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Computational Science and Its Applications – ICCSA 2023 Workshops

Athens, Greece, July 3–6, 2023
Proceedings, Part III

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Editors

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Preface

These 9 volumes (LNCS volumes 14104–14112) consist of the peer-reviewed papers from the 2023 International Conference on Computational Science and Its Applications (ICCSA 2023) which took place during July 3–6, 2023. The peer-reviewed papers of the main conference tracks were published in a separate set consisting of two volumes (LNCS 13956–13957).

The conference was finally held in person after the difficult period of the Covid-19 pandemic in the wonderful city of Athens, in the cosy facilities of the National Technical University. Our experience during the pandemic period allowed us to enable virtual participation also this year for those who were unable to attend the event, due to logistical, political and economic problems, by adopting a technological infrastructure based on open source software (jitsi + riot), and a commercial cloud infrastructure.

ICCSA 2023 was another successful event in the International Conference on Computational Science and Its Applications (ICCSA) series, previously held as a hybrid event (with one third of registered authors attending in person) in Malaga, Spain (2022), Cagliari, Italy (hybrid with few participants in person in 2021 and completely online in 2020), whilst earlier editions took place in Saint Petersburg, Russia (2019), Melbourne, Australia (2018), Trieste, Italy (2017), Beijing, China (2016), Banff, Canada (2015), Guimaraes, Portugal (2014), Ho Chi Minh City, Vietnam (2013), Salvador, Brazil (2012), Santander, Spain (2011), Fukuoka, Japan (2010), Suwon, South Korea (2009), Perugia, Italy (2008), Kuala Lumpur, Malaysia (2007), Glasgow, UK (2006), Singapore (2005), Assisi, Italy (2004), Montreal, Canada (2003), and (as ICCS) Amsterdam, The Netherlands (2002) and San Francisco, USA (2001).

Computational Science is the main pillar of most of the present research, industrial and commercial applications, and plays a unique role in exploiting ICT innovative technologies, and the ICCSA series have been providing a venue to researchers and industry practitioners to discuss new ideas, to share complex problems and their solutions, and to shape new trends in Computational Science. As the conference mirrors society from a scientific point of view, this year's undoubtedly dominant theme was the machine learning and artificial intelligence and their applications in the most diverse economic and industrial fields.

The ICCSA 2023 conference is structured in 6 general tracks covering the fields of computational science and its applications: Computational Methods, Algorithms and Scientific Applications – High Performance Computing and Networks – Geometric Modeling, Graphics and Visualization – Advanced and Emerging Applications – Information Systems and Technologies – Urban and Regional Planning. In addition, the conference consisted of 61 workshops, focusing on very topical issues of importance to science, technology and society: from new mathematical approaches for solving complex computational systems, to information and knowledge in the Internet of Things, new statistical and optimization methods, several Artificial Intelligence approaches, sustainability issues, smart cities and related technologies.

In the workshop proceedings we accepted 350 full papers, 29 short papers and 2 PHD Showcase papers. In the main conference proceedings we accepted 67 full papers, 13 short papers and 6 PHD Showcase papers from 283 submissions to the General Tracks of the conference (acceptance rate 30%). We would like to express our appreciation to the workshops chairs and co-chairs for their hard work and dedication.

The success of the ICCSA conference series in general, and of ICCSA 2023 in particular, vitally depends on the support of many people: authors, presenters, participants, keynote speakers, workshop chairs, session chairs, organizing committee members, student volunteers, Program Committee members, Advisory Committee members, International Liaison chairs, reviewers and others in various roles. We take this opportunity to wholehartedly thank them all.

We also wish to thank our publisher, Springer, for their acceptance to publish the proceedings, for sponsoring part of the best papers awards and for their kind assistance and cooperation during the editing process.

We cordially invite you to visit the ICCSA website https://iccsa.org where you can find all the relevant information about this interesting and exciting event.

