

Investigate Walkability: An Assessment Model to Support Urban Development Processes

Original

Investigate Walkability: An Assessment Model to Support Urban Development Processes / Abastante, Francesca; La Riccia, Luigi; Gaballo, Marika - In: Green Energy and Technology / Adriano Bisello, Daniele Vettorato, Håvard Haarstad, Judith Borsboom-van Beurden. - ELETTRONICO. - Switzerland : Springer, Cham, 2021. - ISBN 978-3-030-57332-4. - pp. 183-197 [10.1007/978-3-030-57332-4_13]

Availability:

This version is available at: 11583/2885252 since: 2021-04-07T20:26:37Z

Publisher:

Springer, Cham

Published

DOI:10.1007/978-3-030-57332-4_13

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

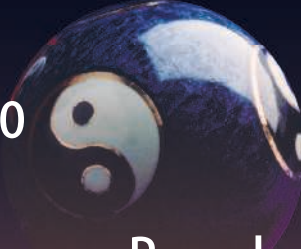
Springer postprint/Author's Accepted Manuscript

This version of the article has been accepted for publication, after peer review (when applicable) and is subject to Springer Nature's AM terms of use, but is not the Version of Record and does not reflect post-acceptance improvements, or any corrections. The Version of Record is available online at: http://dx.doi.org/10.1007/978-3-030-57332-4_13

(Article begins on next page)

Green Energy and Technology

Adriano Bisello
Daniele Vettorato
Håvard Haarstad
Judith Borsboom-van Beurden *Editors*



Smart and Sustainable Planning for Cities and Regions

Results of SSPCR 2019

eurac
research

 Springer

Green Energy and Technology

Climate change, environmental impact and the limited natural resources urge scientific research and novel technical solutions. The monograph series Green Energy and Technology serves as a publishing platform for scientific and technological approaches to “green”—i.e. environmentally friendly and sustainable—technologies. While a focus lies on energy and power supply, it also covers “green” solutions in industrial engineering and engineering design. Green Energy and Technology addresses researchers, advanced students, technical consultants as well as decision makers in industries and politics. Hence, the level of presentation spans from instructional to highly technical.

****Indexed in Scopus**.**

More information about this series at <http://www.springer.com/series/8059>

Adriano Bisello · Daniele Vettorato ·
Håvard Haarstad · Judith Borsboom-van Beurden
Editors

Smart and Sustainable Planning for Cities and Regions

Results of SSPCR 2019

 Springer

Editors

Adriano Bisello
EURAC Research
Bolzano/Bozen, Italy

Daniele Vettorato
EURAC Research
Bolzano/Bozen, Italy

Håvard Haarstad
Centre for Climate and Energy
Transformation and Department
of Geography
University of Bergen
Bergen, Norway

Judith Borsboom-van Beurden
Locality
Driebergen-Rijsenburg, The Netherlands

ISSN 1865-3529

Green Energy and Technology

ISBN 978-3-030-57331-7

<https://doi.org/10.1007/978-3-030-57332-4>

ISSN 1865-3537 (electronic)

ISBN 978-3-030-57332-4 (eBook)

© The Editor(s) (if applicable) and The Author(s), under exclusive license to Springer Nature Switzerland AG 2021

This work is subject to copyright. All rights are solely and exclusively licensed by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, expressed or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Contents

Shaping the Climate and Energy Transition: Clean Energy and Robust Systems for All	
Smart Approach to Management of Energy Resources in Smart Cities: Evaluation of Models and Methods	3
Jana Teremranova and Anna Mutule	
City-Level Evaluation: Categories, Application Fields and Indicators for Advanced Planning Processes for Urban Transformation	17
Carla Rodríguez, Cecilia Sanz-Montalvillo, Estefanía Vallejo, and Ana Quijano	
Proposal for an Integrated Approach to Support Urban Sustainability: The COSIMA Method Applied to Eco-Districts	37
Cristina Becchio, Marta Carla Bottero, Stefano Paolo Corgnati, Federico Dell’Anna, Giulia Pederiva, and Giulia Vergerio	
Open Innovation Strategies, Green Policies, and Action Plans for Sustainable Cities—Challenges, Opportunities, and Approaches	49
Mohsen Aboulnaga, Marco Sala, and Antonella Trombadore	
Governing and Planning Local Climate-Change Adaptation in the Alps	69
Luca Cetara, Marco Pregnotato, and Pasquale La Malva	
Projections of Electricity Demand in European Cities Using Downscaled Population Scenarios	81
Gianni Guastella, Enrico Lippo, Stefano Pareglio, and Massimiliano Carlo Pietro Rizzati	
Integrated Building Data for Smart Regions and Cities—An Italian Pilot	99
Ezilda Costanzo and Bruno Baldissara	

