OXFORD

Oxford Open Infrastructure and Health, 2023, **1**, 1–14

https://doi.org/10.1093/ooih/ouad004

Advance access publication date 19 October 2023

Review

Green and blue infrastructure (GBI) and urban nature-based solutions (NbS) contribution to human and ecological well-being and health

Luis Valenca Pinto [1,2,*], Miguel Inácio[2] and Paulo Pereira[2]

[1]Coimbra Agrarian Technical School, Research Centre for Natural Resources, Environment and Society (CERNAS), Polytechnic Institute of Coimbra, ESAC, Edifício J - Sala J2.09, 3045-601 Coimbra, Portugal

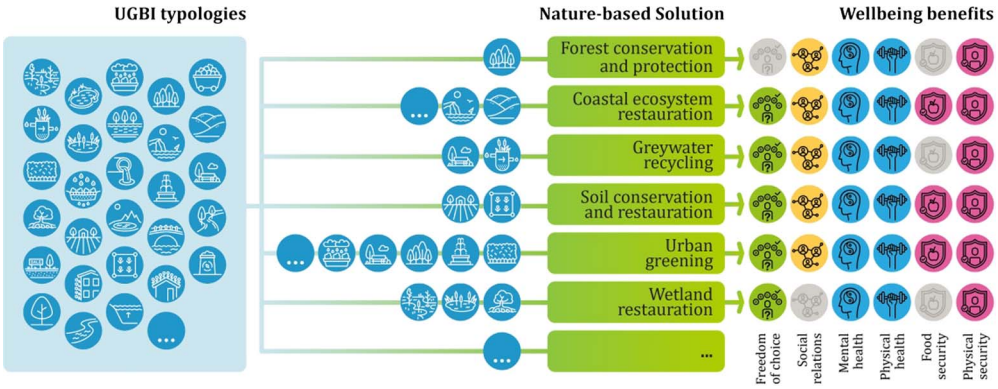
[2]Environmental Management Research Laboratory, Mykolas Romeris University, Ateities st. 55, 08303 Vilnius, Lithuania

[*]Corresponding address. Environmental Management Research Laboratory, MRU. Ateities st. 55. 08303 Vilnius, Lithuania. Tel: +351.966.923.588; E-mail: lmpinto@mac.com

Abstract

The article explores the contributions of urban green and blue infrastructure (UGBI) and nature-based solutions (NbS) to enhance human and ecological well-being and health in urban areas. It delves into the concepts of UGBI and NbS, highlighting their importance in creating sustainable and liveable cities. We consider UGBI natural elements in the urban environment, grouped into different typologies. NbS are considered solutions, or actions, to promote environmental and human health based on the use of UGBI. The assessment was done under the umbrella of human and ecosystem health, linking well-being dimensions from the Common International Classification of Ecosystem Services—freedom of choice, social relations, mental health, physical health, food security and physical security—with the United Nations' Sustainable Development Goals, showing a link with 12 of the 15 goals. The article presents non-exhaustive lists of UGBI types and NbS actions linked to well-being dimensions. We assess ecosystem services provided by GBI and NbS and the implications of incorporating these solutions in urban environments for human and ecosystem health and the future of healthy and liveable cities.

Graphical Abstract



Lay Summaries: Vegetation and water spaces in urban areas, often called urban green and blue spaces (UGBI) in the research field, are fundamental elements in the urban environment. They provide a large set of commodities and services to urban dwellers. Nature-based solutions (NbS) comprise all management actions that try to solve environmental, social and economic problems by implementing solutions based on nature to reduce negative impacts on humans and nature. These solutions always try to avoid artificial structures whenever a solution is found that is based on nature. Both UGBI and NbS positively impact human well-being and ecosystem health. This document highlights the links between UGBI, NbS, their ecosystem services and their relations with the different dimensions of human well-being. NbS actions can involve one or more UGBI areas, usually structured to maximize the provision of ecosystem services (ES). Both UGBI and NbS are fundamental for healthy and liveable cities.

Key words: ecosystem services; green and blue infrastructure; nature-based solutions; well-being

Received: July 5, 2023. **Revised:** September 18, 2023. **Accepted:** October 17, 2023.

© The Author(s) 2023. Published by Oxford University Press.

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted reuse, distribution, and reproduction in any medium, provided the original work is properly cited.

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

INTRODUCTION

As urbanization accelerates, cities face numerous challenges related to human health, environmental degradation and ecological sustainability [1, 2]. In response to these challenges, the adoption of nature-based solutions (NbS) and the establishment of green and blue infrastructure (GBI) are gaining prominence. NbS can be understood as actions or interventions that utilize natural or mimic natural processes to address urban issues [3, 4], while GBI incorporates green spaces and water elements into urban planning and design [5, 6]. This chapter explores the contributions of NbS and GBI to human and ecological well-being and health in urban areas.

GBI and NbS provide many ecosystem services (ES), which are fundamental for human beings. ES are 'the contributions that ecosystems make to human well-being' [7]. These contributions include 'regulating services', e.g. the regulation of flood episodes, water quality and climate conditions; 'provisioning services', e.g. the supply of water, food and raw materials; and 'cultural services', e.g. opportunities for recreation and socialization and improvement of physical and mental well-being. Sustainability and liveability are central aspects of today's urban development. Achieving these objectives requires a holistic approach that considers the well-being of both humans and ecosystems. Human well-being encompasses various factors that contribute to a fulfilling life. Different science fields have assessed different well-being dimensions (e.g. [8–10]). For this discussion, we consider the well-being dimensions commonly associated with the ES concept, addressed in the Millennium Ecosystem Assessment [11] and the CICES 4.3 [12].

