

## Article

# Accessibility to and Availability of Urban Green Spaces (UGS) to Support Health and Wellbeing during the COVID-19 Pandemic—The Case of Bologna

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**Abstract:** In accordance with SDG N11.7, each city should work on providing “by 2030, universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities”. This target became even more crucial during the COVID-19 pandemic restrictions. This paper presents and discuss a method for (i) assessing the current distribution and accessibility of urban green spaces (UGSs) in a city using hierarchical network distances; and (ii) quantifying the per capita values of accessible UGSs, also in light of the restrictions in place, namely social distancing during the COVID-19 pandemic. The methods have been tested in the city of Bologna, and the results highlight urban areas that suffer from a scarcity of accessible UGSs and identify potentially overcrowded UGSs, assessing residents’ pressure over diverse UGSs of the city in question. Based on our results, this work allows for the identification of priorities of intervention to overcome these issues, while also considering temporary solutions for facing the eventual scarce provision of UGSs and related health and wellbeing benefits in periods of movement restrictions.

**Keywords:** ecosystem services; spatial analysis; urban green areas; urban planning standard; ES supply and demand; green and blue infrastructure; distributional justice



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## 1. Introduction

Urban green spaces (UGSs) are an essential element of the urban environment, providing multiple ecosystem services (ES) that have been considered more crucial both during and after the COVID-19 outbreak [1,2]. This is even more relevant when we consider the beneficial effects of UGSs on physical and mental health. Indeed, in a time of societal and health crises, these effects may be even more valuable, requiring effective planning and management—a complex challenge, given the rapid changes in modern society and the need for continual adaptation [3]. Regulating ES are mostly relevant in terms of temperature regulation, including the reduction in cardiovascular risks and heat-wave-related diseases and deaths [4,5]. On the other hand, UGSs may serve as sites of physical and leisure activity associated with enhanced health and reduced risk for all-cause mortality and many chronic diseases, i.e., obesity, mental health, and children’s health [6–8]. In the context of this work, we will specifically investigate publicly accessible urban green spaces for recreational use, including parks, urban forests, and other open spaces available for the community’s daily recreational needs [9]. Many studies focus on the links between UGS proximity [10,11], UGS attractivity [12,13], and physical activity, highlighting the need for carefully distributing, planning, and designing UGSs to increase their usage in the city. An increasing number of studies are also focusing on UGSs’ potential effects on cognitive decline and the prevention of neurodegenerative diseases such as Alzheimer’s disease [14,15].

Studies on citizens' wellbeing and quality of life are now focusing on the multiple functions of UGSs and related cultural ecosystem services (CES), as well as the benefits generated [16]. Social cohesion, intended as sense of community, with a focus on trust, shared norms, and values, positive and friendly relationships, and feelings of being accepted and belonging, can be generated by the presence and the usage of UGSs, as reported by Forrest et al., 2001, Sugiyama et al., 2008 and De Vries et al., 2013 [17–19]. In all of these studies, social cohesion itself is also positively associated with health and wellbeing.

Whilst mapping the location and quantifying the benefits of regulating ES can be relatively straightforward, relying on modelling and assumption and taking into consideration the generated degree of errors, the precise definition of the area's boundary and the quantification of 'intangible' CES could be more challenging. Indeed, CES strongly depend not only on the characteristics and features of the UGSs (looking at the ecological and supply side of the ES cascade model [20,21]), but also on the preferences and needs of the respective users that interact with existing infrastructures, touching upon the demand side of the same ES cascade model. Since the benefits generated by CES are strictly related with access to, and the activities that beneficiaries perform in, a specific place and at a specific time, the distribution and the availability of UGSs in the city assume a crucial importance [22]. Indeed, ES, in general, and CES in particular, are not always evenly distributed in urban areas, and differential access to and the use of UGSs can exacerbate existing disparities [11,23,24]. When faced with the issue of satisfying the needs of high-density population in compact cities, it becomes increasingly important that UGSs are designed to meet the various needs and demands within an urban environment, taking into consideration the ecological, economic, and social constraints of complex socio-ecological systems [25]. While there have been studies on access and provision of public UGSs at the city level in Europe [11,26], there is a knowledge gap surrounding the distributional access of UGSs within urban areas. Indeed, despite the acknowledgment of the importance of proximity to UGSs for human health and wellbeing, and the rise of valuable examples such as the STEP program in the city of Vienna [27], most of European cities have assessed the presence of UGSs through quantitative planning standards. Those standards normally consist of a quantitative indicator, notably the minimum amount of square meters of green space per capita—i.e., 6 m<sup>2</sup> per capita in the city of Berlin, [11], 9 m<sup>2</sup> per capita in Italy [28]—which does not fully consider spatial distribution of UGSs, and may result in bias towards certain locations and, hence, certain social groups [29]. Proximity and accessibility to UGSs, as well as the assessment of the type of CES [30] that UGSs can provide, are therefore assuming a relevant role in debates among diverse disciplines in recent decades [31–34] raising the role of distributional justice studies around ES [35–37]. This role has been emphasized even more in the rise of the COVID-19 pandemic, when lockdown and other restrictions demonstrated the increased need and the changing perception of residents surrounding the issue of having accessible UGSs nearby [2,38,39]. Moreover, research showed that lockdown periods have reduced physical activity, particularly among people of lower socio-economic status, and have increased the risk of depression, anxiety, insomnia, and self-harm, especially for people living in inner-city flats without access to outdoor space or private gardens [40].

