Article

Smart City Governance and Children's Agency: An Assessment of the Green Infrastructure Impact on Children's Activities in Cagliari (Italy) with the Tool "Opportunities for Children in Urban Spaces (OCUS)"

Chiara Garau *[ID] **and Alfonso Annunziata**

Department of Civil and Environmental Engineering and Architecture, University of Cagliari,
Cagliari 09123, Italy
* Correspondence: cgarau@unica.it; Tel.: +39-070-675-5565

check for updates

Abstract: The increases in urbanization, pollution, resource depletion, and climate change underline the need for urban planning policies that incorporate blue–green infrastructure (BGI) and ecosystem services. This paper proposes a framework for assessing BGI's effect on children's outdoor activities. This effect, called meaningful usefulness, is a central issue due to the influence of experiences with nature on children's development and the global trend of concentration of children in urban areas. Based on the concept of affordance, the methodology formalizes meaningful usefulness in terms of an index of usefulness of individual settings (I_{UIS}) and a synthetic index of usefulness of BGI in a specific area (I_{SGI}). These are determined via an audit protocol, Opportunities for Children in Urban Spaces (OCUS), which incorporates a set of indicators measuring micro-scale properties of individual places and contextual macro-scale factors. The methodology is applied to BGI components in Cagliari, Sardinia, Italy, which was selected for its superior density of urban green spaces. The application of the OCUS tool confirms its usefulness for investigating functional affordances incorporated into the trans-scalar structures of BGIs. The analytic protocol further contributes to the implementation of urban planning strategies within the smart city paradigm.

Keywords: green infrastructure; smart city; affordance; children

1. Introduction

As Martintotti [1] observed, the city needs to be celebrated as the product and heart of the most advanced manifestation of civilization, the center for commerce, learning, and culture, and the production of the most significant scientific and technological advancements.

The emergence—and triumph—of cities manifests in the global process of mass urbanization, a trend determining that "today, half the world's population lives in urban areas and, by 2050, all regions will be predominantly urban. According to current projections, virtually the whole of the world's population growth over the next 30 years will be concentrated in urban areas" (p. IX) [2]. This process is associated with the phenomena of pollution, resource depletion, climate change, rising energy costs, decrease in biodiversity, growing inequality, and deterioration of microclimatic conditions [3]. These phenomena, alongside the "preoccupation with preventing and minimizing the effects of the next natural or manmade disaster" and the need to preserve the centrality of cities as places of excellence, will determine the formulation and implementation of urban paradigms that orient the transformation of the built environment, including the smart city paradigm. In fact, the latter calls for governance practices and planning strategies that activate synergies among traditional infrastructures, information and communication technology (ICT) infrastructures, and socio-economic

structures aimed at supporting sustainable economic development and a high quality of life, with proper management of natural resources through participatory action and engagement [4]. In this respect, the green infrastructure-based approach emerges as a key tool for re-configuring the city as an inclusive, healthy, anti-fragile, connected urban ecosystem by achieving a balance among urban and ecological processes and systems, increasing biodiversity, and incorporating resilience measures for preventing and minimizing effects of storm, flood, heat, drought, and pollution [3].

The benefits provided by blue–green infrastructures extend beyond the ecological and environmental dimensions and likewise affect the social and economic structures of the city. These benefits are comprehensively understood within the conceptual framework based on the notion of ecosystem services (ES). A comprehensive definition of urban blue–green infrastructure (BGI) and ecosystem service is presented in Section 2.

Focusing on the social dimension of ecosystem services, the purpose of this paper is to structure the theoretical framework and provide an analytic protocol for assessing the ways in which green infrastructures affect children's opportunities to engage in independent meaningful outdoor activities. These are defined as activities and practices motivated by intentions, goals, and purposes, thereby significantly contributing to the emergence of psychological place experience [5]. The potential of urban BGIs to enable children's mobility, agency, and meaningful engagement with places and objects by supporting their independent functional, optional, recreational, and social outdoor activities is referred to as meaningful usefulness.

The theoretical framework is based on the concepts of capability, affordance, behavior setting, and functional description of places, introduced by Sen [6], Gibson [7], Barker and Wright [8], and Heft [9], respectively. In particular, the affordance concept refers to the functional, social, and emotional opportunities and constraints for a specific individual, incorporated into environmental features. For this reason, it is considered as a central category for describing the public space potential to promote people's activities. The methodology builds on these concepts by operationalizing the concept of meaningful usefulness in terms of an index of usefulness of individual natural settings (I_{UIS}) and of a synthetic index of usefulness of the urban blue–green infrastructure in a specific area (I_{SGI}). These indexes are determined via the application of an audit protocol, the Opportunities for Children in Urban Spaces and Natural Settings (OCUS_NS). This analytic tool, created by the authors, incorporates a set of qualitative and quantitative indicators that measure micro-scale properties of individual places and contextual macro-scale factors. This research focuses on the urban context for two reasons: the potential of building on the findings from the literature on children's independent mobility, physical activity, and walkability, as well as the emergence of the contemporary city as the most common milieu of children's development determined by the global trend toward urbanization. As United Nations Children's Fund (UNICEF) [10] observed, more than one billion children live in urban settings around the world; in the future, the majority of children will grow up in towns and cities. This research fills a gap in the literature on blue–green infrastructure and on children's experience of the public space by underlining the increase in opportunities of children's engagement and transactions with natural settings as a central aspect of the social dimension of ecosystem services.

In fact, children's contact with nature emerges as a central issue for two intertwined reasons: the influence of experiences with nature on children's cognitive, bodily, social, and emotional development [11–14], and the correlation between early nature experiences and the development of human nature connections, which in turn affect the possibility of the "trans-generational establishment of sustainable futures" (p. 2) [15]. The human–nature connection emerges as a central leverage point for enabling the transition of a socio-ecological system to a sustainable and resilient future [16].

The methodology is applied to the assessment of a trans-scalar mosaic of blue–green infrastructure components identified across the city of Cagliari in Sardinia, Italy. The city of Cagliari was selected as a subject for the case study due to its significant availability and density of urban green spaces, which are superior to the average values measured for major urban areas on a national scale [17]. The paper is divided into in five sections. In Section 2, a literature review on urban blue–green infrastructure

and on children's experience of outdoor spaces outlines the theoretical framework by defining the concepts of affordance, behavior setting, green infrastructure, and ecosystem service; afterward, the methodological framework and the case study are described. The results of the application of the audit protocol to the case study are outlined in Section 3, while the most relevant findings are discussed in Section 4. Finally, Section 5 discusses the relevance and the limitations of this research and outlines its development in the future.

2. Materials and Methods

2.1. Urban Blue–Green Infrastructures

Benedict and McMahon [18] define green infrastructure as "an interconnected network of waterways, wetlands, woodlands, wildlife habitats, and other natural areas; greenways, parks, and other conservation lands; working farms, ranches, and forests; and wilderness and other open spaces that support native species, maintain natural ecological processes, sustain air and water resources, and contribute to the health and quality of life of communities and people". Consequently, an urban green infrastructure (Urban BGI) can be conceptualized as an interconnected network of open spaces, natural areas, urban woodland, and parks; green streets, squares, and public realm; sustainable drainage systems, rivers, and waterways; cycleways and pedestrian routes; and smaller-scale interventions such as green roofs, walls, and facades that contribute to people's wellbeing and to the balance between city and nature by providing ecological, economic, and social benefits, including water purification, retention, and drainage, biodiversity, local food production, recreation carbon storage, social cohesion, and identity building [3,19–22]. Hence, the green infrastructure-based approach implies planning, designing, realizing, regenerating, and connecting the components of the green and blue networks into a trans-scalar, capillary, contiguously connected infrastructure.

The benefits that humans obtain from green infrastructures are referred to as ecosystem services. The concept of an ecosystem service is widely utilized since it incorporates and underlines the notion that natural systems are socially valuable and are present in forms that are not immediately intuitable [23]. Nevertheless, several definitions of ecosystem services and different classification protocols can be traced in the current literature [21,22,24–26]. In general terms, ES can be defined as "the benefits of nature to households, communities, and economies" [22]. Several studies underline that ES determines trans-scalar neutral, synergic, and trade-off relationships among households and communities, thus emphasizing the significance of understanding these interactions as a pre-condition for informed decisions on politics and interventions related to environment, economics, and land use [27–29].

2.2. Concepts for Assessing Urban BGI Components

As stated in the introduction, this paper focuses on the social dimension of ecosystem services and highlights the relevance of urban BGI components in terms of children's nature experiences and independent outdoor activities. Children's independent activities are herein defined as the complex of children's practices carried out across public space without adult supervision. These include independent mobility—the freedom and/or ability of children to travel across the urban space and play outdoors. This is conceptualized both as a vector for physical activity [30] and as a creative act of spatial appropriation and of meaningful engagement with spaces and objects, conducive to dwelling and enchantment [31]. Within this framework of reference, nature experiences can be conceptualized as the complex of children's transactions with natural settings. The benefits to children's wellbeing brought about by nature experiences and outdoor activities are better understood through the capability approach. Capability is described as a valuable state of being or a condition that a person can access [6,14,32]. According to Chawla [14], children's transactions with natural settings are associated with the realization of 10 general capabilities: life; bodily health; bodily integrity; affiliation; practical reason; play; senses, imagination, and thought; emotions; connection to nature and other

species; control over one's environment. These capabilities are pre-conditions to the development of foundational capability. In particular, direct nature experiences during childhood emerge as crucial moments of "sustainable enculturation, with long-lasting consequences for sustainable social–ecological systems" (p. 2) [15]. In fact, early nature experience is central to structuring the psychological traits of human–nature connection, which in turn emerges as the most relevant leverage point for modifying society's mindset and for structuring resilient and sustainable social–ecological structures [33,34].

The concept of affordance is, thus, introduced here as a central category for understanding and describing the transactions among individuals and spaces and for investigating environmental factors that influence practices and behaviors. Building on definitions proposed by Gibson [7] and Heft [9], an affordance can be conceptualized as a functionally significant character of the environment, considered in relation to an individual (p. 20). Kyttä [35] observed that the concept of affordance also includes the emotional and social opportunities and restrictions incorporated in an environment in relation to a specific individual. Kyttä [36] likewise introduced a distinction between potential and actualized affordances. The former refer to the infinite number of generic possibilities incorporated into the structures of a setting, while the latter refer to opportunities determined by the attributes of the spatial, material, and sociocultural features of a setting that are congruent with the corporality of individuals, as defined by the complex of their necessities, abilities, and physical, social, and psychological characteristics. Thus, the concept of affordance is relational in nature and overcomes the subject–object dichotomy.

A concept related to that of affordance is the notion of behavior setting, introduced by Barker and Wright [8]. According to Kyttä [35], a behavior setting can be defined as a social and cultural context where a dynamic, yet stable pattern of actions is generated by joint participation of two or more individuals with the support of affordances. The relationship between activity and the milieu is synomorphic, that is, it implies consistency among actions and environmental features.

