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Perspective

Raising Healthy Children: Promoting the Multiple Benefits of Green Open Spaces through Biophilic Design

Alessio Russo [1,*,†] and Maria Beatrice Andreucci [2,*,†]

[1] School of Arts, Francis Close Hall Campus, University of Gloucestershire, Cheltenham GL50 4AZ, UK
[2] Department of Planning, Design, Technology of Architecture, Sapienza University of Rome, 00196 Rome, Italy
* Correspondence: arusso@glos.ac.uk (A.R.); mbeatrice.andreucci@uniroma1.it (M.B.A.)
† These authors contributed equally to this work.

Abstract: Several studies have indicated that children who grow up in green environments enjoy beneficial impacts on their development. However, to date, very little attention has been paid to the types and characteristics of dedicated public open green space for children. In addition, studies on biophilic design that could help landscape architects to design open spaces for children are limited. In order to fill this gap, this perspective examines the scientific literature on the relationship between open spaces and children. The authors specifically discuss and analyze the following points: (1) pathways to and effects on children's health and well-being; (2) types and characteristics of open spaces for child-dedicated facilities (e.g., schools, hospitals, fitness camps, playgrounds, etc.), as well as for child-friendly urban open spaces. Finally, the authors provide inspiring examples and case studies of biophilic design for children's health and well-being. Conclusions from this perspective show that biophilic design could benefit both the physical and mental health of children, as well as improve children's overall resilience to pandemics and other diseases. This perspective provides, for the first time, new insights for designing biophilic and child-friendly cities, and explores areas of future research.

Keywords: salutogenic design; playgrounds; child health; child development; greenspace; urban green infrastructure; inclusive design

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1. Introduction

Twenty-five percent of today's global population is under the age of 15 [1]. Specifically, when we look at developing regions of the world where most urban growth is happening, i.e., Africa, 40% of the population is under 15 [2]. It is predicted that by 2030, 60 percent of urban dwellers in developing countries will be under the age of 18 [3].

Complex regional disparities, migration, rapid rates of urbanization, and historical and cultural differences imply that many of the world's children are born into or already reside in poorly performing urban conditions [4]. Despite some fundamental advantages of children who live in urban settings (i.e., increased opportunity for survival and wellbeing, access to health care, education, and sanitation), most children face a difficult urban existence [5].

Due to increasing urbanization and population density, many people reside in communities lacking vegetation, parks, and other natural settings, which restricts the availability of easily accessible and safe outdoor play spaces for children [6,7]. Recently, the social issues surrounding child-friendly spaces have drawn significant critical attention [8–13].

The United Nations Sustainable Development Goal 11, target 11.7 aims to provide: "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" [14].

Increasing urbanization has left our children with far fewer opportunities than previous generations to play freely outdoors and appreciate the natural environment [15,16].

The decline in children's play and active mobility has negative implications for the child's growth, including elevated levels of obesity, diabetes, and mental health issues [17]. The built environment can influence children's lifestyle, and can have negative impacts on children's mental health and well-being [18]. Vrijheid et al. (2020) found 77 prenatal exposure and 96 childhood exposure factors, including indoor and outdoor air pollutants, built environment, green spaces, and biomarkers of chemical pollutants. The same authors have also identified that air pollution and the built environment (residence in more densely populated areas and areas with fewer dedicated facilities) may play a role in childhood obesity [19].

Childhood obesity caused by a sedentary lifestyle is linked with a poor quality of life and a low level of well-being [20]. In a large U.S.-representative cross-sectional survey, the researchers reported that children living in poverty are more likely to lack parks, whether or not they lived in urban environments [21]. Considering the significant benefits of play on children's health, well-being, and happiness, the design of a new neighborhood should begin with the question: "How can we provide the youngest residents with opportunities to freely play outdoors, walk independently, and feel a sense of belonging and ownership within their communities?" [17]. In view of the increase of mental health issues in childhood and adolescence [22], there is an urgent need to find landscape architecture solutions (e.g., well-designed playgrounds and green infrastructure) that can improve children's quality of life and well-being. In the last two years, prolonged school and playground closure (Figure 1) and home confinement during the COVID-19 pandemic may have exacerbated negative effects on children's physical and mental health [22–25].

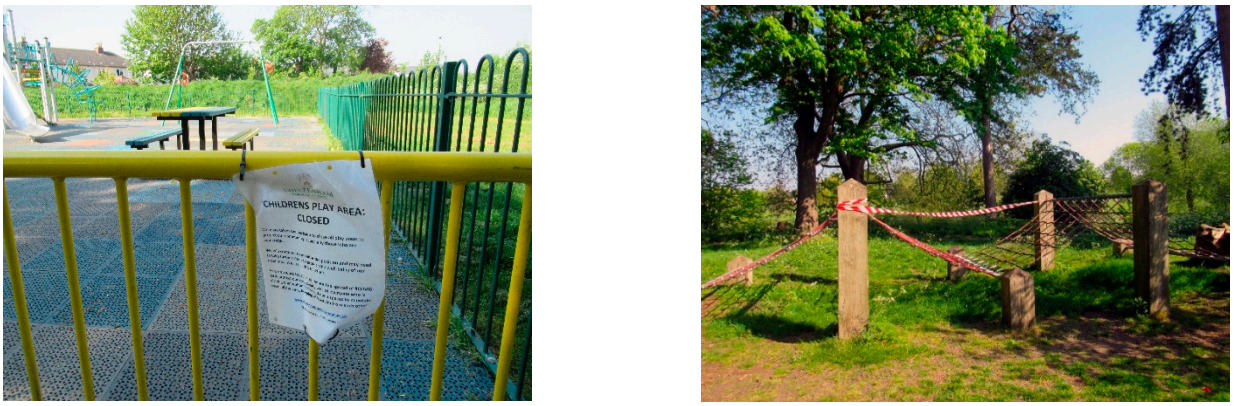

Figure 1. Children's playground closure in the UK (Photo by Alessio Russo).

