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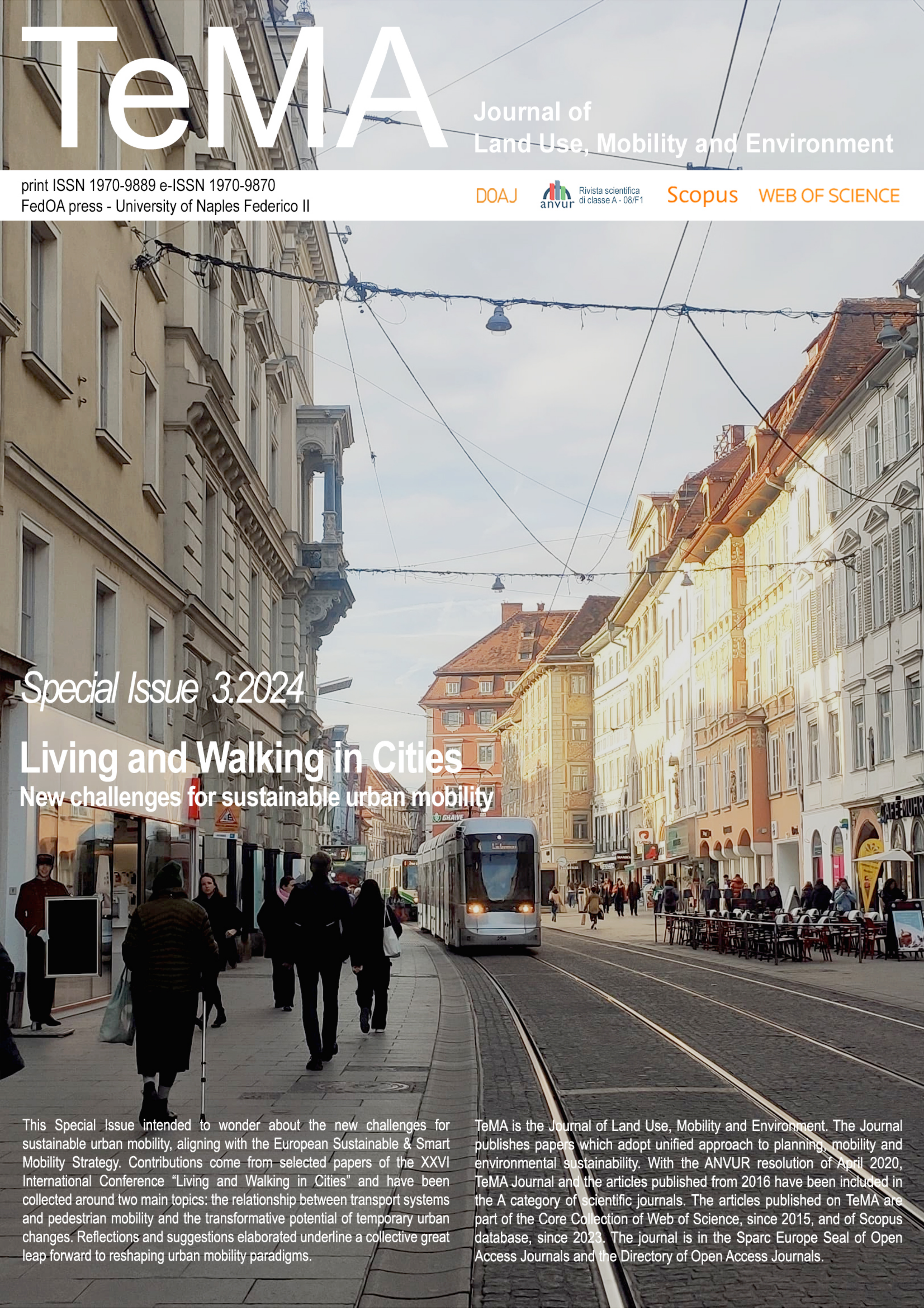

Special Issue 3.2024

Living and Walking in Cities

New challenges for sustainable urban mobility

This Special Issue intended to wonder about the new challenges for sustainable urban mobility, aligning with the European Sustainable & Smart Mobility Strategy. Contributions come from selected papers of the XXVI International Conference "Living and Walking in Cities" and have been collected around two main topics: the relationship between transport systems and pedestrian mobility and the transformative potential of temporary urban changes. Reflections and suggestions elaborated underline a collective great leap forward to reshaping urban mobility paradigms.

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Living and walking in cities: new challenges for sustainable urban mobility

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Editorial correspondence
Laboratory of Land Use Mobility and Environment
DICEA - Department of Civil, Building and Environmental Engineering
University of Naples "Federico II"
Piazzale Tecchio, 80
80125 Naples

web: www.serena.unina.it/index.php/tema
e-mail: redazione.tema@unina.it

Cover photo: Herrengasse street in Graz (Austria), baroque pedestrian avenue and centre of public life, provided by Michela Tiboni (June, 2024)

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Living and walking in cities: new challenges for sustainable urban mobility

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Assessment of urban green spaces proximity to develop the green infrastructure strategy. An Italian case study

Monica Pantaloni [a]*, Francesco Botticini [b], Giovanni Marinelli [c]

[a] Department of Materials, Environmental Sciences and Urban Planning SIMAU
Polytechnic University of Marche, Ancona, Italy
e-mail: m.pantaloni@staff.univpm.it
ORCID: https://orcid.org/0000-0003-3913-4615
* Corresponding author