Thermal Performance Evaluation of Unshaded Courtyards in Egyptian Arid Regions	109
Hatem Mahmoud and Ayman Ragab	
Societal, Research and Innovation Challenges in Integrated Planning and Implementation of Smart and Energy-Efficient Urban Solutions: How Can Local Governments Be Better Supported?	123
Judith Borsboom-van Beurden and Simona Costa	
Urban (Big) Data: Challenges for Information Retrieval and Knowledge Discovery	
Transposing Integrated Data-Driven Urban Planning from Theory to Practice: Guidelines for Smart and Sustainable Cities	141
Viktor Bukovszki, Ahmed Khoja, Natalie Essig, Åsa Nilsson, and András Reith	
City Indicators Visualization and Information System (CIVIS)	157
Álvaro Samperio-Valdivieso, Paula Hernampérez-Manso, Francisco Javier Miguel-Herrero, Estefanía Vallejo-Ortega, and Gema Hernández-Moral	
Methodology and Operating Tool for Urban Renovation: The Case Study of the Italian City of Meran	171
Alice Schweigkofler, Katrien Romagnoli, Dieter Steiner, Michael Riedl, and Dominik T. Matt	
Investigate Walkability: An Assessment Model to Support Urban Development Processes	183
Francesca Abastante, Marika Gaballo, and Luigi La Riccia	
Assessing the Level of Accessibility of Railway Public Transport for Women Passengers Using Location-Based Data: The Case of H2020 DIAMOND Project	199
Andrea Gorrini, Rawad Choubassi, Anahita Rezaallah, Dante Presicce, Ludovico Boratto, David Laniado, and Pablo Aragón	
New Value Propositions in Times of Urban Innovation Ecosystems and Sharing Economies	
Assessing Integrated Circular Actions as Nexus Solutions Across Different Urban Challenges: Evidence Toward a City-Sensitive Circular Economy	215
Maria Beatrice Andreucci and Edoardo Croci	
Build or Reuse? Built Environment Regeneration Strategies and Real Estate Market in Seven Metropolitan Cities in Italy	227
Alessia Mangialardo and Ezio Micelli	

Addressing the Problem of Private Abandoned Buildings in Italy. A Neo-Institutional Approach to Multiple Causes and Potential Solutions 235
 Anita De Franco

Unlocking the Social Impact of Built Heritage Projects: Evaluation as Catalyst of Value? 249
 Cristina Coscia and Irene Rubino

Renewable Energy Communities: Business Models of Multi-family Housing Buildings 261
 Valeria Casalicchio, Giampaolo Manzolini, Matteo Giacomo Prina, and David Moser

Relevance of Cultural Features in Contingent Valuation: A Literature Review of Environmental Goods Assessments 277
 Valentina Antonucci, Giuliano Marella, Roberto Raga, and Shinya Suzuki

Circular Economy Meets the Fashion Industry: Challenges and Opportunities in New York City 293
 Younghyun Kim and Savannah Wu

Dissolving Borders: Towards Integrated Territorial Approaches, from Smart Cities to Smart Regions

Beyond the City Limits—Smart Suburban Regions in Austria 315
 Nina Svanda and Petra Hirschler

Rural Areas as an Opportunity for a New Development Path 329
 Stefano Aragona

The Impact of Action Planning on the Development of Peripheral Rural Villages: An Empirical Analysis of Rural Construction in Yanhe Village, China 341
 Qiuyin Xu and Tianjie Zhang

Sustainability of Cultural Diversity and the Failure of Cohesion Policy in the EU: The Case of Szeklerland 355
 Attila Dabis

Thriving Governance and Citizenship in a Smart World: Environments and Approaches Fostering Engagement and Collaborative Action

Toward a Smart Urban Planning. The Co-production of Contemporary Citizenship in the Era of Digitalization 373
 Enza Lissandrello