The recent formative evaluation of the UNICEF Work on Children in Urban Settings considered unplanned rapid urban growth as a driver of inequality in cities [26]. One of the key recommendations of the evaluation, which has been accepted by UNICEF in its management response, was: "In partnership with sister United Nations agencies, strengthen advocacy for child-responsive urban planning, participatory slum upgrading, safe public spaces for children and child-friendly transportation systems, and issues around urban waste and environmental degradation" [26].

Urban children, compared to children from rural areas, are generally exposed to higher levels of several environmental hazards such as air pollution, noise, and heat, and have limited access to natural environments [27], including green spaces. Analysis of the main urban contexts shows that urbanization does not necessarily lead to sustainable urban environments for children [4]. An estimated 300 million of the global population of slum dwellers are children [28], who suffer from multiple deprivations, live without a voice, and have no access to land, housing, and services.

Urban expansion mostly occurs in a fragmented way, resulting in a lack of public space and lower quality of the urban environment [29]. For children, it implies unhealthy

and unsafe environments, limited options for playing and interaction, and limited access to social infrastructure and services.

Cities are also responsible for higher energy consumption and pollutant emissions, thereby increasing stress on the environment as well as on the most vulnerable urbanites [30,31]. Early exposure to air pollution, particularly exposure to fine particulate pollution, can have a profoundly negative impact on children's health and development [31]. Thus, there is a need to implement large-scale urban afforestation projects to tackle air pollution [32,33].

Urban children have been reported to be more likely to suffer from neurodevelopmental problems such as ADHD and autism spectrum disorders than rural children [34,35].

In general, children's needs are not prioritized in urban policymaking, as clearly demonstrated during the COVID-19 pandemic, when school closures prevented 1.57 billion children, 90 per cent of the global student population, from attending in-person school and significant restrictions were imposed on their outdoor activities and socialization [25,36,37].

Recent research by Fernández-Barrés et al. (2022) suggests that areas of cities with more biodiversity, greater service and facility density, lower population density, and without major roads may be associated with more physical activity, less sedentary behaviors, better sleep, and more active mobility [38]. Several physical qualities have also been proven as fundamental for child-friendly environments, such as varying and complex green spaces [39], low levels of car traffic [40], and a moderate urban density [41], indicating the need for an inclusive perspective that can situate both the physical and social qualities of the environment.

Despite the growing awareness of the multiple benefits of being in natural environments, academics are concerned that children are losing their connection to the natural world around them [42]. Children, in particular, are considered to have a strong emotional connection to life (biophilia), and conditions including attention deficit hyperactivity disorder, stress, obesity, and depression are linked to a lack of contact with the natural world, or what is known as "nature deficit disorder" [43].

To our knowledge, studies on biophilic design for children have mainly been conducted in educational settings [44,45]. This research explores, for the first time, the types and characteristics of dedicated public green open space for children.

Specifically, in this perspective, planners, architects, and landscape architects can offer a significant contribution using evidence-based biophilic urban design [46,47] as a critical approach for achieving human rights-based sustainable development. Biophilic design can help to connect the infrastructural and spatial characteristics of the built environment and shine a spotlight on the vulnerability of disadvantaged children and their communities. Drawing from their own and emerging research, as well as innovative practice, in the following sections the authors illustrate the pathways to and effects on children's health and well-being (Section 2); the types and characteristics of open spaces for child-dedicated facilities (e.g., schools, hospitals, fitness camps, playgrounds), as well as of child-friendly urban open spaces (Section 3); examples and case studies of biophilic design for children's health and well-being (Section 4); and the policy context (Section 5). Concluding remarks, including research gaps and scope for further investigation, are offered in Section 6.

2. Green Open Space Pathways to Children's Health and Well-Being

Many studies have investigated the relationship between exposure to natural environments and various health outcomes [7,48–50]. Positive effects of natural environments have been observed for multiple childhood health outcomes including decreased emotional and behavioral difficulties [51], improved birth outcomes [52], higher academic achievement [53], and improved overall mental well-being and cognitive development [54].

Multiple pathways have been hypothesized to explain the association between natural environment exposure and health, such as through the reduction of heat, air, and noise pollution [55], increased physical activity [56], restoration of attention [57], and decreased stress [51,55]. Childhood mental health and development encompasses socioemotional

functioning, cognitive development, academic achievement, overall development and well-being, and mental disorders such as attention deficit hyperactivity disorder (ADHD) [58].