[c] Department of Materials, Environmental Sciences and Urban Planning SIMAU
Polytechnic University of Marche, Ancona, Italy
e-mail: g.marinelli@staff.univpm.it
ORCID: https://orcid.org/0000-0003-3705-5251

[b] Department of Materials, Environmental Sciences and Urban Planning SIMAU
Polytechnic University of Marche, Ancona, Italy
e-mail: f.botticini@staff.univpm.it
ORCID: https://orcid.org/0000-0002-0580-4265

Abstract
To consolidate new models of sustainable growth based on the management of natural resources, the traditional spatial planning tools are being integrated with new approaches based on ecological and environmental "performance" which consider the provision of ecosystem services through the design of Green Infrastructure (GI), a possible way to improve the quality of life in the contemporary city. The paper describes a sectoral study developed on the public green spaces system at the city scale. The work is part of a research project aimed at developing strategic guidelines for Green Infrastructures at the local scale for the definition of the new Urban Green Plan of the Municipality of Falconara Marittima, located in the province of Ancona (center of Italy), selected as a case study. The study provides a method to estimate the proximity of urban green spaces based on the evaluation of their level of accessibility and usability, to maximize the provision of cultural ecosystem services in response to citizen needs. This contribution aims to help public administrations in evaluating the 'performance' of green spaces based on the ecosystem services approach to support urban and territorial planning and decision-making tools.

Keywords
Green infrastructure; Ecosystem services; Urban green spaces proximity.

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1. Introduction

To consolidate new models of sustainable growth based on the management of natural resources, the traditional spatial planning tools are being integrated with new approaches based on ecological and environmental "performance" (Auzins et al., 2014; Kendig, 1980) which consider the provision of ecosystem services through the design of Green Infrastructure (GI), a possible way to improve the quality of life in the contemporary city (Gómez-Baggethun et al., 2010; Ronchi et al., 2020).

Defined as "network of natural and seminatural areas with other environmental features that is supposed to deliver ecosystem services (ES)" (EU, 2013), GI is considered the most adequate tool aim at planning, design, and manage a framework of Urban Green Spaces (UGS) (Chatzimentor et al., 2020) at the city scale, which represent key elements for the conservation of biodiversity and landscapes (Casavecchia et al., 2020) and the provisioning of regulating ES (Gómez-Baggethun & Barton, 2013a; Gómez-Baggethun & Barton, 2013b), particularly relevant for their beneficial effects on physical and mental health (Tamosiunas et al., 2014).

In fact, some of the most significatively ecosystem functions (such as shading, evapotranspiration and wind shielding (Cortinovis & Geneletti, 2020)) performed by UGS can significatively contribute to improve cooling capacity of the urban ecosystems to contrast urban heat islands (Singh et al., 2020). Several studies also demonstrate that UGS plays a fundamental role in provision of cultural ecosystem services (CES) (Andersson et al., 2015; Carrus et al., 2013; Haines-Young & Potschin, 2018) such as recreational activities, sense of place, health, and aesthetical values (de Groot et al., 2012; Gómez-Baggethun & Barton, 2013b).

Since the social benefit deriving from ES depends on the proximity of UGS inside the cities, measured by their level of accessibility and usability (De Luca et al., 2021) it is essential to investigate a complete set of indices; not just the 'quantity' of UGS through the development of specific indicators and parameters (De La Barrera et al., 2016), but also the availability and the spatial distribution of UGS according to social milieu and specific demand, to be effective in propose planning policies.

Moreover, benefit deriving to ecosystem services provided by urban environment can improve public value. This aspect is supported by several studies that aim to quantify through monetization the benefits in terms of health linked to the presence of green areas in cities (EEA, 2022; Lee et al., 2015).

In this context, the research work evaluates the proximity (Maas et al., 2006) of UGS with high ecosystem values within the urban areas. The methodology was based on the assessment of the level of accessibility ad usability of UGS within the site-specific network systems and urban settlement barriers.

Specifically, analysis have been conducted in the municipality of Falconara Marittima (province of Ancona), located in Marche region (central part of Italy), where the Department of Materials, Environmental Sciences and Urban Planning of Marche Polytechnic University provide the scientific support to draw up the Green Masterplan. In this scenario, this sectoral instrument allows us to define a new vision for the future development of the green component of the city, supported by the Green and Blue Infrastructure concepts and applications (EU, 2013).

Here, to perform a geostatistical analysis of the distribution of public green areas and population served by them have been essential to support planning action aimed at guaranteeing an equal distribution of green spaces based on citizen's needs and supporting in the definition of the hierarchy of priority interventions for development GI policies and strategies.

The analytic process is multi-object, as it considers elements from different information databases, including the regional ecological networks (REM, *Rete Ecologica Marche*), the Regional Landscape Plan (PPAR*, Piano Paesistico Ambientale Regionale*) and the Provincial Territorial Plan (PTC, *Piano Territoriale di Coordinamento Porvinciale*), which constitute the main reference framework of the project; but also, multiscale. In fact, data was obtained both from the downscaling of ESA Copernicus program databases but also from municipality databases. Moreover, demographic analysis allows to define the target of residential population that can potentially benefit from the ecosystem services provided by the Urban Green Infrastructure (UGI).

