

# How to assess urban quality: a spatial multicriteria decision analysis approach

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*keywords:* urban quality, spatial analysis, MCDA,  
decision-making process, hedonic price

## Abstract

*From the early 1990s the quality of public space is at the centre of the Agenda of major European cities. Today, more than before, the health emergency due to the Covid-19 pandemic has pointed out the importance of the relationship among public space, quality of life and health. Public and semi-private spaces, especially in high-dense cities and in the most affected areas by Covid-19, represent a strong driver both for restarting and for helping cities to face the new normal age.*

*Despite the advancement of research during the past two decades and empirical evidence about the relationship among quality of open spaces, quality of life and urban sustainability, there is still a lack of studies on how to measure the quality of open spaces. Among the several research lines, the Urban Design approach across its evolution has always focused on it, starting from aesthetic as well as technical issues and increasingly including the social and economic ones. The current paper proposes an integrated approach supported by Geographic Information System (GIS) and Multi-Criteria Decision Analysis (MCDA) able to provide a comprehensive evaluation of the quality of*

*open spaces under the Urban Design perspective. In detail, the issue of urban quality has been divided into 5 criteria and 12 sub-criteria which consider both the characteristics of the built environment and its organization and the perception of users. The evaluation process has been structured according to the traditional steps – Intelligence, Design and Choice – and it has been applied to three different areas in the city of Milan, in order to achieve a broad measurement of urban quality with respect to various urban locations. What's new in this research is the spatialization of the urban quality scores and their assessment based on specific value functions, that shows potentials for future implementations in the sphere of urban planning, where the proposed evaluation approach could be applied with different purposes: an evaluation model for supporting public and private planning agreements by the use of value maps; a companion guide with operational recommendations for open spaces design; a model to estimate the marginal price of the urban quality through hedonic price analyses.*

## 1. INTRODUCTION

The quality of public space is now at the centre of the agenda of major European cities. From the late 1980s and early 1990s, cities have started to be considered as the most suitable scale for a transition to the social health model recommended by the WHO, for achieving the sustainability objectives launched by the Aalborg Charter, and, more in general, for actively promoting high-standard quality of life and well-being. The interrelation among public space, quality of life and health become even more important in the context of the health emergency of Covid-19 pandemic, which is forcing us to rethink how we live in our cities (Capolongo et al., 2020; 2016). Density and compactness are two of the most controversial topics in urban planning decisions related to the pandemic waves (Hamidi et al., 2020) showing that the spread of the virus also depends on the shape and the density of urban areas. Public spaces (squares, streets, open spaces, gardens, urban parks) and semi-private spaces (courtyards, rooftops, residential blocks common areas), especially in high-dense cities and in the most affected areas by Covid-19, represent a strong driver both for restarting and for helping cities to face the new normal age (OECD, 2020).

Given these premises, even if it has been recognised a huge importance to the quality of open spaces (Gehl, 1987; Jacobs, 1961; Lynch, 1960) and underlined its correlation with the quality of life and the urban sustainability (Ewing & Handy, 2009; Speck, 2013; Talen, 2002), there are no studies aimed at measuring it and able to define a common and shared methodology.

The aim of the current research is to assess the quality of public open spaces by providing a comprehensive evaluation approach under the Urban Design perspective supported by Geographic Information System (GIS) and Multi-Criteria Decision Analysis (MCDA). Within this context, the paper proposes an integration of socio-economic, environmental and aesthetic values for evaluating and designing public spaces according to the Urban Design research line (Oppio et al., 2016; 2018) and its recent evolution. The focus is on the active role the urban design plays for combining all the sustainable dimensions within urban development, being the cities considered as a whole and not as the aggregation of elements (Dias et al., 2014; Urban Design Group, 2011). Starting from the literature review on the main Urban Design research perspectives provided by Oppio et al. (2018a), the urban quality can be defined as a complex issue which encompasses both tangible and intangible aspects. Despite the multiple definitions of urban quality emerging from urban design studies, there is a clear convergence on the relationship between the built environment and the social dimension (Lynch, 1960), on how it is influenced by spatial factors as the physical features and size of urban blocks, the connectivity, the compactness (Southworth, 2003) and at same time from the perception of people moving and living within the cities (Gehl, 2001; 2010).

Considering this perspective, the current research shows many potential practical sides: the value maps about the quality of open spaces may support Public Administrations within negotiations with private developers for setting the quality requirements of new open spaces design as well as of the existing ones' renewal; operational recommendations as companion guide for open space design and renewal could be defined according to the results emerging by value maps; a model to estimate the marginal price of the urban quality through hedonic price analyses. With respect to these multiple objectives, the paper is divided into 5 parts. After the Introduction (§1), the steps of the Methodological framework are described with a special attention to how the decision problem has been structured (§2) and then applied (§4) to the selected case study (§3). The Conclusions (§5) are focused on the main achievements as well as on the limits of the research.