Davis et al. (2021), in a recent systematic review, identified six prevalent health outcome categories with multiple outcomes: emotional and behavioral functioning; social functioning; academic achievement; well-being; prevalence of doctor-diagnosed disorders; and cognitive skills [48]. Academic achievement describes a child's performance in school either through scores on standardized tests or through attendance. Prevalence of doctor-diagnosed disorders refers to the rate of disease diagnosis within populations. Emotional and behavioral function describes various disabilities related to, for example, attention and interpersonal relationships, and includes some of the common symptoms associated with ADHD. The well-being category refers to measures of overall development and well-being. The social functioning category refers to prosocial behavior and positive functioning. Finally, the cognitive skills category refers to tests that evaluate memory performance and cognitive performance [48].

Past studies have highlighted that children living near street trees have a lower prevalence of asthma [59,60].

Children living in urban neighborhoods with more green space have better spatial working memory [61]. Exposure to green outdoor space is associated with a positive impact on cognitive development in primary schoolchildren [62]. Furthermore, classroom views of green landscapes significantly improve student attention and test performance, and increase student recovery from stressfulness experiences [63]. High levels of green space during childhood are associated with better mental health, as well as with a lower risk of developing a wide range of adult psychiatric disorders [64].

In a cross-sectional study in Lithuania, Andrusaityte et al. (2020) found that lower levels of residential greenness and less time spent in the park were associated with poorer general and mental health among 4–6-year-old children [65]. A systematic review conducted by Vanaken and Danckaerts (2018) documented a beneficial association between green space exposure and children's emotional and behavioral difficulties, particularly for hyperactivity and inattention [51].

Akpinar (2017) found that the closeness of urban green space to home was positively associated with higher frequency of children's physical activity and less screen time (i.e., TV viewing and computer use) [66]. In Canada, Janssen and Rosu (2015) investigated whether the presence of undeveloped green spaces in home neighborhoods is associated with physical activity amongst 11 to 13-year-old children [67]. They found that the proportion of neighborhood areas covered by trees is positively associated with the frequency of physical activity performed in free time outside of school hours [67]. Kim et al. (2016) assessed the association that the urban natural environment measured by landscape spatial patterns may have with obesity and health-related quality of life among Hispanic children [20]. The results showed that larger and more tree-covered areas were positively correlated with children's health-related quality of life [20].

The immune system benefits from direct exposure to natural environments or through contact with certain factors in the green space. It has been shown that children with the highest exposure to specific allergens or bacteria during their first year of life were the least likely to have recurrent wheezing and allergic sensitization [68].

Controversial effects of natural environments on children's health and well-being have equally been assessed. Dadvand et al. (2014) simultaneously estimated the potential benefits and negative aspects (i.e., increased risk of asthma and allergy) associated with exposure to greenness in children. They found that living close to parks was associated with a 60% higher relative prevalence of current asthma [69]. There is limited knowledge of the contributions of green space to specific allergens [70]. However, there is a suggested connection between urban greenness in early life and the prevalence of allergic respiratory diseases during childhood [71].

3. Types and Characteristics of Dedicated Public Green Open Space for Children

3.1. Parks, Schools, Trails, and Recreation Facilities

Parks, schools, trails, and recreation facilities provide settings that can facilitate physical activity, as well as relaxation [72]. School grounds are potential spaces for childhood exposure to nature, which is essential for the success of environmental education as well [73]. "Green" school grounds contain a greater diversity of environmental features such as trees, gardens, and nature trails, which may affect the quantity and quality of physical activity among elementary schoolchildren. Asphalt and turf grounds are only conducive to certain activities, such as basketball, which not all children may be interested in or able to play. Offering a natural environment with which children can interact at school may stimulate physical activity in greater numbers. Recently, schools have engaged in efforts to emphasize these features to encourage children to be more active and imaginative [74]. Gardsjord et al. (2014) have identified a range of characteristics and components of urban green spaces essential to youth physical activity (e.g., sports fields/facilities for movement, walkways and paths, shadow and shelter, trees, water elements, maintenance, renovation, form and size, openness, naturalness, and safety) [75].

3.2. Forest and Edible Schools

School resources such as playgrounds and green space, as well as routines and practices, affect the child's lifestyle behaviors [76]. Forest School is "an inspirational process, that offers all learners regular opportunities to achieve, develop confidence and self-esteem, through hands-on learning experiences in a woodland or natural environment with trees. Forest School is a specialized learning approach that sits within, and compliments, the wider context of outdoor and woodland education" [77]. Forest school offers significant opportunity for children to gain access to and become familiar with nature and woodlands [78] (Figure 2). Furthermore, they have the potential to significantly benefit children and young people's physical health and mental well-being [79]. Forest gardens or edible schools are "edible polyculture landscapes with different layers of mostly perennial vegetation that can be created in urban settings" [80]. Such spaces have the "potential to be places where children can connect emotionally and cognitively to other organisms" [80]. "Biodiverse edible schools" link local urban nature and healthy food, which are informal components of edible green infrastructure (GI) that can jointly support cultural and provisioning ecosystem services in cities [81,82].

3.3. Informal Green Spaces

Informal green spaces are a subcategory of the formality–informality domain of urban green space literature [83–85], with many scholars viewing informal green spaces as unplanned vegetation that is not traditionally considered in urban and ecological planning and governance [85]. An IGS, as defined by Rupprecht and Byrne, is a socio-ecological entity, not just a cultural or biological one. Any urban space with a history of significant anthropogenic disturbance that is covered at least partially with non-remnant, spontaneous vegetation is classified as an informal green space [86].