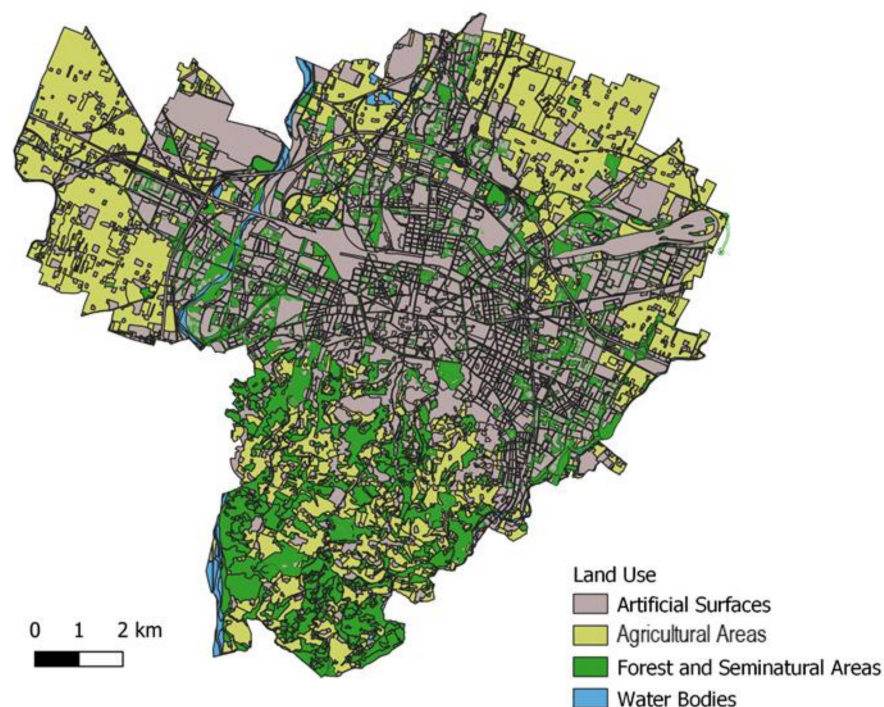
In this context, this paper presents and discusses a method for (i) assessing the current distribution and accessibility of UGSs in cities (supply of ES) using hierarchical network distances; and (ii) quantifying the per capita values of accessible UGSs, considering the number of people (*demand* of ES) able to access UGSs, also in light of the restrictions imposed during the COVID-19 pandemic regarding movement and social distancing. This approach has been tested in the city of Bologna and it aims to support urban planners and decision makers to address more targeted solutions for ensuring improved accessibility to UGSs for all; this approach not only takes into account possible movement restrictions during emergency times, but aims at providing insights on how to improve urban plans for a more just and resilient city.

## 2. Materials and Methods

This study used spatial analysis and calculation to assess both UGS proximity and relative per capita accessibility. To perform the analysis, a set of heterogeneous data was required. Most of the spatial data used such as the UGS location, road networks, georeferenced building position, and land use, came from Copernicus (<https://land.copernicus.eu/local/urban-atlas>, accessed on 4 October 2021) and the open access platform of the Municipality of Bologna (<http://dati.comune.bologna.it/> accessed on 4 October 2021) and the Emilia-Romagna region (<https://geoportale.regione.emilia-romagna.it/> accessed date 4 October 2021). As for the spatial data, the georeferenced information of the people living in each street was retrieved from direct communication with city functionaries, since this information was not publicly available. Most of the other data (e.g., UGS access points, sport feature presence and type, etc.) were obtained through analysis via Google Earth and Google Street View; this data collection method was also due to the COVID-19 restrictions in place during most of the data collection period of this study.