## 2. METHODOLOGICAL FRAMEWORK

Since the quality of open spaces deals with several spatial elements, a Multiple Criteria Spatial Decision Support Systems (MC-SDSS) has been defined in order to combine spatial data, provided through Geographical Information Systems (GIS), and Decision Maker's (DMs) preferences into value maps (Malczewski, 2007; Malczewski and Rinner, 2015), which aid the DM to explore a decision problem and to choose the most suitable option. Within MC-SDSS models, the GIS is seen as a set of tools useful to collect, elaborate and visualise geographical data for decision problems, while the MCDA methods allow to structure decision problems and to improve the quality of the decision phases (Caprioli & Bottero, 2020; Dell'Ovo et al., 2018; 2020a; Oppio & Dell'Ovo, 2020).

With respect to the potentials previously pointed out, given the spatial nature of the problem and the multifaceted aspects to consider, a MC-SDSS model is proposed (fig. 1), divided into the most common phases of a decision-making process (Simon, 1972):

### Phase I - Intelligence

1. *Problem definition*: identification of the problem to be solved underlying its limits and boundaries by defining the set of objectives to be achieved. The objectives allow to frame a value tree structured by an appropriate set of criteria, able to consider the spatial dimension of the problem according to the decision context.
2. *Data acquisition*: when the value tree has been defined, data can be collected according to the nature of the criteria selected (vector or raster).
3. *Processing*: deals with the most suitable operations to be applied to data previously collected, i.e. distance; density; etc.

### Phase II - Design

4. *Standardization*: represents a mathematical representation of the human preferences (Keeney, 1992)

that allows to transform the unit of measurement of the selected criteria in comparable units. According to the software used and to the geo-operation applied to the original data, it is possible to assign a dimensionless score (0-1; 0-10) to different performances. The definition of value functions is a delicate phase in the whole process since, together with next phase, it strongly influences the final output (Beinat, 1997).

5. *Criteria weights elicitation*: weights are assigned to the criteria according to their power to influence the achievement of the overall aim. Different methods could be used and different stakeholders engaged according to the decision context.

**Phase III - Choice**

6. *Data overlay*: the standardized performances and the weights previously assigned are aggregated to results in a suitability map. The Weighted Linear Combination (WLC) has been chosen as aggregation procedure (Malczewski, 2000);

**Phase IV - Review**

7. *Results and Conclusions*: deals with the elaboration of the results obtained into value maps to be used as a support for addressing conscious decisions. Finally, it is strongly suggested to perform a sensitivity analysis to validate the outputs and check their robustness.

**3. CASE STUDY**

The study area selected to apply the model presented in the previous section is the city of Milan (Lombardy region, Italy). The Municipality has been divided in 2011 into 88 districts called Nuclei di Identità Locale (NIL, Centres of Local Identity), for a strategic operation to define the territory both from the social and from the administrative

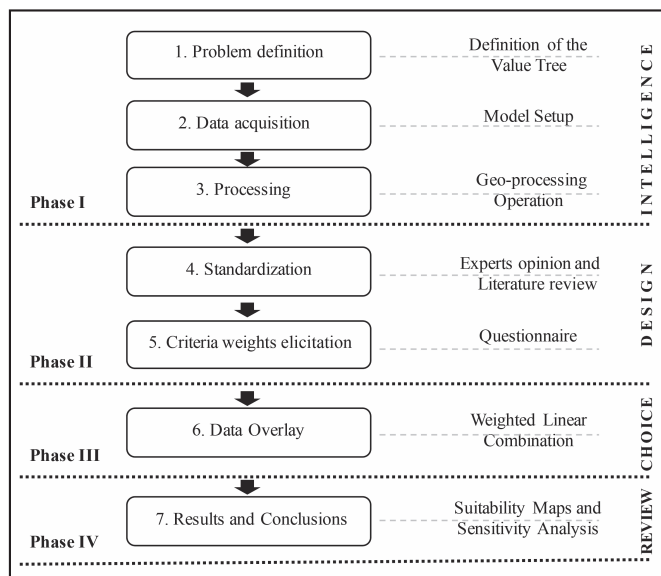


Figure 1 - Methodology Flowchart.

point of view. Moreover, the current Territorial Government Plan (Piano di Governo del Territorio, PGT2030) underlines the role of the NIL aimed at supporting the organization of community services to meet the new socio-economic needs of the population with a focus on foreigners, elderly people and commuters. Within this context three different NIL have been chosen (Fig. 2) given their spatial location within a common axis, starting from the historic heart of the city until the administrative boundaries by following the northeast direction.