July 2023

Osvaldo Gervasi
Beniamino Murgante
Chiara Garau

Welcome Message from Organizers

After the 2021 ICCSA in Cagliari, Italy and the 2022 ICCSA in Malaga, Spain, ICCSA continued its successful scientific endeavours in 2023, hosted again in the Mediterranean neighbourhood. This time, ICCSA 2023 moved a bit more to the east of the Mediterranean Region and was held in the metropolitan city of Athens, the capital of Greece and a vibrant urban environment endowed with a prominent cultural heritage that dates back to the ancient years. As a matter of fact, Athens is one of the oldest cities in the world, and the cradle of democracy. The city has a history of over 3,000 years and, according to the myth, it took its name from Athena, the Goddess of Wisdom and daughter of Zeus.

ICCSA 2023 took place in a secure environment, relieved from the immense stress of the COVID-19 pandemic. This gave us the chance to have a safe and vivid, in-person participation which, combined with the very active engagement of the ICCSA 2023 scientific community, set the ground for highly motivating discussions and interactions as to the latest developments of computer science and its applications in the real world for improving quality of life.

The National Technical University of Athens (NTUA), one of the most prestigious Greek academic institutions, had the honour of hosting ICCSA 2023. The Local Organizing Committee really feels the burden and responsibility of such a demanding task; and puts in all the necessary energy in order to meet participants' expectations and establish a friendly, creative and inspiring, scientific and social/cultural environment that allows for new ideas and perspectives to flourish.

Since all ICCSA participants, either informatics-oriented or application-driven, realize the tremendous steps and evolution of computer science during the last few decades and the huge potential these offer to cope with the enormous challenges of humanity in a globalized, 'wired' and highly competitive world, the expectations from ICCSA 2023 were set high in order for a successful matching between computer science progress and communities' aspirations to be attained, i.e., a progress that serves real, place- and people-based needs and can pave the way towards a visionary, smart, sustainable, resilient and inclusive future for both the current and the next generation.

On behalf of the Local Organizing Committee, I would like to sincerely thank all of you who have contributed to ICCSA 2023 and I cordially welcome you to my 'home', NTUA.

On behalf of the Local Organizing Committee.

Anastasia Stratigea

Organization

ICCSA 2023 was organized by the National Technical University of Athens (Greece), the University of the Aegean (Greece), the University of Perugia (Italy), the University of Basilicata (Italy), Monash University (Australia), Kyushu Sangyo University (Japan), the University of Minho (Portugal). The conference was supported by two NTUA Schools, namely the School of Rural, Surveying and Geoinformatics Engineering and the School of Electrical and Computer Engineering.

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Advances in Artificial Intelligence Learning Technologies: Blended Learning, STEM, Computational Thinking and Coding (AAILT 2023)

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Advanced Processes of Mathematics and Computing Models in Complex Computational Systems (ACMC 2023)

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Artificial Intelligence Supported Medical Data Examination (AIM 2023)

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Advanced and Innovative Web Apps (AIWA 2023)

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Assessing Urban Sustainability (ASUS 2023)

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Advances in Web Based Learning (AWBL 2023)

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Blockchain and Distributed Ledgers: Technologies and Applications (BDLTA 2023)

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Bio and Neuro Inspired Computing and Applications (BIONCA 2023)

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Choices and Actions for Human Scale Cities: Decision Support Systems (CAHSC–DSS 2023)

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Computational and Applied Statistics (CAS 2023)

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Conversations South-North on Climate Change Adaptation Towards Smarter and More Sustainable Cities (CLAPS 2023)

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Computational Astrochemistry (CompAstro 2023)

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Workshop on Computational Science and HPC (CSHPC 2023)

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International Workshop on Defense Technology and Security (DTS 2023)

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Integrated Methods for the Ecosystem-Services Accounting in Urban Decision Process (Ecourbn 2023)

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Evaluating Inner Areas Potentials (EIAP 2023)

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Sustainable Mobility Last Mile Logistic (ELLIOT 2023)

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Ethical AI Applications for a Human-Centered Cyber Society (EthicAI 2023)