These dimensions include 'good health', encompassing both 'mental well-being' and 'physical well-being' in a clean environment with fresh air and clean water; 'good social relations', marked by social cohesion, mutual respect and the ability to support others and provide for children; 'security', involving access to resources, personal safety and protection from natural and human-influenced disasters, which can be divided into 'food security' and 'physical security'; and 'freedom of choice and action', which grants individuals the opportunity to pursue their valued endeavours. Other well-being factors and education influence this freedom and are a prerequisite for achieving societal fairness and equality. GBI and NbS contribute significantly to these goals. They offer a range of ES, including improved air and water quality, climate regulation, biodiversity conservation and physical and mental health benefits for urban residents [13–15]. By integrating natural elements into urban landscapes, GBI and NbS enhance cities' overall sustainability and liveability [16].

According to the United Nations (UN) Sustainable Development Goals (SDGs) [17], GBI and NbS align with several crucial objectives for creating sustainable and liveable cities. Table 1 shows the main links between the UN SDGs and GBI and NbS, highlighting the most relevant contributions to human well-being.

This article reviews and summarizes the links between UGBI, NbS and well-being, presenting non-exhaustive lists of UGBI types and NbS actions linked to well-being dimensions and associated ecosystem services. We also address environmental equity concerns related to UGBI and NbS. In the conclusion section, we assess research gaps, suggesting a possible research agenda.

GBI AND NbS IN URBAN AREAS AND PROVIDED ES

There is no universal definition of GBI [19] nor NbS [20]. Green and Blue infrastructure (GBI)—sometimes called green infrastructure (GI)—plays a crucial role in the successful implementation of policies that can be partially achieved through nature-based solutions. The European Commission defines green infrastructure as a strategically planned network of natural and semi-natural areas with additional environmental features to provide diverse ecosystem services [21]. GBI encompasses incorporating green spaces, such as parks and urban forests and integrating water elements, such as rivers and wetlands, into urban settings. GBI has proven effective in naturally delivering ecological, economic and social benefits [22, 23]. When in the urban environment, GBI can also be called urban GBI or UGBI. By adopting GBI strategies, societies can comprehend the inherent value of nature's benefits and allocate the required resources to sustain and improve these benefits [24]. Table 2 lists UGBI types, the main ES provided and well-being benefits.

Regarding nature-based Solutions (NbS), the European Commission defines them as 'solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes and seascapes, through locally adapted, resource-efficient and systemic interventions' [25].

The International Union for the Conservation of Nature (IUCN) definition of a NbS is 'an action to protect, sustainably use, manage and restore natural or modified ecosystems, which addresses societal challenges, effectively and adaptively, providing human well-being and biodiversity benefits' [26].

NbS refer to interventions that utilize nature or mimic natural processes to address urban challenges. These solutions focus on integrating natural elements into urban planning and design, enhancing urban environment quality. The overarching goal of NbS is to address a wide range of challenges related to ecosystem resilience, climate change, human health and overall well-being. These solutions achieve this by incorporating established approaches focused on protecting biodiversity, conserving ecosystem services and implementing green infrastructure. By integrating these approaches, NbS can comprehensively address social, economic and environmental issues while enhancing resilience to future threats [24].

Although GBI and NbS are distinct concepts, they are closely intertwined and share common objectives. NbS, as previously explained, is a comprehensive concept encompassing various approaches to addressing problems by utilizing nature and considering entire ecosystems. Upgrading an ecosystem may necessitate the implementation of multiple NbS strategies, which are based on multiple UGBI elements. To mitigate the urban heat island effect, it may be necessary to incorporate street trees, green walls, green roofs and a network of parks of varying sizes. The connectivity between these NbS interventions gives rise to complementary, often overlapping, solutions using multiple UGBI. In turn, these multiple UGBIs can become part of broader UGBI. For example, a project using an urban forest and a nearby lake can 'create' a new urban park from previously informal natural areas. NbS also prove effective in resolving issues within green-blue networks. It is helpful to perceive NbS interventions as a system of methodologies that expand and enrich the existing framework of UGBI, thereby establishing a network of thriving ecosystems.

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

Table 1. UGBI and NbS links with UM SDGs and main well-being dimensions (based on [18])

UN Sustainable Development Goals		UGBI and NbS Contribution	Well-being benefits (CICES 4.3)
	No poverty	Reduce exposure of vulnerable population to climate related extreme events (e.g. floods; heat waves).	
	Zero hunger	Food supply.	
	Good health and well-being	Increase air, soil and water pollutant removal. Provision of green spaces for human-nature interaction.	
	Clean water and sanitation	Reduce water pollution through pollutant retention and removal.	
	Affordable and clean energy	Contribution to the increase of building energy efficiency.	
	Decent work and economic growth	Increase green jobs, via UGBI and NbS design, implementation and management.	
	Industry, innovation and infrastructure	NbS research and development and implementation in urban areas.	
	Sustainable cities and communities	Reduce population vulnerability to climate related extreme events (e.g. floods; heat waves) and increase accessibility to green spaces.	
	Responsible consumption and production	Provision of green spaces for the delivery of food and fibres, contributing to circular economy.	
	Climate action	UGBI and NbS contribution to climate regulation and carbon sequestration in urban areas.	
	Life bellow water	Reduction of diffuse and point source pollution.	
	Life on land	Increase biodiversity and reduce land affected by floods and droughts.	

Well-being benefits: Freedom of choice; Social relations; Mental health; Physical health; Food security; Physical security. Coloured icon correspond to effective contributions towards the specific well-being dimension.

Collectively, UGBI and NbS strive to create and maintain a robust system of interconnected nature-based interventions [27].

Urban areas often lack natural environments and suffer from heat island effects, air pollution and a decline in biodiversity [23, 28, 29]. Incorporating GBI and NbS in urban planning can mitigate these issues, transforming urban areas into sustainable and resilient spaces. These solutions bring numerous benefits, including improved air and water quality, temperature regulation, enhanced biodiversity and increased aesthetic value [16].