This axis is particularly significant because, by analyzing the areas it crosses, it is possible to capture differences from the city center to suburban areas. In detail:

- Brera (NIL n. 2) can be defined as the artistic district of Milan which combines history, culture and architecture. Over the last few centuries, the neighborhood has become increasingly populated, thanks mainly to the presence of the Academy of Fine Arts that has attracted artists from all over the world. Brera is one of the main touristic attraction in the city and is characterized by narrow streets, low level of traffic, good public accessibility and the presence of several services.
- Loreto – Casoretto - NoLo (NIL n. 20) is one of the most populous neighborhoods of Milan and due to the demographic development, which occurred mainly with the migration flows of the twenty-first century, is one of the most multiethnic area, characterized by high urban density and heavy traffic. Until a few years ago the area was known for its social problems and crime, but today is one of the main hubs, interested by urban renewal interventions that have made the area attractive for residential purposes, also given to the presence of numerous services and connections with the whole city. In the recent years Loreto is becoming increasingly populated by young people and artists, galleries, stores and co-working facilities that are giving a new image to the neighborhood.
- Adriano (NIL n. 17) is located on the administrative

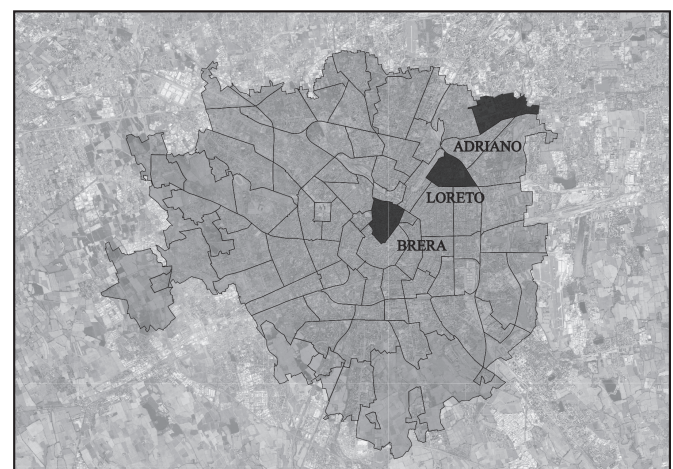


Figure 2 - The three neighborhoods under investigation.



boundary of the municipality and it has been developed on areas that previously hosted industrial plants. It is not characterized by a strong spatial identity, but the urban and social problems are gradually disappearing thanks to a greater attention from the City of Milan for the sub-urban areas. Currently, the district is recognizable by high residential buildings, numerous green areas, some new services and public transport lines that have improved the connection with the rest of the city.

#### 4.1. Intelligence Phase

With respect to the objective of the research together with the analysis of the literature and the investigation of existing rating tools on this topic already described by Oppio et al. (2018a), the decision problem has been structured into five main criteria, further divided into twelve sub-criteria and measured by specific indicators. The evaluation framework allows to consider different dimensions of the open spaces' quality underlining its spatial nature, as it is below described:

1. Physical settings considers how different elements can shape and design the built environment and it is better described by the sub-criteria 1.1 Permeability able to measure the internal flows; 1.2 Environmental Comfort to define the level of interaction of people with the urban environment, 1.3 Sustainability to preserve and implement the natural environment;
2. Connectivity considers how the context under analysis is reachable from other areas of the city, by the sub-criterion 2.1 Walkability, which analyses the pedestrian accessibility, and the sub-criterion 2.2 Access and links

focused on different kind of interchanges nodes and accesses;

3. Vitality measures the social aspects of the neighborhood and in particular the presence of associations and events (3.1 Active community) and how the district is vibrant during the whole day (3.2 Functional mix);
4. Meaning involves again a social and perceptive dimension connected to the memory focusing on 4.1 Sense of place, which considers the degree of flexibility and adaptability of the neighborhood and 4.2 Landmarks the presence of tangible or intangible values;
5. Protection is linked to the level of safety of the place and to the perception of the users, since 5.1 Noise evaluates the presence of negative elements and 5.2 Risk perception the degree of maintenance.

As already mentioned, these sub-criteria have been further measured by indicators, each requiring specific data that have been collected, mainly by the use of the GIS data developed by the Municipality of Milano and by other sources such as direct observation, Open Street Map and Google Maps. Table 1 shows a synthesis of the overall value tree with the source of the information and the different types of analysis developed. The work has been carried out with the support of the software ArcGIS and with the Spatial Analyst tool that allows to perform the MC-SDSS.

#### 4.2. Design Phase

The standardization procedure and the criteria weight elicitations have been carried out with the support of

Table 1 - Value tree

CRITERIA	SUB-CRITERIA	DESCRIPTION	SCALE	SOURCE DATA	ANALYSIS
1. Physical setting	1.1 Permeability	Urban blocks Crossing Bike paths Elevated/ underground path	1:5.000	Google maps, Open Street Map and Observation	Creation of shape file and Euclidean distance
	1.2 Environmental comfort	Seating availability Tree rows Lighting	1:2.000	Municipality of Milan, Google maps, Open Street Map and Observation	Creation of shape file and Euclidean distance
	1.3 Sustainability	Low emission buildings Trees and vegetation infill	1:1.000	CENED 2.0 and Municipality of Milan	Euclidean distance
2. Connectivity	2.1 Walkability	Pedestrian walkways and restricted traffic zones Pedestrian safety	1:1.000	AMAT - Agenzia Mobilità Ambientale Territorio and Municipality of Milan	Euclidean distance