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13th International Workshop on Future Computing System Technologies and Applications (FiSTA 2023)

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Collaborative Planning and Designing for the Future with Geospatial Applications (GeoCollab 2023)

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Geomatics in Agriculture and Forestry: New Advances and Perspectives (GeoForAgr 2023)

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Geographical Analysis, Urban Modeling, Spatial Statistics (Geog-An-Mod 2023)

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Geomatics for Resource Monitoring and Management (GRMM 2023)

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International Workshop on Collective, Massive and Evolutionary Systems (IWCES 2023)

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Multidimensional Evolutionary Evaluations for Transformative Approaches (MEETA 2023)

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The Analysis of the Urban Open Spaces System for Resilient and Pleasant Historical Districts

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Abstract. Cities are the places where multiple challenges related to environmental, economic, social, and cultural phenomena are condensed. The increasing physical and systemic sensitivity/vulnerability of cities represents an opportunity to experiment with new models of urban development. Among these models, the scientific community is devoting particular attention to the use and the reuse of public spaces, especially in historical urban areas. What still lacks substance is the identification of which are the most suitable transformations to reorganize the urban spaces system according to its existing characteristics. Indeed, taking into account the intrinsic features of urban spaces means optimizing the benefits as well as cutting the costs associated with the necessary interventions.

This study proposes the analysis of the urban open spaces system – squares, green urban areas, gardens, paved areas, etc. – of seven historical districts in the city of Naples, according to their physical, functional, and accessibility characteristics. The aim is to define their structure and prevailing features in order to support decision-makers in the identification of appropriate and efficient adaptation, reorganization, and reuse measures. 13 indicators referred to 3 dimensions (Climate adaptation, Accessibility and equity, Urban quality) were aggregated into 3 composite indexes, through GIS elaborations, with the aim of identifying portions of territory where to primarily intervene, as well as the characteristics to be improved.

One of the main pieces of evidence of this study is that the suitability of urban spaces for adaptation measures cannot be separated from aspects like accessibility and pleasantness.

Keywords: Urban Resilience · Spatial Planning · Historical Districts · Urban Open Spaces

1 Introduction

Cities are the places where multiple challenges related to environmental, economic, social, and cultural phenomena are condensed [1, 2]. Firstly, climate change, due to global temperatures rising, increases the likelihood that extreme weather events will impact cities, compromising their physical integrity, organization, as well as public health and safety [3, 4]. Secondly, urban development (characterized by shrinking or

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sprawl phenomena) [5, 6], along with ever-faster societal/demographic changes [7, 8], impose the challenge of accessibility and equity, with the necessity of enabling access to urban services to disparate categories of people, especially the most fragile [9]. Finally, diffuse degradation, air pollution, and overcrowding, unless controlled, may undermine the quality and liveability of our cities [10, 11]. This non-exhaustive list of challenges contributes to the increasing physical and systemic vulnerability of urban areas. In historical city centres, the issue is even more thorny [12, 13], due to the consolidated urban structure and the presence of constraints that limit the transformation of the territory [14, 15]. Here, over the past decades, depopulation processes sparked urban decay and deterioration that have led to two different reactions: on one side, the establishment of immigrants and lower-income people, which transformed some historical areas (e.g., the next areas to central metro stations) into poverty and inequalities scenarios [16]; on the opposite side regeneration processes that, far from being a cure-all, led to gentrification dynamics that emphasized inequalities [17]. Beyond this, historical areas suffer problems that are the results of a stratified urban structure and a not-always planned urban fabric, such as the shortage of urban services, the lack of variegate facilities and economic activities [16] and, for what concern the focus of this study, the scarcity of green urban areas and the inadequacy of open public spaces [18].

Urban open spaces systems are intended as multipurpose infrastructures including different urban spaces (i.e., squares, green urban areas, gardens, paved areas), vital to urban resilience, as well as sustainability, health, safety, and well-being [19]. The inadequacy of the open spaces system of historical neighbourhoods, if, on the one hand, contributes to increasing physical and systemic vulnerability, on the other hand, represents an opportunity to enhance their resilience [18, 20] and, thus, experiment with new models of urban development.