Digital Technologies for Community Engagement in Decision-Making and Planning Process	387
Antonella Galassi, Lucia Petříková, and Micaela Scacchi	
Emerging Interpretation Models of Social and Institutional Innovation in the City. The Role of ‘Intermediate Places’ Between the USA and Italy	399
Bruno Monardo and Martina Massari	
Smart Creative Cities and Urban Regeneration Policy: Culture, Innovation, and Economy at Nexus. Learning from Lyon Metropolis	411
Maria Beatrice Andreucci	
Analysis of National Research Programs to Boost Urban Challenges in Transnational Cooperation	425
Gilda Massa	
The Role of Stakeholders’ Risk Perception in Water Management Policies. A Case-Study Comparison in Southern Italy	435
Stefania Santoro and Giulia Motta Zanin	
Devising a Socioeconomic Vulnerability Assessment Framework and Ensuring Community Participation for Disaster Risk Reduction: A Case-Study Post Kerala Floods of 2018	451
Fathimah Tayyiba Rasheed	
Towards Sustainable and Inclusive Cities: Discrimination Against Vulnerable and Marginalized Groups—A Review of a Hidden Barrier to Sustainable Urbanization	469
Vivien Benda	
Tackling Energy Poverty	
Exposure and Vulnerability Toward Summer Energy Poverty in the City of Madrid: A Gender Perspective	481
Miguel Núñez-Peiró, Carmen Sánchez-Guevara Sánchez, Ana Sanz-Fernández, Marta Gayoso-Heredia, J. Antonio López-Bueno, F. Javier Neila González, Cristina Linares, Julio Díaz, and Gloria Gómez-Muñoz	
The Ecobonus Incentive Scheme and Energy Poverty: Is Energy Efficiency for All?	497
Chiara Martini	
A Behavioral Model for In-Home Displays Usage in Social Housing Districts	511
Valeria Fanghella and Nives Della Valle	

Investigating the Role of Occupant Behavior in Design Energy Poverty Strategies. Insights from Energy Simulation Results 525
Angela Santangelo, Simona Tondelli, and Da Yan

Energy Retrofitting in Public Housing and Fuel Poverty Reduction: Cost–Benefit Trade-Offs 539
Chiara D’Alpaos and Paolo Bragolusi

Rural-Urban Relationships for a Better Territorial Development

Rural–Urban Relationships for Better Territorial Development 557
Elisa Ravazzoli, Christian Hoffman, Francesco Calabrò,
and Giuseppina Cassalia

Multiscale Urban Analysis and Modelling for Local and Regional Decision-Makers 567
Janka Lengyel and Jan Friedrich

Preference-Based Planning of Urban Green Spaces: A Latent-Class Clustering Approach 581
Gianluca Grilli and John Curtis

A Smart and Open-Source Framework for Cultural Landscape Policies 589
Alexandru Calcatinge

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

F. Abastante (✉) · M. Gaballo · L. La Riccia
Politecnico di Torino (DIST Department), viale Pier Andrea Mattioli 39, 1012 Torino, Italy
e-mail: francesca.abastante@polito.it

© The Author(s), under exclusive license to Springer Nature Switzerland AG 2021
A. Bisello et al. (eds.), *Smart and Sustainable Planning for Cities and Regions*,
Green Energy and Technology, https://doi.org/10.1007/978-3-030-57332-4_13

183

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 equitable 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.

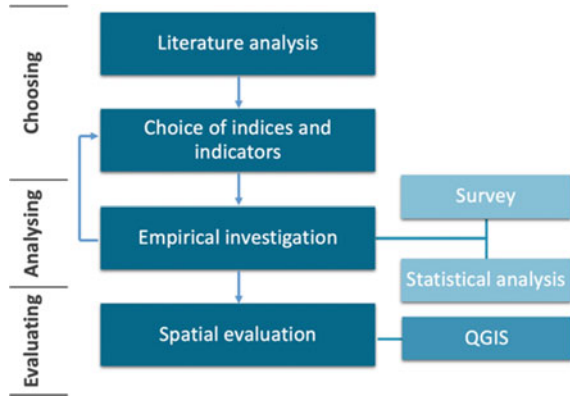
In our opinion, this could risk leading the city projects in diametrically opposite directions, complicating the decision-making processes and producing ineffective results.