Table follows 1 - Value tree

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CRITERIA	SUB-CRITERIA	DESCRIPTION	SCALE	SOURCE DATA	ANALYSIS
2. Connectivity	2.2 Access and links	Interchange nodes Number of entrances Street connectivity	1:1.000	Municipality of Milan, Google maps and Open Street Map	Creation of shape file and Euclidean distance
3. Vitality	3.1 Active Community	Neighbourhood association Events recurrence	1:1.000	Municipality of Milan and Observation	Creation of shape file and Euclidean distance
	3.2 Functional mix	24h services Street plurality	1:2.000	Municipality of Milan, Google maps and Open Street Map	Creation of shape file and Euclidean distance
4. Meaning	4.1 Sense of Place	Viewpoints Interesting facades	1:500	Google maps, Open Street Map and Observation	Creation of shape file and Euclidean distance
	4.2 Landmarks	Iconic buildings Links with the past	1:500	Google maps, Open Street Map and Observation	Creation of shape file and Euclidean distance
5. Protection	5.1 Noise	Vehicular traffic Tram lines	1:2.000	AMAT - Agenzia Mobilità Ambientale Territorio and Municipality of Milan	Euclidean distance
	5.2 Risk perception	Building maintenance Inactive fronts	1:500	Municipality of Milan and Observation	Creation of shape file and Euclidean distance

experts. In the first case ranges of acceptability have been defined through the creation of value functions, while in the second case a different influence on the criteria involved in the framework have been assessed. The interview with the experts aimed at designing the value functions has been carried out by the use of the Evalue techniques proposed by Demetriou et al. (2012). The abovementioned procedure is divided into four steps: 1. the selection of a range and type of curve; 2. the values assignment; 3. the revision of the curve; 4. the consistency control. During the process the expert is asked to draw a curve, assign a direction, associate values and review its decision about the curve generated which transform real performances in values between 0 and 10. In this research the most analyzed variable is the distance where usually lower is the distance and higher is the value associated. In order to give more consistency and robustness to this phase, for the generation of value functions in addition to the experts' opinion has been considered the literature previously reviewed (Oppio et al., 2018a) and how the rating tools have measured the same indicators (Rebecchi et al., 2019). Figure 3 shows an example of how different indicators have been analysed and the related information interpreted. In detail it is possible to appreciate how the value function has been designed and the process developed. For what concerns the criteria weight elicitation, a questionnaire has been submitted to 13

experts in different fields, with the aim of asking to weight the criteria selected for the value tree and by using the point allocation method. In detail it has been asked to allocate 100 points among the criteria and to consider the level of influence according to their opinion. Weights have been assigned only at the level of the criteria while for the sub-criteria a neutral scenario has been selected. The experts interviewed, with their skills and backgrounds, cover all the dimensions involved into the framework: Urban health; Planning; Urban economics; Project appraisal; Comfort and open spaces. Figure 4 shows the results disaggregated, with respect to the preferences of different categories of experts involved, while table 2 shows the weights aggregated.

Table 2 - Criteria weight elicitation

CRITERIA	WEIGHTS
1. Physical setting	23%
2. Connectivity	25%
3. Vitality	23%
4. Meaning	13%
5. Protection	16%