Leveraging policies and planning practices that involve the open spaces system might well accelerate the adaptation of cities to the abovementioned changing environmental and social conditions [21]. And the benefits for historical districts might be even more. The scientific community is devoting particular attention to the use and the reuse of public spaces to cope with the impacts of climate change, social degradation, and inequalities [22, 23]. What still lacks substance is the identification of which are the most suitable transformations to reorganize the urban spaces system according to its existing characteristics and the territory's vulnerabilities and hazards. Indeed, taking into account the intrinsic features of the urban spaces system means optimizing the benefits as well as cutting the costs associated with the necessary interventions [24].

With these premises in mind, this paper proposes the analysis of the urban open spaces system of seven historical districts in the city of Naples, Italy, according to their physical, functional, and accessibility characteristics. In detail, the work includes characteristics of i) climate adaptation, considering the climatic zone of the city and its sensitivity to urban heat islands and water bombs; ii) accessibility and equity, considering the proximity to services and cultural facilities, along with the equable access of fragile people; iii) urban quality, considering urban design, value, and comfort. The aim is to define the structure and the prevailing features of the urban spaces system in order to support decision-makers in the identification of appropriate and efficient adaptation, reorganization, and reuse measures and the recognition of priority cases. The work was

carried out through the construction of 3 composite indexes in GIS, whose visualization options allow for the systemic interpretation of results. The objectives are: i) to verify if there is a correspondence between homogeneous characteristics and the reciprocal position of open spaces (in other words, if there is a systemic pattern); ii) to identify portions of territory where to primarily intervene; ii) to identify the characteristics to be improved. One of the main pieces of evidence of this study is that the suitability of urban open spaces for climate adaptation measures cannot be separated from social and quality/design aspects. The three dimensions go hand in hand since a good performance in one dimension cannot compensate for climate adaptation, equity, or quality deficiency.

This paper is organized as follows. The next section deepens the role of urban open spaces for cities' liveability and quality of life and the benefits that can be reached if pulled towards a systemic behaviour. Section 3 describes the utilized materials and the criteria to select the meaningful indicators, as well as the GIS-based methodology adopted to recollect the data and develop the descriptive indexes. Section 4 regards the application to the case study, including seven districts of the city of Naples having historical, architectural, and cultural value. Section 5 draws the conclusions of the work.

2 Advantages of an Efficient Urban Open Spaces System

The topic of urban open spaces has been widely studied in the literature. According to Tang and Wong [25], open spaces encompass different elements such as parks, gardens, recreational spaces, squares and undeveloped natural areas. Carr et al. [26] defined public open spaces as places where people can carry out their functional and leisure activities, creating a community. However, several studies deal with urban open spaces by defining them as a "system" [27–29], to the extent that they can work together to improve sustainability and resilience, being part of a network. According to numerous international organizations and scientific works, the urban open spaces system plays a key role in the definition of urban life, environment, and image [30, 31]. Indeed, an interconnected system of both green and public spaces provides a wide array of benefits related to environmental sustainability, air, and noise pollution decrease, groundwater management, land consumption, reduction of climatic risks, improvement of microclimatic conditions, and energy savings. In other words, the urban open spaces system is connected to a wide range of ecosystem services [32, 33].

For what concerns climate change, the right management and organization of urban open spaces system can be a significant tool in the hands of decision-makers, if addressed towards climate adaptation strategies [34]. Rising global temperatures and the consequent extreme weather events are causing severe impacts on urban areas, damaging basic services and infrastructure, and threatening human life, health, and housing [35]. Climate adaptation of urban open spaces (increase of green surfaces, permeable paved areas, nature-based solutions, etc.) constitutes a substantial part of the actions to be implemented to reduce these impacts and improve safety in urban areas [36]. To this end, it is necessary to know and classify open spaces according to their existing characteristics and systemic behaviour, and the territory's vulnerabilities and hazards. Diffuse and interconnected open spaces represent an opportunity to increase the climate resilience of urban areas [37], with benefits that range from the mitigation of heat island phenomena to the prevention of damages caused by storms/droughts cycles.