Accessibility to UGS seen as the maximum distance to travel from the residence to a public green area is now considered a key parameter for measuring the quality of green infrastructures on a city scale (WHO, 2017), and for defining planning strategies aimed at overcoming disparities in accessing these resources, with a view to equity and justice (Rishbeth, 2010). To evaluate the proximity of UGS related to the population served would orient planning and management strategies to build the strategic vision of the green system within the land-use plan (Vignoli et al., 2021). Moreover, contributes to defining a qualitative criterion to guide the green infrastructures design and to improve the efficiency of land use and so the quality of the Land use plan (Auziņš & Viesturs, 2017; Botticini et al., 2022).

2. Material and Methods

2.1 General approach and data input

A multi-scale methodology has been developed as a support for the strategic design of green infrastructure. According to the principles of GI such as multifunctionality (GI as a tool for ecological, economic, and social enhancement), multiscale and "multi-object" (i.e. integration) principles (Benedict & MacMahon, 2002; Hansen & Pauleit, 2014; Monteiro et al., 2020), the analysis is based on multiple factors, incorporate elements from different sources and with different detail scales. These elements refer both to ecological and socio-demographic aspects. To bridge these two spheres, a network analysis was carried out to evaluate the proximity of UGS, based on the assessment of the level of accessibility and the usability of green areas (Quatrini et al., 2019) (Fig.1). In this general framework, this contribution describes an experimental study conducted on public green spaces at the urban scale, essential for redesigning the continuity of green infrastructures within the city (Tulisi, 2017).

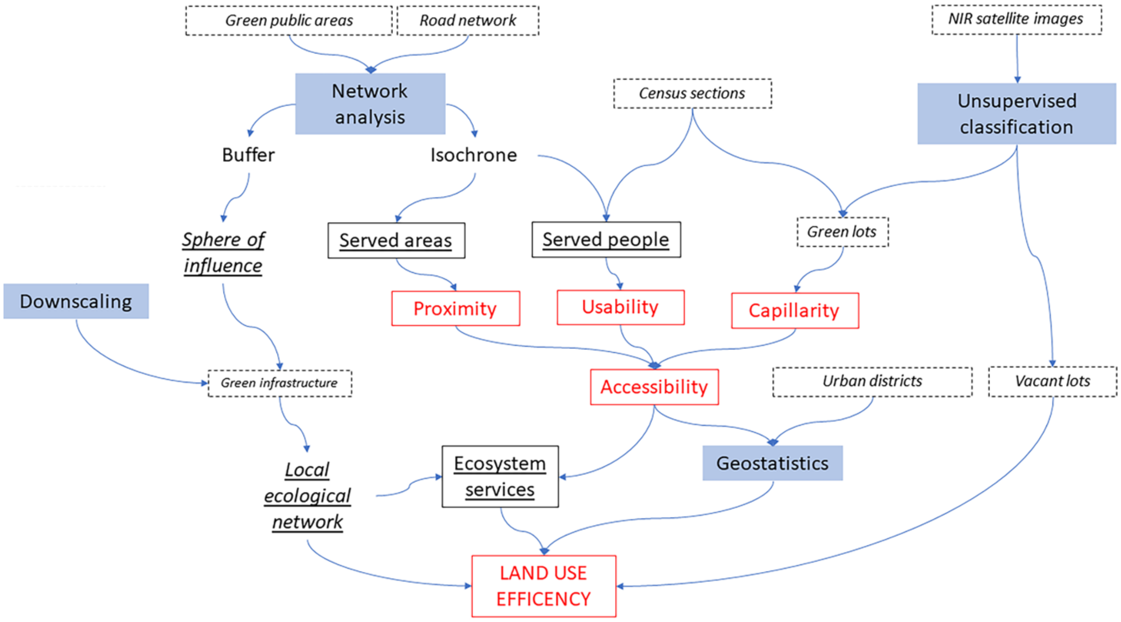

Fig.1 Methodological process for the creation of the cognitive framework at the basis of the project of the local ecological network (municipality of Falconara Marittima). The scheme highlights: a) input data (dotted line); b) goals of the research (red); c) different procedures used to connect the various elements (blue); d) main results (black)

3. Case study

Falconara Marittima is a small town located in the terminal part of the Esino river valley on the Adriatic coast and close to Ancona, the regional capital of the Marche region (central Italy, Fig.2).

The municipal area extends for 25.81 km^2, with a residential population of 25,727 and a population density of 996.78 inhabitants/ km^2 (ISPRA, 2022; ISTAT 2021).

Here, the urban area (a) measure 7.9 km^2 while the natural area (b) about 20 km^2, that corresponds respectively 31% and 77% of the total administrative land area.

We limited the analysis to green spaces within the urban area (a) selected as the study area. Here, UGS represents approximately 1.98 km^2, equal to 25% of the total (a).

Fig.2 Ecological connectivity of urban green spaces of Falconara Marittima. The green systems connect peri-urban and rural areas to the sea

Then, according to urban morphology and development of the city, the study area has been divided in three districts: 1) city center - 2.1 km^2; 2) Castelferretti - 3.1 km^2; 3) Rocca-Villanova - 2.7 km^2.

The study intends to outline new strategies to increase the multifunctionality of greenery and the provision of ES that supported the Municipality for the development of Green Masterplan to improve the quality of the Land Use Plan (the Italian General Urban Plan, PRG). The main goal of the applications was to add qualitative criteria based on the comparison of demand / supply of ES to select areas with priority of intervention. This operation is essential in supporting the decision-making process and helps urban planners to outline future scenarios and direct economic resources based on citizens' needs. To do so, we firstly analyse the framework of the 'green standard' for public facilities (Italian Ministerial Decree n. 1444/68) as a part of the green component of the Land Use Plan (UGS) at the city scale. Here, we outline a critical situation. In fact, just the 16% of green standards of the public green areas have been developed (and currently manage) by the Municipality, while the 84% of the total of green areas are not implemented and therefore unable to maximize the provision of CES to citizens (Fig.3).

