Towards the Definition of a Comprehensive Walkability Index for Historical Centres

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Abstract. Historical centres are crucial areas where urban and transport planners should aim at enhancing adequate walkability conditions. This should be considered a priority in order to allow all users, including the most vulnerable ones, to access the activities they wish to engage in.
Based on this premises, the paper aims at defining a methodological approach to comprehensively assess the existing pedestrian network infrastructure within historical centres, considering safety, comfort, and enjoyment factors of the walking experience.
In-field inspections have been carried out for the main pedestrian paths and crossings within the historical centre of Parma, and data have been georeferenced in a GIS database. The indicators considered in the walkability analysis are: sidewalks width, change of levels, bottlenecks, coloured ground signs, protection level, presence of seats, maintenance level, presence of tactile flooring. A comprehensive walkability index has been developed to assess the quality of each pedestrian link and crossing. The results have been represented in GIS-based thematic maps, that can support local authorities in defining priorities of intervention.

Keywords: Pedestrian Mobility; Paths; Crossings; Walkability; Historical Centres

1 Introduction

Even if historic centres have extremely different characteristics depending on their origins, evolution, size, and geographical location, in the historical city the primary type of movement has always been the pedestrian one: city centres were from the very beginning planned and designed to support and foster walkability.

But nowadays, except for pedestrian areas closed to motorised vehicles, historic centres are often affected by different types of traffic: this determines a promiscuity of circulation that is managed, in most cases, with horizontal and vertical signs, and which with difficulty integrates within the historical-monumental fabric and its spaces [1].

However, it is still crucial to consider walking as the main modal component within city centres, and consequently adopt measures that do not limit the pedestrian movement by providing a high-quality design of pedestrian paths provisions to maximise accessibility and safety for the weakest road users [2].

Within this framework, the paper aims at presenting a methodology to comprehensively assess the existing pedestrian network infrastructure within historical centres, where walkability conditions should be particularly enhanced. This can be considered as comprehensive assessment for evaluating pedestrian paths provisions and prioritise possible maintenance, renewal, and regeneration interventions, rooting on detailed in-field inspections of pedestrian paths and crossings.

The reminder of the paper is organised as follows. Section 2 describe the literature and the research framework in which the paper roots. Section 3 focuses on the materials and methods adopted to conduct the assessment, starting from data collection based on in-filed inspections of pedestrian paths and the construction of a GIS-based model (3.1); then describing the variables considered in the study (3.2) and the walkability index calculation (3.3). Section 4 presents the case study of the historical centre of Parma. Section 5 presents the results and the assessment maps obtained, providing a discussion. Finally, section 6 will conclude by presenting future research steps.

2 The theoretical framework on walkability and pedestrian friendly environments

The research on how to create pedestrian friendly environments, to improve walkability, and to proper design pedestrian paths is nowadays still dense and articulated [3-12], providing also focuses on specific aspects of the pedestrian movement, like road safety [13, 14]; accessibility to urban functions [15, 16]; universal design or pedestrian accessibility for specific vulnerable users group [17-20] and urban planning legal tools to support this form of sustainable mobility [21, 22].

In this respect, the Pedestrian Environment Review System (PERS) developed by TRL (Transport Research Laboratory) [23] constitutes a walkability audit tool to assess the level of service and quality provided for pedestrians across a range of pedestrian environments.

In addition, in the literature there are many walkability indices and measures, generally based on urban form features like density, land use mix and street connectivity, used to describe the overall walkability level of a city, or of a given area [24, 25]. Those indices are mainly based on evaluations made through GIS-based applications and geoprocessing tools that process different datasets allowing to measure and assess the spatial walkability conditions.

Starting from this theoretical framework, the proposed methodology bases on in-field inspections that allow a very detailed and punctual approach to comprehensively assess the existing pedestrian network infrastructure within historical centres.

3 Materials and Method

3.1 GIS-based model

In the proposed study, the walkability of pedestrian paths has been assessed using a Territorial Information System created by implementing and enriching a model previously adopted for other studies carried out at the University of Parma [26]. This model provided for a survey methodology and a detailed filing and mapping of pedestrian paths and crossings in a GIS environment.

The GIS database has been built on a vector basis as a network data structure (link-node graph) and allowed the analysis of the existing pedestrian network system.

All the selected pedestrian paths available in the public space, sidewalks and pedestrian crossings have been mapped in the database, associating each link with a series of qualitative and quantitative attributes.

The processing of these data has resulted, firstly, in a series of thematic maps that identify the main critical issues related to the degree of walkability of each link and crossing, secondly, in the calculation of a walkability index, detecting whether the pedestrian network is able to meet the needs of all users, even the most vulnerable ones.