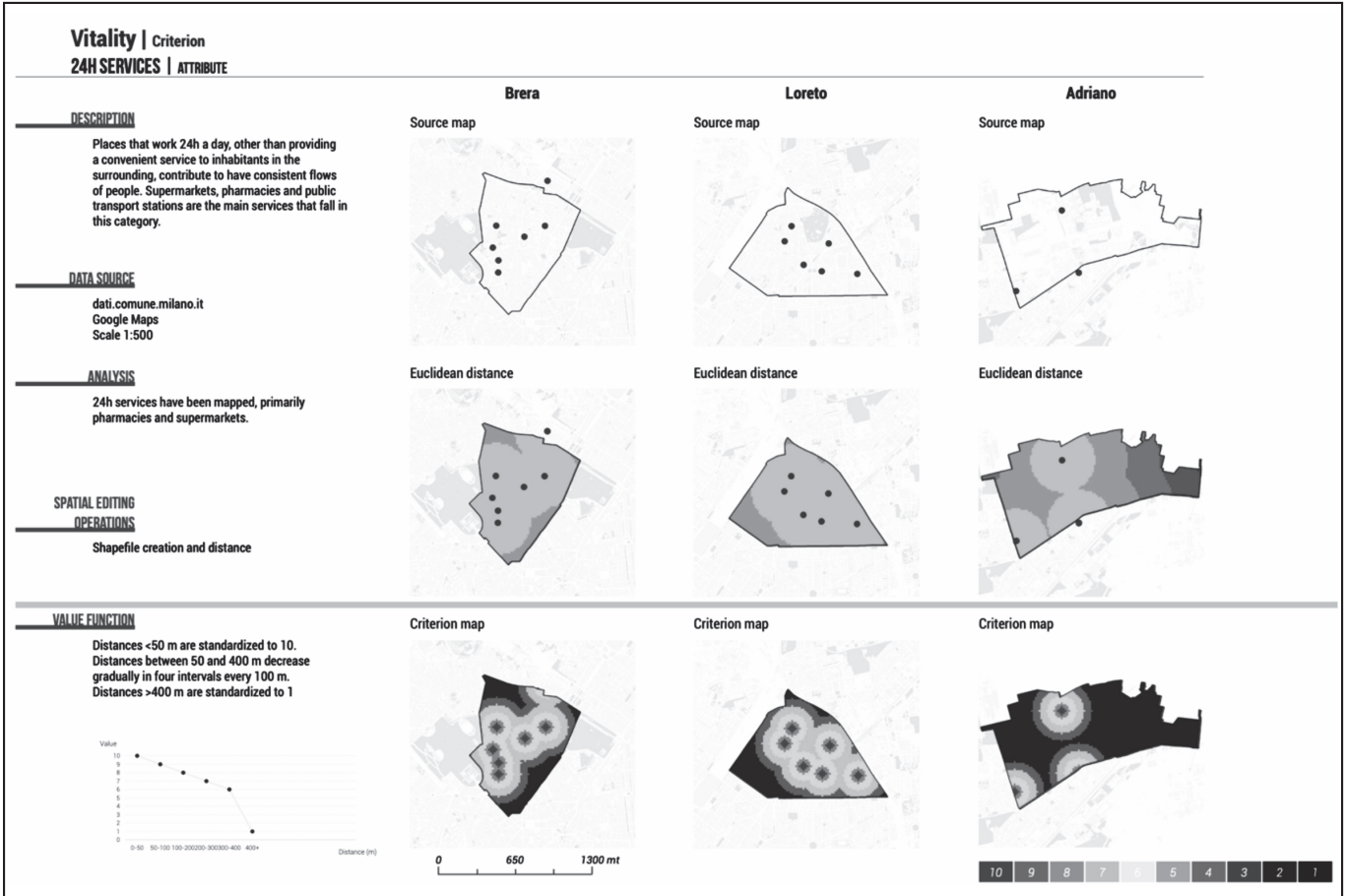


Figure 3 - Example of fact-sheet defined for each indicator.

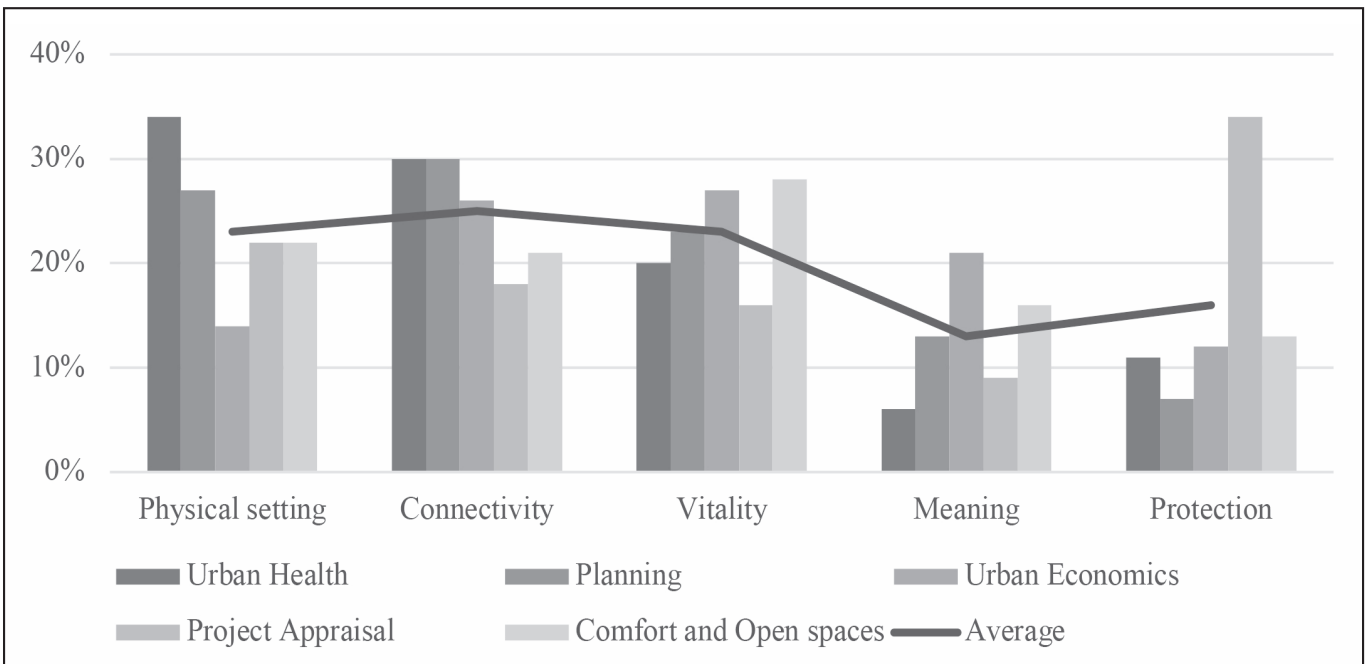


Figure 4 - Weights assigned by the categories of experts interviewed.