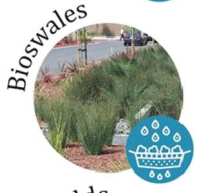
Considering the definition of NbS as 'solutions' [25] or 'actions' [26], table 3 shows a (non-exhaustive) list of various types of NbS, with a short description and links with different UGBI elements. It is important to note that NbS are often multifaceted and can provide several benefits simultaneously.

ES PROVIDED BY UGBI AND NBS

UGBI and NbS, through the integration of UGBI, provide crucial ecosystem services that positively impact human and ecological well-being [30], e.g. urban green spaces and vegetation assist in reducing air pollution by absorbing and filtering harmful pollutants such as nitrogen dioxide and particulate matter [31]. They also act as carbon sinks, mitigating climate change effects [32]. Urban forests and wetlands help regulate temperature by providing shade and evaporative cooling, combating heat island effects and reducing the energy demand for cooling [33]. These services have been classified and organized under the Common International Classification of Ecosystem Services (CICES), the latest version (v5.1) being from 2018 [7]. Green spaces act as habitats for numerous species, promoting biodiversity while supporting ecological balance. Access to nature in urban areas has been associated with various health benefits, including reduced stress levels, improved mental health, increased physical activity and enhanced overall well-being [34]. Table 1 describes the main ES associated with the different UGBI types. UGBI and NbS also contribute to biodiversity conservation by restoring and integrating natural elements into urban environments.

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

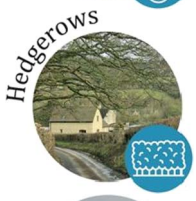
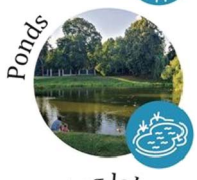
Table 2. UGBI typologies, main ecosystem services and associated well-being dimensions

UGBI type	Description	Main well-being benefits
	Shared spaces where individuals or groups can rent or cultivate small plots of land to grow plants and vegetables. They promote community interaction, access to fresh produce and a connection with nature.	
	Eco-friendly elements consisting of a drainage ditch filled with vegetation, compost and/or rockfill, designed as natural filtration systems to remove runoff water pollution, improving water water quality in urban areas.	
	Abandoned or underutilized industrial or commercial land that may be contaminated with hazardous substances. These areas often require remediation before they can be safely redeveloped, posing environmental and health risks to nearby communities. They can also contribute for flood regulation, nutrients retention and recreation.	
	Patches of agricultural land within densely populated cities. These green spaces can provide locally produced food, while enhancing urban biodiversity, air quality and fostering a sense of eco-sustainability in urban environments.	
	A set of organic solid waste composters, allowing to efficiently manage organic waste while simultaneously generating fertilizers for the local community and organizations to utilize.	
	Raised banks constructed to control the flow of water in rivers. They provide various ecosystem services including flood protection, erosion control and habitat for both aquatic and terrestrial species. They contribute to water purification, carbon sequestration and provide recreational and aesthetic benefits.	
	Designated routes or areas that prioritize and promote ecological connectivity, conservation and sustainable development by facilitating the movement of wildlife and plant species. They can also provide for recreation benefits.	
	Vertical installations of plants on the exterior or interior walls of buildings, contributing to improved air quality, thermal regulation, noise reduction and aesthetic value.	
	Living vegetation installed on rooftops of buildings, providing multiple benefits such as stormwater retention, insulation, air quality improvement, reduced urban heat island effect and habitat creation.	

(Continued)

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

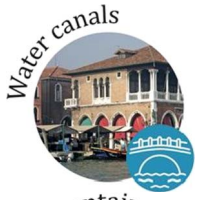
Table 2. Continued

UGBI type	Description	Main well-being benefits
	Areas collecting and treating household or commercial greywaters, excluding toilet waste. Greywaters are filtered and biodegraded, allowing it to be reused for purposes like landscape irrigation, reducing the strain on freshwater resources and promoting sustainability.	
	Dense rows of shrubs, trees and plants that serve as barriers or boundaries. They provide ecosystem services such as wildlife habitat, biodiversity support, erosion control, carbon sequestration and windbreaks. Hedgerows also enhance water filtration, pollination and visual aesthetics in the landscape.	
	Large bodies of freshwater that provide important ecosystem services. They offer habitat for diverse aquatic species, regulate water flow, support nutrient cycling and help stabilize local climate. Lakes also offer recreational opportunities, serve as water sources and contribute to cultural and aesthetic values.	
	Mangroves are coastal trees and shrubs that thrive in salty, muddy environments. These unique ecosystems provide vital services, including coastal protection against storms, erosion prevention, water filtration, carbon sequestration and crucial habitats for a diverse range of marine species, supporting local fisheries and biodiversity conservation.	
	Public spaces with grass, trees, vegetation and recreational facilities. They enhance biodiversity by supporting plant and animal species, improve air quality through oxygen production and pollution absorption, regulate temperatures, offer recreational activities and contribute to social, mental and physical well-being of communities.	
	Wetland ecosystems with decaying vegetation. They serve as carbon sinks, storing large amounts of carbon and mitigating climate change. They also provide habitats for unique plant and animal species, regulate water flow and quality and offer opportunities for research and educational activities.	
	Small bodies of water, natural or man-made. Natural ponds can derive from alluvial plains, as part of a river, or as an isolated depression. They provide carbon sequestration, flood regulation, climate regulation, nutrients retention, water purification, groundwater recharge, food provisioning, recreation and landscape aesthetic values.	
	They develop in excavated mining pits, after mining operations have ceased. Filled naturally or artificially, they can have unique ecological characteristics. They can provide valuable ecosystem services such as water storage, flood regulation, biodiversity preservation and recreational opportunities.	
	Managed landscaped depressions that capture and absorb rainwater, reducing stormwater runoff, preventing water pollution, recharging groundwater, creating habitats for water-loving plants and insects. Also providing aesthetics enhancement.	