These concepts are the structural categories for investigating the activities across a given space. Building on Barker and Wright's "one boy's day" [37], Heft outlines a taxonomy of environmental features alternative to that "of the standard classification by form". In Heft's words, environmental elements within this taxonomy are classified in terms of distinctive functional properties—being ride-on-able, climb-on-able, sit-on-able, run-on-able, etc.—that constitute the environmental counterparts of observed activities [9].

The observation of different hierarchical relationships in affordance categories results in the establishment of a synthetic functional taxonomy of environmental features, which are structured into 10 categories: (i) flat, relatively smooth surface; (ii) relatively smooth slope; (iii) graspable/detached object; (iv) attached object; (v) non-rigid attached object; (vi) climbable feature; (vii) aperture; (viii) shelter; (ix) moldable material; and (x) water [9].

The functional perspective incorporated into Heft's taxonomy suggests a conceptualization of environmental features that is commensurate to the intentional and active characteristic of psychological functioning. Moreover, it emphasizes the developmental dimension of places and of interactions within places; the functional possibilities incorporated into environmental features change according to the developmental status of the individual or group.

Building on these considerations, Lerstrup and Konijnendijk van den Bosch [38] clarified Heft's definitions and revised the hierarchical relationships among the functional categories, defining an alternative functional taxonomy structured in 10 classes: open ground, sloping terrain, shielded places; rigid fixtures; moving fixtures; loose objects; loose material, water; creatures; fire. Two fundamental considerations emerge from this study. The first concerns the individuation of transversal characteristics of environmental features that significantly influence children's patterns of activities; these qualitative properties are variation and uniqueness, abundance, novelty and change, and size and gradation. These properties affect the significance and attractiveness of environmental features, the availability of the affordance for a particular activity to all users, and the creation of a testing environment, which in turn enables the development of children's abilities and competencies.

The second observation concerns the constitutive ambiguity of the notion of affordance, whose meaning depends on the particular perspective adopted. Hence, the term affordance can be interpreted as "affordances of a setting", referring to the action possibilities incorporated into a setting, as "affordances for an activity", thus identifying features that support specific actions, and sometimes as "affordances for someone", referring to either of the two. Nevertheless, according to the definition of affordance as a multi-dimensional concept, which includes social, emotional, cognitive, and cultural properties, an analysis on the affordances incorporated into a setting should extend beyond the dimension of instrumental functionality. According to Broeberg et al. [39], social affordances, thus, refer to the opportunities "to be with adults", "meet friends", and "make new friends", as well as including the unpleasant possibilities of contact with social milieu fragilities, i.e., antisocial practices, such as "unpleasant gangs" and "scary adults", or of negative social interactions including "feeling like an outsider" or "being lonely". Moreover, social affordances also refer to conditions conducive to sense of privacy and territoriality, affected by adults' practices and appropriation of spaces, including "kids not allowed" or "strict control". On the other hand, emotional/contextual affordances refer to possibilities, incorporated into the spatial and social structures of a place, of experiencing positive or negative emotions and stimuli, including the possibilities of perceiving a place as beautiful, calm, quiet, safe, exciting, and clean or, contrastingly, noisy, dirty, dangerous, and stressful.

Finally, accessibility is defined either as potential for interaction or as the actual freedom to participate in different activities, thus partially overlapping with the definition of capability. Geurs and Van Wee [40] observed that the concept of accessibility incorporates four dimensions: a transport component, a land-use component, a temporal component, and an individual component. The concepts of capability, affordance, accessibility, and behavior setting are central to the construction of the theoretical model of the proposed audit tool. The complex of functional, emotional, social affordances, and accessibility conditions incorporated in environmental features determines the potential of urban BGI components to support children's nature experiences and meaningful outdoor activities, which in turn enable children's realization of foundational capabilities. This potential is referred to as meaningful usefulness.

The concept of meaningful usefulness, hence, incorporates the conceptualization of child-friendliness as the potential of the public space to support intense engagement with the environment, leading to experiences of enchantment, learning, and gaining competence through experience, as well as the claiming, interpreting, and appropriation of spaces and environmental features. Nevertheless, while the concept of child-friendliness, as observed by Whitzman et al. [41], is pre-eminently associated with a social and health planning perspective, the introduction of the concept of meaningful usefulness reflects the intention to focus on material and spatial conditions of the environment that incorporate the functional, social, and emotional opportunities that influence children's experience of the urban space.

2.3. Review of Methodological Approaches

Finally, a central contribution for structuring a methodological framework is derived from different methodological approaches incorporated in models which operationalized the concepts of child-friendliness and walkability.

In particular, the Bullerby model, structured by Kyttä [36,42] and revisited by Broberg et al. [39] and Kyttä et al. [35,43], combines children's experiences, operationalized in terms of actualized affordances and of their diversity, collected through public participation geographic information systems (PPGIS), and objectively measures structural properties of the built environment. PPGISs are also central in the web-map-based survey structured by Lopes et al. [44]. A different observational protocol is incorporated in audit tools. These tools—including the Survey on Conditions of Practicable Environments (SCOPE), the Public Open Space Desktop Audit Tool (POSDAT), the Pedestrian Environment Data Scan (PEDS), the Environmental Assessment of Public Recreation Spaces (EAPRS), and the Procedure and the Quality Index of Parks for Youth (QUINPY)) [45–48]—incorporate qualitative and quantitative indicators

and sub-indicators and aggregate data collected from direct on-site observation and/or secondary data retrieved from informative territorial services, internet-based street-level imagery services (Google Street View), and territorial imagery services (Google Maps, Google Earth, Bing Maps). The combination of primary and secondary data, and of qualitative and quantitative indicators, is also central to multicriteria evaluation models [49–52]. These tools integrate spatial information related to macro-scale built environment factors and evaluation of micro-scale site-specific urban design features, reflecting a conceptualization of a place's inclusivity or usefulness as the product of both inherent and endowed contextual properties. Finally, questionnaires focus on reporting pedestrians' perceptions and preferences related to significant spatial, environmental, and social properties of the urban space (Neighborhood Environment Walkability Survey (NEWS)) [53]. In Section 3, the methodological framework for assessing the meaningful usefulness of natural settings does not incorporate the urban blue/green infrastructures and describes the "Opportunities for Children in Urban Spaces" tool.

3. Methodology

The OCUS tool is considered an audit tool that integrates quantitative and qualitative indicators for evaluating and measuring the availability of functional, emotional, and social affordances and the conditions of access to open public spaces, determined by the configurational, compositional, and material conditions of the urban blue/green infrastructures at different scales (Table 1). Indicators and sub-indicators are, hence, organized into four categories: (i) functional opportunities; (ii) social opportunities; (iii) emotional/contextual opportunities; and (iv) independent accessibility opportunities. With respect to the functional opportunities dimension, each indicator refers to a specific category of functional properties that evaluates and measures the availability, variety, size, gradation, and uniqueness of environmental features incorporating a specific class of affordances. For instance, the indicator potential appropriation of open grounds measures the presence of flat void surfaces, the number of available regions of open ground, the size and dimensions of the most favorable surface, and variety in form, size, and surface among the regions of open ground. Moreover, the developmental characteristic of transactional interactions among users and settings, incorporated in the concept of affordance, compels the definition of the users considered and the determination of the pertinent indicators of meaningful usefulness. Consequently, the research focuses on users ranging from 9–13 years of age. According to Shaw et al. [54], this range is consistent with existing studies on children's experience of places and reflects sensible variations in children's level of independent mobility. The lower limit of this age range is associated with a relevant increase in the number of children in Italy who are allowed to cross major roads and go to relevant places within walking distance. On the other hand, age 13 is associated with the threshold beyond which the majority of children exercise the ability to cross major roads, travel alone on local buses, and independently go to school and to relevant places within walking distance.

Indicators included in the emotional and social opportunities dimensions assess and measure conditions and materials of the public space that incorporate specific social and emotional opportunities and restrictions for children. The social and emotional affordances, which were defined through building on findings from studies conducted by Kyttä [42], Broberg et al. [39], and Kyttä et al. [35], are associated with specific configurational, compositional, and material characteristics of the public space, operationalized in terms of representative indicators and sub-indicators. The correlation among features of natural settings, emotional and social affordances, and the individuation of pertinent indicators is based on the literature on built environment. This study correlates walkability, children's independent mobility, and children's physical activity.

Table 1. Indicators incorporated into the Opportunities for Children in Urban Spaces (OCUS) tool. POS—public open space.

Affordance	Environmental Features	Indicator (Ind.)
Functional affordances		
Walking, running, cycling, playing ball	Open ground	Ind. potential appropriation of open grounds (presence, size, quantity, variety)
Rolling/sliding/running down, rolling objects down, jumping down, jumping over, sitting in	Sloping terrain	Ind. potential appropriation of sloping terrains (presence, gradation, quantity, variety)
Hiding, as frame, microclimate	Repaired space	Ind. potential appropriation of repaired spaces (presence, quantity, variety)
Sitting-on, jumping, running around, hiding behind	Rigid features	Ind. potential transaction with rigid features (presence, quantity, variety)
Climbing, balancing on, hanging by arms, hanging in legs	Rigid climbable features	Ind. potential transaction with rigid climbable features (presence, quantity, variety)
Swinging on, dangling swaying in, seesawing on, spinning	Non-rigid, moving features	Ind. potential transaction with non-rigid moving features (presence, quantity, variety)
Drawing, scratching, throwing, hammering, batting, building	Loose objects	Ind. potential manipulation of loose objects (presence, quantity, variety)
Construction of objects, pouring, modification of surface features	Loose materials	Ind. potential manipulation of moldable materials (presence, quantity, variety)
Splashing, pouring, floating objects, drinking	Water	Availability of water (presence, quantity, variety, size)
Following, catching, caring for	Creatures	Presence of animals, insects, birds
Ensuring hygienic conditions	Lavatories	Availability of lavatories
Accessing web-based apps, communicating	Internet access	Internet coverage
Feeling safe	Natural control of the POS	Eyes on the POS
Pleasant place	Conspicuousness	Imageability of the POS
Quiet	Acoustic Environment	Quality of the acoustic environment
Breathing clean air	Pollution	Concentration of particulate matter
Clean public space	Maintenance of POS	Cleanliness of surfaces, equipment
Luminous	Illumination	Ind. of potential usability of the POS during night hours
Meeting friends	Meeting places	Presence or visibility of meeting places
Privacy/control	Sense of privacy and territoriality	Degree of children's appropriation of spaces
Being with adults	Intergenerational activities	Presence of intergenerational activities
Make new friends	Anchor places	Presence of anchor places within a 400-m buffer (sports facilities, educational institutions, shopping malls, formal sites for play)
Lively	Presence of people	Degree of liveliness of the public space (density of retail activities and services; presence of outdoor activities)
Unpleasant/scary people/antisocial practices	Signs of neglect	Broken window
Access by collective transport	Access to mass transit	Proximity of collective transport nodes
Access by walking alone or with friends	Accessible pedestrian network	Category of contiguous pedestrian facilities
Dealing with vehicular traffic	Priority of vulnerable users and soft mobility modes	Barrier effect (main entrance or worst condition)
Access by cycling alone or with friends	Accessible bicycle facilities	Category of contiguous bicycle facilities
Access to other relevant places	Land-use diversity	Walk score
Frequent access	Residential density	(Prevailing typology/segments surrounding the POS)

Moreover, according to Garau and Pavan [51], Garau et al. [45], and Abis et al. [55], indicators and sub-indicators are selected as a function of criteria of objectivity (indicators must be clear, unambiguous,

and precise); relevance (significance and pertinence to the focus of the analysis, i.e., the concept of practicability); measurability and reproducibility (indicators must be quantitative and systematically observable); validity (implying possibility of verification and data quality control); representativeness, comparability over time, and applicability (possibility of use of findings from previous research and existence of accessible databases); and understanding (indicators must be easily understandable by the target audience, i.e., by decision-makers and the general public) [45,51,55].