3.2 Selected attributes for evaluating walkability

To perform a comprehensive assessment of the walkability associated with the analysed pedestrian paths, a selection of qualitative and quantitative attributes has been made referring to the literature analysis and the territorial context. In fact, in addition to attributes strictly related to the road infrastructure, which can affect the operational performance of the path and pedestrian safety, in consideration of the analysed context represented by a historical centre, attributes related to comfort and attention to users with special needs have also been included.

From an operational point of view, the attributes to be measured have been identified both for the links in which the route is divided and for the pedestrian crossings. Furthermore, it is important to highlight that an in-depth analysis has been carried out, distinguishing the values assumed by these parameters for both directions, that is, for each side of the road.

Table 1 summarises the selected attributes to perform the walkability assessment: those underlined have been detected both for links and for pedestrian crossings.

Table 1. Selected attributes

Attribute	Qualitative assessment	Quantitative assessment
A_1 - Sidewalk width	<90cm; 90cm-150cm; >150cm	-1; 1; 2
A_2 - Change of levels	Access with steps; with ramps; None	-1; 1; 2
A_3 - Bottlenecks	Present; Absent	-1; 1
A_4 - Coloured ground signs	Absent; Present	-1; 1
A_5 - Protection level	None; Low; Medium- High	-1; 1; 2
A_6 - Presence of seats	Absent; Present	-1; 1
A_7 - Maintenance level	Poor; Good; Excellent	-1; 1; 2
A_8 - Presence of tactile flooring	Absent; Present	-1; 1

3.3 Index calculation

Following the detailed in-field survey, in addition to a specific evaluation of each individual attribute, in order to have a comprehensive assessment of the analysed area, global indices have been calculated, both for links and pedestrian crossings. The formulation of the indicators considers, in an aggregate way, all the attributes, and the calculation is shown by the following equations (Equation 1 and Equation 2):

$$I_{link} = A_1 * \left(1 + \frac{\sum_1^n A_n}{12}\right) \quad (1)$$

$$I_{crossing} = A_2 * \left(1 + \frac{\sum_1^n A_n}{8}\right) \quad (2)$$

where *n* indicates the number of considered attributes and the denominator of the fraction corresponds to the sum obtained considering the maximum values assumed by these attributes.

Afterward to the link calculation and crossing calculation indices, to realise their graphic representation through a chromatic scale map, a normalisation of these indices has been performed.

The normalisation consisted in calculating the ratio between the two absolute values respectively obtained as (i) the difference between the index value and the minimum value and (ii) the difference between the maximum value and the minimum value of the index.

4 Case study

4.1 Territorial framework

The proposed analytic method has then been applied to the case of Parma's historic centre. Parma is a medium-sized city, with a population constantly growing of about 198.200 inhabitants. About 24,500 reside in the historic centre, which has an extension of 272 hectares and a population density of about 90 inhabitants per hectare.

In the historic city there are functions with the highest rank, a wide range of cultural, commercial, and institutional services that project the entire city on a national and international scale. The historic centre has a strongly characterising plural nature. It is crossed in an east-west direction by the historical route Via Emilia and it is organised in two districts, *Parma Centro* and *Oltretorrente*, separated on the north-south axis by a stream with its wide natural green corridor. The historical urban fabric hosts monumental buildings with a strong identity and a wide range of cultural heritage, museums and theatres. Noteworthy is the Ducal Park, an extensive historical open space surrounded by cultural functions, schools and research institutions, covering a large portion of the district *Oltretorrente*.

A valid premise for the analysis of the pedestrian infrastructure accessibility requirements is the consistent presence of the elderly which, on average, constitute the 20% of the population residing in the historic centre, with peaks of over 30% in many urban sectors. Moreover, the city has been nominated "Capital of Culture 2020+21", and it is assumed that over the next few years, regardless of the health emergency, the influx of people in the city, especially in the historic centre, may increase. Major urban events generally represent, for cities in which they take place, an opportunity of verification, redevelopment, and urban re-organisation. The city government, therefore, in addition to responding to the daily needs of its citizens, should be able to manage the increased flow of tourists, especially in the historic centre.

The enhancement of pedestrian mobility is one of the strategic issues for Parma city government, which is committed in collaboration with the University of Parma in identifying criteria, methods and guidelines for planning pedestrian accessibility for people with special needs or disabilities.