Thanks to its significant environmental, social, and economic value, the open spaces system is regarded as one of the most important components of sustainable development in cities [38]. After the Covid-19 outbreak, the benefits associated with public open spaces were further emphasized, as open spaces revealed themselves as essential places for promoting human health, social exchanges, and citizens' well-being [9, 39]. If easily accessible and connected, open spaces are able to influence people's quality of life since they indirectly encourage physical activity and subjective well-being, also constituting spaces of social aggregation that give value to the community's life [40, 41]. This is particularly important for fragile categories of the population, such as age-related categories (i.e., elderly and children) and socially and economically disadvantaged citizens (i.e., lower-income people and immigrants) [9]. For kids and older people, spending time outside is vital to their mental and physical well-being [30]. It reduces the chances of suffering from stress-related pathologies, anxiety, and depression, as well as the risk of cardiovascular disease, obesity, diabetes, and mortality among adults and of obesity and myopia in children [42]. Also, a diffused network of gardens, recreational, and gathering places can be the trigger point to promote passive recreation, social interactions, and inter-community contacts. This is particularly true for those citizens that suffer marginalization and deprivation due to poverty conditions or lack of integration in the community (e.g., foreigners). From an urban planning perspective, it follows the necessity of guaranteeing accessibility of open spaces, especially to these fragile categories.

In conclusion, the scientific community recognizes that green and high-quality the open spaces system provides a pleasant and comfortable environment where to live [43]. As a matter of fact, pleasant, well-lit, and cosy spaces contribute to the overall urban quality and guarantee a better perception of safety [44]. To a certain extent, their spatial structure and visual quality can impact directly and indirectly people's sense of wellness and satisfaction, impacting the way people gather and socialize in these spaces [45]. Three main factors are linked to the effective use of open spaces and the correct functioning of the open spaces system namely, users' needs, the quality of the physical features, and the spatial relationship with the context [44]. Understanding these three aspects is the keystone for a well-designed open space that attracts people, facilitates their activities, and encourages them to spend more time open air [46]. In particular cases, they contribute to defining urban identity and image, constituting a tool for city branding and promotion [47]. High-quality open spaces offer economic advantages since they are able to increase property values and neighbourhood attractiveness.

3 Materials and GIS-Based Methodology

3.1 The Dimensions of Urban Open Spaces System

The significance of urban places such as squares, green areas, built widenings, etc. in the development of transformation strategies and policies contextually oriented towards reducing vulnerability, increasing sustainability (including the energy one), and improving urban attractiveness and liveability has been continuing to rise and it requires the definition of appropriate techniques and tools to support local decision-makers.

Therefore, the main aim of the work described in these pages is to analyse the asset of the urban open spaces system in relation to some of the main current and near-future urban challenges. To this end, the method described in the section and the following ones was developed.

Through the lens of the systemic and integrated approach, characterising the urban areas that aim at reaching the previous goals, three main features were defined to assess the performance of open spaces, first. These three dimensions reflect the key role of open spaces system to facilitate the climate adaptation of urban areas, to improve their equitable accessibility to match the demand of nearby citizens (especially the most vulnerable ones) and to enhance the liveability and pleasantness of the urban built environment. The dimensions are:

- Climate adaptation;
- Accessibility and equity;
- Urban quality.

They can represent the three main criteria to satisfy when reorganising and improving the provision of open built and unbuilt spaces and the related pedestrian connectivity and ease of use of the related network. This is in line with the recent EU strategies that are oriented to stimulate the definition of valuable opportunities that can arise when cities re-think the use and the design of their open spaces system. As stated in the EEA [48], UN [49] and JRC [50] reports, the way open spaces in the city are laid out contributes strongly to affecting health, the perception of the urban context, especially in terms of pleasantness and safety, and to demonstrate the sensitivity of local administrators to issues of redevelopment, regeneration and adaptation of urban systems.