In his book "Manifesto of the Third Landscape" (Manifeste du Tiers Paysage, 2020), Gilles Clément, a French landscape architect, classified such spaces as those left behind urban or rural sites, transitional spaces, and neglected land on the periphery of the "third landscape" [87]. Informal urban greenspace typologies include street verges (e.g., roadside verges, informal trails, and footpaths), lots (e.g., vacant lots, abandoned lots), gaps (e.g., the gap between walls or fences), railway (e.g., rail tracks, verges), brownfields (e.g., landfill, industrial park), waterside (e.g., rivers, canals), structures (e.g., walls, fences, roofs), microsites (e.g., vegetation in cracks or holes), and power line (e.g., power line rights of way) [86].

Figure 2. Forest bathing for children in Finland (photo by Mari Hukkalainen for Maria Beatrice Andreucci).

Informal urban green spaces are equally as important as formal ones [88]. Such spaces can help to reduce disparities in access to formal green spaces among children and the elderly [88]. According to a study conducted in Angola, informal green space serves as a supplement to children's daily lives by providing food, playgrounds for recreational activities, and a way to connect classroom lessons with nature [85].

3.4. Healing, Sensory, and Therapeutic Gardens for Children

Sensory gardens are popular in schools, veteran rehab centers, and nursing homes in the United Kingdom [89]. Sensory gardens stimulate the five senses by providing a visual, audible, tactile, scented, and tasty experience [89]. They are made to appeal to both wildlife and humans, and they help us reconnect with nature [89]. Such gardens can be used in a variety of settings, including providing deep memory prompts, providing a calm space in a school where experiential learning can take place outdoors, assisting developmentally delayed children in reaching milestones, and balancing digital information overload [89]. Furthermore, a sensory garden, such as a 'snoezelen' room, can provide a variety of sensory stimuli to children with special educational needs [90] (Figure 3).

Figure 3. Sensory garden in Bremervörde, Germany (source: Wikipedia CC BY-SA 3.0).

On the other hand, a therapeutic garden is a term used primarily in correctional and healthcare settings in the United States. Horticultural therapy, also referred to as social and therapeutic horticulture, takes place in these gardens. Horticultural therapy differs from sensory and healing gardens because it uses gardening activities to provide active healing [89]. Gardens specifically designed for dementia, mobility, rehabilitation, and community cohesion are examples of therapeutic landscapes. Gardens for special needs groups follow the same design principles, elements, and processes as any other garden [91]. There are, however, special considerations for certain groups, and it is critical to fully comprehend their specific diagnosis, psychological condition, and needs to successfully create a truly "therapeutic" space [91] (Figure 4).

Figure 4. Therapeutic garden in Sørenga, Oslo, Norway (photo by Maria Beatrice Andreucci).

Studies on healing gardens in children's hospitals have emerged over the last two decades, showing that these gardens need unique design elements to attract and provide a therapeutic environment for children [92].

3.5. Playgrounds, Sport Facilities, Fitness Camps

Outdoor recreational spaces such as playgrounds, sports facilities, and fitness camps are designed to enable and foster physical activity in children [93,94]. Playgrounds should provide a range of different equipment and offer spaces (e.g., paved areas) for a variety of play activities to meet the needs of as many children of both sexes as possible [93]. A study in Australia revealed that as children transition from preschool (3–5 years) to primary school age (6–11 years), they visit parks that have more facilities to support physical activities and active recreation [95]. Several studies have also shown that the perceived existence of playground equipment and services in parks are essential factors for encouraging both children and parents to be active [95–97]. A good example of an outdoor recreational space with playgrounds and sports facilities is Nelson Mandela Park in Amsterdam [98], shown in Figure 5.

Figure 5. Nelson Mandela Park in Amsterdam. This neighborhood park consists of six hectares of sports facilities, 700 residences, and three recreation zones, each defined by a different identity and function [98] (aerial image:Imagery ©2023 Google, Imagery ©2023 Aerodata International Surveys, Maxar Technologies, Map data ©2023; photos by Alessio Russo).

4. Biophilic Design for Children's Health and Well-Being

Biophilic design, inspired by Wilson's 1984 hypothesis of 'biophilia', advocates that people have an instinctive affinity with nature and that increasing the presence of nature in the built environment can lead to an increase in benefits [99–101]. Kellert (2008) originally identified two dimensions of biophilic design—organic/naturalistic and place-based/vernacular—and six elements—environmental features, natural shapes and forms, natural patterns and processes, light and space, place-based relationships, and evolved relationships to nature–which, in turn, he related to some seventy biophilic design attributes [102].

The first basic dimension of biophilic design—organic/naturalistic—encompasses "Shapes and forms in the built environment that directly, indirectly, or symbolically reflect the inherent human affinity for nature" [102]. Direct experience refers to the "relatively unstructured contact with self-sustaining features of the natural environment", such as daylight, plants, animals, natural habitats, and ecosystems [102]. Indirect experience involves contact with nature that "requires ongoing human input to survive", such as potted plants, water fountains, or aquariums [102]. Symbolic or vicarious experience involves "no actual contact with real nature but rather the representation of the natural worlds" through images, pictures, videos, metaphor, etc. [102]. The second basic dimension of biophilic design is a place-based or vernacular dimension, defined as "buildings and landscapes that connect to the culture and ecology of a locality or geographic area" [102].