For instance, a repaired space is an enclosed region of space incorporating a refuge, affording prospects for hiding, lying in, or sitting in. An enclosed region is defined as a space bounded on three sides, or as a space covered by a ceiling of height not superior than 2.15 m. The indicator potential appropriation of repaired spaces is calculated as the mean of the scores assigned to sub-indicators assessing the presence, number, and variety of enclosed regions of space. Similarly, the indicator potential transaction with rigid features assesses the presence, quantity, and variety of rigid, non-movable features (including trees, retaining walls, benches, stairs) that afford sitting on, jumping on/over/down from, running around, hiding behind, and building on [9,38]. The presence of creatures, determining the affordances of observing, following, and caring for creatures, is considered as a condition that affects the central children's capability to live with concern for and in relation to animals, plants, and the world of nature [32].

Moreover, according to Jacobs's [56] seminal work, the emotional affordance of feeling safe is associated with the opportunities of natural surveillance of the public space. This environmental parameter is operationalized in terms of the sub-indicators "visibility of the nearest buildings", "interactivity of façades", and "presence of activity with extended open hours", introduced by Saelens et al. [47], Gehl [57], and Moura et al. [49], respectively. These sub-indicators are then aggregated into the indicator "eyes on the street". Furthermore, the social affordance for making new friends is associated with the proximity of anchor places and, thus, to the presence of primary functions conducive to the concentration of people. This environmental factor is operationalized in terms of the indicator "existence and visibility of anchor places", introduced by Moura et al. [49]. The conspicuousness of a setting, related to the emotional affordance of being in a pleasant space, is conceptualized as the resultant of the geometric layout of a surface, captured by the sub-indicator articulation of edges, and of the presence of unique elements, including natural structures, artifacts, major landscape features, and distinctive buildings. These distinct aspects of a setting are associated with the coherence and imageability of a space and to its effects on re-orientation and individuation of goal locations. In fact, a study by Lee, Shusterman, and Spelke [58] revealed that children's navigation behaviors depend on two distinct processes: a modular process of re-orientation based on the geometry of the surrounding surface layout and an associative process that relates unique elements and landmarks to locations.

In addition, developmental processes extend core abilities, permitting more flexible strategies, emerging from the combination of geometric and non-geometric information [58]. Opportunities for independent accessibility refer to a multi-dimensional [40,59] concept of accessibility, encompassing transport, land use, temporal, and individual components within the conceptual framework of the OCUS tool. This concept is related to macro-scale contextual factors, including access to mass transit [45], access to pedestrian facilities [59], access to bicycle facilities, priority of vulnerable users [49], residential density, and land-use diversity [45].

The determination of indicators related to micro-scale features incorporating functional, emotional, and social affordances is based on primary data, collected during on-site observation and integrated with secondary data retrieved from informative territorial services and internet-based street-level imagery services. Moreover, on-site observations are conducted according to a form, containing a list of items related to specific environmental features and properties to assess. Information retrieved from the forms is integrated with images taken during the observation. Finally, accessing internet is considered a relevant opportunity for children in order to interact, via their mobile phones, with peers and parents, for instance, exchanging images, audio files, and text messages.

The combination of qualitative and quantitative indicators, measured via specific scales, poses the problem of the normalization of results in homogeneous quantitative terms in order to aggregate the single indicators, related to specific affordances, into the global index of meaningful usefulness. Consequently, with respect to the qualitative indicators, a score ranging from 0–4 is determined for each scale level. For quantitative indicators, levels of performance corresponding to a specific range of values are defined.

Afterward, a score ranging from 0–4 is assigned to each value band. Each indicator incorporating a set of sub-indicators is expressed via a score calculated as the mean of the score determined for the single sub-indicators (Table 2).

Table 2. Examples of indicators and scoring procedures.

Indicator	Type	Measurement	Scale	Score
Ind. potential appropriation of open grounds	Quantitative	Presence (binary evaluation)	Yes	4
			No	0
		Size (L_1 and/or L_2)	70 m $\geq L_1$ and $L_2 > 25$ m	4
			100 m $\geq L_1$ and/or $L_2 > 70$ m	3
			25 m $\geq L_1$ and $L_2 > 15$ m	3
			15 m $\geq L_1$ and/or $L_2 > 6$ m	2
			(L_1 and/or L_2) > 100 m	1
			6 m $\geq$ (L_1 and/or L_2)	0
		Quantity	=1 region of open ground	0
			=2 regions of open ground	2
			>2 regions of open ground	4
		Variety in terms of surface, size, geometry	Yes	0
			No	4
		Average	$(S_1 + S_2 + S_3 + S_4)/4$	
Density of retail activities and services	Quantitative	r/100 m; r = number of retail activities	$20 \geq$ r/100 m > 16	4
			$16 \geq$ r/100 m > 12	3
			$12 \geq$ r/100 m > 8	2
			$8 \geq$ r/100 m > 4	1
			$4 \geq$ r/100 m ≥ 0	0
Proximity of collective transport nodes	Quantitative	Distance from the nearest transport node	Dct ≤ 100 m	4
			200 m $\geq$ Dct > 100 m	3
			300 m $\geq$ Dct > 200 m	2
			400 m $\geq$ Dct > 300 m	1
			Dct > 400 m	0
Degree of children's appropriation of spaces	Qualitative	Degree of adults control of POSs	Restrictions on access	0
			Constraints on uses	1
			Competition for space	2
			Time/coupling constraints	3
			Manicured spaces	3
			No constraints on activities	4

The indicators representative of specific micro- and macro-scale environmental factors are, thus, aggregated into a global index of usefulness of individual natural settings, formalized as a score ranging from 0–120. This score is then converted to a value ranging from 0–1 by dividing the actual level of meaningful usefulness *n* by the potential level (120) (Table 3).

Moreover, four additional synthetic indexes are determined: (i) a functional affordances index, I_f; (ii) an emotional affordances index, I_e; (iii) a social affordances index, I_s; and (iv) an access conditions index, I_a. Hence, each index aggregates the single indicators related to a specific category of affordances. The synthetic category indexes are expressed by a value ranging from 0–1, defined as the ratio of the sum of the scores attributed to single indicators (S_{II}) compared to a potential score (P_j) (Table 2).

Table 3. Examples of determination of the index of usefulness of individual natural settings (I_{UIS}), of the continuity factor f, and of the synthetic index of usefulness of urban blue–green infrastructure (BGI) in a specific area (I_{SGI}).

Index	Measurement	Scale	Rating
I_{UIS}	$(\sum I_{Ci})/P$ (P = 120)	$1.00 \geq I_{UIS} \geq 0.85$ $0.84 \geq I_{UIS} \geq 0.75$ $0.74 \geq I_{UIS} \geq 0.65$ $0.64 \geq I_{UIS} \geq 0.55$ $0.54 \geq I_{UIS} \geq 0.35$ $0.34 \geq I_{UIS} \geq 0$	Optimal Good Fair Adequate Inadequate Poor
I_f; I_e; I_s; I_a	$(\sum S_{II})/Pj$, Pf = 48, P_e = 24, P_s = 24, P_a = 24	$1.00 \geq I_{UIS} \geq 0.85$ $0.84 \geq I_{UIS} \geq 0.75$ $0.74 \geq I_{UIS} \geq 0.65$ $0.64 \geq I_{UIS} \geq 0.55$ $0.54 \geq I_{UIS} \geq 0.35$ $0.34 \geq I_{UIS} \geq 0$	Optimal Good Fair Adequate Inadequate Poor
f	$A_{pce}/(\sum A_i)$	$1.00 \geq I_{UIS} \geq 0.80$ $0.79 \geq I_{UIS} \geq 0.60$ $0.59 \geq I_{UIS} \geq 0.45$ $0.44 \geq I_{UIS} \geq 0$	Optimal Fair Inadequate Poor
I_{SGI}	$[(\sum I_{UISi} \times A_i)/(\sum A_i)] \times f$	$1.00 \geq I_{UIS} \geq 0.85$ $0.84 \geq I_{UIS} \geq 0.75$ $0.74 \geq I_{UIS} \geq 0.65$ $0.64 \geq I_{UIS} \geq 0.55$ $0.54 \geq I_{UIS} \geq 0.35$ $0.34 \geq I_{UIS} \geq 0$	Optimal Good Fair Adequate Inadequate Poor

Note: P is the Potential Performance of a Natural Settings, Represented by a Score of 120; Apce = Surface Area of the Primary Connected Element; Ai = Surface Area of the *i*-th BGI Component.

The layout of the audit tool is expressed via a matrix that organizes the single indicators and sub-indicators into the four dimensions (functional, social, emotional, and independent access opportunities) and formalizes the relationships among dimensions, functional categories or affordances, environmental features, and indicators. Moreover, for each indicator and sub-indicator, there are specified scales, levels of performance, bands of values, definitions of conditions related to each scale level for qualitative indicators, and, if required, queries for measuring the value of quantitative indicators via GIS platform data processing tools. The subsequent stage consists of the determination of a continuity factor f that measures whether the urban blue–green infrastructure components in a specific area are dispersed or connected in a continuous spatial structure. The continuity factor, thus, measures the ratio of the surface area of the urban BGI primary component compared to the total surface area of natural settings constituting the components of the urban BGI in a determined area. The primary component is defined as the segment of contiguously connected urban BGI components that comprises the largest surface area of natural settings. Multiplying the weighted average index of usefulness of urban BGI components by the continuity factor f, both considered for a specific area, determines the value of the synthetic index of usefulness of urban BGI in a specific area (I_{SGI}). This index, thus, formalizes the extent to which the urban blue–green infrastructure constitutes a continuous spatial structure that reinforces children's rights to the city by enabling their agency and independent mobility, and that promotes children's meaningful nature experiences and transactions with the environment. Moreover, the I_{SGI} index, as a synthetic indicator representative of the conditions of continuity, inclusivity, and friendliness of the network of natural settings in a specific area, enables the comparison between distinct areas. The audit tool incorporates a procedure structured on eight stages: (i) selection and characterization of the case study; (ii) selection of pertinent indicators; (iii) individuation of publicly available datasets; (iv) definition of measurement scales for

single indicators as a function of the availability of secondary data and definition of observational protocols for collecting data from on-site direct observations; (v) data collection and evaluation of single indicators; (vi) normalization of measurements and aggregation of partial results into the synthetic index of meaningful usefulness for single urban BGI components; (vii) determination of the continuity factor f; and (viii) measurement of the global index of usefulness of urban BGI in a specific area.