3.2 The Indicators

The three Climate adaptation, Accessibility and equity and Urban quality dimensions were measured through a set of indicators that reflect the main physical and urban context characteristics of the urban open space system. 13 indicators were selected based on their meaningfulness and the availability, accessibility, measurability and coverage of data (Table 1). Moreover, they allowed measuring the performance of urban open spaces system in terms of adaptation capacity (e.g. permeable surface of the soil that is relevant for both rainfall drainage and mitigating heat-wave effects), usability and proximity (e.g. suitability for vulnerable users such as the elderly), amenity (e.g. the value of the urban context due to the historical-architectural resources).

To make characteristics comparable and aggregable, the normalisation of indicators was necessary. The min-max method was used (1) as it is applicable to indicators with positive, negative or zero values and because it allows one to widen the variability of indicators lying within a small interval:

$$y_{Di} = \frac{x_{Di} - min(x_{Di})}{max(x_{Di}) - min(x_{Di})} \tag{1}$$

where D indicates the dimension and i the indicator.

The distances obtained from normalisation represent the absolute measurements of the gap between each element (the single open space) and the "ideal" one. The indicators that have a negative impact on the three dimensions were considered negative.

To measure the indicators, data were retrieved through processing in a GIS environment from open databases, such as ISTAT for population, Urban Atlas for land uses and Open Street Map for activities localization.

Table 1. The system of indicators.

Dimension	ID	Indicator
Climate Adaptation	01	Run-off coefficient
	02	Permeable surface
	03	Air temperature
	04	Tree coverage
Accessibility and equity	05	Distance from cultural services
	06	Distance from schools
	07	Foreign population pedestrian accessibility
	08	Elderly pedestrian accessibility
Urban quality	09	Historical, architectural and cultural value
	10	Real estate values
	11	Urban open space equipment
	12	Air pollution
	13	Noise pollution

3.3 Aggregation into the Three Dimensions Indexes

The normalised indicators were then aggregated into three main indexes. The literature states that there are several criteria for weighing and aggregating variables, ranging from ex-ante assignable weighting schemes to standards that determine the significance of indicators based on data analysis (e.g., through multivariate statistical analysis). This work did not define a system of weights since the paper represents a first approach to the research.

Hence, the average value of the indicators of each dimension was calculated so to obtain three indexes, one for each dimension (2). This operation is conceptually equivalent to putting all indicators on an equal footing.

$$\mathrm{I_{Dj}} = \frac{\mathrm{x_{Dj1}} + \mathrm{x_{Dj2}} + \ldots + \mathrm{x_{Djn}}}{\mathrm{n}} = \frac{\sum_{l=1}^{\mathrm{n}} \mathrm{x_{Dj}}}{\mathrm{n}} \tag{2}$$

While I_{Dj} indicates the index of the j dimension x_{Dj} is the normalised indicator of that dimension, n is the total number of indicators of the considered dimension.

The three aggregated indexes allow to assess the current functioning of the whole open space system about Climate adaptation, Accessibility and equity and Urban quality dimensions.

The outputs were then represented in GIS.

4 The Application

The proposed methodology was applicated to a part of the municipality of Naples, Italy. Naples is the third most populous city in Italy, with about 900,000 inhabitants and an average population density of 8,000 inhabitants on a surface of 118 sqkm. In particular, Naples historic centre is a unique example of architectural stratification through the centuries and is a vibrant catalyst of mixed activities. Along with these positive aspects there are many issues, such as the high population density and the strong rehabilitation needs of the built environment, including the cultural heritage (Fig. 1).

Fig. 1. Study area in the city of Naples, in Italy, embedding some historical districts.

The complexity of this local scenario of resources and challenges makes the area of Chaia, San Ferdinando, Montecalvario, San Giuseppe, Pendino, Porto, San Lorenzo an interesting study area, due also to their assorted characteristics in terms of urban fabrics, historical and architectural resources, activities distribution and geomorphological features, such as hilly conformation and coastal location.