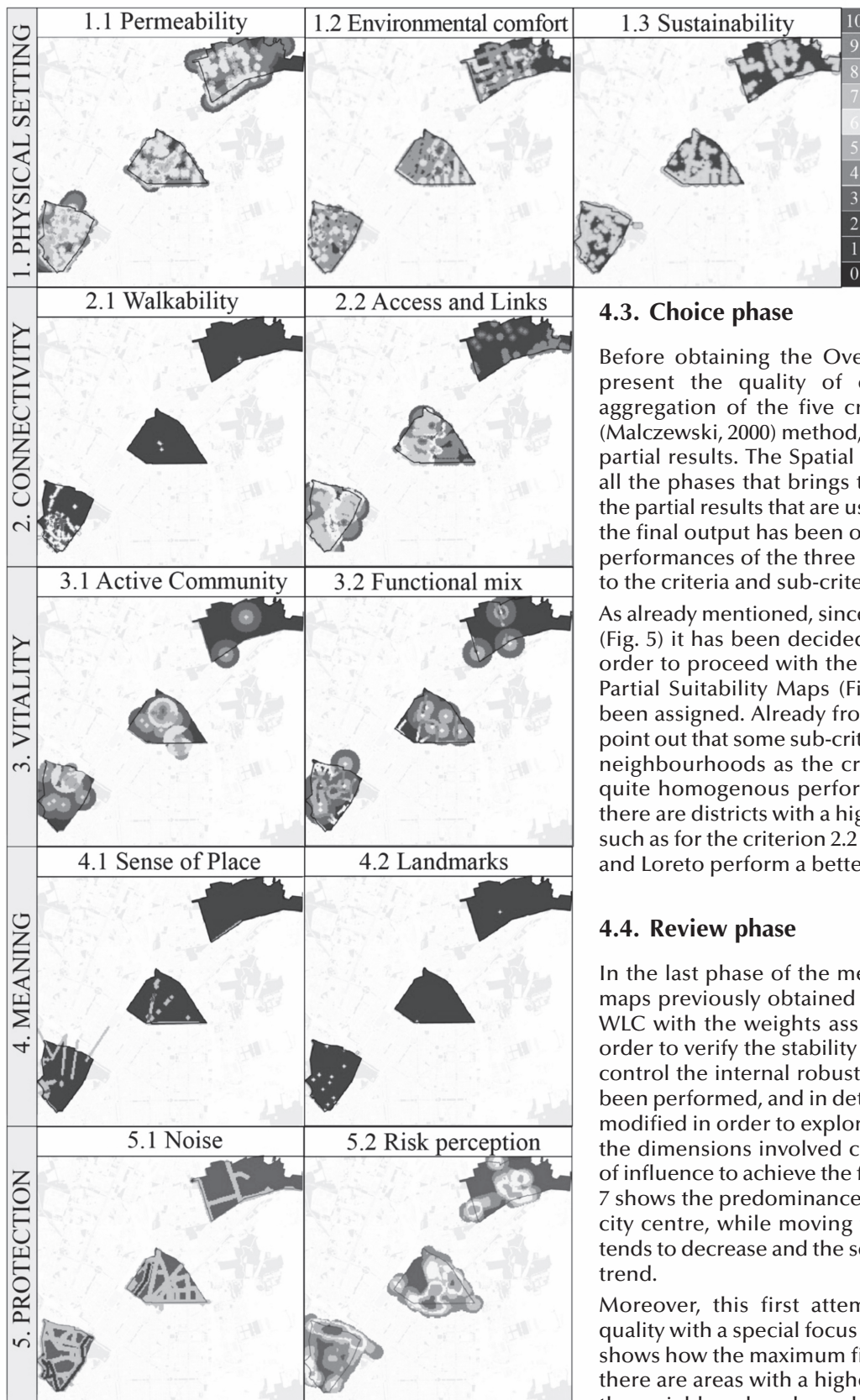


Figure 5 - Sub-criteria Suitability Maps.

It is possible to notice from figure 4 how as an average, the weights assigned from different experts are quite stable. Since the modal value, the median and the average values are very close, the average among the five categories has been considered as an adequate method to obtain a final weight (Tab. 2).

### 4.3. Choice phase

Before obtaining the Overall Suitability Maps able to present the quality of open spaces by the linear aggregation of the five criteria according to the WLC (Malczewski, 2000) method, it is important to interpret the partial results. The Spatial Analyst tool allows to control all the phases that brings to the final maps, by showing the partial results that are useful to better understand how the final output has been obtained and to investigate the performances of the three neighbourhoods with respect to the criteria and sub-criteria selected for the value tree.

As already mentioned, since at the level of the sub-criteria (Fig. 5) it has been decided to use a neutral scenario, in order to proceed with the aggregation and result in the Partial Suitability Maps (Fig. 6), the same weights have been assigned. Already from these maps it is possible to point out that some sub-criteria are critical for all the three neighbourhoods as the criterion 4.2 Landmarks, with a quite homogenous performances, while in other cases there are districts with a higher performance than others, such as for the criterion 2.2 Access and Links, where Brera and Loreto perform a better score than Adriano.

