indicators and their range of weight through an in-depth analysis of the literature;
(ii) Analyzing, which includes qualitative and quantitative methods in order to test the results of the previous phase;
(iii) Evaluating, related to a spatial evaluation of phases 1 and 2.

To develop the multi-methodological framework, we approached the logic of so-called case study research (Stake 1995, p. 7) in which the case is understood as a "complex, functioning thing" useful to come to general understanding about the research question (Stake 1995, p. 2).

2.2 The Case Study: The Politecnico di Torino Campus

The case study that we "instrumentally" used to start developing the multi-methodological framework is based on the Politecnico di Torino Campus. In Fig. 2, the area under examination is depicted including the Politecnico di Torino Campus but also the main train station of the city and the major streets around the campus. This is due to the need to properly consider the accessibility to the campus.

The reasons for choosing this particular case study are many: (i) It is similar to a urban district in terms of territorial scale; (ii) it is the node of interesting actors' networks; (iii) it is usually the place in which ideas of urban transformations are produced together with the PA; (iv) a large amount of information is available, facilitating the development and test of the multi-methodological framework; and (v) it provides the chance to study, implement, and evaluate different aspects in the perspective of raising awareness among students, professors and staff about the crucial issues of our times.

Fig. 2 Case study area

2.3 Phase 1: Choosing

The first phase (Choosing) is fully based on literature analysis with the purpose of defining indices and indicators (Cambra 2012; D'Alessandro et al. 2016) that are able to reflect the complexity of the reality about the planning of walkability, considering both its tangible/objective elements and intangible/subjective aspects.

We therefore conducted a scientific literature review basing on Scopus and Google Scholar databases using four keywords: walkability, walkability measure, walkability indicators, and walkability indices. In turn, we decided to limit the analysis to the papers that were facing the "walkability" topic in an assessment perspective, coming up with 25 results. Those have been analyzed in depth to understand: (i) indices and indicators used to assess "walkability"; and (ii) the weights that usually are assigned to each index in terms of range (Table 2).

From Table 2, we can notice that the main indices found in literature are four (Safety/Security, Quality of paths, Comfort and Intermodality) which in turn are divided into 27 indicators. Moreover, the index safety/security seems to be the most important one with a range of weights among 25% and 50% followed by the quality of paths (21–40%), comfort (10–20%), and intermodality (10–20%). It is important to

Table 2 Main indices and indicators according to the literature review

Indices	Weights	Indicators	Frequency
Safety/Security	25–50%	Presence of busy roads	Cerin et al. (2011), Ford (2013), Lee and Talen (2014), D'Alessandro et al. (2016), Keat et al. (2016), Wibowo and Nurhalima (2018) Chiantera et al. (2018)
		Crossing equipped with traffic lights	
		No signaled pedestrian crossings	
		Separation of routes	
Quality of Paths	21–40%	Width of routes	Reid and Handy (2009), Cerin et al. (2011), Galanis and Eliou (2011), Cambra (2012), Ford (2013), Moayedib et al. (2013), Lee and Talen (2014), D'Alessandro et al. (2016), Keat et al. (2016), Wibowo and Nurhalima (2018), Shatu and Yigitcanlar (2018) Chiantera et al. (2018)
		Condition of the pavement	
		Non-sliding paths (with obstacles)	
		Well-connected paths	
		Slope	
Comfort	10–30%	Presence of trees	Reid and Handy (2009), Cerin et al. (2011), Cambra (2012), Ford (2013), Moayedib et al. (2013), Domokos et al. (2014), Lee and Talen (2014), D'Alessandro et al. (2016), Keat et al. (2016), Wibowo and Nurhalima (2018), Yin (2017), Chiantera et al. (2018)
		Adequate lighting	
		Presence of benches	
		Presence of baskets	
		Noise pollution	
		Covered routes	
		Presence of water points	
		Presence of tall buildings	
		Buildings with monotonous colors	
		Possibility to see the continuity of the routes	
		Refreshment points	
		Study points	
		Crowded spaces	
Intermodality	10–20%	Parking for private bikes	Cambra (2012), Ford (2013)
		Easy accessibility by public transport	
		Parking for private cars	
		Bike-sharing stations	
		Car-sharing stations	

underline that the intermodality indicator is addressed by only two included papers, diminishing the sensibility of the range here classified.

2.4 Phase 2: Analyzing

The second phase (analysing) is both qualitative and quantitative and pursues a double aim: testing the sensibility of the indices and indicators (Table 2) through the use of surveys and finding their weights through statistical analysis.

The interview sample selected for the surveys' analysis was composed of students, teachers and technicians of the Politecnico di Torino, for a total of 100 interviewees. It is fundamental to underline that, in this phase of the research, a small sample was sufficient to conduct experimental validation of the framework. The 100 interviewees were asked to answer to 36 questions using the five-point Likert scale of evaluation in which 1 means "strong disagreement" and 5 means "totally agree" (Likert 1932).