(Continued)

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

Table 2. Continued

UGBI type	Description	Main well-being benefits
	structures designed to collect and temporarily store excess stormwater runoff. It can be a natural and/or artificial drainage infrastructure. They help regulate water flow, mitigate flooding risks and improve water quality by filtering pollutants before releasing the water into natural water bodies.	
	Waterlines, including river margins and Riparian vegetation. They contribute to flood regulation, provide habitats for aquatic plants and animals, contribute to nutrient cycling and supply water for drinking, irrigation and industrial use. They also offer recreational opportunities and act as transportation corridors.	
	Dynamic landforms shaped by the wind. They provide ecosystem services such as coastal protection from storms, habitat for specialized dune vegetation, biodiversity support, erosion and flooding prevention and recreation opportunities.	
	Dynamic interface between the land and the ocean. It offers coastal protection from storms, erosion and flooding, supports diverse habitats and species, provides tourism and recreational opportunities, and serves as a source of food, transportation and economic activities like fishing and shipping.	
	Trees planted alongside streets, providing shade, improving air quality by reducing pollution, mitigating the urban heat island effect and enhancing the visual appeal of neighbourhoods.	
	Sustainable drainage systems (SuDS) are integrated approaches to manage surface water, including features like swales, ponds, permeable pavements and green roofs, to reduce flooding, improve water quality and enhance biodiversity.	
	Large-scale tree canopies and green spaces within cities, offering ecosystem services such as air and water filtration, carbon sequestration, stormwater management, temperature reduction, wildlife habitat. They also offer recreational spaces for residents and contribute to mental and physical well-being, making cities more liveable and sustainable.	
	Man-made channels that transport and distribute water for various purposes such as irrigation, navigation and supplying drinking water. They provide ecosystem services like habitat creation, water storage and flood regulation, climate control. They also support agriculture, biodiversity and recreational activities.	
	Artificial water fountains located in urban areas. They range in design and size, from small ornamental structures to large displays of cascading water, often becoming focal points and gathering spaces within urban settings. They provide benefits for recreation and microclimate control.	

(Continued)

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

Table 2. Continued

UGBI type	Description	Main well-being benefits
	Ecosystem flooded by water, either seasonally or permanently. Can include, e.g. mangroves, or marshes. They provide valuable ecosystem services such as water filtration, flood control, carbon storage, habitat for numerous species, recreation opportunities and landscape aesthetic values.	

Well-being benefits: Freedom of choice; Social relations; Mental health; Physical health; Food security; Physical security. Faded icon corresponds to no contributions towards the specific well-being dimension. Photos credits: Bioswales: Guzzardo Partnership (Wikimedia Commons), Cultivated areas: Linda from Chicago (Wikimedia Commons), Compost areas: Zarateman (Wikimedia Commons), Green facades: Nemo (Wikimedia Commons), Green roofs: Joalpe (Wikimedia Commons), Hedgerows: Maurice Pullin (Wikimedia Commons), Mangroves: Shagil Kannur (Wikimedia Commons), Post mining lakes: Elkman (Wikimedia Commons), Water canals: Nino Barbieri (Wikimedia Commons). All other images by the authors.

IMPLICATIONS FOR HEALTH AND LIVEABLE CITIES

Incorporating NbS and GBI in urban planning and design is imperative for creating liveable cities, providing good health and supporting the ecosystems. They enhance the quality of life for urban residents by fostering connections with nature, improving physical and mental health and creating pleasant and sustainable urban spaces. Implementing NbS and GBI projects also promotes community engagement and social cohesion while fostering a sense of pride and ownership among residents.

Many studies demonstrate the contributions of GBI and NbS to human and ecological well-being in urban areas. For instance, the study by Colding [35] emphasizes the role of ecosystem services provided by urban green spaces and highlights their importance in contemporary urban planning. The World Health Organization [36] presented a brief on urban green spaces, emphasizing their significance in promoting human health and biodiversity conservation. In a special issue focused on NbS solutions to climate change adaptation in urban areas, Kabisch et al. [37] highlight the linkages between science, policy and practice, providing good examples of GBI and NbS contribution towards human and ecosystem health. Braubach et al. [38] assessed the effects of green space on environmental health, equity and resilience. Andersson et al. [39] assessed ecological and social factors contributing to durable and effective NbS for extreme climate episodes. Frantzeskaki et al. [40] assessed NbS's contribution to accelerating urban sustainability transitions in three European cities. Van Ham and Klimmek [41] highlighted successful examples of partnerships for NbS in urban areas, e.g. a reforestation project in Puebla-Tlaxcala Valley, Mexico, with a partnership between Volkswagen de Mexico, the National Committee for Protected Areas and the Secretary of the Environment for Mexico, successfully ensuring 1 300 000 cubic meters of additional water per year to be fed into the ground reserves in the source region. The links between the UGBI types and well-being dimensions have been assessed and corroborated multiple times from different perspectives and research fields.

Concerning the domain of 'freedom of choice and action', several UGBIs have been assessed regarding their relevance for place attachment and environmental justice, e.g. parks and gardens [42], allotment gardens [43] or urban wetland parks [44]. Research has shown, e.g. that UGBI, in general, can contribute to reducing health inequalities [45]; urban farms can contribute to economic growth [46]; or that parks and gardens can increase citizens' environmental awareness [47] and contribute to spiritual freedom [48]. Poe et al. [49] assessed urban forests for environmental justice regarding access to wild foods, medicines and materials. Regarding the dimension of 'mental health', diverse UGBIs have been found to contribute to mental well-being. For example, urban parks and gardens have been associated with mental well-being in general [50] and improved cognitive development [51]. Natural parks have been related to personal satisfaction from observing nature [52]. Botanical Gardens contribute to mental health and well-being in urban areas [53]. Allotment gardens have also improved mental health [54]. Regarding 'physical health', researchers have verified that UGBI promotes physical activity [55]. Zhang et al. (2015) assessed the links between parks, gardens and physical activities [56]. Soga et al. [54] confirmed improved physical benefits from activities in allotment gardens.