### 2.1. Case Study Area: The City of Bologna

Bologna is a compact city in the north of Italy, at the heart of the Emilia-Romagna region, with around 390,000 inhabitants. The average resident population density is around 2700 inhabitants/km<sup>2</sup>, reaching around 10,000 inhabitants/km<sup>2</sup> in the historical city center. As shown in Figure 1, the compact city center hosts mainly residential and tertiary areas, while the industrial and commercial areas are in the outer parts of the urban settlement. The remaining parts of the territory host agricultural land in the northern and western plains, while forests and seminatural areas prevail in the southern hilly area. The urban area is located on the floodplain between the Reno River and its tributary, the Savena River; the city is also crossed by a rather extensive network of artificial canals that run from the hills to the plain, crossing the urban center. This network has historically been an important resource for the city, especially during the medieval period when some of the canals were navigable. Over the centuries, they have been progressively buried, and today only a few small sections are visible.



**Figure 1.** Land-use distribution in the city of Bologna following the Corine Land Cover classification.

Impervious areas are prevalent in the historic city center, where the presence of green spaces is limited mainly to a few UGSs (Parco 11 settembre and Parco della Montagnola are the most representative), tree-lined squares, and green furniture. This scarcity is due to the medieval nature of the city center, where public spaces are mainly composed of streets, squares, and porticoes, with green areas mostly hidden in private courtyards. Outside the city center, UGSs are generally wider and better distributed, especially in those districts built since 1970, when minimum requirements for green areas were introduced into Italian planning law.

## 2.2. Distribution and Proximity Analysis of UGSs

The distribution of UGSs and relative CES generated in the city, district, or neighborhood has been addressed by many authors [41–44]. Moreover, there is a consensus regarding proximity and accessibility as crucial indicators [45] and essential pre-conditions to enabling the flow of CES from UGSs to the final users. Several methods and tools have been developed to evaluate the accessibility and proximity of urban green spaces. In the context of this work, we investigate publicly accessible UGSs of Bologna, including parks, urban forests, and other open spaces available for the community's daily recreational needs, identified through the Urban Atlas data sourced from Copernicus, and additional data sourced from the open data platform of the municipality. To identify public and accessible UGSs, we relied on manual mapping, since access points were not included in the land-use database. In this work, the access points to urban UGSs were identified through Google Earth, and later imported using ArcGIS.

Proximity analysis of the UGSs has been assessed through an ArcGIS network analysis using UGS access points, road networks, and network distances expressed in meters [34,46]. The network analysis produced polygons of 'served' and 'non-served' areas of the city. Even though a linear distance of 300 m is normally used and suggested by WHO, people may choose to cover longer distances to reach a certain place if this provides a particular service or features [46], and diverse UGSs may have diverse significance. Therefore, we propose to use hierarchical levels by applying different network distances to different UGSs categories of UGSs size (pocket park, community park, neighborhood park and urban park). To identify the diverse values of walking distances, that people may walk to reach a certain UGSs category, we referred to the existing literature [47–49], further adapting the diverse hierarchical levels to the case study dimension and characteristics. Indeed, the analyzed literature proposes case studies mostly covering metropolises (an area with more than one million inhabitants), with hierarchical distances that may be inappropriate for the case of a middle-sized city such as Bologna. The UGS hierarchical classes and relevant distances we propose are presented in Table 1.

**Table 1.** UGS class, related size, and network distance considered in this study for the city of Bologna.

UGS Class	UGS Area	Network Distance
Pocket park	0–0.5 Ha	200 m
Community park	0.5–2.5 Ha	300 m
Neighborhood park	2.5–10 Ha	500 m
Urban park	>10 Ha	1000 m

The following data have been considered to perform the network analysis:

- UGS distribution;
- Access points to the UGS as the intersections of the park roads and main road points;
- Road network (one layer including all road networks that crosses the city, including cycle lane, hiking, and pedestrian paths).