4.2 In-field survey campaign

The proposed methodology has been tested with an initial focus on the investigation of the main distribution axes that connect the main cultural sites within the historical city centre (*Oltretorrente* and *Parma Centro* neighbourhoods). The surveyed paths are the north-south axis connecting the train station - recently involved in a regeneration intervention (2015) - with the city centre, and the east-west axis corresponding to the path of the Via Emilia, a historic road which provides a connection with *Piazza del Duomo* (Fig. 1).

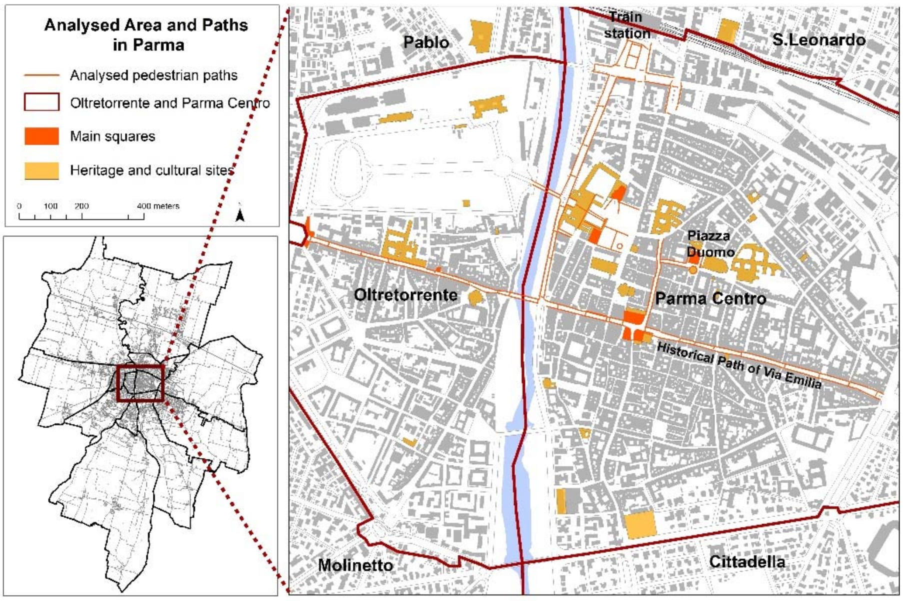

Fig. 1. In field surveyed pedestrian paths within the historic centre of Parma (*Oltretorrente* and *Parma Centro* neighbourhoods)

In order to build the cognitive framework for the application of the proposed methodology, in-field investigations have been carried out, involving direct survey operations and the filling of inspection sheets. The in-field survey campaign has been conducted in 2020.

The proposed inspection sheet, described in [27], is an essential tool for highlighting both the quantitative and qualitative features of each homogeneous link of a pedestrian path. The inspection sheet has been filled in for each pedestrian path section and for each pedestrian crossing along the analysed routes.

The outcomes have been georeferenced and returned into the GIS database, for the calculation of the walkability index. By querying the database, it has been possible to draw up thematic maps that identify the potentialities and criticalities of the analysed pedestrian infrastructure.

5 Results and discussion

5.1 Thematic maps representing individually indicators

The following figures (Figures 2 to 8) represent the detailed maps of the inspected indicators which have been used to calculate the walkability indices. The maps consider the pedestrian path width, the presence of changes in level (ramps and steps), bottlenecks, coloured ground signs, protection, seats and maintenance level of each analysed pedestrian path link.

Fig. 2 highlights that only few of the analysed pedestrian links have a critical width of less than 90 cm, while the majority are more than 150 cm large.

Fig. 3 shows where paths or crossing with changes in level are located. In a few sidewalks and in some crossings the presence of steps has been detected, although steps should be avoided to ensure a comprehensive accessibility for all the users. Anyway, the map highlights that most of the crossings have proper ramps and the majority of paths do not have level changes.

Fig. 4 shows the presence of some bottlenecks along the analysed paths, where the width presents narrowing points. Those bottlenecks are usually caused by street furniture, lamps, garbage bins, etc. and may represent critical points for the pedestrian flow.

Fig. 5 highlights an overall lack of coloured ground signs for the pedestrian paths, except for some links.

Fig. 6 shows the protection level provided to pedestrians with regard to the motorised traffic; the map highlights some paths and crossing where the protection level should be increased.

Fig. 7 shows that seats along the paths are rare and, in fact, many sidewalks are not equipped with seats.

Fig. 8 highlights an overall excellent or good maintenance level of the pedestrian infrastructure, except for some critical points.

Finally, fig. 9 shows that there are few links and crossings where tactile flooring is available for visually impaired pedestrians.