UGBI, in general, have been confirmed to benefit 'good social relations', e.g. through social interactions for older people [57]. Social integration and social cohesion, social bonding, or social meets have been reported from allotment gardens (e.g. [54, 58]), urban wetland parks [44], from urban parks and gardens [59, 60], or from urban ponds [61].

Considering 'food security', research has shown the relevance of diverse UGBI for human well-being, e.g. private gardens providing local food [62], brownfields providing wild berries [63], or urban farms [46] and allotment gardens [64, 65] contributing towards the circular economy. Lakes and ponds were assessed regarding their relevance for local farmers in the context of social equity [66]. However, studies have also addressed challenges to food security, e.g. evaluating pollution issues in urban areas regarding, e.g. urban orchards [67].

Multiple UGBI have also been found to influence well-being benefits regarding 'physical security'. Perceived safety and risk of exposure to crime are often related to UGBI aspects such as visibility, technical condition, cleanliness, external protection, other users in the area and mobility facilities [68]. These characteristics can affect many UGBI types and depend more on management interventions to reduce them than on having specific UGBI to tackle them. For example, converting brownfields into new green areas has been proven to reduce crime rates and increase safety perception [69]. On the other hand, physical safety from natural hazards is another issue which can be effectively tackled with UGBI and associated NbS interventions. Many UGBI types provide effective water flow control and flood regulation, such as urban parks and gardens (e.g. [70]), bioswales [71], rivers, canals, lakes and other blue elements [72].

As shown in Table 1, UGBI and NbS have a strong link with many of the UN SDGs, highlighting the relevance of these elements for human health and the liveability of urban areas. Their role is even more relevant, considering climate change and global

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

Table 3. Non exhaustive list of NbS actions, with examples of UGBI integration

NbS actions	Description	Examples of integrated UGBI
Afforestation	Establishing forests in areas where they did not previously exist, such as planting trees in open grasslands, to create new green spaces, increase carbon sequestration and provide habitat for wildlife.	
Coastal areas—Ecosystem restoration	Rehabilitating coastal areas like mangroves, seagrass meadows and salt marshes to protect against erosion, attenuate storm surges, sequester carbon, support marine biodiversity and enhance fisheries.	
Coastal areas—restoration of sand dunes	Restauration of coastal sand dunes, to ensure coastal protection from storms, habitat for specialized dune vegetation, biodiversity support, erosion and flooding prevention and recreation opportunities.	
Coastal areas—Sustainable management	Implementing strategies to protect marine ecosystems, promote sustainable fishing practices, establish marine protected areas and prevent pollution to preserve marine biodiversity and ecosystem services.	
Forest conservation and protection	Protecting existing forests from deforestation, logging and other threats to maintain ecosystem services, preserve biodiversity and prevent carbon emissions.	
Greywater recycling	Treating and reusing wastewater generated from sources like sinks, showers and laundry. Through natural processes like filtration and biological treatment, the water is purified and repurposed for non-potable uses like irrigation, reducing water demand and promoting sustainability.	
Implementing green infrastructure	Deploying natural or nature-inspired elements within urban environments, such as green roofs, green walls and urban parks, to enhance air quality, manage stormwater, reduce urban heat island effect and improve overall liveability.	**All UGBI types**
Reforestation	Planting trees in deforested or degraded areas to restore forest ecosystems, enhance biodiversity, mitigate climate change and provide other ecological benefits, such as water conservation.	
River and stream restoration	Restoring natural river channels, reconnecting floodplains, removing dams and managing water flow to improve water quality, reduce flooding, restore fish populations and enhance ecosystem functions.	
Soil conservation and restoration	Implementing practices like agroforestry, terracing and cover cropping to prevent soil erosion, improve soil quality, increase agricultural productivity and promote carbon sequestration.	
Sustainable agriculture	Promoting regenerative farming practices, minimizing chemical inputs, promoting crop rotation and agroforestry to enhance soil health, conserve water, reduce greenhouse gas emissions and protect biodiversity.	
Urban greening	Introducing green spaces, urban forests and rooftop gardens in cities to improve air quality, enhance urban biodiversity, reduce heat stress and provide recreational opportunities.	
Urban ponds and lakes restoration	Constructing or restoring water bodies in urban settings, providing opportunities for recreation, wildlife habitat and improving the microclimate through evaporative cooling.	
Wetland restoration	Rehabilitating and preserving wetlands, such as swamps, marshes and peatlands, to enhance water quality, reduce flooding, provide wildlife habitat and store carbon.	

(Continued)

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

Table 3. Continued

NbS actions	Description	Examples of integrated UGBI
Wildlife conservation and habitat protection	Preserving and restoring habitats to safeguard endangered species, promote biodiversity and maintain ecosystem resilience.	

warming are today's pressing challenges [73]. The rapid and global growth of urban populations exacerbates these issues, leading to increased energy consumption, greenhouse gas emissions and the degradation of natural resources [74]. However, UGBI presents a promising solution to mitigate the impacts of climate change, global warming and urban population growth.

Climate change and global warming are primarily driven by human activities, including burning fossil fuels and deforestation, which release large amounts of greenhouse gases into the atmosphere [75]. As urban populations expand, energy demands rise, increasing carbon emissions. Moreover, the urban heat island effect, caused by the concentration of buildings and pavement, leads to elevated city temperatures, intensifying the warming trend. UGBI can help counter these effects by reducing energy consumption, sequestering carbon and regulating local microclimates. Integrating NbS and UGBI into urban planning and development is thus crucial for sustainable city growth [14]. It requires innovative design approaches that prioritize NbS and the preservation of natural systems [76]. By incorporating green and blue elements, cities can enhance their resilience to climate change, create more liveable environments and reduce their ecological footprint.

However, it is essential to recognize that implementing UGBI requires collaboration and long-term commitment from various stakeholders [77]. Urban planners, policymakers and communities must work together to ensure the incorporation of these sustainable solutions. In addition, adequate financial investments and supportive policies are necessary to incentivize the adoption of green and blue infrastructure strategies.