## 2.3. UGS Availability Analysis in the Park

As detailed in the previous section, proximity analysis supports in identifying city areas where there is higher or lower supply of CES based on UGSs distribution in the



different parts of the city. Nevertheless, proximity does not consider the overall number of citizens living nearby UGSs, thus the per capita space available and the potential pressure generated over the UGSs by the nearby residents. Moreover, the limitations imposed by several administrations during the COVID-19 lockdowns (especially in terms of social distancing and mobility restrictions) and, at the same time, the increasing need for CES in the times of full/partial lockdowns [1,3], created overcrowded UGSs [2], hampering the flow of CES to users. For this reason, we propose to analyze not only the proximity to urban UGSs, but also the per capita UGS available as a proxy to understand congestion or ‘pressure’ of each UGS service area. Since data related to UGS usages by residents were not available for the city of Bologna, we considered the total resident population living in the polygons previously generated by the proximity network analysis as the potential total demand of CES. Specifically, to calculate the potential pressure generated by nearby residents over a specific UGS, we calculated the number of people living in the polygons generated by the proximity network analysis (Section 2.3), using the georeferenced data of the population. Next, we divided the area of the UGS by the number of residents living in the polygon generated by the network analysis, as defined in Equation (1).

$$\text{UGSpresure} = \frac{\text{UGSdimension (Ha)}}{\text{Number of resident in the proximity area}} \quad (1)$$

Moreover, building on [50], we then defined three categories of UGS pressure as detailed here below in Table 2.

**Table 2.** UGS pressure categories according to the number of per capita square meters of a UGS.

Per Capita Sqm	UGS Pressure
>17	Low
9–17	Medium
<9	High

Within the scope of this work, we tested this method over two relevant examples around UGSs with a high resident population in the city using two diverse UGS types and relative hierarchical proximity distance (i.e., a community park, Parco 11 Settembre, and an urban park, Giardini Margherita).

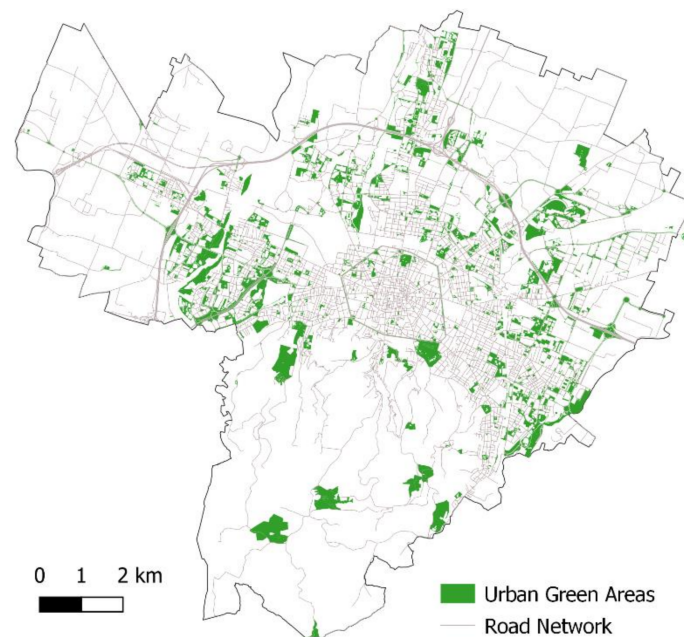
### 3. Results

#### 3.1. Proximity Analysis

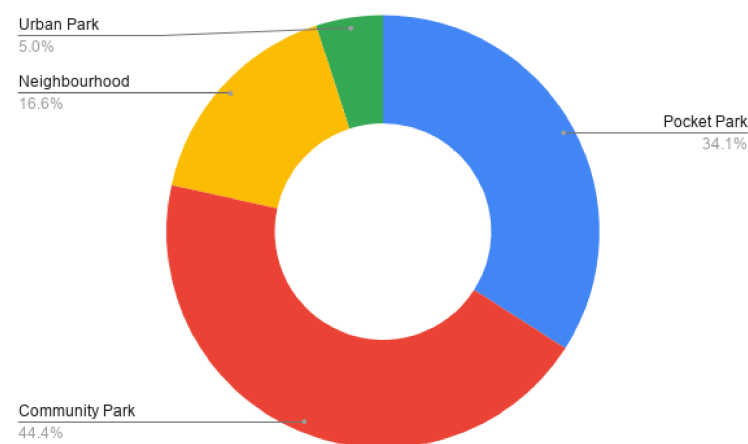
While previous studies addressing regulating ES in the city [51] evaluated the ES produced by the whole urban UGS (including private and non-accessible areas), within this study, we have identified 321 accessible UGSs in the city, as shown in Figure 2.

Similar to what has been acknowledged in previous studies [33], smaller areas are found to be the highest in number (Figure 3). Among these, pocket and community parks (up to 2.5 ha) represent around 80% of the total UGSs of the city, with community parks counting for the majority among all categories (44.4%).