These data highlight the need to define new policies and strategies to plan and design UGS to implement GI at the city scale. Strategies could be based on these two main approaches:

a) to better orient financial resources (for example the adoption of diversified maintenance and management criteria of green spaces (Pantaloni et al., 2022));

b) to draw up the revisions of the Land Use Plan by proposing appropriate zoning variations to implement green standard services based on city users and specific targets of resident.

Therefore, to build qualitative evaluation criteria we develop a series of sectorial study including the network analysis to assess the urban green spaces proximity, described as follows.

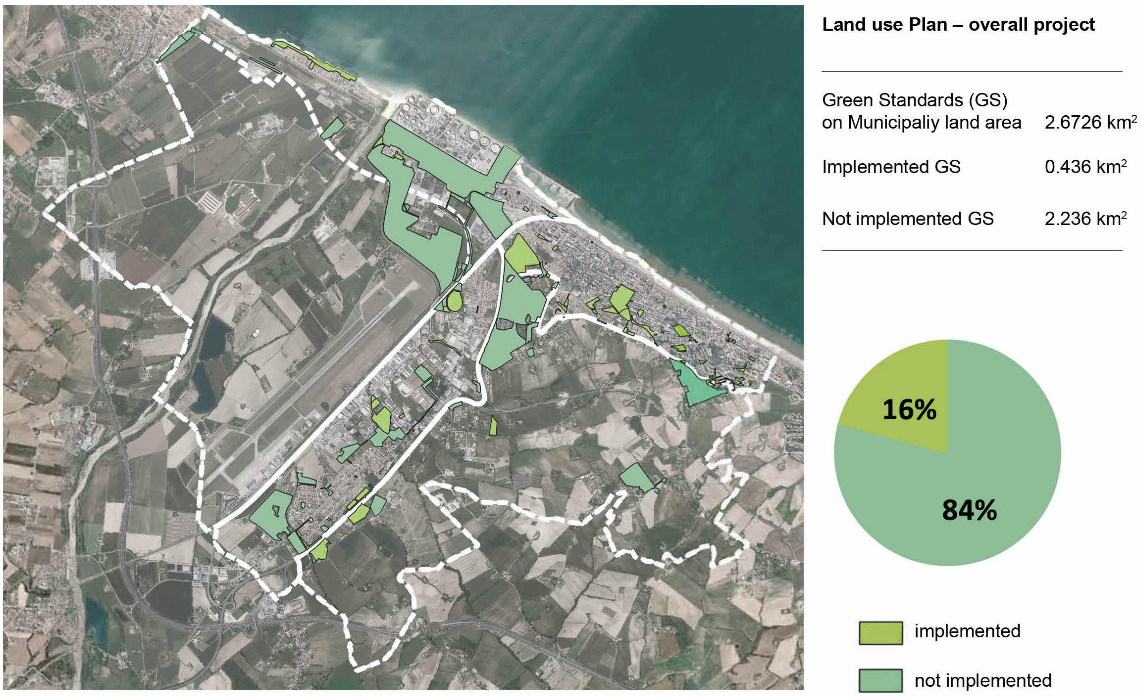

Fig.3 Urban green spaces analysis on the three urban district

3.1 Accessibility and usability assessment: urban area

At the city scale, we first evaluated the accessibility level (Nicholls, 2001) within the three selected urban districts. For this purpose, we perform network analysis testing the isochronous method (Tiboni et al., 2021). It allowed to identify the iso-distances calculated by evaluating the walking area within a radius of 300 m and 800 m, corresponding to about 5 minutes and 15 minutes (Busi, 2009, 2011; Tiboni & Rossetti, 2014).
To do this, we considered the following spatial layers as input data:

a) the public green spaces managed by the Municipality of Falconara Marittima;

b) infrastructure system (streets and roads).

The assessment of (a) has been developed by applying a multi-scale and multilevel overlay process, concerning:

1) downscaling of the environmental elements of the regional planning instruments (Pantaloni et al., 2023);

2) mapping the green census resources developed at the city scale.

Spatial data such as public green spaces, network system and street furniture have been provided by the Municipality Topographic Database of the Green Heritage manageable through the QGIS open-source software (SIT, https://sit.comune.falconara-marittima.an.it). The data were obtained through direct survey of green areas and environmental resources across the municipal area. Infrastructural system has been downloaded by the open-source street map (OSM) platform. Resident population and distribution dataset to define the user target related to green spaces are available on ISTAT website (2021). Then, we evaluated the level of usability by considering "the presence of structures capable of supporting people's activities" (Quatrini et al., 2019). Therefore, the "possibility and degree of enjoyment by citizens of a specific green area [...] (law no. 63/2015 Marche Region) was assessed through the spatial level of street furniture for each public green space (Pantaloni et al., 2022). This operation allows:

a) to check the suitability of the pedestrian pathway, especially for specific group of users. For instance, to consider benches for elderly people or adequate system of streetlight to guarantee public safety. This analysis intends to verify whether the public green areas served as street furniture. To do this, we evaluated the presence of street furniture along the pedestrian path through the application of the buffer method of 300 m diameter (by applying the Euclidean distance) from each public green area (Nicholls, 2001);

b) to verify the presence of street furniture within the public green areas to measure their multifunctionality with particular attention to the target of vulnerable users.