UGBI, NBS AND ENVIRONMENTAL JUSTICE ISSUES

An increase in policies and actions regarding urban greening and green regeneration has been observed across the world, with governments trying to address several issues, such as adaptation to climate change, the improvement of housing and living conditions, or the pursuit of well-being and health through the provision of recreational spaces [78, 79]. However, market-driven regeneration and construction strategies are increasingly capitalizing on greening initiatives [78, 80], promoting greening actions that tend to favour the middle class and higher-income groups, neglecting the needs and interests of less privileged residents [79, 80]. The implementation of new UGBI has often resulted in gentrification, wherein the proximity to new or renovated UGBI projects contributes to positively influence the market value of the area, which in turn raises real estate interests from higher-income households, leading to increased property values and the subsequent displacement of lower-income households ([18, 81]), contributing to an increase in social exclusion and inequality ([82–84]).

The term 'equity' refers to fairness and justice, meaning a recognition that we do not all start from the same place and must acknowledge and adjust imbalances [85]. Regarding the planning and implementation of UGBI and NbS, equity can be understood as the just involvement of—and fair distribution of outcomes for—all stakeholders potentially affected by such actions. Multiple factors are considered in equity: race, gender, socioeconomic status, socio-cultural world views, or value and belief systems. Equity concerns are related to understanding how these multiple factors influence participation in project planning and decision-making processes and how they affect different groups and communities [86]. Research considers equity as divided into three complementary dimensions, which, adjusted to UGBI and NbS, can be described as: (1) 'distributional equity', i.e. the fair distribution of costs, benefits, burdens and rights of UGBI and NbS projects among all affected stakeholders and communities; (2) 'procedural equity', i.e. how inclusive decision making is concerning UGBI and NbS projects; and (3) 'recognitional equity', i.e. the consideration and recognition of stakeholders' knowledge systems, values and rights in the planning and execution of UGBI and NbS initiatives ([87, 88]).

Discussion and research on gentrification and (in)equalities have explored the conflicts and trade-offs between green projects and green regeneration and their impact on social equity and the housing market [78]. There is a complex interplay between social vulnerabilities, gentrification and urban greening, with several authors assessing that there is a significant association between socioeconomic status and the equitable distribution of UGBI across various urban built-up areas, with less privileged individuals residing in densely populated residential neighbourhoods experiencing lower levels of UGBI provision (e.g. [89, 90]). Not only that but benefits from active green space have also been found to be mainly associated with wealthier users (high education or high incomes) (25, 80]). Among other variables, gentrification issues have also been associated with UGS size and aesthetics [91].

However, one of the fundamental factors impacting gentrification related to UGBI and NbS development and implementation is the traditional top-down planning approach in urban management. Imposing excessively rationalized top-down planning

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

approaches in UGBI and NbS planning, disregarding the existing residents' relationship with the surrounding natural and built environment, has been shown to impact all dimensions of equity negatively [92]. Although governments increasingly adopt NbS in cities, a typical top-down approach might fail to address and counter-balance the prevailing forces converting urban nature into valuable assets that primarily benefit the urban elites [93]. Several authors have reported that unless issues such as urban sprawl and health and class disparities are addressed, NbS could become agents of further inequity ([93–96]).

To address these issues, several options have been proposed. First, UGBI and NbS structural interventions, such as new UGBI or conversion of abandoned areas into UGBI, should always be planned and evaluated within all equity dimensions [82].

Second, considering the influence of the size of UGBI on gentrification, several authors suggest the 'just green enough' approach (e.g. [90, 91, 97, 98]). This approach suggests distributing smaller UGS with lower maintenance costs, including greening vacant or obsolete areas (brownfields), e.g. former transportation infrastructure [98]. Although indirectly, the World Health Organization also aligns with this approach, suggesting distributing green space investments evenly between city districts [36].

However, most importantly, there is a need to change the dominant top-down approach into a bottom-up one. Implementing an approach that moves away from the rationalized top-down planning and embraces a design process supported by local communities, incorporating and respecting local knowledge systems, practices and preferences, is fundamental to achieving equitable solutions focused on co-production [99, 100]. Experimental, innovative ideas and methods, such as living labs or adaptive experimentation, can create new political backgrounds for green governance, where stakeholder participation is critical in the design and demonstration of innovative projects related to UGBI and NbS [99, 101].

Nevertheless, as innovative and influential as these alternatives might be, these new approaches face the challenge of prevailing traditional power structures governing resource allocation, which demands a common front aimed at the promotion of knowledge, equity and resource accessibility, addressing multi-scalar social, political and economic factors [102].

CONCLUSIONS

UGBI and NbS are vital in enhancing human and ecological well-being, health and sustainability in urban areas. They provide numerous ecosystem services, improve air and water quality, regulate temperature, support biodiversity and promote human health and well-being. By incorporating natural elements and processes into urban planning, GBI and NbS contribute to the United Nations Sustainable Development Goals (SDGs), promoting sustainable cities and communities, ensuring good health and well-being, contributing towards healthier ecosystems and acting against climate change. Understanding well-being requires considering many dimensions that impact an individual's overall quality of life. Freedom of choice, social connections, mental and physical health, food and physical security provide a comprehensive framework for assessing well-being across different human life aspects. These dimensions, assessed through the CICES classification, provide valuable insights into the interrelationships between human well-being and the ecosystem services that support it. This integrated perspective is crucial for guiding research, policy and decision making to promote sustainable development and foster well-being at individual, community and global scales.

UGBI offer multiple environmental benefits, thereby improving the overall quality of life in cities. These natural systems play a crucial role in mitigating the impacts of climate change by providing shading, reducing heat island effects and contributing to the regulation of local microclimates. They also help manage stormwater runoff, reducing the risk of flooding and improving water quality by filtering pollutants. In addition, green spaces and urban forests act as carbon sinks, sequestering greenhouse gases and mitigating air pollution, resulting in cleaner and healthier urban environments.