As shown in Figure 4, most of the pocket and community parks are located within and around the city center and the first ring of periphery, while the biggest UGSs are farther from the city center.

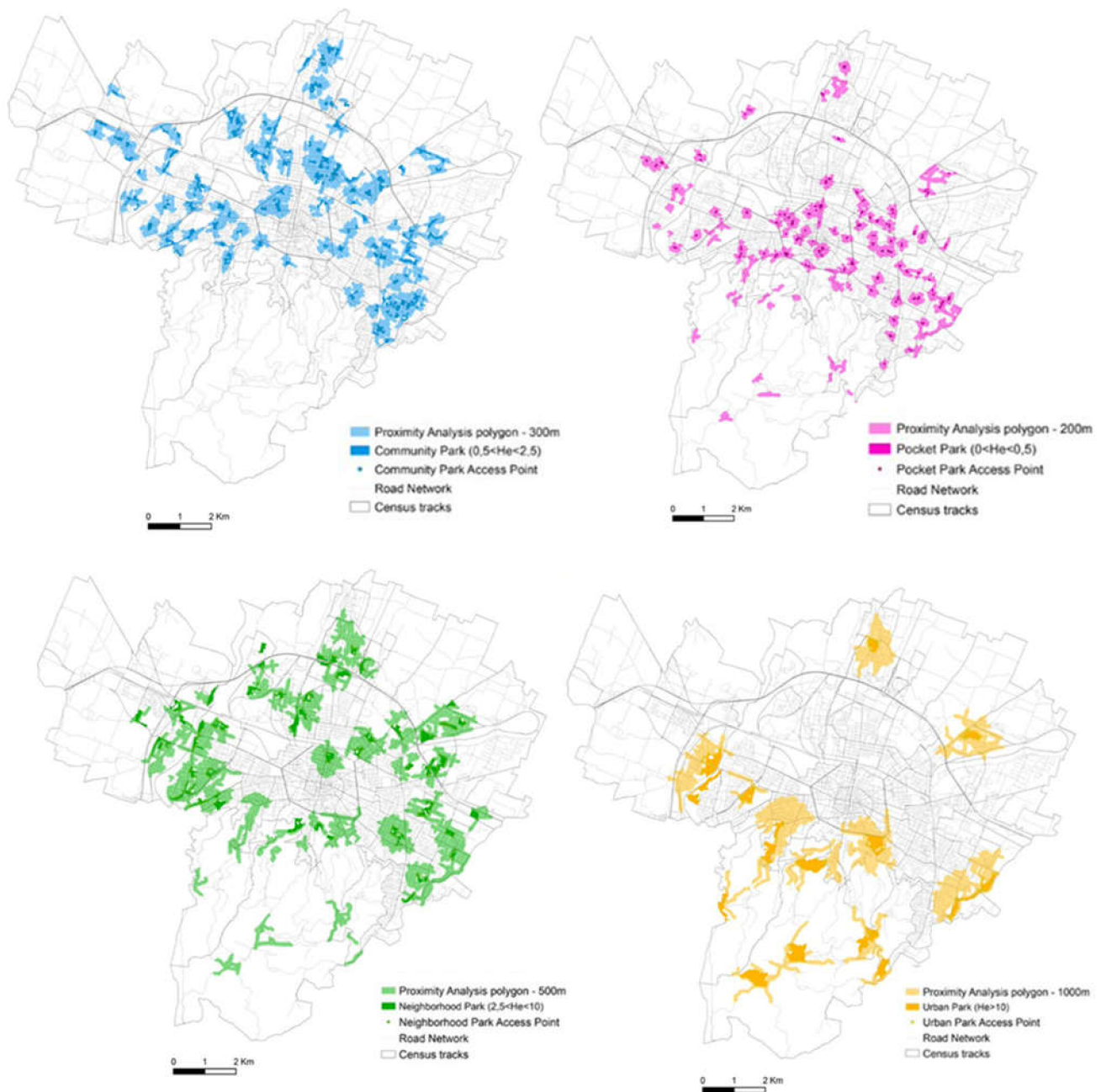


**Figure 2.** Map of accessible UGS distribution in the city of Bologna (Authors' elaboration).



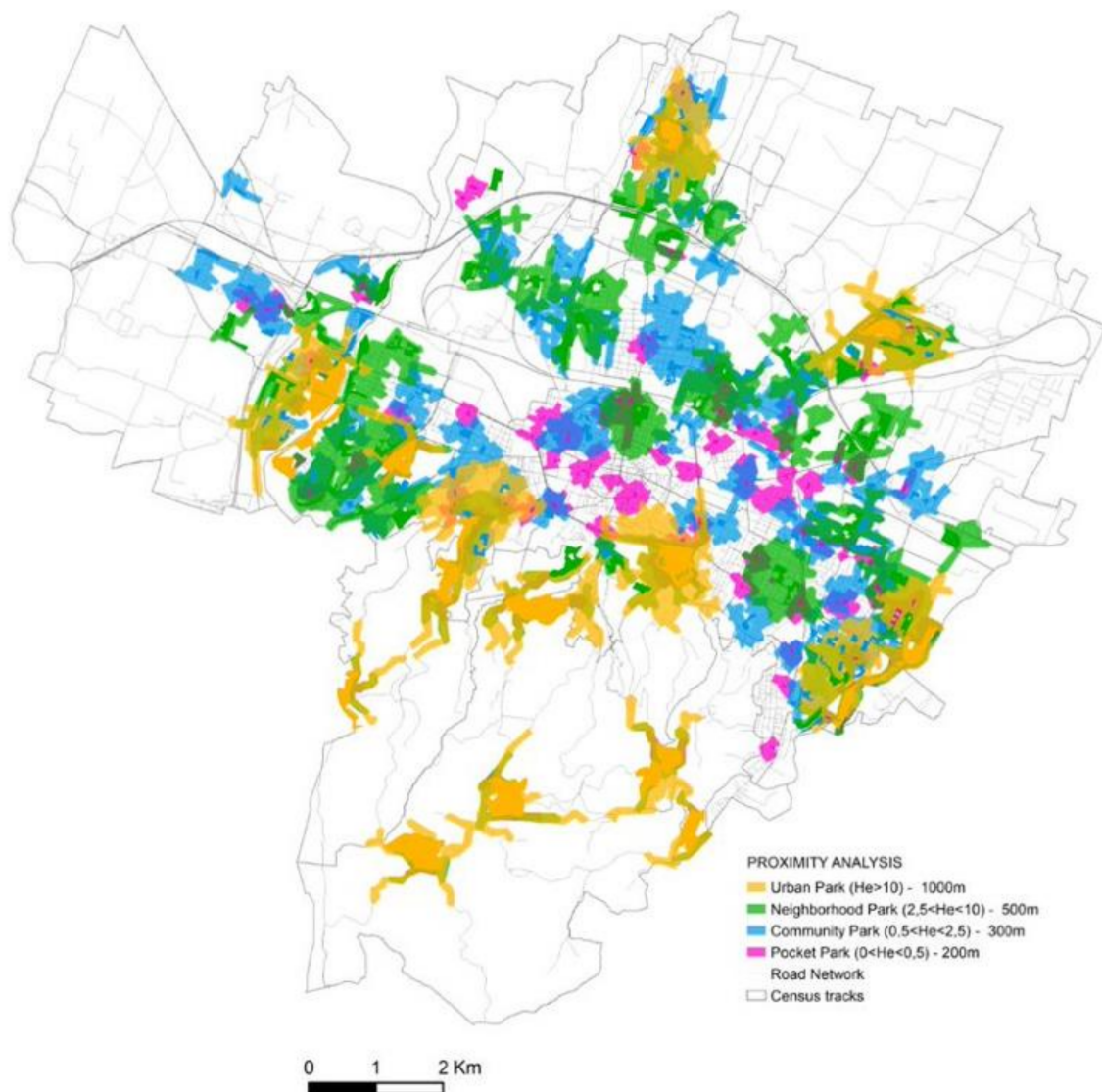
**Figure 3.** Share of UGS type based on their dimension (urban park, neighborhood park, pocket park, and community park).

Most of the city center districts are rich in pocket and community parks, highlighting the lack of large recreational UGSs in the dense city center, and highlighting urban portions totally deprived by such services, i.e., the south-east of the city center. On the other side, while there is just one park that overcomes the 2.5 ha threshold in the city center (Parco della Montagnola, located in the south-east area of the city center), most of the peripheral districts are covered by bigger UGSs, such as neighborhood and urban parks. The majority of the urban parks are located in the southern part of the city, mostly characterized by low density and low accessibility districts, being mainly hilly areas; this area contributes significantly to regulating services in the city of Bologna [51]. One urban park covering the north peripheral area and two river parks bordering the city at the east and west are the main exceptions. Neighborhood parks are well spread out around the city, except for in the city center, which presents a medieval structure, with narrow streets, arcades, and very few public green areas.