This dimension includes what has been called a 'sense', or 'spirit of place', "underscoring how buildings and landscapes of meaning to people become integrated into their individual and collective identities, metaphorically transforming inanimate matter into something that feels lifelike and often sustains life" [102].

This understanding, according to Kellert (2008), can assist designers and developers in pursuing practical application of biophilic design in the built environment [102].

In this paper, we use the term biophilic design as the process of designing open space leveraging biophilic attributes in order to improve children's health and well-being (Table 1).

Table 1. Attributes of biophilic design (adapted from Kellert and Calabrese, 2015 [103]; Andreucci, 2020 [104]).

Direct Experience of Nature	Indirect Experience of Nature	Experience of Space and Place
Light	Images of nature	Prospect and refuge
Water	Natural materials	Organized complexity
Vegetation	Natural colors	Integration of parts to wholes
Animals	Simulated natural light and air	Transitional spaces
Weather conditions	Naturalistic shapes and forms	Mobility and wayfinding
Natural landscape and ecosystems	Evoking nature	Cultural and ecological attachment to place
Fire	Information richness	
	Age, change, and patina of time	
	Natural geometries	
	Biomimicry	

Biophilic design presents the opportunity to develop brand-new, cutting-edge, and nature-based learning settings that may assist cognitive processes and encourage a sense of connection to nature [105].

Examples of biophilic design for children's health and well-being are illustrated below at two different levels of implementation (Figure 6):

- Children's dedicated facilities, such as schoolyards, fitness camps, sports facilities, and playgrounds; and
- Child-friendly public open spaces, such as neighborhood open spaces and urban parks.

4.1. Kids' City Christianshavn, Copenhagen as a Case Study of Biophilic Design in Children's Open Space

Over the next 10 years, the population aged 0 to 15 in Copenhagen is expected to grow by more than 18,000 [106]; more and more families are choosing to stay with their children in the Danish capital Copenhagen rather than moving to the suburbs. Copenhagen is characterized by many different neighborhoods with special buildings that carry a particular history or functional purpose. These buildings provide different areas with character and atmosphere. In the same way, Kids' City Christianshavn has been conceived and designed to reflect the city's architectural diversity [107].

		Direct Experience of Nature	Indirect Experience of Nature	Experience of Space and Place
SCALE **Schoolyard** PLACE **Ørestad Gymnasium Copenaghen**		Light, Water, Vegetation, Animals, Weather Conditions	Natural Materials, Natural Colours, Simulated Natural Light and Air, Naturalistic Shapes and Forms, Evoking Nature, Information Richness, Natural Geometries Biomimicry	Prospect and Refuge, Organized Complexity, Integration of Parts to Wholes, Transitional Spaces, Mobility and Wayfinding
SCALE **Kids City** PLACE **Kids' City Christianshavn Copenaghen**		Light, Water, Vegetation, Animals, Weather Conditions, Natural Landscape and Ecosystems, Fire	Images of Nature, Natural Materials, Natural Colours, Simulated Natural Light and Air, Naturalistic Shapes and Forms, Evoking Nature, Information Richness, Age, Change, Natural Geometries, Biomimicry	Prospect and Refuge, Organized Complexity, Integration of Parts to Wholes, Transitional Spaces, Mobility and Wayfinding, Cultural and Ecological Attachment to Place
SCALE **Playground** PLACE **Superkilen Copenaghen**		Light,Vegetation, Animals, Weather Conditions	Naturalistic Shapes and Forms, Evoking Nature, Information Richness, Age, Change, Natural Geometries	Organized Complexity, Transitional Spaces, Mobility and Wayfinding, Cultural and Ecological Attachment to Place
SCALE **Residential open space** PLACE **8 House Copenaghen**		Light, Water, Vegetation, Animals, Weather Conditions, Natural Landscape and Ecosystems	Natural Materials, Natural Colours, Naturalistic Shapes and Forms, Evoking Nature, Information Richness, Age, Change, Natural Geometries,	Prospect and Refuge, Organized Complexity, Integration of Parts to Wholes, Transitional Spaces, Mobility and Wayfinding, Cultural and Ecological Attachment to Place
SCALE **Urban park** PLACE **Byparken Copenaghen**		Light, Vegetation, Weather Conditions	Natural Materials, Natural Colours, Information Richness, Age, Change, Natural Geometries	Organized Complexity, Integration of Parts to Wholes, Transitional Spaces, Mobility and Wayfinding, Cultural and Ecological Attachment to Place

Figure 6. Examples of multiscale biophilic design for children's health and well-being in Copenhagen (photos by Maria Beatrice Andreucci).

The site is a triangular plot wedged in between the Freetown Christiania to the South, the urban blocks of Christianshavn to the west, and Aresenaløen and the canal to the east. (Figure 7).

Kids' City Christianshavn has all the iconic elements of an actual city, scaled down to children's size, providing the different areas with own character and atmosphere (Figure 8).

Kids' City Christianshavn's next door neighbor is the self-sustaining community of Christiania, a world-famous and notorious social experiment and free city with a self-grown and playful architecture.