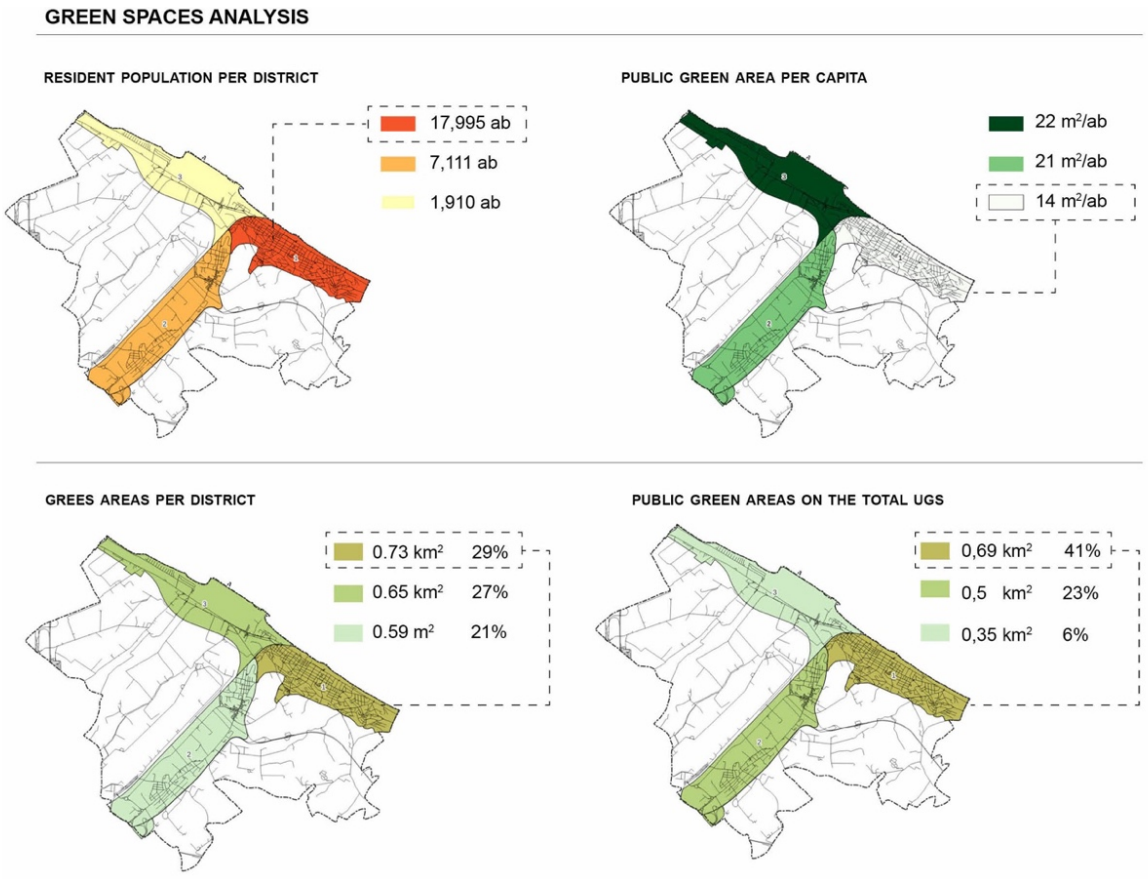

Fig.4 Analysis of green spaces in the three urban neighborhoods. The area of interest of district 1 "city center" is marked by the dashed line

Finally, we correlate the green areas with the resident population and the identification of potential users.

The overlay process in GIS environment allows us to perform geostatistical analysis for each district to define the network of pedestrian paths within the basin of potential users of the green space. Thus supported the proximity-based planning process for the provision of ecosystem services. Data show that, despite the highest percentage of public green areas on the total UGS, the district 1 "city center" has the largest number of resident population with the lowest percentage of public green areas per capita (m^2/inhabitant) and the highest percentage of public green areas on the total UGS (Fig.4). For this reason, we select district 1 "city center" as the focus area to cross-reference the network analysis with UGS and the resident population to define potential catchment area.

3.2 Focus area

On the total of 153 green areas surveyed in the "city center" (Tab.1) we applied a rapid evaluation methodology based on the correlation between a quantitative and qualitative indicator.

The first one is a quantitative indicator (binary type). Value 1 correspond to presence of street furniture; value 0 to the absence of street furniture. By applying this, n. 122 areas are not equipped, while the equipped area are 41. This means that the non-equipped areas are double those equipped, and number around 99,121 sqm with an incidence of 45% on the total public green areas.

Municipality land area [ha]	Urban area [ha]	Resident population* [inh.]	Population density [inh./ha]	Public green areas [n]	Total green surface [ha]
2,500	207.6	16,507	79.50	153	22.14

* source: ISTAT 2021

Tab.1 Focus area - general data

Then we applied a qualitative indicator type (multi-value) on the total of the 41 equipped areas to assess the provision of CES according to the level of usability. This correlates number of equipment and dimension of the green surface of each area. The indicators are assessed and ranked individually by assigning a value between 1 and 5, according to the criteria described for each level (1 low performance; 2 medium/moderate; 5 high performance) (Pantaloni et al., 2022), Tab.2.