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 an 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.

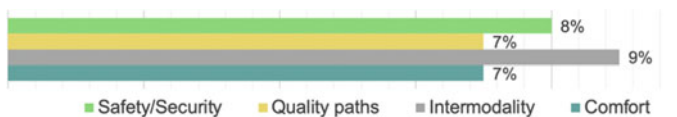


Fig. 3 Standard deviation of the Indices

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.

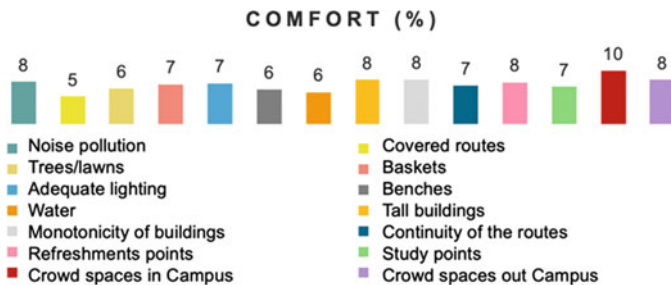


Fig. 5 Weighted averages of the comfort indicators

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.

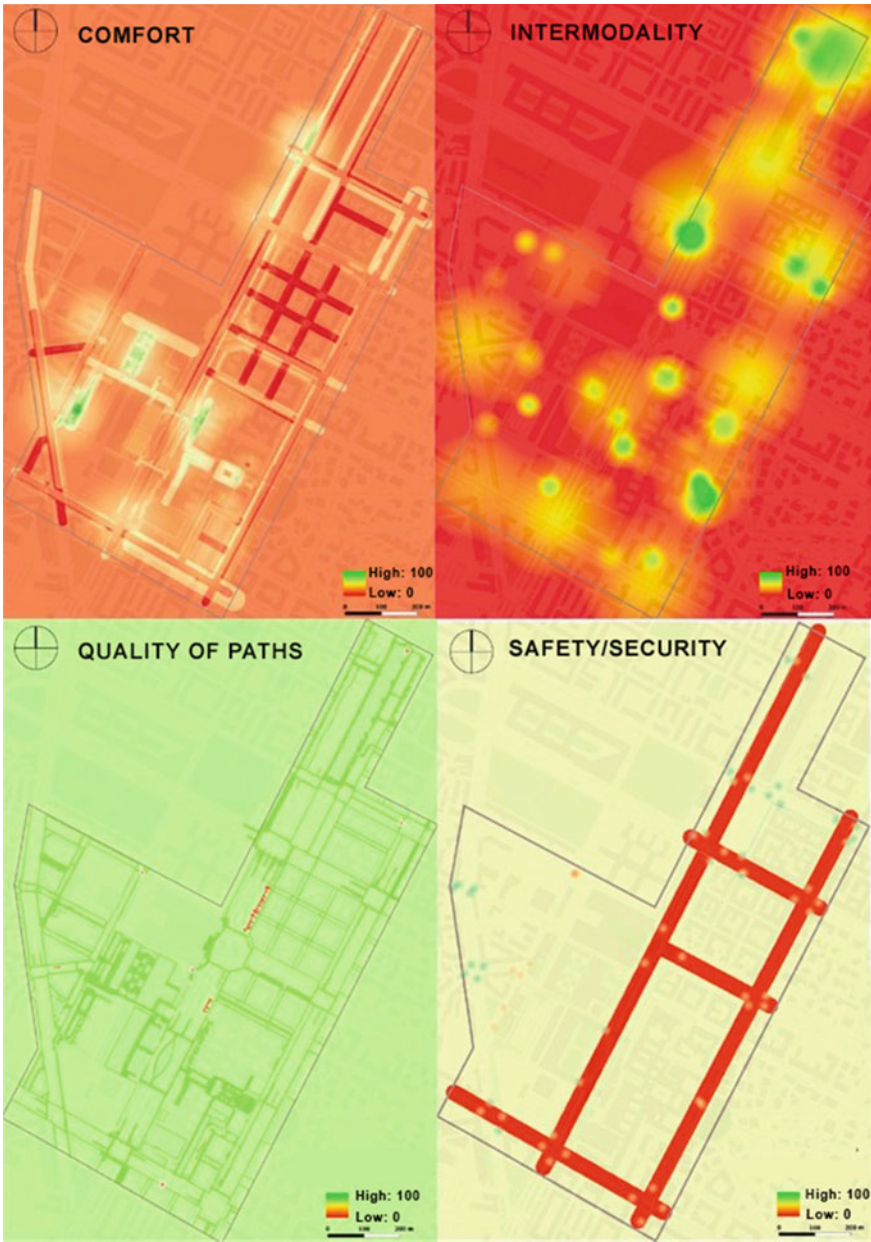


Fig. 6 Cost raster (indices)

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.