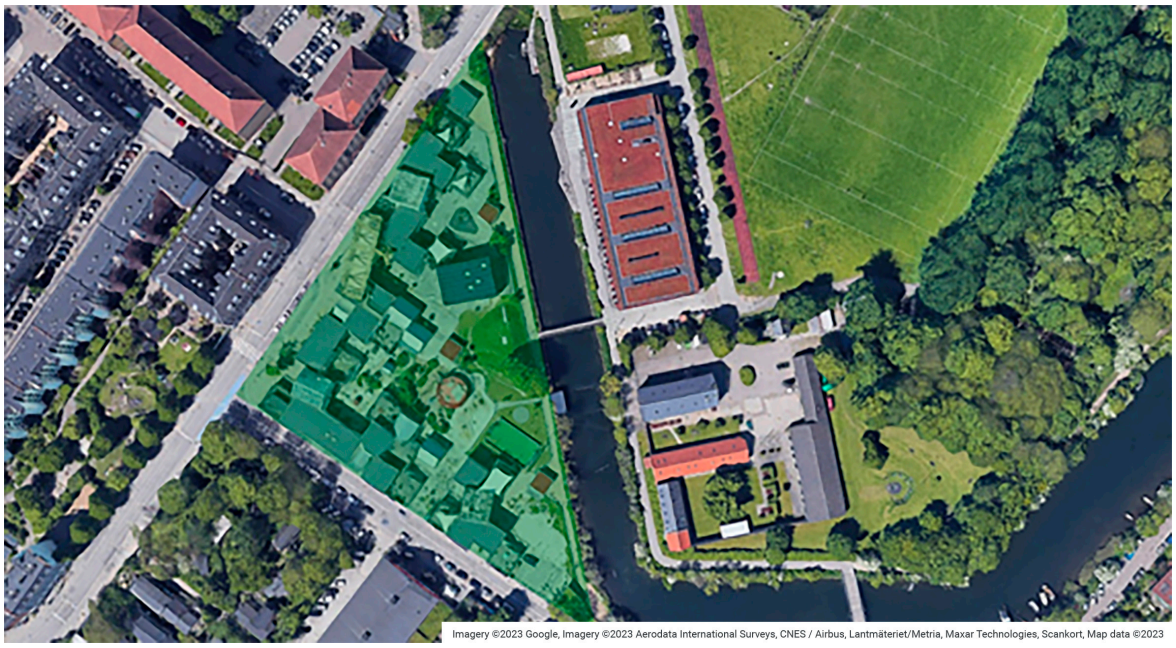

Figure 7. The site is a triangular plot wedged in between the Freetown Christiania to the south, the urban blocks of Christianshavn to the west, and Aresenaløen and the canal to the east (aerial image:Imagery ©2023 Google, Imagery ©2023 Aerodata International Surveys, CNES/Airbus, Lantmäteriet/Metria, Maxar Technologies, Scankort, Map data ©2023). The architects of Cobe Design considered Kids' City Christianshavn in similar terms as Copenhagen, with different neighborhoods for different age groups. The different neighborhoods in Copenhagen all have different types of citizens with different sets of preferences. Similarly, Kids' City Christianshavn addresses different groups with different needs: infants, preschool children, and school children, as well as young people. Incorporating variety and diversity in both indoor and outdoor spaces is essential when designing for such a mix of ages, needs, and personalities. Spaces vary in both scale and content, with small, secure, and intimate spaces as well as large and challenging areas [107].

4.2. Birmingham as a Case Study of Child-Friendly Public Open Space

Birmingham is the UK's first biophilic city and has specifically targeted children among the most vulnerable population groups [108,109]. Birmingham, which received the renowned Tree Cities of the World designation, is one of the greenest cities in Europe, with 591 parks and green areas [110]. A recent remarkable project is "Naturally Birmingham", which demonstrates how cities can transfer the environment to the core of their decision-making to ensure that parks have a sustainable future [110]. This includes how greenspace can support children through their early development, engaging young and vulnerable people and empowering them to influence the future direction of the city, achieving good quality greenspace in housing developments, connecting skills and employment programs to environmental programs, and embedding green interventions into the local social fabric. Public Health England views green spaces a large part of children's education and part of the wider support for children in care [110].

Another notable project is the Science Garden in Birmingham (Figure 9), which is an outdoor discovery area full of surprises and entertaining activities for both children and adults. It provides an exciting and entertaining day out by bringing engineering, mechanics, and transportation themes to life through over 30 hands-on exhibits [111].

Figure 8. Facing the street, the golden City Gate spans between two buildings. While creating a covered urban space beneath, the city gate and ball cage also pays homage to another famous gate in the neighborhood, namely, the entrance to neighboring Christiania. Photo by Maria Beatrice Andreucci.

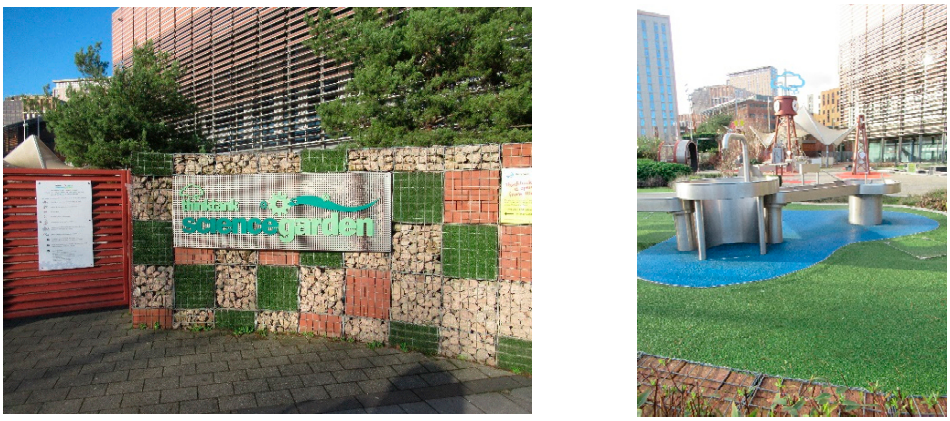

Figure 9. Science Garden in Birmingham, UK (photos by Alessio Russo).