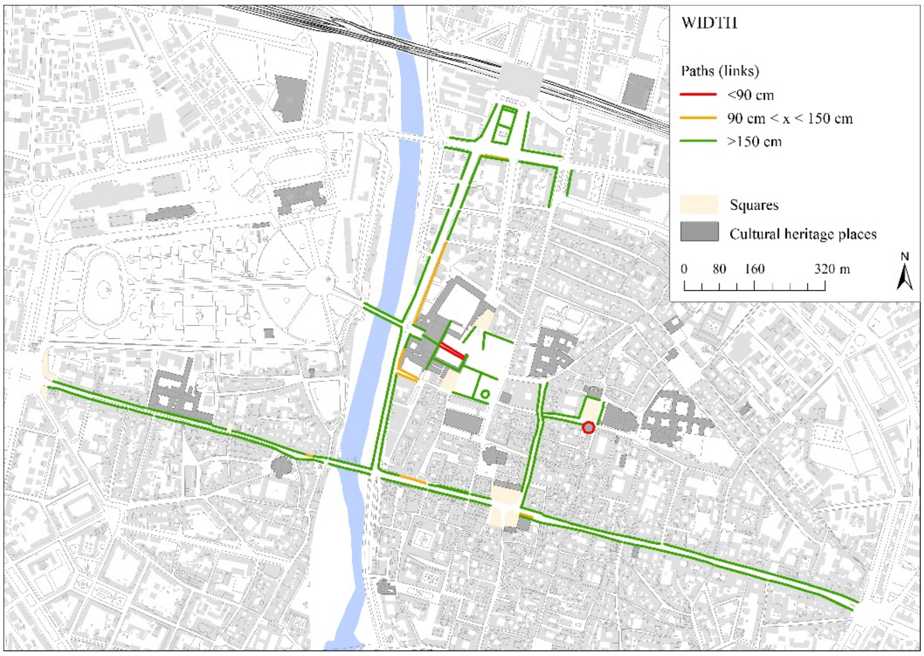

Fig. 2. Width

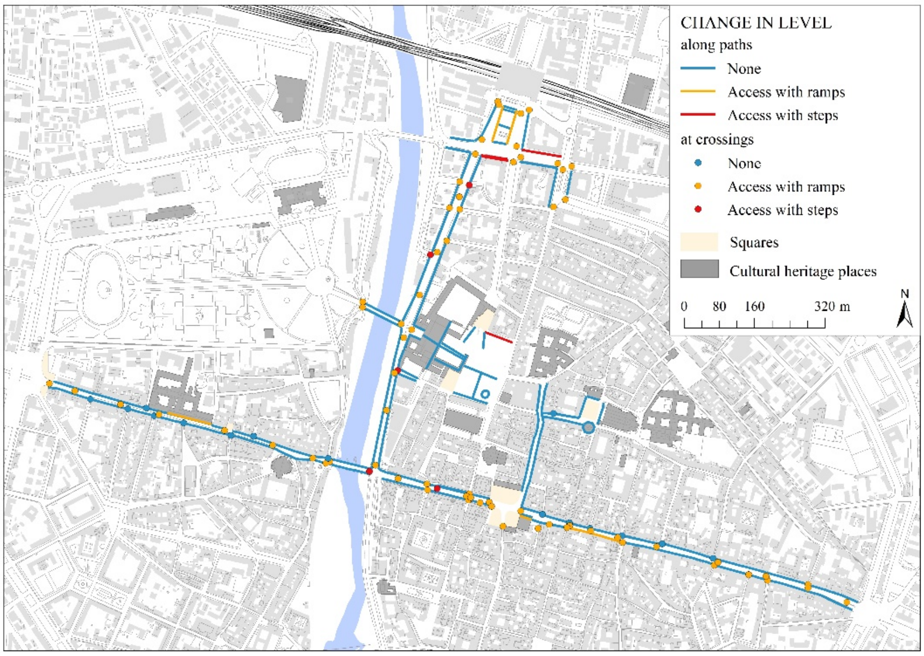

Fig. 3. Change in level

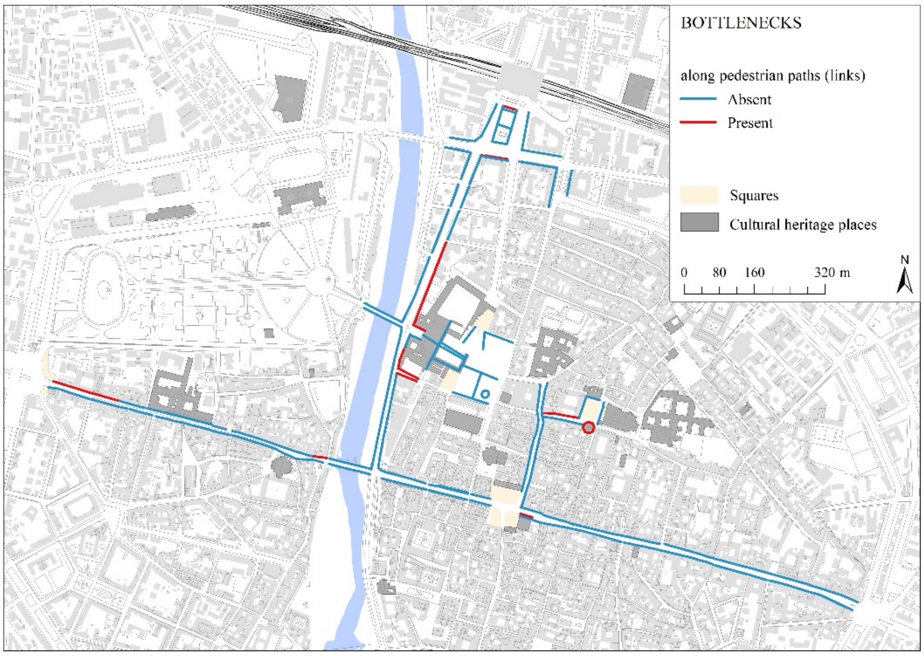

Fig. 4. Bottlenecks

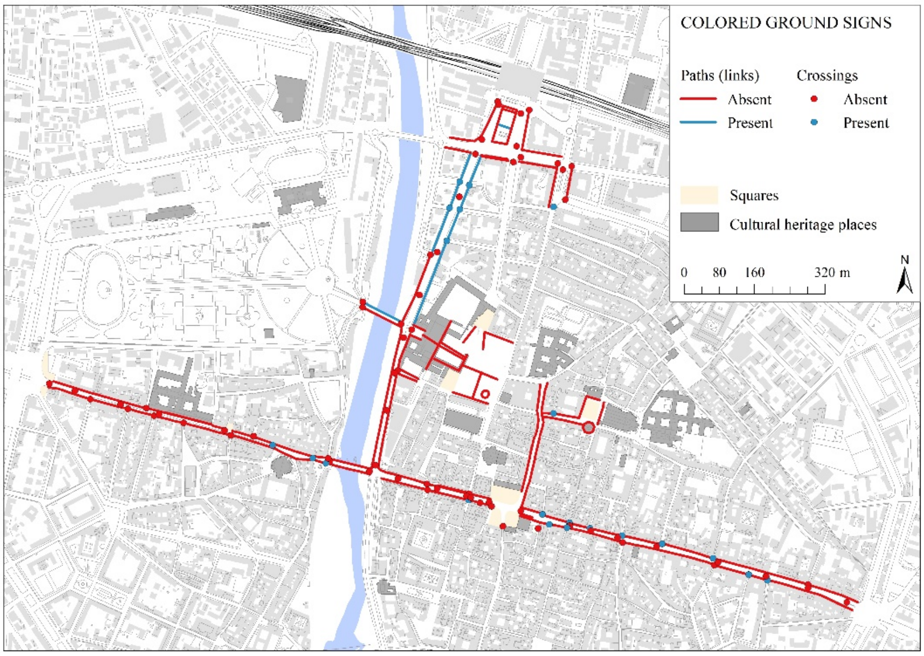

Fig. 5. Coloured ground signs

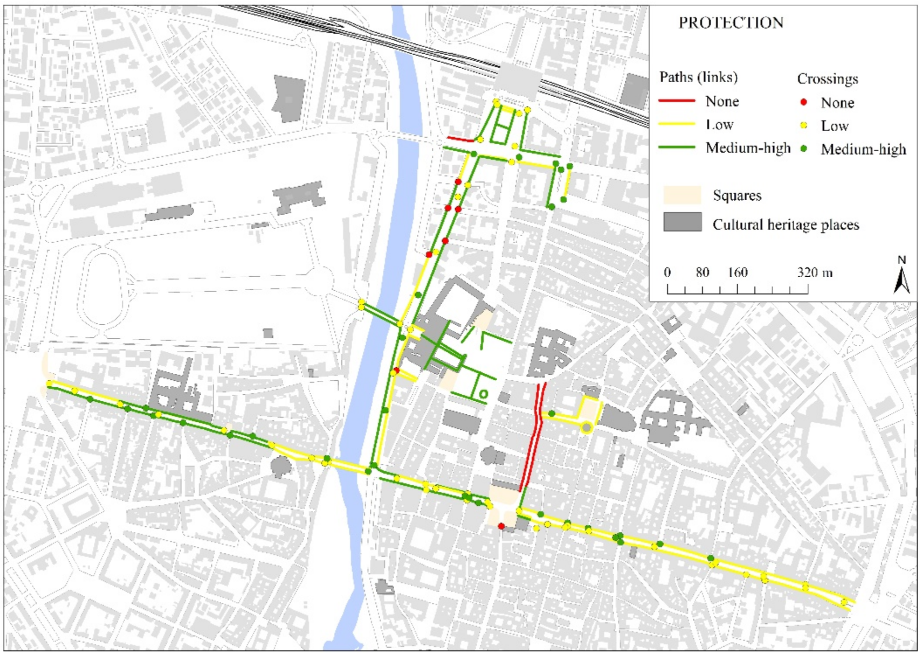

Fig. 6. Protections

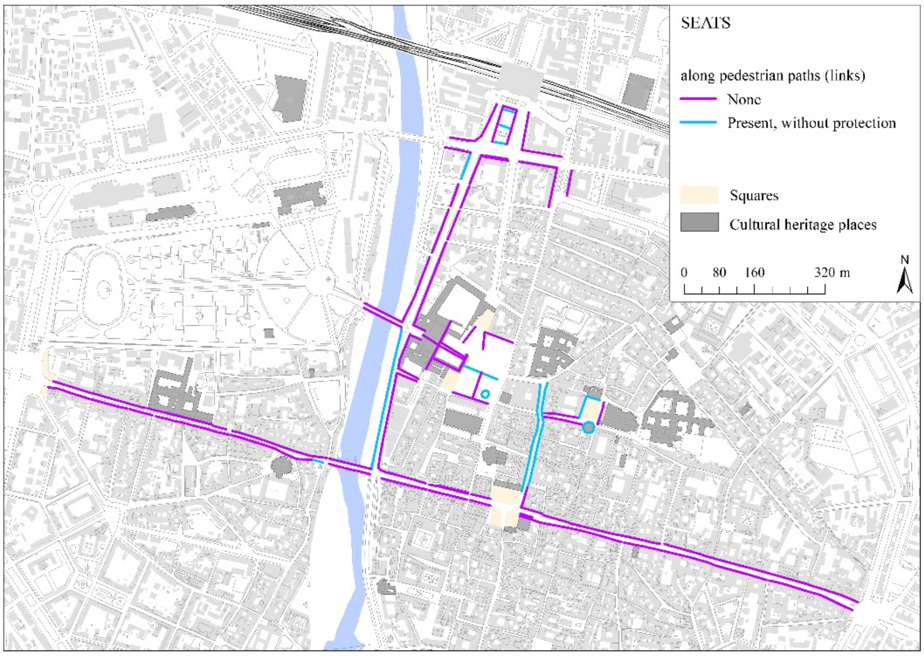

Fig. 7. Seats

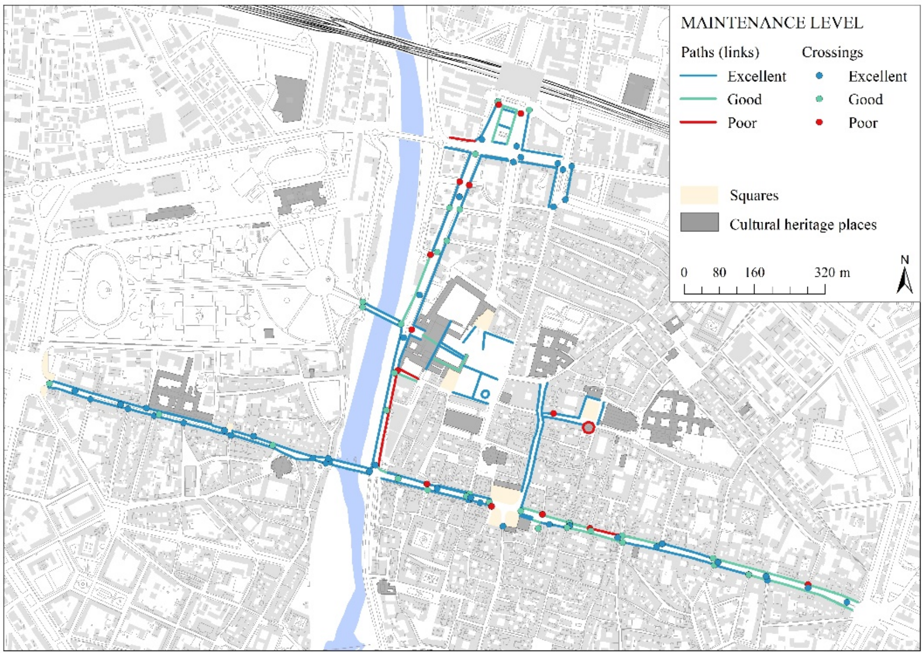