4. Selection of the Case Study

The city of Cagliari was selected as a case study for three reasons: firstly, the tradition in terms of policies aimed at promoting children's mobility and agency (Figure 1); secondly, the recognition of the strategic relevance of the networks of natural and green areas within territorial and urban planning; and thirdly, the density of green and natural areas, superior to the national average. With respect to the second point, both the municipal urban plan [60] and the plan for the historic center [61] recognize the strategic relevance of the network of natural spaces, parks, safeguard areas, and edges as a carrying structure of the urban fabric and as an infrastructure that provides aesthetic, social, ecological, and climatic benefits, as well as fundamental services, in terms of environmental education and quality of life. In particular, the plan for the historic center [61] individuates the creation of an urban historic park as an intervention aimed at reinforcing the distinctive and environmental characteristics of the compact city and public city.

Furthermore, Cagliari is among the greenest provincial capitals and metropolitan city municipalities in Italy. Approximately 61.6% of its surface area constitutes green areas, including preserved natural areas and urban green spaces; this value is superior to the 19.2% national average ratio of green areas compared to municipal surface areas [17]. The OCUS tool was used to compare the meaningful usefulness of urban BGIs within two distinct districts of the urban area. The characterization of the case study was based on a consideration grounded in the literature on children's practices across public spaces; the possibility of children's outdoor independent activities is associated with the availability of areas close to home and not dominated by adults [14,62]. According to Tonucci [63], the proximity of places available for spontaneous practices emerges as a pre-condition for children's experience of autonomy and for the development of competencies and abilities. Consequently, the application of the OCUS tool aims to evaluate the opportunities for children's agency, autonomy, and nature experience by assessing the extent to which natural settings, including parks, gardens, buffer areas, and planted squares, to constitute a capillary and continuous structure of meaningful and stimulating places, which, at the local scale, support children's independent functional, recreational, and social practices.
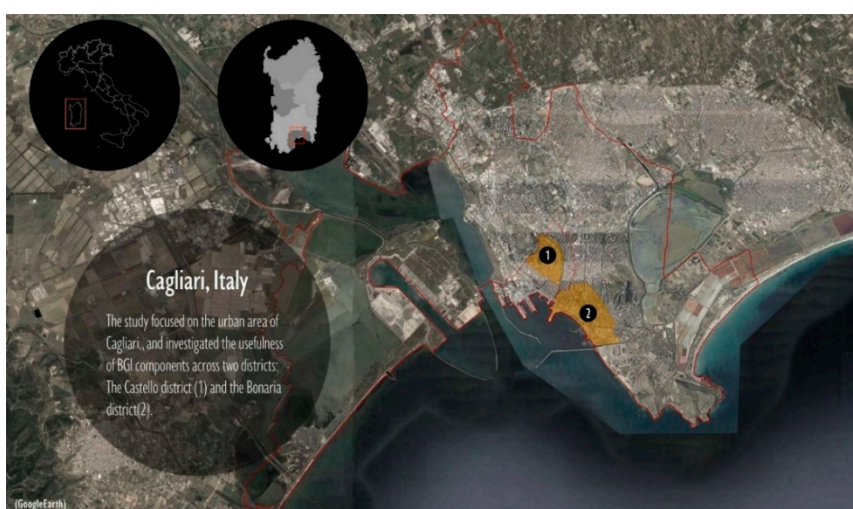
Figure 1. Cagliari: the red line delimits the boundary of the municipality of Cagliari; the orange field delimits the area of study.

The analysis compared two districts that differ in terms of morphology, building typology, and population density (Figure 2): the historic center, characterized by a population density of 12,013.76 inhabitants per km^2, a dense and compact urban fabric delimited by and intertwined with different forms of public open spaces, including gardens, parks, specialized green areas, and fringes that are individuated as the components of a continuous structure of natural spaces, the historic urban park, and environments instrumental to the reconstruction of an inclusive public city; and the Bonaria district, a modern residential district with a population density equal to 5022.72 inhabitants per km^2, structured by a regular grid of secondary and local streets serving detached houses and apartment buildings. The result of the application of the OCUS tool and the comparison of the selected districts in terms of usefulness and continuity of the local urban blue–green infrastructure are discussed in the Section 5.

1	Giardino sotto le mura	1	Su Siccu Waterfront	6	Parco Maxia
2	Hortus Botanicus_HBK	2	Parco di Bonaria	7	Piazza San Cosimo
3	Orto dei Cappuccini	3	Via Ravenna	8	Parco Martiri delle Foibe
4	Giardini Pubblici	4	Via Milano		
5	Viale Buoncammino	5	Banco di Sardegna		
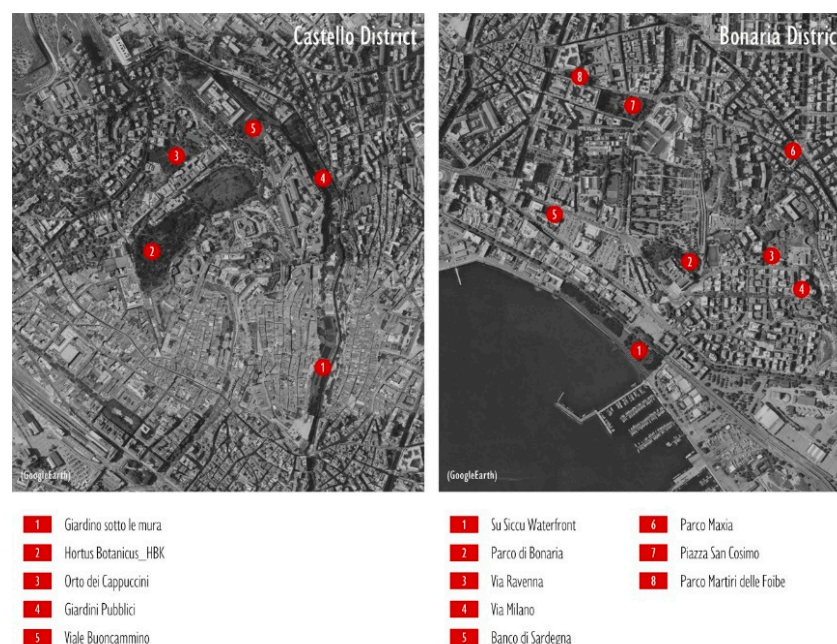
Figure 2. Representation of urban blue–green infrastructure (BGI) components explored during the study.

5. Results

Results obtained via the application of the audit tool revealed that the meaningful usefulness of the urban BGIs identified in the areas of study was marginal for the district of Castello (I_{SGI} equal to 0.34) and for the Bonaria district (I_{SGI} equal to 0.30).

The weighted average index of practicability of single spaces was equal to 0.70 in the Castello district and 0.62 in the Bonaria district (see Figure 3 and Table 4). These values were different from the results determined for the indexes of meaningful usefulness of single natural settings (I_{UIS}). The levels of usefulness for the BGI components within the Castello district ranged from inadequate (I_{UIS} equal to 0.52 for the fringe area in Viale Buoncammino) to fair (I_{UIS} equal to 0.72, 0.73, and 0.74 for Giardino Sotto le Mura, Giardini Pubblici, and Orto dei Cappuccini, respectively) and good (I_{UIS} equal to 0.76 for the vast area including the Roman Amphitheatre and the Hortus Botanicus Karlitanus); conversely, the values of the I_{UIS} for the BGI components within the Bonaria district ranged from to 0.50 for the Garden in via Milano (indicative of an inadequate level of usefulness) to 0.69 for Piazza San Cosimo, 0.65 for Parco Martiri delle Foibe and for the garden area along via Ravenna, and 0.64 for Parco Maxia (indicative of a fair level of usefulness). Nevertheless, the other individuated available BGI components revealed adequate levels of usefulness, corresponding to values of the I_{UIS} ranging from 0.60 for Parco di Bonaria to 0.62 for the Su Siccu waterfront.
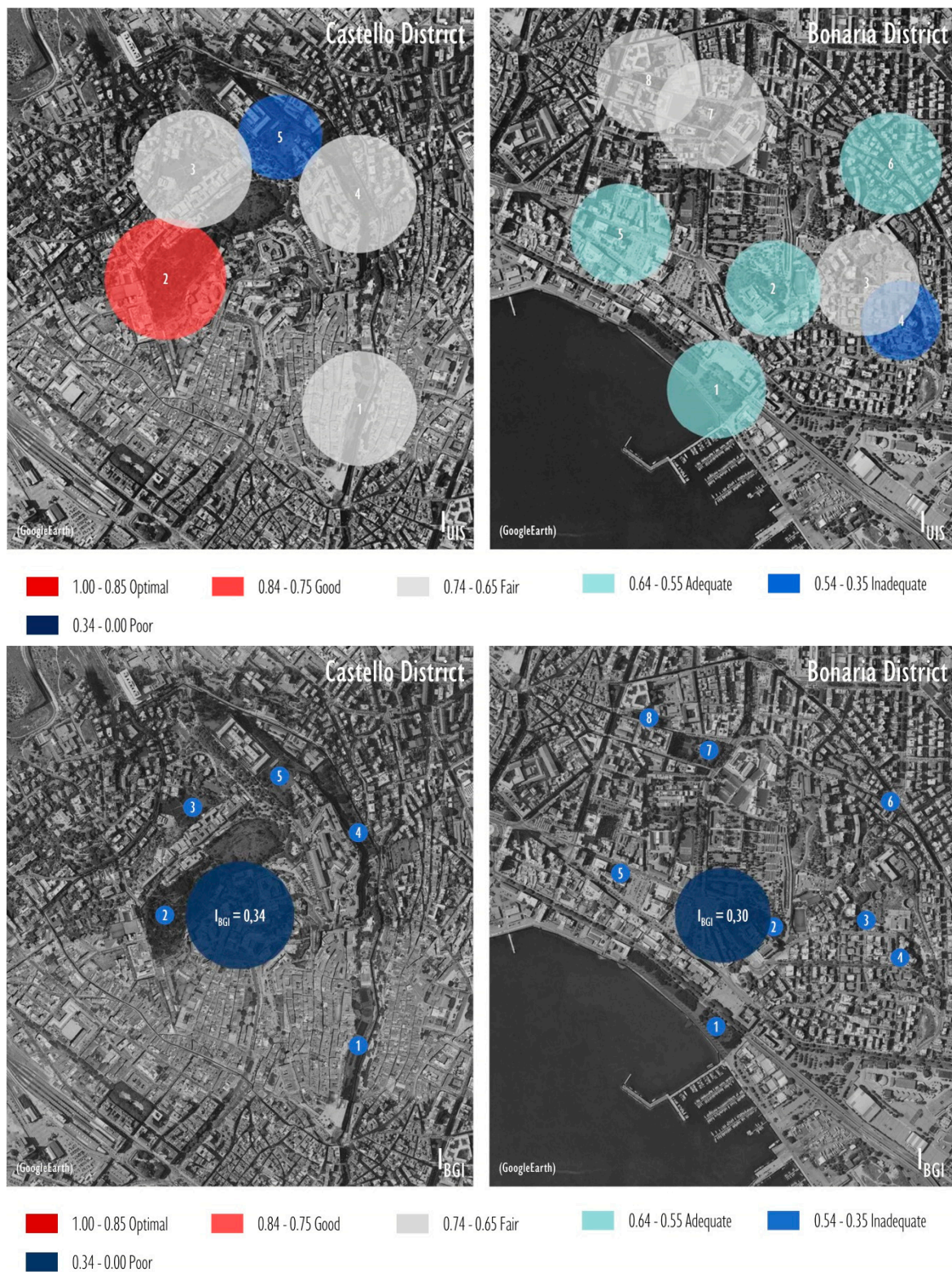
Figure 3. Distribution of values of the index of usefulness of individual settings (I_{UIS}) and the synthetic index of usefulness of BGI in a specific area (I_{SGI}): varying levels of meaningful usefulness of the selected BGI components.