References

- Abastante F, Lami IM, Lombardi P (2017) An integrated participative spatial decision support system for smart energy urban scenarios: a financial and economic approach. *Buildings* 7(4):103
- Abastante F, Gaballo M (2020) How to assess walkability as a measure of pedestrian use: first step of a multi-methodological approach. In: *International symposium of new metropolitan perspectives*. Springer, Cham, pp 254–263
- Abastante F, Pensa S, Masala E (2020a) The process of sharing information in a sustainable development perspective: a web visual tool. In: *Values and functions for future cities*. Springer, Cham, pp 339–350
- Abastante F, Lami IM, La Riccia L, Gaballo M (2020b). Supporting resilient urban planning through walkability assessment. *Sustainability* 12(19):8131
- Andersen DF, Richardson GP (1997) Scripts for group model building. *Syst Dyn Interview* 13(2):107–129
- Blečić I, Cecchini A, Congiu T, Fancello G, Trunfio GA (2015) Evaluating walkability: a capability-wise planning and design support system. *Int J Geogr Inf Sci* 29(8):1350–1374
- Bush J, Doyon A (2019) Building urban resilience with nature-based solutions: how can urban planning contribute? *Cities* 95:102483

- Cambra P (2012) Pedestrian accessibility and attractiveness indicators for walkability assessment. Department of Civil Engineering and Architecture, Instituto Superior Técnico, Universidade Técnica de Lisboa, Lisbon
- Cerin E, Chan KW, Macfarlane DJ, Lee KY, Lai PC (2011) Objective assessment of walking environments in ultra-dense cities: development and reliability of the Environment in Asia Scan Tool—Hong Kong version (EAST-HK). *Health Place* 17(4):937–945
- Chen Y, She J, Li X (2019) Calculate accurate 3D cost distance efficiently. Abstracts ICA 1
- Chiantera G, Cittadino A, Del Carlo G, Fiermonte F, Garnero G, Guerreschi P, Vico F (2018) Walkability della città: analisi raster per supportarne la progettazione e il suo incremento. In: Conferenza Nazionale ASITA 2018, pp 1–8
- Cittadino A, Eynard R, Fiermonte F, Garnero G, Guerreschi P, Melis G, La Riccia L (2019) Improving the WALKABILITY for next-generation cities and territories, through the reuse of available data ad raster analysis. In: XXIV international conference LWC 2019, living and walking in cities, pp 1–38
- D'Alessandro D, Appolloni L, Capasso L (2016) How walkable is the city? application of the walking suitability index of the territory (T-WSI) to the city of Rieti (Lazio Region, Central Italy). *Epidemiol Prev* 40(3–4):237–242
- Domokos S, Tier A, Wiitala C, Villasis E (2014) Walkability on University Avenue European Union. <https://www.sustainabledevelopment.un.org>. Accessed on 10 Nov 2019
- Ewing R, Handy S (2009) Measuring the unmeasurable: urban design qualities related to walkability. *J Urban Design* 14(1):65–84
- Feizizadeh B, Roodposhti MS, Jankowski P, Blaschke T (2014) A GIS-based extended fuzzy multi-criteria evaluation for landslide susceptibility mapping. *Comput Geosci* 73:208–221
- Ford AM (2013) Walkability of campus communities surrounding Wright State University.
- Galanis A, Eliou N (2011) Evaluation of the pedestrian infrastructure using walkability indicators. *WSEAS Trans Environ Devel* 7(12):385–394
- Google Scholar. <https://www.scholar.google.com>. Accessed on 10 Jan 2020
- Jacobs J (1961) *The death and life of Great American cities*. Random House, New York
- Jensen OB (2013) *Staging mobilities*. Routledge, London
- Kaczynski AT, Robertson-Wilson J, Decloe M (2012) Interaction of perceived neighborhood walkability and self-efficacy on physical activity. *J Phys Activity Health* 9(2):208–217
- Kartschmit N, Sutcliffe R, Sheldon MP, Moebus S, Greiser KH, Hartwig S, Maier W (2020) Walkability and its association with prevalent and incident diabetes among adults in different regions of Germany: results of pooled data from five German cohorts. *BMC Endocrine Disorders* 20(1):1–9
- Keat LK, Yaacob NM, Hashim NR (2016) Campus walkability in Malaysian public universities: a case-study of Universiti Malaya. *Plann Malaysia* 14(5)
- Krambeck HV (2006) *The global walkability index*. Doctoral dissertation, Massachusetts Institute of Technology
- Lami IM, Tavella E (2019) On the usefulness of soft OR models in decision making: a comparison of problem structuring methods supported and self-organized workshops. *Eur J Oper Res* 275(3):1020–1036
- Lami IM, Abastante F, Bottero M, Masala E, Pensa S (2014) Integrating multicriteria evaluation and data visualization as a problem structuring approach to support territorial transformation projects. *EURO J Decision Process* 2(3–4):281–312
- La Rocca RA (2010) Soft mobility and urban transformation. *Tema J Land Use Mobil Environ* 2
- Lee S, Talen E (2014) Measuring walkability: a note on auditing methods. *J Urban Design* 19(3):368–388
- Leslie E, Saelens B, Frank L, Owen N, Bauman A, Coffee N, Hugo G (2005) Residents' perceptions of walkability attributes in objectively different neighbourhoods: a pilot study. *Health Place* 11(3):227–236
- Likert R (1932) A technique for the measurement of attitudes. *Arch Psychol*
- Lo RH (2009) Walkability: What is it? *J Urban* 2(2):145–166