	Established value	Number of equipment
Usability	1	1 - 4
	2.5	5-9
	5	≥ 10
Size		**Area [sqm]**
	1	< 200
	2.5	≥ 200; ≤ 5,000
	5	> 5,000

Tab.2 Indicators, evaluation criteria and level of estimation to classify green areas by qualitative approach

Applying this evaluation methodology, we grouped the 41 public green areas into three levels based on the connection between 'usability' and 'size' indicators (Tab.3).

Level	Threshold	Formula
L1	< 5	Nvalue + Dvalue
L2	≥ 5; ≤ 7.5	
L3	> 7,5	

Tab.3 Three levels according to threshold index. 'Nvalue' means the value assigned to usability indicator (number of equipment). 'Dvalue' means the value assigned to size indicator (green area surface)

This rapid assessment method based on multicriteria analysis allows us to select 8 areas in L3 level with a high performance of supply CES (Tab.4).

Level	Areas [n]	Surface [sqm]	Incidence on the total of equipped green areas [%]
L1	10	21,360	18
L2	23	28,120	22
L3	8	72,800	60

Tab.4 Three levels of usability. L1 (low performance), L2 (medium performance) and L3 correspond to a high provisioning capacity of CES

About resident population data, we grouped the 7 categories based on classification provided by ISTAT, National Institute of Statistics (updated to 2021, ISTAT) in 4 specific targets of the resident population (children <5 years; kids 10<x<15; adults 15<x<64, elderly 65<x<74, elderly >74 years. This is particularly relevant in the design of public areas for active ageing (Longhi et al., 2014).

Considering the definition of "usability" selected in this study, the identification of resident targets is based on the wide range of CES provided to citizen, that could be simplified with the evaluation of different categories of urban furniture (Tab.5).

Social milieu	**Age (range)**	**Residents per age**	**Residents per target**	**Incidence on the total resident population**	**Type of CES**	**Usability evaluation**
[targets]	**[years]**	**[inh.]**	**[inh.]**	**[%]**		
1	<5	535	1,081	6.55	Recreational, emotional	Safety spaces for sport and recreational activities for families (both children and adults)
	5-9	546				
2	10-14	681	10,459	63.36	Sense of identity, sense of community, sense of belonging to a place	
	15-64	9,778			Physical and mental health, well being, mental health	
3	65-69	1,055	2,193	13.29	Safety spaces, esthetic, and well being	Lightning system, benches and assisted pathways
	70-74	1,138				
4	>74	2,774	2,774	16.80	Safety spaces	
Total		16,507				

Tab.5 Focus area – usability of green areas related to resident population

Finally, we evaluate accessibility to the 8 areas selected by performing the network analysis, and cross-referenced data with resident population to define potential catchment area.

To do this, we considered a walkable distance of 300 m, 150 m and 50 m proximity thresholds, that have been crucial during the COVID-19 pandemic restrictions in place. The distance of 50 meters meets the needs of the elderly, who represent over 25% of the total residents in this area. Demographic data were divided by census sections defined by ISTAT. These correspond to the urban blocks defined by network systems (path and roads, Fig.5)

4. Results and discussions

At the city scale, network analysis allows us to define two spatial layers that represent the area covered by a walking distance of 5 minutes and 15 minutes (Bocca, 2024, Fig.6). Applying the 5-minute rule, 7.16 sq km are served by public green areas (equal to 28% of the municipal area), while 10.6 sq km access public green areas by applying the 12-minute rule (equal to 41% of the municipal area).

About the limitation, this method only considers spatial distance without space characteristics.

The district 1 "city center" measure the highest level of usability of public green areas according to the criteria selected. As we expected, parks are the most equipped areas where we register the highest level of usability (Fig.7).

The lower level of usability of the green areas located in neighborhoods 2 and 3 could be crucial for weak users, such as the elderly (Akhavan & Vecchio, 2018).

Fig.5 Number 41 public green areas in district 1 "city center". The eight L3 areas are marked in dark green

On the focus area, the results of network analysis demonstrate that just 61% of the residential population is served by 300 m rule. This means that, despite the urban planning compliance of the Land Use Plan with the minimum quantities of green standard for public facilities imposed by the Italian Ministerial Decree 1444/68 (9 sqm/inhabitant) and the Regional Law of Marche Region n.34/92 (12 sqm/inhabitant), almost half users are not served by public green spaces (Tab.6, Fig.8).

Accessibility radius [m]	**Urban blocks [n]**	**Potential users [inh.]**	**Incidence [%]**
50	55	3,620	21,9
150	100	7,429	45
300	143	10,096	61
Not served	100	6,411	38

Tab.6 Urban blocks and resident population served by the equipped green areas

Focusing on weak users, about 10% of elderly people of the total of resident population, 3% can use public greenery though a walkable distance of 50 m, while the over 75 are just 4% (Tab.7).

Moreover, the investigation highlights that about 10% of the over 65 does not have access to green facilities. This means that around 1,000 of elderly people are not able to access to urban services that are essential for mental and physical well-being (WHO, 2017). These areas could be strategical for the effectiveness of active ageing and health policies (Tab.8, Fig.9).