Fig. 8. Maintenance level

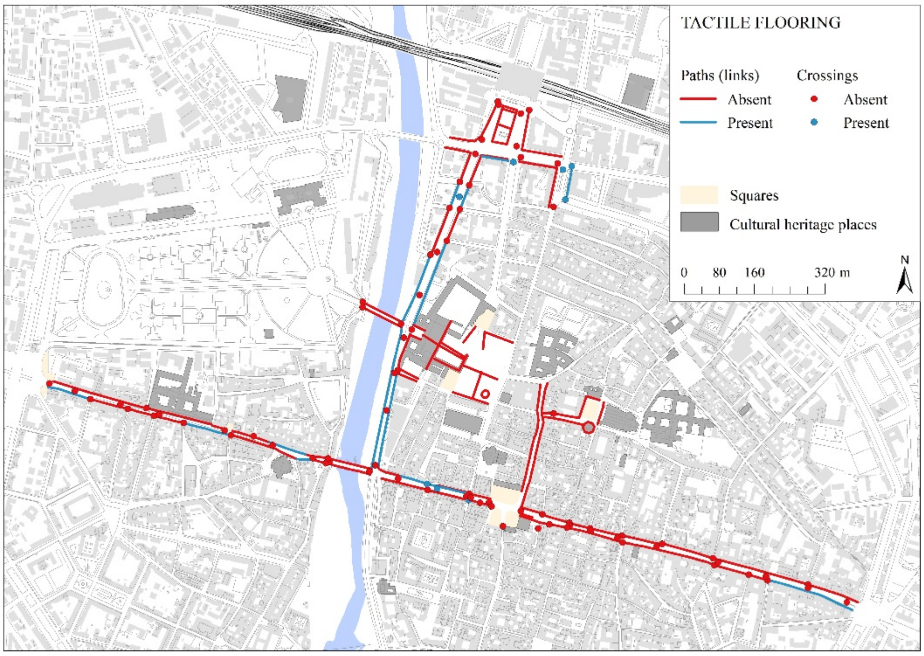

Fig. 9. Presence of tactile flooring

5.2 Global index

Finally, the considered parameters were merged to calculate the walkability index, as explained in paragraph 3.3. The results are mapped in fig. 10 that shows the assessment index for each analysed link and crossing belonging to the pedestrian paths.

It is noticeable that the obtained analytical results showed a close correspondence of the index to the real physical configuration of the paths.

Links with a very low walkability index along Viale Bottego, in front of the station, are characterised by the absence of the sidewalk. In this case, the transit of pedestrians takes place in the maneuvering area of parking areas.

Similarly, the links with a low walkability along Viale Toschi near the Pilotta, have a sidewalk with an insufficient width. The path is often mixed pedestrian-cycle and the presence of very crowded bus stops significantly restricts the passage.

In addition, many pedestrian crossings have a low or very low index due to the absence of adequate road markings and colour signs, the poor state of maintenance or the low/absent level of protection, i.e. they are not raised or are characterised by poor visibility and lack of life-saving islands.