- Lombardi P, Abastante F, Torabi Moghadam S, Toniolo J (2017) Multicriteria spatial decision support systems for future urban energy retrofitting scenarios. *Sustainability* 9(7):1252
- Moayed F, Zakaria R, Bigah Y, Mustafar M, Puan OC, Zin IS, Klufallah MM (2013) Conceptualising the indicators of walkability for sustainable transportation. *Jurnal Teknologi* 65(3)
- Okabe A, Satoh T, Sugihara K (2009) A kernel density estimation method for networks, its computational method and a GIS-based tool. *Int J Geogr Inf Sci* 23(1):7–32
- Open Data Charter. <https://www.opendatacharter.net>. Accessed on 10 Jan 2020
- QGIS software. <https://www.qgis.org>. Accessed on 10 Jan 2020
- Rogers SH, Gardner KH, Carlson CH (2013) Social capital and walkability as social aspects of sustainability. *Sustainability* 5(8):3473–3483
- Saelens BE, Sallis JF, Frank LD (2003) Environmental correlates of walking and cycling: findings from the transportation, urban design, and planning literatures. *Ann Behav Med* 25(2):80–91
- Scopus online. <https://www.scopus.com>. Accessed on 10 Jan 2020
- Shatu F, Yigitcanlar T (2018) Development and validity of a virtual street walkability audit tool for pedestrian route choice analysis—SWATCH. *J Transp Geogr* 70:148–160
- Solnit R (2005) *Storia del camminare*, vol 33. Pearson Italia Spa
- Stake RE (1995) *The art of case study research*. Sage
- United Nation General Assembly (2017) *Global indicator framework for the sustainable development goals and targets of the 2030 agenda for sustainable development*. United Nation, New York. Available at <https://unstats.un.org/sdgs/indicators/indicators-list/>. Accessed on 5 May 2020
- Urry J (2016) *Mobilities: new perspectives on transport and society*. Routledge, London
- Vennix JA, Akkermans HA, Rouwette EA (1996) Group model-building to facilitate organizational change: an exploratory study. *Syst Dyn Rev J Syst Dyn Soc* 12(1):39–58
- Wibowo SS, Nurhalima DR (2018) Pedestrian facilities evaluation using pedestrian level of service (PLOS) for university area: case of Bandung Institute of Technology. In: *MATEC web of conferences*, vol 181. EDP Sciences, p 02005
- Yin L (2017) Street level urban design qualities for walkability: combining 2D and 3D GIS measures. *Comput Environ Urban Syst* 64:288–296