Table 4. Values of the I_{SGI} and of I_{UIS} indexes for the selected area of study. HBK—Hortus Botanicus Karlitanus.

Urban BGI Components	Indexes of Meaningful Usefulness		
	I_{UIS}	Continuity Factor f	I_{SGI}
Giardino Sotto le Mura (1)	0.72		
HBK (2)	0.76		
Orto dei Cappuccini (3)	0.74		
Giardini Pubblici (4)	0.74		
Viale Buoncammino (5)	0.53		
Castello district	0.71	0.48	0.34
Su Siccu (1)	0.62		
Parco Bonaria (2)	0.60		
Via Ravenna (3)	0.66		
Via Milano (4)	0.50		
Banco di Sardegna (5)	0.63		
Parco Maxia (6)	0.64		
Piazza San Cosimo (7)	0.69		
Parco Martiri Foibe (8)	0.65		
Bonaria district	0.62	0.48	0.30

Further insights could be derived from the review of partial indexes (I_f, I_e, I_s, I_a), which aggregated the indicators related to the specific dimensions of functional affordance, emotional affordance, social affordance, and accessibility (Table 5).

Table 5. Values of the I_f, I_e, I_s, and I_a indicators.

Urban BGI Components	Indexes of Meaningful Usefulness			
	I_f (Functional)	I_e (Emotional)	I_s (Social)	I_a (Access)
Giardino Sotto le Mura (1)	0.67	0.78	0.81	0.64
HBK (2)	0.86	0.83	0.67	0.60
Orto dei Cappuccini (3)	0.77	0.83	0.81	0.52
Giardini Pubblici (4)	0.79	0.89	0.81	0.43
Viale Buoncammino (5)	0.71	0.49	0.25	0.50
Castello district	0.79	0.76	0.63	0.55
Su Siccu (1)	0.63	0.42	0.83	0.59
Parco Bonaria (2)	0.69	0.78	0.27	0.56
Via Ravenna (3)	0.61	0.81	0.67	0.59
Via Milano (4)	0.52	0.64	0.23	0.59
Banco di Sardegna (5)	0.40	0.88	0.85	0.60
Parco Maxia (6)	0.42	0.93	0.83	0.61
Piazza San Cosimo (7)	0.72	0.82	0.69	0.52
Parco Martiri Foibe (8)	0.62	0.77	0.69	0.54
Bonaria district	0.63	0.61	0.66	0.57

Natural settings within the Castello district revealed fair to optimal levels of availability of functional affordances (I_f ranging from to 0.67 for Giardino Sotto le Mura, 0.79 for Giardini Pubblici, and 0.86 for the Hortus Botanicus), and good to optimal levels of availability of emotional and social affordances (see Figures 4–6). In particular, a value of the index of availability of emotional affordances superior to 0.80 was observed for Giardini Pubblici and the Hortus Botanicus. Furthermore, the index of availability of social affordances was equal to 0.81 for Giardini Pubblici, Giardini Sotto le Mura, and Orto dei Cappuccini.

A significant exception was represented by the fringe area along Viale Buoncammino, connoted by an inadequate level of availability of positive emotional affordances (I_e = 0.49) and by a poor level of availability of social opportunities (I_s = 0.25). Conditions of accessibility were likewise observed to be inadequate for Giardini Pubblici, Orto dei Cappuccini, and the fringe area along Viale Buoncammino (I_a equal to 0.43, 0.52, and 0.5, respectively) and adequate (I_a equal to 0.60 and 0.64) for Hortus Botanicus and Giardino Sotto le Mura. Finally, conditions of accessibility were inadequate for Giardini Pubblici, the fringe area along Viale Buoncammino, and Orto dei Cappuccini, while they were adequate for the remaining settings (Figure 7).

The values of the I_f, I_e, I_s, and I_a indexes for the districts were determined as the weighted average of the indexes calculated for each BGI component.

Contrastingly, natural settings within the Bonaria district revealed the lesser availability of functional affordances (Figure 4). The most significant space in terms of functional affordances was Piazza San Cosimo (I_f = 0.72), while three settings (Via Milano garden, Parco Maxia, and Banco di Sardegna garden) revealed marginal levels of availability of functional affordance (I_f equal to 0.52, 0.42, and 0.40, respectively).

The potential to actualize emotional affordances (Figure 5) was optimal in both Parco Maxia (I_e = 0.93) and underneath the Banco di Sardegna Building (I_e = 0.88), and good in Piazza San Cosimo (I_e = 0.82), Parco di Bonaria (I_e = 0.78), in the public gardens along via Ravenna (I_e = 0.81), and in Parco Martiri delle Foibe (I_e = 0.77), while it was marginal in the Su Siccu waterfront (I_e equal to 0.42).

Moreover, the availability of social affordances (Figure 6) was particularly variable. A scarce potential to actualize social affordances was observed in Parco di Bonaria and Via Milano gardens, a good potential was estimated in the Su Siccu waterfront and Parco Maxia (I_s = 0.83), and an optimal one was found in the Banco di Sardegna gardens (I_s = 0.85).
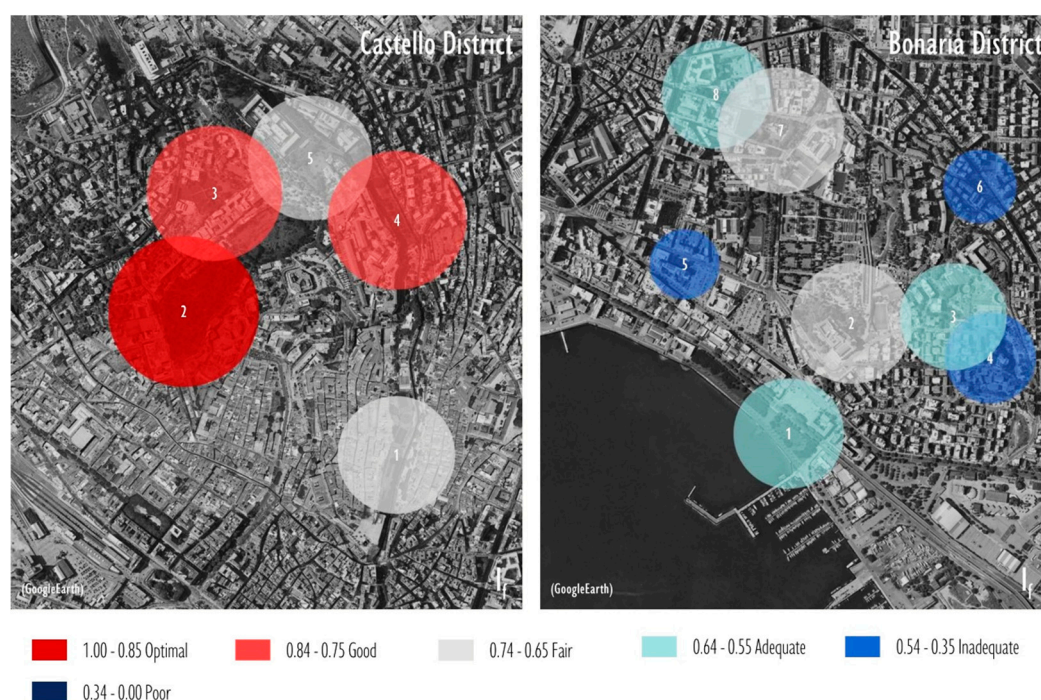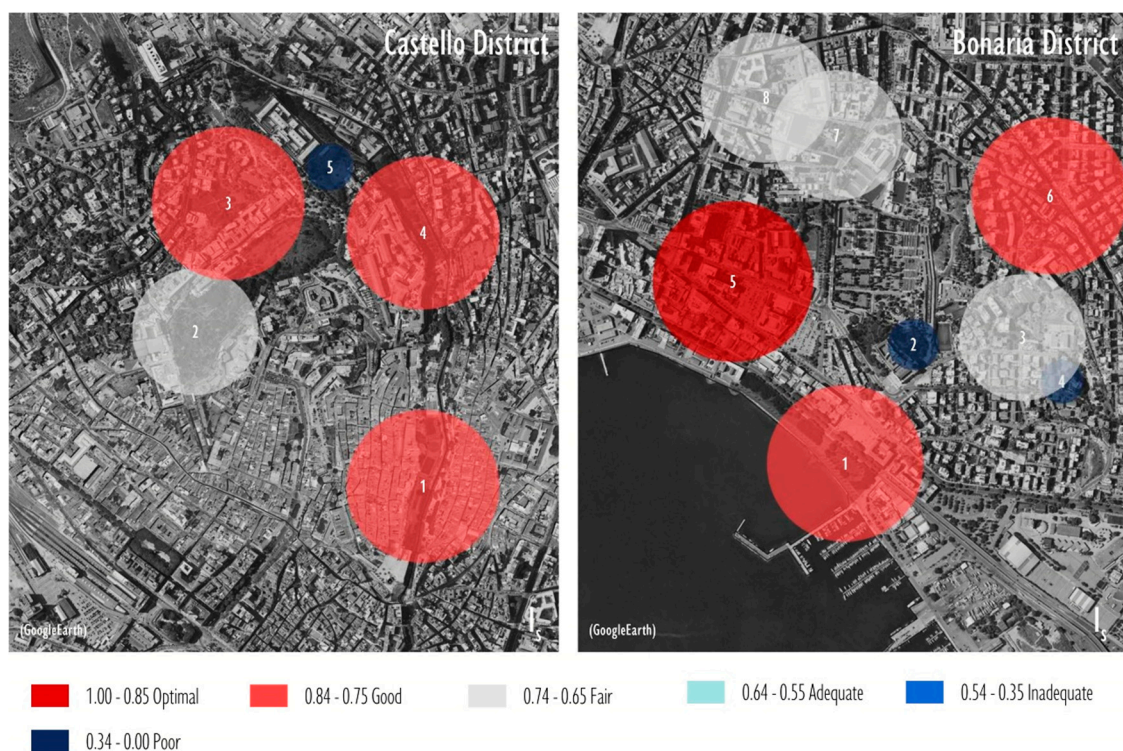