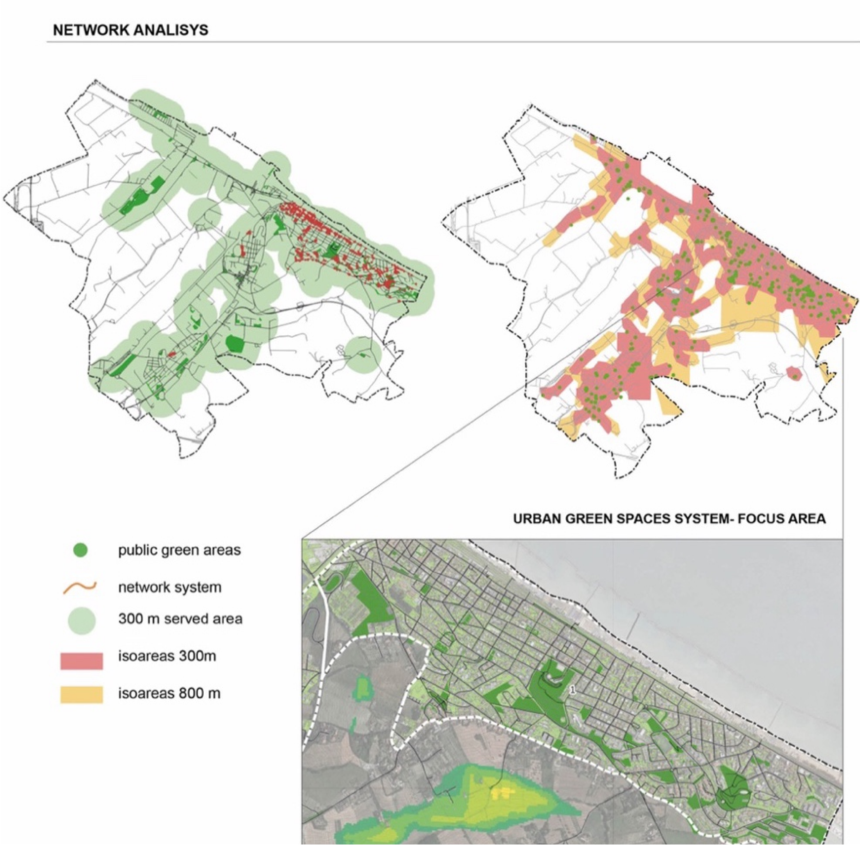

Fig.6 Network analysis developed based on isochronous method. The spatial layer represents the walkable distance to public green areas on 300 m (red) and 800 m (yellow) distances

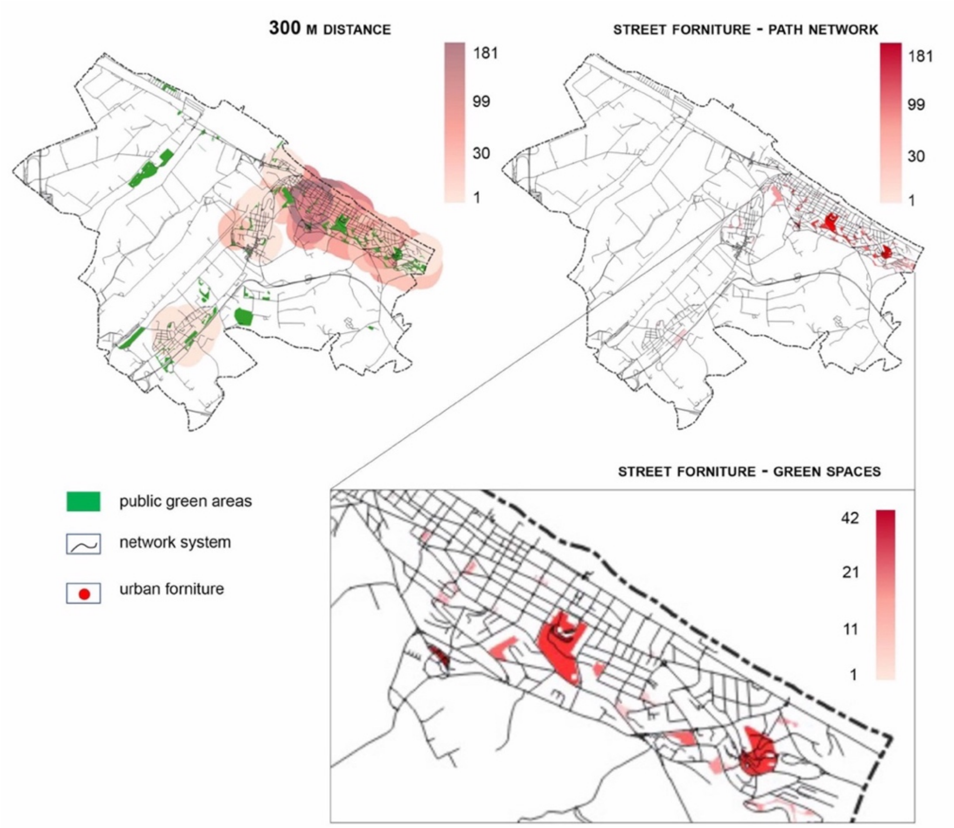

Fig.7 Evaluation of street furniture related to public green spaces using the buffer method

Fig.8 Urban blocks identified by spatial layers at the fixed distances

Social milieu [target]	Age [range]	Inh. per target [n]	Incidence [%]	Inh. per target [n]	Incidence [%]	Inh. per target [n]	Incidence [%]
		300 m		**150 m**		**50 m**	
1	< 5 5-9	10,395	62.9	7,648	46.3	3,722	22.5
2	10-14 15- 64	716	4.3	535	3.2	260	1.5
3	65-69 70-74	1,401	8.4	1,021	6.1	483	2.9
4	> 74	1,774	10.7	1,329	8.0	677	4.1

Tab.7 Catchment areas according to social milieu and walkable distances selected in this study