The questions were of the type:

- Considering the indices proposed (safety/security, quality of the paths, intermodality and comfort) how much performing is each index in the Politecnico di Torino Campus? Provide a percentage according to your experience
- Considering the index "safety/security," the Politecnico di Torino Campus is characterized by the presence of busy roads. Provide an answer according to the Liker scale.

The results obtained by the surveys have been analyzed by calculating the modal value, the arithmetic average, the weighted average and the standard deviation to achieve a detailed statistical overview of the answers obtained.

A first result of this phase was related to the level of agreement in the responses: The answers collected were widely varied in relation to some indices compared to others, reporting a low degree of agreement for some indices.

Accordingly, Fig. 3 reports the calculation of the standard deviation of the answers.

Figure 3 highlights that the highest dispersion of the responses is related to the Intermodality index, showing the high subjectivity of this index. In fact, the transport modalities to reach the Politecnico di Torino Campus are many (by foot, train, subway, bus, bike, car, or shared transport), and this causes various perceptions of the intermodality efficiency depending on the transport modes that the interviewee usually uses.

Fig. 3 Standard deviation of the Indices

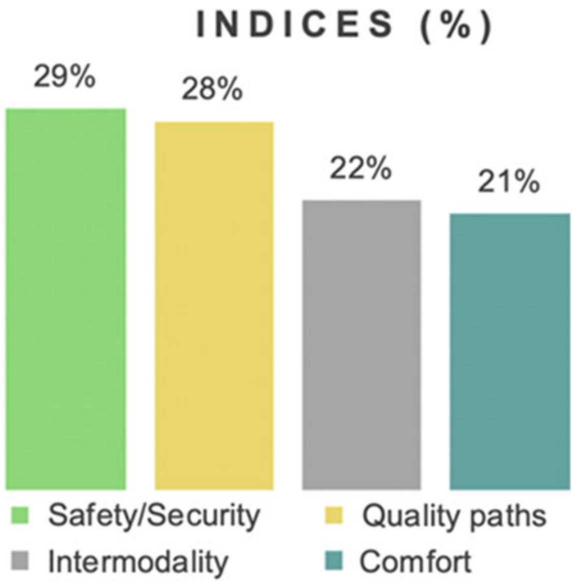

Fig. 4 Weighted averages of indices

According to the results obtained by the surveys, Fig. 4 graphs the weighted averages calculated at the level of the Indices.

In terms of indices (see Fig. 4), it is possible to notice that the Safety/Security index has the highest weight followed by that of quality of the paths while the index with the lowest weight is the Comfort index, highlighting that Comfort is the least critical aspect in the Politecnico di Torino campus. With reference to this, Fig. 5 shows the weighted averages calculated at the level of the Comfort's indicators.

Figure 5 illustrates that the most problematic indicator is the presence of "Crowd spaces in Campus." This means that the spaces inside the Politecnico di Torino Campus need a better planning in this sense.

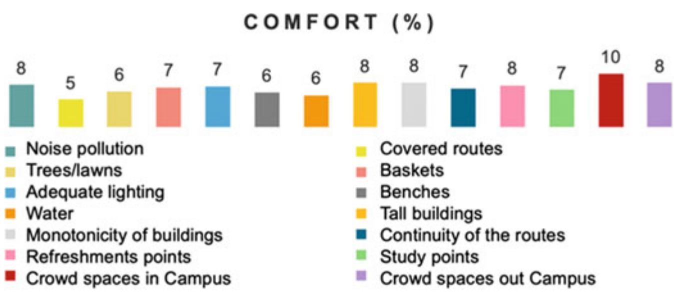

Fig. 5 Weighted averages of the comfort indicators

2.5 Phase 3: Evaluating

The third phase (Evaluating) involves the use of GIS (Feizizadeh et al. 2014) to provide a visual and spatial evaluation of phases 1 and 2. In recent years, research in the urban planning field has stressed the importance of combining qualitative/quantitative tools with visualization tools (Abastante et al. 2020a, 2017). Those demonstrate that having a visual representation of what is evaluated is useful to obtain a holistic picture of the situation, on the one hand, and to provide technical support for future strategic and/or design choices, on the other (Vennix 1996; Lami et al. 2014).

In the research presented in this paper, we decided to use the QGIS (qgis.com) which is an open-source software that makes possible calculating the characters useful for the evaluation of walkability (Yin 2017), thus improving understanding from the perspective of proposing urban projects.

It is important to underline that this third phase of the multi-methodological framework has a double aim:

1. Providing a spatial representation of the indicators assumed in the case study area, starting from selected tangible/objective territorial aspects;
2. Weighting the indicators with the percentages identified in the previous phases 1 and 2, to emphasize the importance to the intangible/subjective aspects.