Figure 4. Distribution of values of the I_f functional indicator among urban BGI components across the Castello and the Bonaria districts.
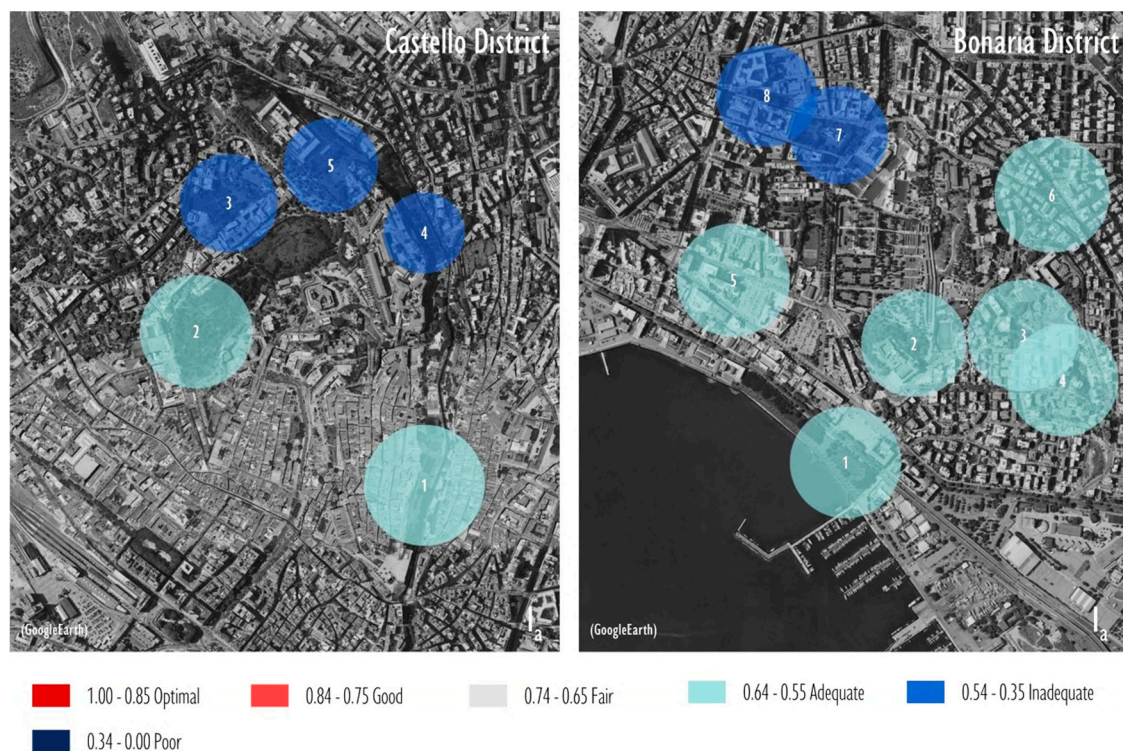
Figure 5. Distribution of values of the I_e emotional indicator among urban BGI components across the Castello and the Bonaria districts.

Figure 6. Distribution of values of the I_s social indicator among urban BGI components across the Castello and the Bonaria districts.

Figure 7. Distribution of values of the I_a access indicator among urban BGI components across the Castello and the Bonaria districts.

Finally, the condition of accessibility (Figure 7) was assessed as inadequate only for Parco Martiri delle Foibe (I_a equal to 0.50) and adequate for the remaining considered settings. In conclusion, the continuity factor f of the system of natural spaces was equal to 0.48 both in the Castello district and in the Bonaria district.

A comprehensive discussion of these results and a synthetic description of the relevant criticalities observed and related to the modest level of practicability measured are presented in Section 6.

6. Discussion

The results described in the previous section revealed a set of common criticalities, both at the scale of the specific setting and at the scale of the system of urban BGIs. In particular, the continuity factor revealed the scarce arteriality of the network of natural settings, which is fragmented and configured as a patchwork of dispersed natural and semi-natural settings.

This characteristic affects both the ecological and the social dimension of ecosystem services; it reduces the potential of the urban BGI to constitute a reserve for biodiversity and its potential to constitute a continuous structure of walkable and meaningful spaces, which are conducive to children's outdoor practices and independent mobility across the urban space.

Moreover, the analysis of the case study revealed that, in the case of the Bonaria district, the regeneration of residual spaces and specialized areas (the monumental cemetery, the buffer zone around it, the surface area of a disused industrial facility, the surface of an abandoned military facility) could lead to the configuration of an urban blue/green infrastructure with a continuity factor f equal to 0.79 (see Figure 8).
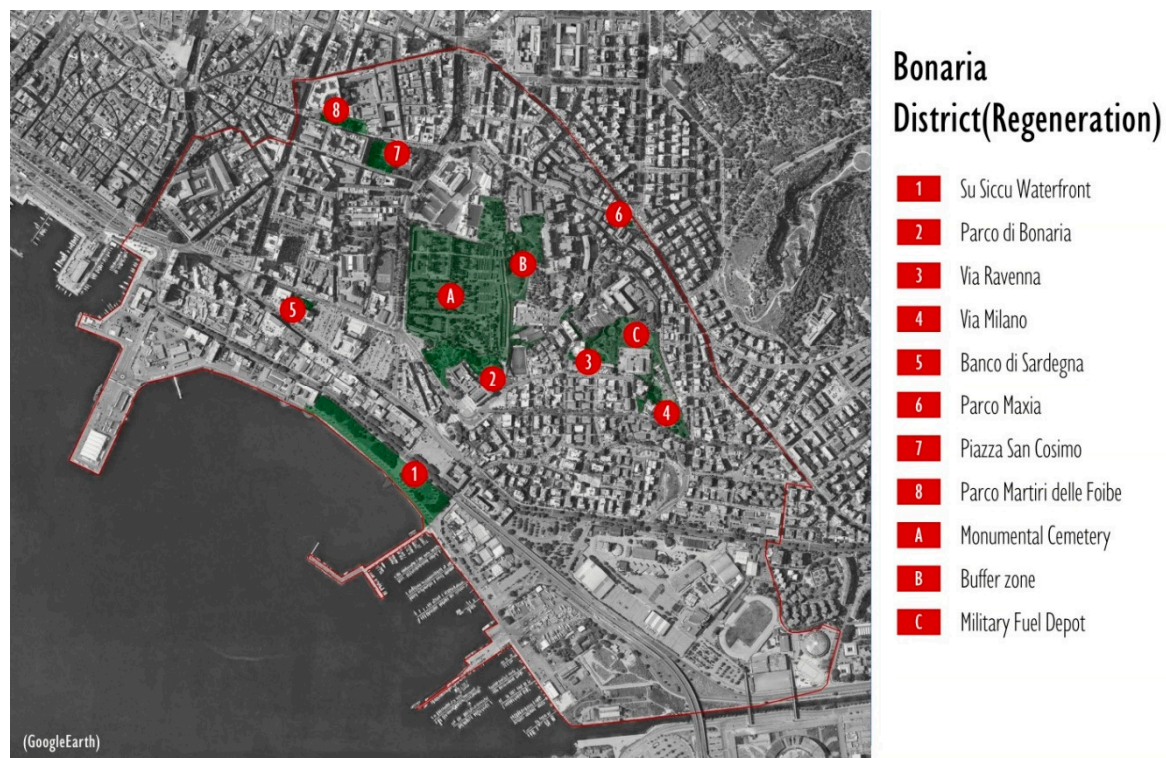
Figure 8. Possible reconfiguration of the BGIs across the Bonaria district.

This value indicates the potential to structure a contiguously connected subnetwork comprising 79% of the surface area of public spaces constituting urban BGI components in the area of study.

Focusing on site-specific factors, a relevant issue underlined by the evaluation of functional properties of urban green areas is the constraint on children's social and recreational practices determined by over-designed and by neatly maintained—or manicured—surfaces, reflecting adults' control and possession of public spaces. Vilanueva et al. [64] observed that natural play environments, incorporating natural elements and vegetation, appear more conducive to children's cognitive and physical development rather than physical manmade play areas.

In particular, the modest size and the uniformity in terms of surface textures and materials of regions of open ground limit opportunities for group practices and physical activities (riding a bike, running, playing football). Moreover, the morphological uniformity and regularity of surfaces reduces the variety of spatial conditions, consequently reducing the opportunity to explore, experiment, and appropriate spaces, and to combine intense physical activities with balancing acts.

A further related issue is the limited quantity and variety of loose objects and moldable materials which can constitute enabling materials for creative and imaginative games, including construction, manipulation, drawing, creation of patterns, and make-believe play. In her seminal work, Jacobs [56] observed that diversity at the ground level, determined by variations in the morphology of surfaces, concentration and dispersion of vegetation, and openings toward focal points, increases the availability of a space to different uses, rhythms, and purposes, and reinforces its complexity and attractiveness. Inversely, if a space, such as a billboard, can be embraced and understood at a glance, with its parts appearing to be homogeneous, then it barely supports diversity of uses or frequency of visits.

As for emotional affordances, a relevant issue is represented by the contextual conditions promoting the natural control of the space and determining the perceived safety of the public space. These conditions are positively related to children's outdoor activities, independent mobility, and to the perception of a space as an enabling place [13,64]. In particular, the partial or non-visibility of buildings and the absence of activities with extended service hours affect the natural surveillance of Giardini Sotto le Mura and Viale Buoncammino in the Castello district, as well as of the Su Siccu waterfront and

Parco di Bonaria in the Bonaria district. A related issue is the presence of signs of neglect and physical decay, including the quantity and content of graffiti, traces of drugs or alcohol consumption, and the condition of surfaces, seating facilities, illumination, and furniture.

These factors are individuated as a proxy of the occurring anti-social practices within the public space and are negatively related to levels of children's independent mobility and to perceptions about the child-friendliness of the urban space; furthermore, they are associated with parental restrictions on children's independent activities [13,65–67]. The analysis reveals the critical conditions of the fringe area along Viale Buoncammino, Via Milano garden, Piazza San Cosimo, and Parco Martiri delle Foibe. Thus, maintenance, reinforcement of perceptual relationships among natural settings, the built environment, and the collocation of specialized activities and functions could increase the natural surveillance, as well as the vitality, liveliness, and attractiveness of natural spaces. Another relevant aspect affecting emotional affordances is the degree of illumination of natural settings; this factor is related to perceptions about safety, comfort, and usability of spaces during night hours. In particular, the analysis revealed good to optimal condition of lampposts, underlined by the broken window indicator, and, more significantly, the non-uniform distribution of lampposts in larger natural settings. In fact, illumination is concentrated along paths, thus limiting the possibility for children's exploration, spatial appropriation, and structured group activities to daylight hours.