### 4.4. Review phase

In the last phase of the methodological framework, the maps previously obtained have been aggregated by the WLC with the weights assigned by experts (table 2). In order to verify the stability of the results obtained and to control the internal robustness, a sensitivity analysis has been performed, and in detail the set of weights has been modified in order to explore a neutral scenario, where all the dimensions involved contribute with the same level of influence to achieve the final aim. More in detail, Figure 7 shows the predominance of cells with high value in the city centre, while moving toward the suburb, the value tends to decrease and the sensitivity analysis confirms this trend.

Moreover, this first attempt of measuring the urban quality with a special focus on the quality of open spaces, shows how the maximum final value obtained is 7. Even if there are areas with a higher quality than others, in all of the neighbourhoods under analysis, criticalities to be solved have been detected. Figure 8 confirms this result,



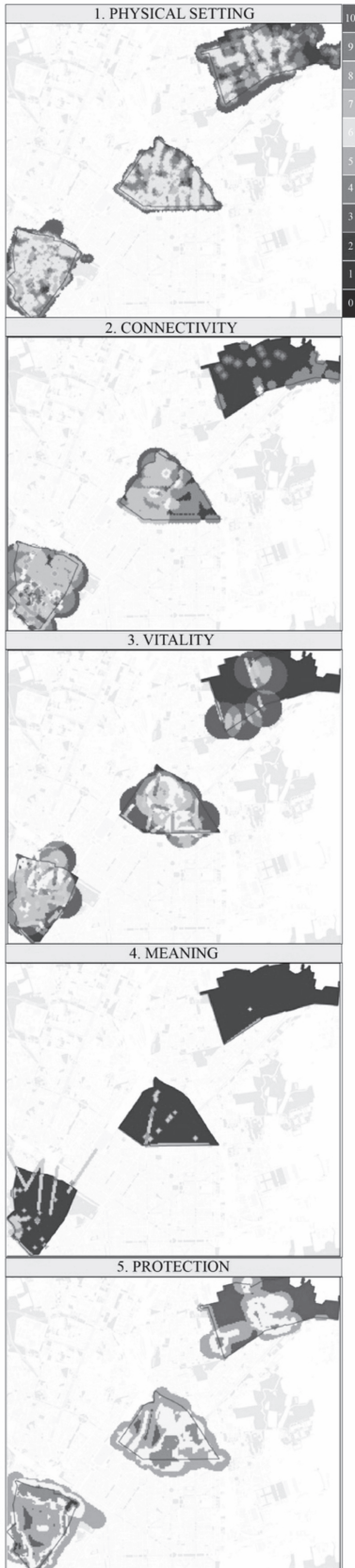


Figure 6 - Criteria Suitability Maps.

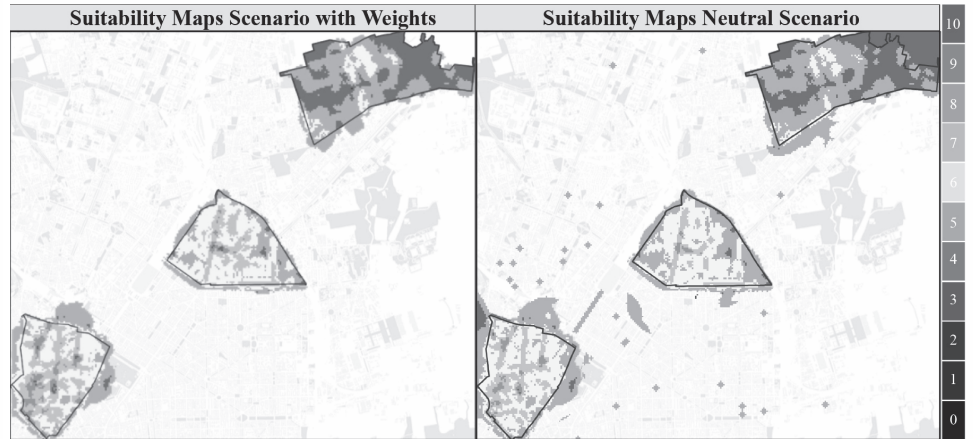


Figure 7 - Suitability Maps and Sensitivity Analysis.