**Figure 4.** Proximity analysis at diverse hierarchical levels: yellow: urban park 1000 m; green: neighborhood park 500 m; blue: community park 300 m; pink: pocket park 200 m.

Figure 5 summarizes the four different analyses overlapping the proximity buffer areas of the four hierarchical levels of walking distances. The map shows that the southern hilly part of the city, despite its high concentration of greenery, presents many areas that are not served by any UGSs, partly due to the minimal access points of the UGSs present in this zone, and partly due to the low presence of road networks reaching these areas because of the territory's morphology. The city center presents an uneven situation, since some areas in the northwest are very well covered by the UGS services, while others, such as the southern and eastern areas, are not served.



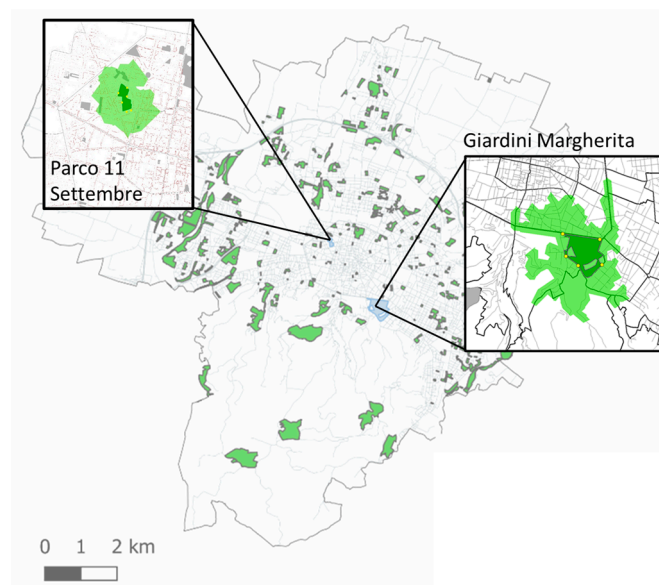
**Figure 5.** Merged proximity analysis hierarchical level: yellow: urban park 1000 m; green: neighborhood park 500 m; blue: community park 300 m; pink: pocket park 200 m.

While Figure 5 partly summarizes the results already described in Figure 4, it also provides additional information. Indeed, the overlapping of different buffer areas highlights not only the areas of the city that are served by UGSs, as shown in Figure 4, but it also introduces some additional information over the type, the size, and thus the related quality of accessible UGSs in the different parts of the city, as well as the multiple options in the same area covered by the different buffer zones. Notably, Figure 5 highlights that most of the services provided by UGSs in the city center come pocket and community parks; these are relatively small areas (<2.5 ha) that present consequent limited recreational possibilities, and have the potential to be overcrowded by multiple users. Moreover, several areas of the city center are deprived of the access to any kind of UGS within the adopted hierarchical distances. On the other hand, the southern area of the city center, despite the presence of few UGS, it is covered by large urban parks within a 1000 m network distance. Areas in the first periphery in the northern part of the city are served mostly by community and pocket parks, still leaving wide urban portions not covered by any UGS. Notably, areas in the extreme east and west of the city present much overlapping in the proximity buffer areas, suggesting that those areas are well covered by all four hierarchical levels considered.



### 3.2. Availability Analysis

Having analyzed the proximity of UGS and having identified some hotspots of well served/not served areas of the city, we addressed the potential pressure generated over the UGSs by nearby residents. To achieve this, we analyzed the proximity maps (Figures 4 and 5) and selected two relevant UGS within the city of Bologna (Figure 6). The selected UGSs are Parco 11 Settembre, a community park located in a relatively well-served area of the city center, and Giardini Margherita, an urban park close to the southeast area of the city center, among the least-served areas of the city. To understand the pressure on the considered parks, we calculated the population living within the areas highlighted within the proximity area (300 m for a community park, Parco 11 Settembre, and 1000 m for an urban park, Giardini Margherita).



**Figure 6.** Pressure analysis using two diverse UGS of Bologna (Parco 11 Settembre, community park, 300 m, and Giardini Margherita, urban park, 1000 m).

Results of this analysis are summarized in Table 3, and clearly show that, even though Parco 11 Settembre is placed in a generally well-covered area, it is actually under high pressure due to the high number of residents living within a 300 m network distance from the access point of the park. At the same time, Giardini Margherita, even though its network distance is larger, is under lower pressure, at it is able to provide 17.6 sqm/capita.