Real-world examples across the globe support the positive impacts of NbS and GBI on urban environments, highlighting their importance in creating sustainable and liveable cities. By prioritizing the implementation of NbS and GBI, we can foster healthier, more resilient and environmentally conscious urban communities.

The implementation of UGBI requires collaboration between multiple stakeholders, including urban planners, architects, policymakers and the community. It necessitates innovative approaches to design and development, integrating nature into the urban fabric while considering each city's unique characteristics and needs. Engaging local communities in planning and decision-making promotes a sense of ownership, fostering long-term stewardship and ensuring successful outcomes. Not including the local community in a bottom-up approach significantly increases the risk of contributing to gentrification and green (in)equity.

UGBI has far-reaching implications for human well-being and the creation of liveable cities. Enhancing access to nature in urban areas improves physical and mental health, strengthens social connections, builds resilience to climate change and contributes to environmental sustainability. As cities grow and urban populations increase, incorporating UGBI into urban planning becomes essential for creating healthier and more liveable environments for present and future generations.

Regarding research gaps, most research on well-being benefits from UGBI and NbS has been particularly focused on 'mental' and 'physical health' and 'good social relations'. In contrast, 'freedom of choice' and 'physical' and 'food security' have been less assessed. Suggested future research regarding well-being dimensions includes focusing on these topics, with particular relevance for 'food security', especially in the global south. Assessing the dimensions of 'freedom of choice' and 'physical security' is also particularly relevant, giving a world trend for an increase in autocratic governments [103], and for an increase in the number and intensity of extreme weather episodes due to climate change [104, 105].

Regarding equity issues, most research has been devoted to 'distributive equity'. As such, future research should be more integrative, focusing on assessing 'procedural' and 'recognitional equity'. More research should be developed on living labs and adaptive experimentation. For NbS to succeed, research should provide policy- and decision-makers with clear and objective information on the advantages and disadvantages of a governance model based on a bottom-up approach involving local inhabitants and stakeholders. A major challenge is to project NbS in an innovative and participative way, different from the usual decision-making processes, which often lead to 'inequity' situations.

Declaration of interest

The authors declare no conflict of interest.

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

Funding

This research was funded by the Portuguese Foundation for Science and Technology (FCT), through the PhD grant SFRH/BD/149710/2019 attributed to Luís Valença Pinto.

Data availability

Not applicable.