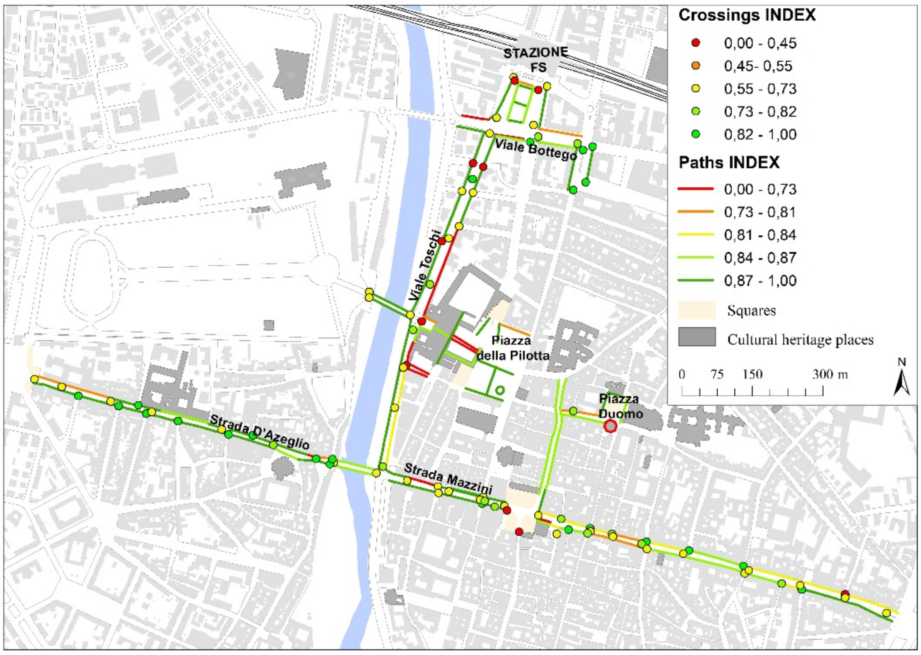

Fig. 10. Global index

However, apparent inconsistencies may also be highlighted. The index value of some links is low despite they are mainly in pedestrian areas e.g., in *Piazza Duomo*. The square is characterised by a paving made of cobblestones or "*san pietrini*" which make the transit difficult especially for weak road users. Therefore, only the sidewalks along the edges of the square have been detected, considering them the only paths potentially accessible to all. However, these sidewalks often have an insufficient width (i.e. definitely less than 90 cm) often aggravated by the presence of fixed obstacles that hinder the passage. For these reasons, what is shown by the indices is once again consistent.

Similarly in the case of *Piazza della Pilotta*, due to the cobbled paving, only the sections with a stone slabs paving have been detected (Fig. 11).

Fig. 11. The stone slabs pedestrian sections considered in Piazza della Pilotta

6 Conclusions and further research

The renewal of historic centres, intended as an improvement in accessibility and safety for the weakest and most vulnerable road users, can play a fundamental role in the development of cultural itineraries.

The performed analysis can provide the Public Administration with a useful tool for assessing the walkability of pedestrian mobility in the historical centre. The proposed methodology, initially applied only to the main road axes (e.g. to evaluate accessibility on the occasion of major cultural events), can then also be applied in the management practice, extending the survey to the entire historical centre. In this way, the proposed model can provide a complete cognitive framework of the pedestrian network, highlighting the criticalities, and suggesting possible solutions.

The processing of a complete walkability map, in fact, can provide support for the decision-makers in selecting the relevant urban policies and related planning, ordering the implementation phases, and defining the priority interventions. Furthermore, the availability of a representation characterised by specific and detailed information on the walkability of pedestrian paths would allow local administrations to identify which areas need interventions to ensure accessibility for all users, thus implementing localised improvement interventions and avoiding the insertion of invasive solutions.

Among the identifiable criticalities of the presented analysis model, it is possible to highlight the onerousness associated with the in-field survey of all the analysed paths as well as the need for periodic updating of the data to ensure its effectiveness. For these updating and monitoring activities, it could be very useful to provide forms of community involvement (e.g., crowdsourcing methodologies for data collection), in order to highlight the main criticalities of public spaces, also related to the different types of disabilities or needs. A perceptive rating approach could also be developed, including utility-based information, such as the presence of amenities or commercial activities capable of enhancing the route attractiveness. Also, surveys among a sample of pedestrian paths users could be carried out, and then correlated with the aggregate walkability index.

Furthermore, as the visual inspections conducted are subjected to bias, more accurate measuring methods could be preferred, perhaps having them performed by more than one person to allow a more precise auditing procedure.

The GIS based database containing all the information collected during the on-site inspections may be enriched including measured or foreseeable pedestrian flows, to assess the Level of Service and capacity of each pedestrian connection. Geo-tagged photos of the analysed paths and of the main criticalities observed may also be added in the informative layers, as well as maintenance planning information.

Further improvements of the applied index may also consider among the indicators:

- the presence of pedestrian areas restricted to traffic, that allow a wider use of the public space for pedestrians, not strictly limited to sidewalks;
- the paving materials of each link, to assess the limits it imposes on the transit of certain types of road users.

The proposed methodological approach could be useful in the drafting and implementation of the Sustainable Urban Mobility Plans (SUMPs) and the Urban Furniture Plans. About the last one, it is also necessary to identify the presence or absence of street furniture along the pedestrian paths and whether it constitute a risk or impediment for the correct use of the public space by citizens.

Finally, the model developed could also be used as a support for the drafting of the Plans for the Elimination of Architectural Barriers (PEBA), in the different steps of urban analysis, classification of walkability and accessibility levels and identification of architectural barriers. Therefore, future research developments will foresee the extension of the study to the entire historical centre and the inclusion of other indicators within the calculation of the global index.

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