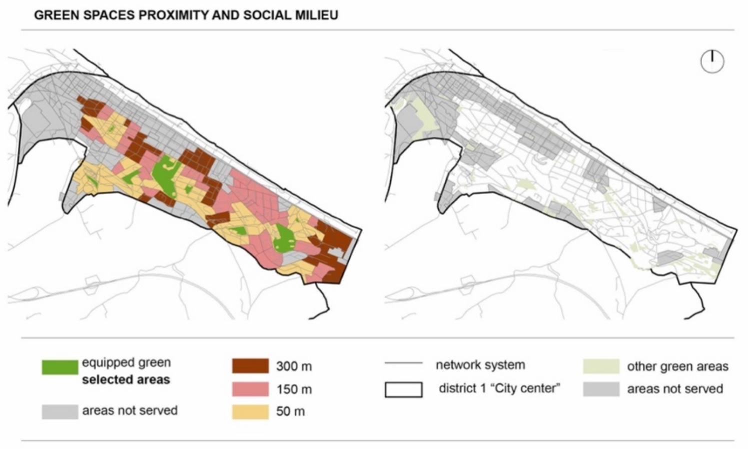

Fig.9 Potential catchment area. On the total of 398, 100 urban blocks are unserved by public green areas

Social milieu [target]	Age [range]	Inhabitants per age [n]	Inhabitants per target [n]	Incidence [%]
			300 m	
1	< 5 5-9	236 221	457	2.7
2	10-14 15- 64	290 3,872	4,162	25.2
3	65-69 70-74	375 417	792	4.8
4	> 74	1,000	1,000	6.0
total		6,411		38.8

Tab.8 Resident population unserved by public green areas

To summarize, in Falconara Marittima 16% of the green standards are implemented while 84% are not implemented by the Municipality according to the Ministerial Decree n. 1444/68 (to see Fig.2).

Results of the sectorial study highlights that on the 153 public green area just 41 are equipped, while 112 are not equipped. According to rapid evaluation criteria, 8 of these areas are classified as L1, while 33 are L2, L3.

The overlay between legal framework and the spatial layers deriving from the assessment of green spaces proximity permit to outline different scenarios, summarized in (Tab.9).

This conceptual framework can support the decision-making process to guide planning action based on the maximization of CES to better orient financial resources and improve the performance of urban ecosystems.

Green standard for public facilities (Ministerial Decree 1444/68)	**Green area type**	**Green spaces proximity**	**Planning action**	**Zoning variance**
Implemented green standards (16%)	Equipped green areas	L1	To maximize the provisioning of CES starting from the resident population target with specific needs.	X
		L2 – L3	Application of the diversified maintenance approach to critically select the public green area that needs to provide CES to citizens (based on rapid evaluation assessment, see "Material and Methods" section).	X
	Not equipped green areas	Excluded by the sectorial study	Confirm the existing green standard and invest money in actions to maximize the provision of CES based on the assessment of the proximity of green areas.	X
			The green areas do not meet the proximity criteria in the selected area. To be evaluated whether to provide a zoning variance on the green standard selected.	✓
Not implemented green standards (84%)		Not carried out	The green areas are outside the study area (or area of interest in the design phase). Further proximity studies on other areas of interest are necessary to foresee/exclude a zoning variance to confirm/not confirm the green standard selected.	✓

Tab.9 Planning action to guide the decision - making process and orient the urban policies and manage the green component of the Land use Plan

5. Conclusions

The work is part of a research project aimed at supporting public administrations in the assessment of 'performance' of green spaces and estimate ecosystem services application in urban and territorial planning (Rodas et al., 2018).

To perform geo-spatial models based on proximity evaluation of public green areas is essential to enhance the performance of urban environment based on citizen needs. It also helps to awareness on the gap between "quantitative" vs "performance-based" planning models (Cortinovis & Geneletti, 2020; Kendig, 1980) that taste qualitative evaluation criteria to guide planning process.

This study could be crucial in supporting the decision-making process of the green component of the Land Use Plan, defined as green standards for public facilities by the Italian normative framework. About the limitations of the study, the results depend to the availability of local data. For this reason, it could be carefully replicable to other similar Italian contexts. These analyses help local planners and politicians in using financial resources to update the role of the Land Use Plan: a) by selecting the urban green 'standards' endowments that respond to citizen needs; b) by defining the zoning variance within the Land Use Plan to implement urban green facilities and boost green and blue infrastructure in the urban area.

All these actions could enhance the quality of the Land Use Plan and increase the quality of life in our cities.

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Image Sources

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Author's profile

Monica Pantaloni

Civil Engineer - Architect, Phd in Urban and Regional Planning, Postdoctoral Research Fellow position at the Department of Materials, Environmental Sciences and Urban Planning, SIMAU, UNIVPM. Research on urban and territorial planning, landscape design, and management at different scales. Main interests include green infrastructures, nature-based solutions, and ecosystem services integrated with specific natural and agronomic sciences skills.

Francesco Botticini

Civil Engineer, Ph.D in Civil and Environmental Engineering, International Cooperation and Mathematics with the Urban Planning and Transportation curriculum, his main research fields are the enhancement of architectural heritage urban regeneration processes, urban resilience and the implementation of GIS software to develop functional databases to support spatial planning decisions.

Giovanni Marinelli

Architect, Associate Professor in Urban and Regional Planning at the Department of Materials, Environmental Sciences and Urban Planning, SIMAU, UNIVPM. Research on urban and territorial planning, environmental infrastructures and green networks, urban and landscape project.