5. Policy Context

Children's access to safe green spaces has relevance to several international frameworks, including the Sustainable Development Goals, the Convention on the Rights of Persons with Disabilities, the Convention on the Rights of the Child, and others [112].

Many of the Sustainable Development Goals (SDGs) are linked with children's development [113], and ensuring children's access to green space can effectively contribute to the achievement of many SDG targets [114], including:

- Target 3.4: By 2030, reduce by one third premature mortality from noncommunicable diseases through prevention and treatment, and promote mental health and well-being;
- Target 4.7: By 2030, ensure all learners acquire knowledge and skills needed to promote sustainable development, including, among others, education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of

a culture of peace and non-violence, global citizenship, and appreciation of cultural diversity and of culture's contribution to sustainable development;

- Target 11.7: By 2030, provide universal access to safe, inclusive, and accessible green, and public spaces, in particular, for women and children, older persons, and persons with disabilities;
- Target 12.8: By 2030, ensure that people everywhere have the relevant information and awareness for sustainable development and lifestyles in harmony with nature;
- Target 13.1: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries;
- Target 15.9: By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies, and accounts [114].

Policy and legislation to encourage children's access to green spaces and outdoor activities have been discussed in several books and reports [112,115]. For example, the book "Designing cities with children and young people", edited by Kate Bishop and Linda Corkery, includes legislation, policy, and case studies, and also focuses on how to promote greater benefits in the built environment for children and young people in cities around the world [116]. Several nations have implemented policies to ensure children's right to play, as outlined in Article 31 of the United Nations Convention on the Rights of the Child [117]. The Welsh government adopted a play policy in 2002, recognizing the value of play activities for children's learning and development [112]. This policy requires local authorities to create enriched play spaces that adhere to minimum national requirements and that are accessible to all children [112]. According to a review on child-friendly planning in the UK by Wood et al. (2019), Wales provides the best support for the national child-friendly planning policy [118]. In reviewing the literature, we found that the amount of green space required for children's play activities is governed by policies that differ from country to country. For example, Krysiak (2020) [17] compared planning policy and guidance for multi-unit residential developments, including minimum requirements for outdoor child-focused amenities in four cities (Table 2).

Table 2. Minimum requirements for outdoor child-focused amenities (adapted from Krysiak, 2020 [17]).

	London, UK	**Sydney, Australia**	**Toronto, Canada**	**Vancouver, Canada**
Communal Outdoor Space	Dependent on local development plans.	Communal open space has a minimum area equal to 25% of the site.	Minimum 40 m^2 of outdoor amenity space.	As per the 'Play Space Provision' requirements.
Play Space Provision	A minimum of 10 m^2 of dedicated outdoor play space per child.	No minimum play space requirements.	25% of allocated indoor and outdoor amenities should be child-focused.	The total outdoor play area should range in size from 130 m^2 to 280 m^2.

Minimum "playable space" requirements should be included for all new multi-unit residential developments [17]. Numerous studies have reported that people with mobility disabilities visit green areas less frequently than the general population [109,110]. Thus, architects, landscape architects, and planners must consider policies and guidelines that ensure access to green spaces for children with disabilities. Children and teenagers with disabilities have the right to play and to be a part of their local communities, but this can only be achieved if the obstacles to accessible play are recognized and removed [119]. In particular, the design of play areas for children with disabilities should be considered from the beginning of the project [120]. Government legislations and nonprofit organizations provide a variety of standards, recommendations, and guidelines that can assist landscape architects in creating inclusive green spaces [115]. Recently, design guidelines from the

international grey literature were reviewed by Moore et al. (2022) to strengthen the body of knowledge for creating inclusive public playgrounds [121]. For example, the UK Plan Inclusive Play Places (PiPA) methodology was designed to develop inclusive outdoor play areas, as well as assess existing installed play areas [122]. The rights of children with disabilities are protected by several international agreements [115]. For example, the Convention on the Rights of the Child recognizes that "children with disabilities should have full enjoyment of all human rights and fundamental freedoms on an equal basis with other children" and recalls "obligations to that end undertaken by States Parties to the Convention on the Rights of the Child". The Convention on the Rights of the Child was adopted by the UN General Assembly in 1989 and has since been ratified by almost every country in the world. Children's access to green space contributes to the fulfilment of many of these rights, including an adequate standard of living (Art. 27), the right to play (Art. 31), health and health services (Art. 24), and others [112,117]. The Convention on the Rights of the Child gave rise to several important UN initiatives, such as the UNICEF Child-Friendly Cities (CFC). The CFC framework builds from a holistic perspective of children's rights as comprising both their access to urban resources (rights in the city) and to meaningful participation in urban governance (rights to the city), and it has given wider visibility to the need to integrate children's rights into decision-making and city governance [112]. Along the same lines, in the discussion paper "The Necessity of Urban Green Space for Children's Optimal Development", among the key recommendations, it is stated that "interventions should focus on empowering communities to claim and maintain their local green spaces, securing government support to improve and create green space in cities, and prioritizing schools and childcare centers for greening" [112].