Considering that this is ongoing research, in this paper we will briefly illustrate the logics undertaken to the first objective, while the integration of intangible aspects still in progress. All data have been spatially represented following three different means of representation (Okabe et al. 2009):

- Maps with "linear" distribution of data (e.g., cycling pathways—objective feature: width)
- Maps with "areal" distribution of data (e.g., public lighting—objective feature: wattage of the lamps)
- Kernel maps with statistical distribution of point data (e.g., traffic lights—not weighted data).

All data have been spatialized, given the value of a phenomenon, representing their diffusion and attenuation with a radius defined in relation to the phenomenon represented. Accordingly, we used the QGIS/GRASS algorithm named "*r.cost*." even though some problems of software instability occurred. An interesting optional output of the algorithm is allocation, i.e., the identification of the area of influence of each activity: The result can be usefully interpreted if referred to destinations of the same kind.

Since the multi-methodological framework is developed starting from the Politecnico di Torino Campus case study, the space is modeled through a raster with 1 × 1 m cells. This dimension is smaller than the usual dimensions, but it perfectly fits the needs of the case study in terms of details.

An impedance (Kartshmit et al. 2020) is assigned to each cell, which is a cost of traveling on foot, more or less pleasantly and safely. The cells that cannot be traversed because they are included in areas destined for vehicular traffic or because they are nonpublic are excluded. The outputs/maps provided by this kind of analysis are often identified as Cost Rasters (Cittadino et al. 2019). The cost raster is understood as a concept which usually results by the application of a multi-criteria analysis (MCDA) (Abastante et al. 2017): It is the weighted sum of several raster whose cells values represent various aspects of cost (Fig. 6).

Figure 6 comprises the cost raster maps of the four indices considered: comfort, intermodality, quality of the path and safety/security. Those are the results of the weighted sum of the cost raster of the indicators (Table 2). Since indices and indicators could be measured in different scales of measure, the values have been normalized. In the maps, the green areas mean high values of indices (high practicability, high security, high pleasure) while the red ones mean low values (obstacles).

It is possible to notice that the index for comfort seems to be the most problematic one while the index for quality of the paths reports a very high evaluation.

3 Discussion and Conclusions

The "walkability" concept, as described in this research, could contribute to the construction of a more sustainable city by designing solutions that improve the possibilities of using public roads as public spaces, making a city more liveable.

Moreover, the role of the assessment appears fundamental in the context of walkability: Such evaluation methodologies are increasingly used as guide in order to support transformation processes addressing the actual challenges of the urban context (Bush and Doyon 2019).

Accordingly, the multi-methodological assessment framework developed in this research could be an aid for stakeholders who want to reason in terms of liveability as an element of growth and sustainability of the urban context or, more generally, who deal with the sustainable mobility issue.

The results that we reported in this chapter, despite their preliminary nature, constitute a strong basis for discussions useful to funding future steps of the research. First, we can affirm that phase 1 (Choosing) the multi-methodological framework proved to be fundamental to identifying the main indices and indicators in a tangible/objective perspective. However, the analysis of the literature also showed that those are the most varied, site-specific and closely related to the area examined.

Phase 2 (Analyzing) constitutes the core of the multi-methodological framework by being able to enrich overall analysis focusing on the intangible/subjective aspects. In our opinion, this second phase constitutes a fundamental contribution to the current international debate about walkability assessment because it puts people at the core of the urban planning by considering their needs, feelings and perception about the walkability of a place.

A strong limitation of this second phase has been the interviewed sample. Due to time constriction, the interviewed sample so far considered is very limited.

Fig. 6 Cost raster (indices)

In turn, we would be able to provide a robust phase 3 (Evaluating) by basing the analysis on a larger amount of data. In fact, despite the European principles of open by default (opendatacharter.net), we faced some difficulties in accessing data, particularly in reference to the absence of meta-documentation of some indicators.

In general, despite the limits showed by the multi-methodological framework proposed, it proved to have a lot of potential in terms of measuring the walkability characteristics, considering both tangible and intangible elements.

4 Future Developments

The future development of the research will involve not simply improving the highlighted weaknesses but also taking steps forward. In the future development of the research, we aim at improve automation of some procedures to structure real-time decision processes (Lami and Tavella 2019) by integrating the calculation of cost distance maps (Chen et al. 2019). This will enable considering simultaneously the weights of indices and indicators objectively defined with the weights stated in the questionnaires.

Moreover, to improve the walkability of the site, we aim at defining alternative planning scenarios for the Politecnico di Torino Campus (Italy).

Finally, it would be interesting to provide a generalization of the results obtained to make possible translating them into strategic policy guidelines for public administrations. This will enable consideration of walkability in developmental processes and their implementation in territorial governance tools in line with the sustainability objectives imposed by European document standards.

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