Furthermore, defining the structure and relationships between the open spaces in this part of the city provides useful indications for assessing possible transformations to increase urban resilience and liveability.

Due to this heterogeneity, we expected that the open spaces located in some districts characterised by numerous urban redevelopment interventions would be more performing in come dimension, compared to the others located in districts where the attention dedicated to the supply and usability of urban places has decreased over time.

4.1 "Climate Adaptation" Dimension Index

Figure 2 shows the classification of open spaces according to the first Climate Adaptation synthetic index. It can be noted that Chiaia and San Ferdinando districts are mainly characterised by open spaces with medium and high normalised values of the index. These positive values, in terms of proper performance about climate vulnerability, can be related to the unified urban project of this part of the city where attention was dedicated to the ratio of full (buildings) to empty (spaces) in the urban fabric, by providing proper urban quality in terms of built and green open areas.

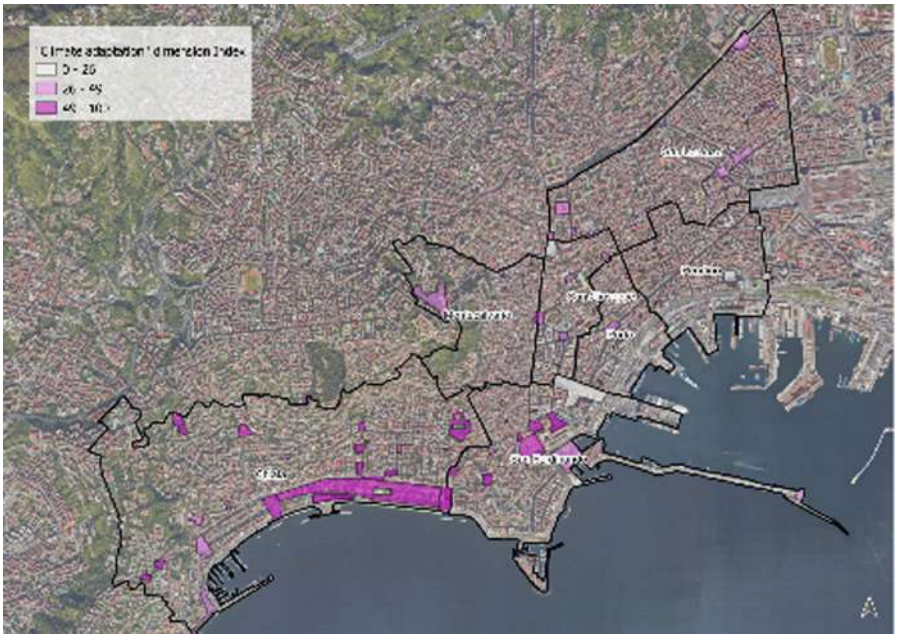

Fig. 2. "Climate adaptation" dimension index in the city of Naples.

The high historical and architectural value that characterises many of the open spaces of the San Giuseppe district and part of Montecalvario seems to be at the expense of their adaptability. The need to enhance and preserve places of such value clashes with the new requirements for water drainage and cooling, which call for adaptive measures

aimed at improving the eco-systemic capacities of these spaces, also affecting their reorganization.

Moving to the Porto, Pendino and San Lorenzo districts, here it is evident how the lack of attention to the quality of the urban environment and its maintenance lead to consequent criticalities both in terms of water runoff (absence of draining surfaces) and thermal comfort (absence of vegetation and therefore shaded surfaces). Some exceptions characterise San Lorenzo district thanks to the recent urban renovation interventions aimed at improving the tourist attractiveness of the relevant cultural and architectural heritage.

4.2 "Accessibility and Equity" Dimension Index

Figure 3 below displays the classification of open spaces according to the "Accessibility and equity" dimension index. It is worth noting that, differently from the climate adaptation index, here the open spaces that obtained the higher scores are the one in the ancient centre of the city (districts of Pendino, San Giuseppe, San Lorenzo, and Porto). What influences this result is the functional *mixité* of these districts and, in particular, the high density of cultural amenities like museums, exhibitions, theatres, and so on, and education facilities.