A further relevant issue related to social affordances is adults' control of spaces, resulting in lesser sense of privacy and territoriality, which affects children's spatial appropriation and the attribution of conceptional and use values to spaces [13,41,68]. The application of the audit tool revealed different forms of adult interference, including manicuring of spaces, time constraints, competition for spaces among adults and children, and practices and restrictions on children's outdoor activities. Moreover, the tokenistic and marginal involvement of children in the planning, design, and maintenance of green areas reinforces the adult-centered approach to the construction of the public space, hindering children's right to participation and reducing their influence on the environment. Finally, the most significant issues are related to the conditions for independent access to urban BGI components. In particular, the analysis revealed three criticalities: the barrier effect, which is the fragmentation of the public space determined by the pervasiveness of surfaces reserved for vehicular mobility and by the discrepancy between formal intersections and total road crossings, including informal crossings; the tokenistic integration between the system of urban BGIs and the network of bicycle facilities; and the contiguity of BGIs components to pedestrian facilities that are inadequate, in terms of separation from spaces for vehicular mobility, functionality of surfaces, and geometric characteristics, to support children's independent mobility, recreational activities, and assimilation. The OCUS tool, thus, underlined an organization of the public space oriented by political and economic interests that do not respond to, and instead marginalize, children's needs. Children's interests and their right to participate in the city's life are considered peripheral elements in the planning and design process. The public space formalizes the segregation of children into controlled environments and their conceptualization as "incomplete individuals" [65], thus reinforcing their psychological distance from the adults. A general question concerns the fragmented and tokenistic approach to the construction of a child-friendly city. This appears to be focused on specific issues (such as active travel to school) and implemented through interventions that affect the social and health planning dimension [41]. On the contrary, an effective approach should affect the structural characters of the built environment. In this regard, a significant opportunity is encompassed in the construction of a continuous trans-scalar network of urban BGIs, incorporating different functional, social, and emotional affordances for children and connecting to the networks of public spaces, pedestrian and bicycle mobility, collective transport, and communication infrastructures. This strategy actualizes the shift to a citizenship approach that acknowledges children's right to the city and broadens the concept of meaningful place to the entire urban realm.

This approach would integrate, as central issues of the planning process, the effects of independent mobility and spontaneous exploration of everyday spaces on children's physical wellbeing, acquisition

of spatial and environmental skills, emotion regulation, intellectual and creative development, and, ultimately, the construction of their social and individual identity.

7. Conclusions

This research underlines a perspective in urban planning founded on the intersection among research on ecosystem services, blue–green infrastructures, and child-friendly cities. In particular, this study addresses a fundamental yet neglected issue: the significance of urban BGI components as enabling and meaningful places supporting children's spontaneous outdoor activities and affecting their wellbeing and integral development. This issue emerges as a central aspect of the social dimension of ecosystem service. At the same time, it emphasizes the need for a radical shift in policies and strategies aimed at constructing an inclusive child-friendly city. In addition to actions focused on the cultural, social, and health planning dimension, there emerges the necessity for strategies that account for children's needs and interests in the planning, design, and management of the different networks that comprise the contemporary city.

Furthermore, this research underlines the centrality of the concept of affordance for understanding and describing the intentional transactions among children and public open spaces. The relevance of this concept, derived from research in the field of environmental psychology, is still overlooked in the field of urban planning. This concept is operationalized in terms of indicators for the assessment of the meaningful usefulness of BGI components from children's perspectives. In this respect, the analysis of the case study revealed that the OCUS tool and the indexes of usefulness of individual natural settings and of BGIs can support different stages of the planning process: (i) the individuation of structural criticalities of the systems of BGIs, expressed by the continuity factor f; (ii) individuation of criticalities related to functional, social, emotional, and access conditions of individual spaces; (iii) evaluation of alternative scenarios of urban regeneration at different scales, in terms of their impact on children's opportunities to independently and meaningfully engage with natural settings; (iv) comparison among different parts of urban areas; and (v) monitoring of interventions of regeneration of open spaces integrated into urban BGIs, via comparison of levels of usefulness over time. Moreover, the proposed methodological framework and its theoretical premises, based on the concepts of affordance and of capability, can be adapted in order to assess the inclusivity and meaningful usefulness of natural settings and of other elements of the public space from the point of view of other categories of vulnerable users, particularly the elderly.

Yet, the research revealed two limitations. Primarily, it underlined the need to determine the relative importance of environmental features and of pertinent indicators. Environmental features and indicators need to be weighted according to contextual factors and children's individual characteristics. Different studies [64,69–71] revealed that children's patterns of activities across public space are influenced by cultural constructs, parents' socio-economic status, individual abilities and purposes, age, and gender. Secondly, the research revealed the need to validate results and to assess the congruency of results with children's actual patterns of activities and perception of the public space. Moreover, Spelke's research underlined the significance of geometrical properties of spaces and of distinctive elements in supporting re-orientation and individuation of locations. Finally, a further consideration concerns the possibility of comparing natural settings differing in terms of scale, morphology, and function. This results from the conceptualization of the index of meaningful usefulness of a single natural setting I_{UIS}, as an index of performance, determined in relation to a potential level of performance. Consequently, the future development of the research will focus on four aspects: (i) determining procedures, founded on the Delphi method, for supporting the participation of experts and stakeholders in the process of establishing the relative importance of environmental correlates of meaningful usefulness of natural settings; (ii) defining procedures based on surveys or direct observations, structured according to the saturation principle and the phenomenological approach, for the validation of results; (iii) reformulating the indicator imageability of the public open spaces to assess the extent to which the geometry of a setting and the presence and organization of its distinctive elements enable children's comprehension

and understanding of the surrounding space; and (iv) increasing the trans-scalarity of the OCUS tool by conceptualizing quantitative indicators related to specific environmental features as indicators of performance or by structuring a taxonomy of BGI components based on morphology, function, and scale and establishing a potential level of performance specific for each category of natural setting. Consequently, the OCUS tool will be increasingly configured as a flexible, modifiable, protocol, whose layout, indicators, and coefficients of relative importance are adapted to the specificity of contextual factors and characteristics of a particular category of users. Thus, consistent with the principle that, with respect to methodological framework for evaluating the public spaces, one size does not fit all, the future development of this research will be aimed at reinforcing the adaptability of the OCUS tool to different contexts and its integrability into the planning process, particularly within the smart city paradigm.

References

1. Martinotti, G. *Sei Lezioni Sulla Città*; Feltrinelli Editore: Milan, Italy, 2017; ISBN 978-880710530-2.
2. Glaeser, E. *Triumph of the City*; Pan: Basingstoke, UK, 2011; ISBN 978-110147567-6.
3. Armour, T.; Armour, S.; Hargrave, J.; Revell, T. *Cities Alive: Rethinking Green Infrastructure*; Arup: London, UK, 2014.
4. Caragliu, A.; Del Bo, C.; Nijkamp, P. Smart cities in Europe. *J. Urban Technol.* **2011**, *18*, 65–82. [CrossRef]
5. Min, B.; Lee, J. Children's neighborhood place as a psychological and behavioral domain. *J. Environ. Psychol.* **2006**, *26*, 51–71. [CrossRef]
6. Sen, A. Capability and Well-being. In *The Quality of Life*; Nussbaum, M., Sen, A., Eds.; Clarendon Press: Oxford, UK, 1993; pp. 30–53.
7. Gibson, J.J. *The Ecological Approach to Visual Perception*; Lawrence Erlbaum: Hillsdale, NJ, USA, 1979.
8. Barker, R.G.; Wright, H.F. *Midwest and Its Children: The Psychological Ecology of an American Town*; Row, Peterson: Evanston, IL, USA, 1954.
9. Heft, H. Affordances of children's environments: A functional approach to environmental description. *Child. Environ. Q.* **1988**, *5*, 29–37.
10. UNICEF. Children in an Increasingly Urban World. 2012. Available online: https://www.unicef.org/sowc2012/pdfs/SOWC-2012-Chapter-1-Children-in-an-increasingly-urban-world.pdf (accessed on 31 March 2019).
11. Goltsman, S.; Kelly, L.; McKay, S.; Algara, P.; Wight, L. Raising "free range kids": Creating neighborhood parks that promote environmental stewardship. *J. Green Build.* **2009**, *4*, 90–106. [CrossRef]
12. Lin, E.Y.; Witten, K.; Oliver, M.; Carroll, P.; Asiasiga, L.; Badland, H.; Parker, K. Social and built-environment factors related to children's independent mobility: The importance of neighbourhood cohesion and connectedness. *Health Place* **2017**, *46*, 107–113. [CrossRef]
13. Witten, K.; Kearns, R.; Carroll, P.; Asiasiga, L. Children's Everyday Encounters and Affective Relations with Place: Experiences of Hyperdiversity in Auckland Neighbourhoods. 2017. Available online: https://www.tandfonline.com/doi/abs/10.1080/14649365.2017.1347700 (accessed on 10 August 2019).
14. Chawla, L. Benefits of nature contact for children. *J. Plan. Lit.* **2015**, *30*, 433–452. [CrossRef]

15. Giusti, M.; Svane, U.; Raymond, C.M.; Beery, T.H. A Framework to Assess Where and How Children Connect to Nature. *Front. Psychol.* **2018**, *8*, 2283. [CrossRef]

16. Abson, D.J.; Fischer, J.; Leventon, J.; Newig, J.; Schomerus, T.; Vilsmaier, U.; von Wehrden, H.; Abernethy, P.; Ives, C.D.; Jager, N.D.; et al. Leverage points for sustainability transformation. *Ambio* **2017**, *46*, 30–39. [CrossRef]

17. ISTAT. Ambiente Urbano. 2018. Available online: https://www.istat.it/it/archivio/225505 (accessed on 31 March 2019).

18. Benedict, M.; McMahon, E. *Green Infrastructure: Linking Landscapes and Communities*; Island Press: Washington, DC, USA, 2006.

19. Cannas, I.; Lai, S.; Leone, F.; Zoppi, C. Green Infrastructure and Ecological Corridors: A Regional Study Concerning Sardinia. *Sustainability* **2018**, *10*, 1265. [CrossRef]

20. Tjallingii, S. Planning with water and traffic networks—Carrying structures of the urban landscape. In *Flowscape—Designing Infrastructure as Landscape*; Nijhuis, S., Jauslin, D., van Der Hoeven, F., Eds.; Delft University of Technology: Delft, NL, USA, 2015; pp. 57–80, ISBN 978-946186472-7.

21. Boyd, J.; Banzhaf, S. What are ecosystem services? The need for standardized environmental accounting units. *Ecol. Econ.* **2007**, *63*, 616–626. [CrossRef]

22. Millennium Ecosystem Assessment. *Ecosystems and Human Well-Being*; Island Press: Washington, DC, USA, 2005.

23. Daily, G. *Nature's Services: Societal Dependence on Natural Ecosystems*; Island Press: Washington, DC, USA, 1997; ISBN 1-55963-476-6.

24. Landers, D.H.; Nahlik, A.M. Final Ecosystem Goods and Services Classification System (FEGS-CS). Available online: https://gispub4.epa.gov/FEGS/FEGS-CS%20FINAL%20V.2.8a.pdf (accessed on 27 May 2019).