6. Concluding Remarks

With this perspective, we have built from the literature on biophilic design and relevant health and well-being policy frameworks, as well as ongoing multiscale dedicated experiments in urban areas, in order to analyze the benefits and trade-offs embedded in urban green-blue infrastructure for children. This study provides new insights and directions for the design of biophilic and child-friendly cities., targeting architects, landscape architects, and urban designers. In the current context, and with this new evidence in hand, it is clear that caregivers, communities, institutions, and governments can take immediate action to create new green spaces and improve existing green spaces in urban neighborhoods, prioritizing places where children naturally congregate, such as around schools and childcare centers [112]. Green spaces can significantly benefit children's physical, mental, and social development—from infancy into adulthood. Each child, no matter where he/she lives in the city, should be within easy walking distance of a safe, inclusive, and welcoming public green space. Interventions recommended by policymakers focus on empowering communities to claim, co-design, and maintain their local green spaces, securing government support to improve and create green space in cities, and prioritizing schools and childcare centers for greening [104]. Cities such as Copenhagen, Birmingham, and Amsterdam are taking proactive measures to create more child-friendly play opportunities. It is also clear that improved use of urban resource systems necessitates innovation in terms of energy efficiency and maintenance, and in forging sustainable lifestyles. As children's behavior is molded by their ongoing interaction with the urban environment, children's participation in shaping sustainable cities will be a determinant for the future of our cities and our planet.

Children and their families, especially the most disadvantaged, are still confronted with spatial inequity in multiple ways: the high cost of living and access to urban services; the unequal geospatial distribution of urban services; the poor characteristics of the built environment; and the inequitable spatial distribution of land and urban space. In urban settings, there is a strong correlation between the vulnerability of the most disadvantaged children and the built environment. An unsustainable built environment constrains children's access to urban services in a physical way, due to unequal distribution, ineffective

planning, and lack of quality in design and construction. It leads to urban-specific environmental health problems that social infrastructure alone cannot address, shifting the focus from communicable to non-communicable diseases. The built environment also reveals itself as a threat when children and their caretakers cannot evaluate, be prepared for, or be safe from risks. Finally, the built environment also influences to what extent children's participation is possible, in terms of public space where children can congregate, as well as other infrastructure that allows physical, social, and digital connectivity [4].

In the literature, we have found that regular access to GI has several mental health benefits for children (i.e., attention restoration, memory, competence, socialization support, self-discipline, stress moderation, improvement of behaviors and symptoms of ADHD) [54]. In addition, the benefits of physical activity, classroom-based physical activity, and academic outcomes in children are documented in systematic reviews and meta-analyses [76]. However, children's physical activities are frequently prohibited in urban areas for cultural reasons, e.g., children are often prevented from using urban green spaces because of their parents' fears about crime or possible accidents [15]. City managers and planners should provide enough green spaces for children's physical activity. Research has found that a two-hour "dose" of nature a week is associated with good health and well-being [123]; however, the concept of a "dose" of nature for children needs to be investigated further [54]. Average medical costs during childhood are small, but investments in interaction with nature early in life can lead to significant changes in health and reduce medical costs later in life [124,125]. A regenerative approach in design and urban transformation [126], rather than secluding children, offers the best prospects for creating healthier neighborhoods and cities—for children as well as for other vulnerable users. In this process, children themselves need to be involved from the early stages, thus enabling decision-makers to implement urban environments that are "designed for all" and managed accordingly. We need to increase both dedicated green spaces for children and improve the overall quality of urban public open spaces. Design codes can be improved and adapted to provide high levels of sustainability and quality green spaces for children [127]. While there is heterogeneity in the reported associations between access to green spaces and physical activity, available studies suggest higher levels of physical activity while children are in green spaces. Researchers and practitioners should cooperate more to provide more evidence about the design characteristics of spaces that have been confirmed to be positive for children. Successful cities are cities where children of all ages are active and visible in public green spaces [128].

In our opinion, children must be in contact with nature from an early age to avoid the phenomenon of biophobia. Biophobia, or an aversion to nature, can develop if children's natural attraction to nature is not allowed to flourish during their early years [129]. Biophobia encompasses a wide range of feelings, from discomfort in natural settings to contempt for anything that is not man-made, managed, or air-conditioned [129]. To date, the vast majority of the studies on the effects of green spaces on child health and development have been conducted in high-income countries. As ethnicity, climate, and lifestyle might modify such effects, the generalizability of studies from these countries to the rest of the world could be limited. There is a need for more studies in low- and middle-income countries. Few studies exist for outcomes such as dyslipidemia, hyperglycemia, hypertension, and pregnancy complications (e.g., pre-eclampsia or diabetes). The available evidence for preterm birth, obesity, and respiratory and allergic conditions has remained relatively inconsistent. Finally, most studies on children's mental health have used residential address as a proxy for exposure; we recommend that future studies aim to assess and incorporate a child's daily exposures at, for example, daycare facilities and schools, to better capture the full extent of children's living environments [48]. A limitation of this perspective is that the authors analyzed the scientific literature only in English; future research will therefore encompass a multilingual systematic review.

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