**Table 3.** Pressure generated over UGS by total served resident population.

Served Population	Network Distance and Type If UGS	Pressure over the UGS
6682	Community Park—300 m	3.4 sqm/capita—high
12262	Urban Park—1000 m	17.6 sqm/capita—low

## 4. Discussion and Conclusions

In accordance with Sustainable Development Goal (SDG) N11.7, each city should work on providing “by 2030, universal access to safe, inclusive and accessible, green and public spaces, in particular for women and children, older persons and persons with disabilities”. The recommendation coming from the SDGs and acknowledged by the World Health Organization (WHO, 2016) was to develop an indicator based on the analysis of GIS data on land use and population, reflecting the proximity of a population to urban green spaces. Within this study, we used network analysis to assess UGS proximity, defining four hierarchical levels of UGSs. While Tian et al. 2014 [52] suggested that an area of approximately 2 ha is the smallest UGS that people regularly want to visit, we noted

that the city, mostly in the densest historically significant areas, is generally well covered just by pocket parks (areas < 0.5 ha), with increasingly less coverage for bigger areas. Especially in the city center, just two areas reach the 2 ha size, leaving a highly densely populated area with few small UGSs to be shared by a great number of people. This is in line with what has been highlighted in other studies, where distribution of UGSs is related to geographical position, where the most central parts have less green space than areas nearer the periphery [33,53]. Even though small UGSs in the city center may have a strong connection with local everyday life [46], improving the quality of life among beneficiaries, this could lead to overcrowded spaces, with many people requesting and sharing the same services, thus impacting the flow of related benefits. This issue became apparent during the last year-and-a-half due to COVID-19 restrictions and the following limited access to UGSs. While people perceived that nature helped them to cope with lockdown measures [38], and while the increasing importance of UGSs for recreation and stress relief has been acknowledged during the COVID-19 pandemic [54,55], at the same time, people living in dense urban areas may have experienced issues in accessing and enjoying UGSs. The pressure analysis undertaken in this research demonstrated that, even though the northwest area of the city center appear to be well covered by diverse accessible UGSs, most of them are pocket parks and are not able to provide the whole range of CES, such as physical recreation, that wider areas are able to offer.

In conclusion, this methodology allowed us to assess the role of UGSs under different perspectives and to reach different levels of detail. While many studies have addressed the overall distribution number of UGSs in cities, the proposed method allows us to assess the proximity to and availability of UGSs in the city by evaluating their presence and ease of access to the spatial distribution of the population within the city. This allows local authorities to clearly identify and evaluate which areas suffer from a scarcity of UGSs or from reduced accessibility to UGSs, and to take appropriate planning decisions to overcome these shortfalls.

The added value of this method is also related to the possibility of considering the provision of UGSs in a period of movement restriction; to assess whether people are able to access a green space dependent on the different and changing distance limitations due to current and future pandemics; and to make the urban community more resilient to current and future health emergencies. This allows decision makers to adopt mitigation actions—e.g., increase the presence of pocket parks, improve UGS accessibility by adding access points, or developing temporary UGS in scarcely-served areas—allowing everyone to count on a green space within a reasonable distance from their homes.

Moreover, the results highlighted that, in order to ensure the proper provision of UGSs in some parts of the city, it could be sufficient to improve accessibility to them—e.g., adding access points to big UGSs—and not to create brand new UGSs, which are frequently more complicated to develop. This also means that improving access to or increasing the number of UGSs in densely populated urban areas with targeted regeneration intervention should be sought wherever possible, even with temporary interventions and solutions; this highlights the added value of considering the hierarchy of different UGSs in terms of different buffer zones as a simple proxy for their attractiveness. Acknowledging the densification tendencies in cities in western countries [56], and that large UGSs are a limited resource in compact cities, careful decisions should be made over such areas, with a view to protecting and enhancing them. By this token, a review by Ekkel et al., 2017 [10], acknowledged that cumulative opportunities matter in terms of health-related benefits, requiring accessibility to different UGS sizes and recognizing that bigger UGSs can provide wider health benefits. Even though the number of public UGSs does not express the quality and the type of the recreation opportunities offer to urban dwellers [57], and further research is needed to address this issue, the results of this analysis, at diverse hierarchical distances, can greatly support planners and decision makers over land-use decisions, providing them with evidence of the services required in different areas of the city.

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