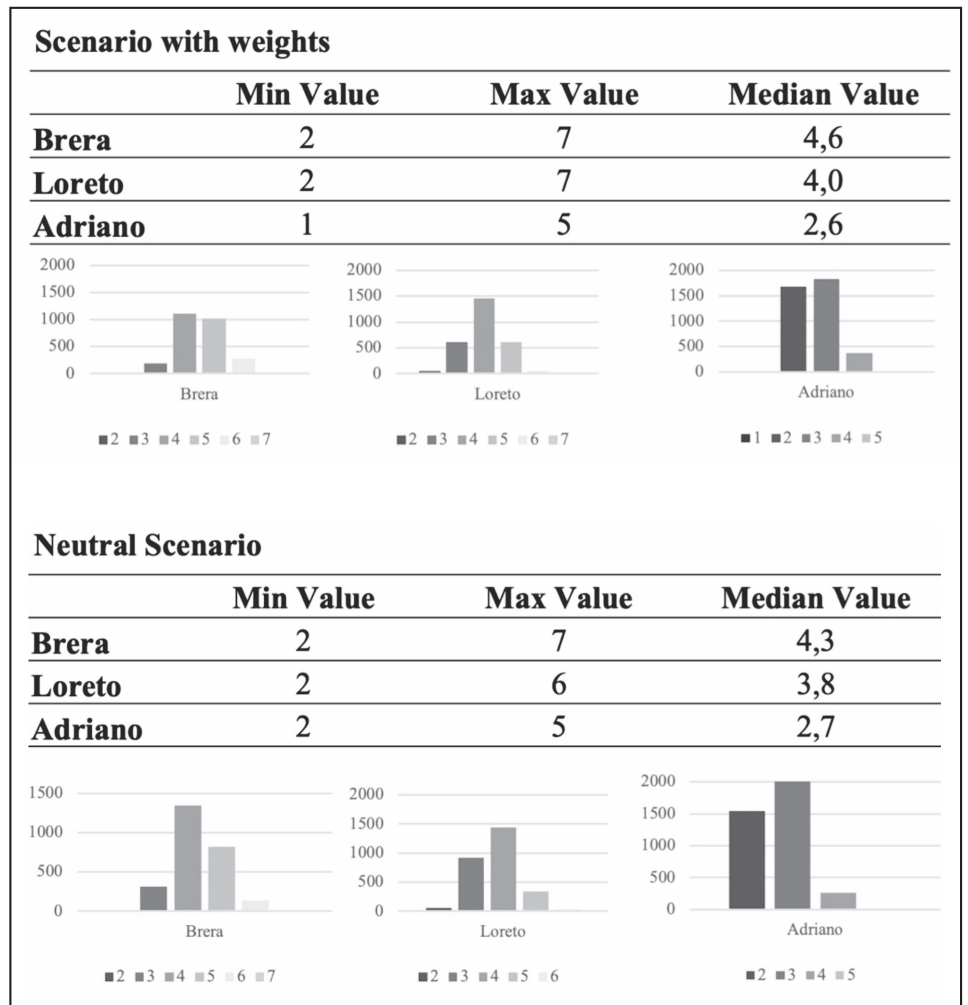


Figure 8 - Value obtained by cells in the proposed scenarios.



by underlying the minimum, the maximum and the median value obtained by each district. Results presented in the neutral scenario provides further evidence of the stability of the performances. Moreover, in order to test the robustness of the first results, the “What if” analysis could be implemented, in order to explore multiple perspectives according to the problem dimensions under investigation. The comparison among different scenarios increases the objectivity of the final choice and the transparency of the overall process and it also allows to control and consider the uncertainty inherent to complex problems (Simanaviciene & Ustinovichius, 2010; Dell’Ovo et al., 2020b).

### 5. CONCLUSIONS

The proposed multi-methodological framework for evaluating the quality of open spaces and its application to three different neighbourhoods in Milano represents a first attempt to provide arguments for both policies and design actions.

On the one side, the value maps provide exhaustive knowledge about the degree of urban quality, on the other, they can support the definition of value-driven urban policies. The clear identification of objectives can address the actions and give the opportunity to monitor achievements over time. Furthermore, on the design side, evaluation can help to highlight the market and/or extra-market values at stake and provide a measure of the differential of value generated by the interventions. When evaluation is embedded into the policy cycle, its potential as diachronic device to support incremental definition of actions increases (Oppio et al., 2018b).

Under this perspective, the value maps should be considered as a dynamic tool for *ex-ante*, *in itinere* and *ex-post* evaluation.

Further research advancements could be outlined with respect to two different instances. The first is the inclusion of the individual perceptions, in fact, in the current version of the evaluation model the value functions have been defined by experts. In addition to their opinion, it could be interesting to receive feedbacks from citizens to understand how they really perceive the quality of places (Torrieri et al.; 2021) and how they would like to implement them. The multidimensional and subjective nature of quality encourages to combine the analysis of the public spaces from a regulatory approach with a constructive one, attentive to the differences between individual attitudes and needs. The capability approach introduced by Sen (1999) and applied by Fancello & Tsoukias (2020) to the urban quality domain enhances to deepen this line of research.

A second instance is represented by the importance of making the monetary value of urban quality explicit (Oppio et al., 2020), in order to support the negotiations of Public Administrations with private developers by a measurement of the economic effects generated by urban transformations, especially in those areas that are characterized by low quality of public and private services (i.e. Adriano district). The economic evaluation of benefits, pursued by multi-methodological approaches able to include a broad spectrum of values, even individual, is essential for attracting and addressing investments towards the improvement of common goods such as open spaces.

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