25. Wallace, K.J. Classification of ecosystem services: Problems and solutions. *Biol Conserv.* **2007**, *139*, 235–246. [CrossRef]

26. Binning, C.; Cork, S.; Parry, R.; Shelton, D. *Natural Assets: An Inventory of Ecosystem Goods and Services in the Goulburn Broken Catchment*; Ecosystem Services Project: Canberra, Australia, 2001.

27. Holt, A.R.; Mears, M.; Maltby, L.; Warren, P. Understanding spatial patterns in the production of multiple urban ecosystem services. *Ecosyst. Serv.* **2015**, *16*, 33–46. [CrossRef]

28. Dennis, M.; James, P. Ecosystem services of collectively managed urban gardens: Exploring factors affecting synergies and trade-offs at the site level. *Ecosyst. Serv.* **2017**, *26*, 17–26. [CrossRef]

29. Vogdrup-Schmidt, M.; Strange, N.; Olsen, S.B.; Thorsen, B.J. Trade-off analysis of ecosystem service provision in nature networks. *Ecosyst. Serv.* **2017**, *23*, 165–173. [CrossRef]

30. Aarts, M.J.; Wendel-Vos, W.; van Oers, H.A.; van de Goor, I.A.; Schuit, A.J. Environmental determinants of outdoor play in children: A large-scale cross-sectional study. *Am. J. Prev. Med.* **2010**, *39*, 212–219. [CrossRef]

31. Pyyry, N. Thinking with broken glass: Making pedagogical spaces of enchantment in the city. *Environ. Educ. Res.* **2017**, *23*, 1391–1401. [CrossRef]

32. Nussbaum, M.C. *Creating Capabilities*; Harvard University Press: Cambridge, MA, USA, 2011; ISBN 978-067407235-0.

33. Conrad, E. Human and social dimension of landscape stewardship. In *The Science and Practice of Landscape Stewardship*; Bieling, C., Plieninger, T., Eds.; Cambridge University Press: Cambridge, UK, 2017; pp. 38–53, ISBN 978-110714226-8.

34. Matsuba, M.K.; Pratt, M.W.; Norris, J.E.; Mohle, E.; Alisat, S.; McAdams, D.P. Environmentalism as a context for expressing identity and generativity: Patterns among activists and uninvolved youth and midlife adults. *J. Personal.* **2012**, *80*, 1091–1115. [CrossRef]

35. Kyttä, M.; Oliver, M.; Ikeda, E.; Ahmadi, E.; Omiya, I.; Laatikainen, T. Children as urbanites: Mapping the affordances and behavior settings of urban environments for Finnish and Japanese children. *Child. Geogr.* **2018**, *16*, 319–332. [CrossRef]

36. Kyttä, M. The extent of children's independent mobility and the number of actualized affordances as criteria for child-friendly environments. *J. Environ. Psychol.* **2004**, *24*, 179–198. [CrossRef]

37. Barker, R.G.; Wright, H.F. *One Boy's Day: A Specimen Record of Behavior*; Archon Books: Hamden, CT, USA, 1951; ISBN 978-0208004857.

38. Lerstrup, I.; van den Bosch, C.K. Affordances of outdoor settings for children in preschool: Revisiting Heft's functional taxonomy. *Landsc. Res.* **2017**, *42*, 47–62. [CrossRef]

39. Broberg, A.; Kyttä, M.; Fagerholm, N. Child-friendly urban structures: Bullerby revisited. *J. Environ. Psychol.* **2013**, *35*, 110–120. [CrossRef]

40. Geurs, K.T.; van Wee, B. Accessibility evaluation of land-use and transport strategies: Review and research directions. *J. Transp. Geogr.* **2004**, *12*, 127–140. [CrossRef]

41. Whitzman, C.; Mizrachi, D. Creating child-friendly high-rise environments: Beyond wastelands and glasshouses. *Urban Policy Res.* **2012**, *30*, 233–249. [CrossRef]

42. Kyttä, M. Children in Outdoor Contexts: Affordances and Independent Mobility in the Assessment of Environmental Child Friendliness. Ph.D. Thesis, Helsinki University of Technology, Helsinki, Finland, 2003.

43. Kyttä, A.M.; Broberg, A.K.; Kahila, M.H. Urban environment and children's active lifestyle: SoftGIS revealing children's behavioral patterns and meaningful places. *Am. J. Health Promot.* **2012**, *26*, e137–e148. [CrossRef]

44. Lopes, F.; Cordovil, R.; Neto, C. Independent Mobility and Social Affordances of Places for Urban Neighborhoods: A Youth-Friendly Perspective. *Front. Psychol.* **2018**, *9*, 2198. [CrossRef]

45. Garau, C.; Annunziata, A.; Coni, M. A Methodological Framework for Assessing Practicability of the Urban Space: The Survey on Conditions of Practicable Environments (SCOPE) Procedure Applied in the Case Study of Cagliari (Italy). *Sustainability* **2018**, *10*, 4189. [CrossRef]

46. Mygind, L.; Bentsen, P.; Badland, H.; Edwards, N.; Hooper, P.; Villanueva, K. Public open space desktop auditing tool—Establishing appropriateness for use in Australian regional and urban settings. *Urban For. Urban Green.* **2016**, *20*, 65–70. [CrossRef]

47. Saelens, B.E.; Frank, L.D.; Auffrey, C.; Whitaker, R.C.; Burdette, H.L.; Colabianchi, N. Measuring physical environments of parks and playgrounds: EAPRS instrument development and inter-rater reliability. *J. Phys. Act. Health* **2006**, *3* (Suppl. 1), S190–S207. [CrossRef] [PubMed]

48. Rigolon, A.; Németh, J. A QUality INdex of Parks for Youth (QUINPY): Evaluating urban parks through geographic information systems. *Environ. Plan. B Urban Anal. City Sci.* **2016**, *45*, 275–294. [CrossRef]

49. Moura, F.; Cambra, P.; Gonçalves, A.B. Measuring walkability for distinct pedestrian groups with a participatory assessment method: A case study in Lisbon. *Landsc. Urban Plan.* **2017**, *157*, 282–296. [CrossRef]

50. Taleai, M.; Amiri, E.T. Spatial multi-criteria and multi-scale evaluation of walkability potential at street segment level: A case study of Tehran. *Sustain. Cities Soc.* **2017**, *31*, 37–50. [CrossRef]

51. Garau, C.; Pavan, V.M. Evaluating Urban Quality: Indicators and Assessment Tools for Smart Sustainable Cities. *Sustainability* **2018**, *10*, 575. [CrossRef]

52. Jabbari, M.; Fonseca, F.; Ramos, R. Combining multi-criteria and space syntax analysis to assess a pedestrian net-work: The case of Oporto. *J. Urban Des.* **2018**, *23*, 23–41. [CrossRef]

53. Rosenberg, D.; Ding, D.; Sallis, J.F.; Kerr, J.; Norman, G.J.; Durant, N.; Harris, S.K.; Saelens, B.E. Neighborhood environment walkability scale for youth (NEWS-Y): Reliability and relationship with physical activity. *Prev. Med.* **2009**, *49*, 213–218. [CrossRef]

54. Shaw, B.; Bicket, M.; Elliott, B.; Fagan-Watson, B.; Mocca, E.; Hillman, M. *Children's Independent Mobility: An International Comparison and Recommendations for Action*; Policy Studies Institute: London, UK, 2015.

55. Abis, E.; Garau, C. An assessment of the effectiveness of strategic spatial planning: A study of Sardinian municipalities. *Eur. Plan. Stud.* **2016**, *24*, 139–162. [CrossRef]

56. Jacobs, J. *The Death and Life of Great American Cities*; Random House: New York, NY, USA, 1961; ISBN 978-067964433-0.

57. Gehl, J. *Cities for People*; Island Press: Washington, DC, USA, 2013; ISBN 9781597265737.

58. Lee, S.A.; Shusterman, A.; Spelke, E.S. Reorientation and landmark-guided search by young children: Evidence for two systems. *Psychol. Sci.* **2006**, *17*, 577–582. [CrossRef]

59. Blečić, I.; Cecchini, A.; Congiu, T.; Fancello, G.; Trunfio, G.A. Evaluating walkability: A capability-wise planning and design support system. *Int. J. Geogr. Inf. Sci.* **2015**, *29*, 1350–1374. [CrossRef]

60. Comune di Cagliari. *Piano Urbanistico Comunale—Indirizzi Programmatici Operativi*; Comune di Cagliari: Cagliari, Italy, 2017. (In Italian)

61. Comune di Cagliari. *Piano Particolareggiato Per il Centro storico, Progetti Strategici Per lo Spazio Pubblico*; Comune di Cagliari: Cagliari, Italy, 2015. (In Italian)

62. Hart, R. *Children's Experience of Place*; Irvington: New York, NY, USA, 1979.

63. Tonucci, F. Citizen child: Play as welfare parameter for urban life. *Topoi* **2015**, *24*, 183–195. [CrossRef]

64. Villanueva, K.; Giles-Corti, B.; Bulsara, M.; Trapp, G.; Timperio, A.; McCormack, G.; Van Niel, K. Does the walkability of neighbourhoods affect children's independent mobility, independent of parental, socio-cultural and individual factors? *Child. Geogr.* **2014**, *12*, 393–411. [CrossRef]

65. Davis, A.; Jones, L.J. Children in the urban environment: An issue for the new public health agenda. *Health Place* **1996**, *2*, 107–113. [CrossRef]

66. Nordström, M. Children's views on child-friendly environments in different geographical, cultural and social neighbourhoods. *Urban Stud.* **2010**, *47*, 514–528. [CrossRef]

67. Chaudhury, M.; Hinckson, E.; Badland, H.; Oliver, M. Children's independence and affordances experienced in the context of public open spaces: A study of diverse inner-city and suburban neighbourhoods in Auckland, New Zealand. *Child. Geogr.* **2017**, *17*, 49–63. [CrossRef]

68. Furneaux, A.; Manaugh, K. Eyes on the alley: children's appropriation of alley space in Riverdale, Toronto. *Child. Geogr.* **2018**, *17*, 204–216. [CrossRef]

69. Galvez, M.P.; McGovern, K.; Knuff, C.; Resnick, S.; Brenner, B.; Teitelbaum, S.L.; Wolff, M.S. Associations between neighborhood resources and physical activity in inner-city minority children. *Acad. Pediatr.* **2013**, *13*, 20–26. [CrossRef]

70. Gillespie, J. Being and becoming: Writing children into planning theory. *Plan. Theory* **2013**, *12*, 64–80. [CrossRef]

71. Villanueva, K.; Badland, H.; Kvalsvig, A.; O'Connor, M.; Christian, H.; Woolcock, G.; Giles-Corti, B.; Goldfeld, S. Can the neighborhood built environment make a difference in children's development? Building the research agenda to create evidence for place-based children's policy. *Acad. Pediatr.* **2016**, *16*, 10–19. [CrossRef]