Fig. 3. "Accessibility and equity" dimension index in the city of Naples.

Other advantages consist in the variegated recreational and cultural offer and the typology of urban fabric, which can be referred to the structure of "walkable" cities, due

to the nature and historical development of this part of the city. The high accessibility for foreign population can be justified by higher percentage of foreigners in the central districts, more than in Chiaia and San Ferdinando.

Chiaia, according to the results, recorded lower levels of accessibility. This may be due to the morphological/orographic shape of the area along with the reciprocal position of open spaces. Who suffer from this distribution is the elderly because they could have greater physical impediments to reach these spaces.

4.3 "Urban Quality" Dimension Index

Figure 4 shows the "Urban quality" dimension index for the study area. We can observe a more homogeneous distribution, especially in the districts of Chiaia and San Ferdinando (higher scores) and Montecalvario, San Giuseppe and San Lorenzo (medium socres). Pendino and Porto still lag behind, because of scarce real estate value in the areas surrounding open spaces, the lack of urban furniture and higher levels of noise and air pollution.

Fig. 4. "Urban quality" dimension index in the city of Naples.

5 Conclusions

"The key to a liveable city is related to the quality of urban life that takes place in its squares, places and streets" claim Lennard and Lennard [51]. This statement can be considered basic for this work, because of the many reflections that can be derived

from it for the governance of urban and territorial transformations. Enhancing inclusive and sustainable development of cities requires effective use of its resources. Thus, it is becoming increasingly important to maximize the utilization of available space. Many sustainable development principles can be implemented directly when building new neighbourhoods, but this is considerably more difficult in historic and consolidated districts where there are few opportunities for new construction. In order to provide its inhabitants with high-quality open spaces, a city should not only set aside enough space for it but also ensure that it is managed and maintained in such a way that it can be fully utilized. Public areas need to be secure, age-friendly, open to all, and inclusive in order to be fully utilized and, in this perspective, there is an effort to creatively utilize the open space system in order to maximize it. For instance, Barcelona is oriented to reroute traffic and building "superblocks," which are refurbished to include more open spaces and walkable paths. Other cities like Vancouver, Milan and Philadelphia have been investing in the green transformation of their urban places, using pro-environmental branding strategies and practices to make them more attractive and desirable places where living.

Given this scientific framework, it is worth analysing the structure of the urban open space system according to its climate vulnerability, usability and liveability components. In order to achieve this objective, we developed a simple methodology to assess the performance of the open spaces related to these three main dimensions, by providing a first cognitive result for the study area located in the central part of the city of Naples. To this aim, 13 indicators were defined and they were then aggregated into three synthetic indexes useful to obtain an overall assessment of the urban open spaces system. The result was a classification of the open spaces according to the Climate Adaptation, Accessibility and equity and Urban quality indexes that can be visualised on digital maps, enabling a comparison of the historical districts under study.

For the application of the proposed method, we chose the central area of the municipality of Naples in Italy, which is characterised by the high heterogeneity of its districts in terms of resources, vocations and sustainable development. We found a great disparity between the central eastern and western districts. Specifically, while the former resulted to have better levels of accessibility and equity, the latter had better results in the fields of climate adaptation and urban quality. This situation is indicative of a diffused decay of the open spaces network in the ancient centre. The high walkability and accessibility of these districts is not enough to make the open spaces a point in favour of the population living there.

The aim of this was to support decision-makers in improving the resilience and attractiveness of the urban open spaces system, to contribute to increasing citizens' quality of life. In this sense, it represents the first step of a wider research work on the subject that will focus on the sustainable transformation and climate adaptation of urban open spaces system.

Future developments of the research will regard the structure of the methodology, especially for what concerns the techniques to classify open spaces and to weigh their main characteristics, according to the proposed dimensions. Furthermore, another application to a different city may confirm the replicability of the Index also for other contexts.

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