References

1. Kuddus MA, Tynan E, McBryde E. Urbanization: a problem for the rich and the poor? *Public Health Reviews* 2020;**41**:1
2. McDonnell MJ, MacGregor-Fors I. The ecological future of cities. *Science* 2016;**352**:936–8
3. Castellar JAC, Popartan LA, Pueyo-Ros J *et al.* Nature-based solutions in the urban context: terminology, classification and scoring for urban challenges and ecosystem services. *Sci. Total Environ.* 2021;**779**:1–13. https://doi.org/10.1016/j.scitotenv.2021.146237
4. Cohen-Shacham E, Walters G, Janzen C *et al. Nature-based solutions to address global societal challenges*. Gland, Switzerland:IUCN, 2016
5. Ghofrani Z, Sposito V, Faggian R. A comprehensive review of blue-green infrastructure concepts. *Int. J. Environ.* 2017;**6**:15–36
6. Puppim, de Oliveira JA, Bellezoni RA, Shih W *et al.* Innovations in urban green and blue infrastructure: tackling local and global challenges in cities. *Journal of Cleaner Production* 2022;**362**:1–16. https://doi.org/10.1016/j.jclepro.2022.132355
7. Haines-Young R, Potschin M. Revision of the common international classification for ecosystem services (CICES V5.1): A policy brief. *One Ecosystems* **3**:e27108. https://doi.org/10.3897/oneeco.3.e27108
8. Smith F, Turner DW. What are the psychological and cognitive wellbeing benefits as reported by people experiencing green space? A meta-ethnography. *Wellbeing, Space and Society* 2023;**5**:1–14. https://doi.org/10.1016/j.wss.2023.100158
9. Stoewen DL. Dimensions of wellness: change your habits, change your life. *The Canadian Veterinary Journal* 2017;**58**:861–2
10. Voukelatou V, Gabrielli L, Miliou I *et al.* Measuring objective and subjective wellbeing: dimensions and data sources. *Int. J. Data Sci. Anal.* 2021;**11**:279–309
11. Millennium Ecosystem Assessment [MEA]. *Ecosystem and Human Wellbeing—Synthesis*. Washington, DC:Island Press, 2005
12. Haines-Young R. *Common International Classification of Ecosystem Services (CICES): Consultation on Version* 4August-December 2012 (No. EEA Framework Contract No EEA/IEA/09/003). Nottingham, UK:University of Nottingham, 2013
13. Babí, Almenar J, Elliot T, Rugani B *et al.* Nexus between nature-based solutions, ecosystem services and urban challenges. *Land Use Policy* 2021;**100**:1–22. https://doi.org/10.1016/j.landusepol.2020.104898
14. Pereira P, Yin C, Hua T. Nature-based solutions, ecosystem services, disservices, and impacts on wellbeing in urban environments. *Current Opinion in Environmental Science & Health* 2023;**33**:1–7. https://doi.org/10.1016/j.coesh.2023.100465
15. Veerkamp CJ, Schipper AM, Hedlund K *et al.* A review of studies assessing ecosystem services provided by urban green and blue infrastructure. *Ecosystem Services* 2021;**52**:1–10. https://doi.org/10.1016/j.ecoser.2021.101367
16. Haase D. In: Weith T, Barkmann T, Gaasch N *et al.* eds. *Integrating Ecosystem Services, Green Infrastructure and Nature-Based Solutions—New Perspectives in Sustainable Urban Land Management BT—Sustainable Land Management in a European Context: A Co-Design Approach*. Cham:Springer International Publishing, 2021, 305–18
17. United Nations. *The new urban agenda*. Kenya:Nairobi, 2020
18. Pinto LV, Inácio M, Ferreira CSS *et al.* Ecosystem services and wellbeing dimensions related to urban green spaces—a systematic review. *Sustainable Cities and Society* 2022;**85**:1–18. https://doi.org/10.1016/j.scs.2022.104072
19. Pauleit S, Ambrose-Oji B, Andersson E *et al.* Advancing urban green infrastructure in Europe: outcomes and reflections from the GREEN SURGE project. *Urban Forestry & Urban Greening* 2019;**40**:4–16
20. Sowińska-Świerkosz B, García J. What are nature-based solutions (NBS)? Setting core ideas for concept clarification. *Nature-Based Solutions* 2022;**2**:9. https://doi.org/10.1016/j.nbsj.2022.100009
21. European Commission. *Green Infrastructure (GI) — Enhancing Europe's Natural Capital*, 2013. Brussels, Belgium: European Commission. https://eur-lex.europa.eu/resource.html?uri=cellar:d41348f2-01d5-4abe-b817-4c73e6f1b2df.0014.03/DOC_1&format=PDF.
22. Andersson E, Haase D, Kronenberg J *et al.* Based on nature, enabled by social-ecological-technological context: deriving benefit from urban green and blue infrastructure. *Ecology and Society* 2022;**27**:1–7. https://doi.org/10.5751/ES-13580-270418
23. Liu Z, Cheng W, Jim CY *et al.* Heat mitigation benefits of urban green and blue infrastructures: a systematic review of modeling techniques, validation and scenario simulation in ENVI-met V4. *Building and Environment* 2021;**200**:1–15. https://doi.org/10.1016/j.buildenv.2021.107939
24. CEEweb for Biodiversity. *Green Infrastructure and Nature-Based Solutions for Urban Biodiversity (Position Paper)*. Budapest, Hungary: CEEweb for Biodiversity, 2020
25. European Environment Agency. Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction (EEA Report No. No 01/2021). Luxembourg, 2021, 159. doi: https://doi.org/10.2800/919315
26. ARUP. *Blue Green Infrastructure and Nature-based Solutions Framework—Our Green Region*. Ireland:Southern Regional Assembly, 2022
27. Liang L, Gong P. Urban and air pollution: a multi-city study of long-term effects of urban landscape patterns on air quality trends. *Scientific Reports* 2020;**10**:18618
28. Marselle MR, Lindley SJ, Cook PA *et al.* Biodiversity and health in the urban environment. *Curr. Environ. Heal. Reports* 2021;**8**:146–56
29. IUNC. *The IUCN Global Programme 2013–16*, 2012
30. Degerickx J, Hermy M, Somers B. Mapping functional urban green types using high resolution remote sensing data. *Sustainability* 2020;**12**:2144
31. Klingberg J, Broberg M, Strandberg B *et al.* Influence of urban vegetation on air pollution and noise exposure—a case study in Gothenburg, Sweden. *Science of the Total Environment* 2017;**599-600**:1728–39
32. Chen WY. The role of urban green infrastructure in offsetting carbon emissions in 35 major Chinese cities: a nationwide estimate. *Cities* 2015;**44**:112–20
33. da Schio N, Haase D, Scheuer S *et al. Stories on Trees: Urban Forests & Green Space during COVID-19 Pandemic*. Zenodo, 2020, 228–37
34. Aerts R, Honnay O, Nieuwenhuyse AV. Biodiversity and human health: mechanisms and evidence of the positive health effects of diversity in nature and green spaces. *British Medical Bulletin* 2018;**127**:5–22

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

35. Colding J. The role of ecosystem Services in Contemporary Urban Planning. In: Niemelä J, Breuste JH, Elmqvist T *et al.* eds. *Urban Ecology: Patterns, Processes, and Applications*. Oxford, UK: Oxford University Press, 2011, 228–37
36. WHO-ROE (World Health Organization. Regional Office for Europe). *Urban green spaces: a brief for action*. Copenhagen:World Health Organization. Regional Office for Europe, 2017
37. Kabisch N, Korn H, Stadler J *et al. Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice, Theory and Practice of Urban Sustainability Transitions*. Cham, Switzerland: Springer International Publishing, Cham, 2017
38. Braubach M, Egorov A, Mudu P *et al.* Effects of urban green space on environmental health, equity and resilience. In: Kabisch N, Korn H, Stadler J *et al.* eds. *Nature-Based Solutions to Climate Change Adaptation in Urban Areas*. Cham:Springer International Publishing, 2017, 187–205
39. Andersson E, Borgström S, McPhearson T. Double Insurance in Dealing with extremes: Ecological and social factors for making nature-based solutions last. In: Kabisch N, Korn H, Stadler J *et al.* eds. *Nature-Based Solutions to Climate Change Adaptation in Urban Areas*. Cham:Springer International Publishing, 2017, 51–64
40. Frantzeskaki N, Borgström S, Gorissen L *et al.* Nature-based solutions accelerating urban sustainability transitions in cities: Lessons from Dresden, Genk and Stockholm cities. In: Kabisch N, Korn H, Stadler J *et al.* eds. *Nature-Based Solutions to Climate Change Adaptation in Urban Areas*. Cham:Springer International Publishing, 2017, 65–88
41. Van Ham C, Klimmek H. Partnerships for nature-based solutions in urban areas—showcasing successful examples. In: Kabisch N, Korn H, Stadler J *et al.* eds. *Nature-Based Solutions to Climate Change Adaptation in Urban Areas*. Cham:Springer International Publishing, 2017, 275–89
42. Łaszkiewicz E, Kronenberg J, Marcińczak S. Attached to or bound to a place? The impact of green space availability on residential duration: the environmental justice perspective. *Ecosystem Services* 2018;**30**:309–17
43. Dennis M, James P. Ecosystem services of collectively managed urban gardens: exploring factors affecting synergies and trade-offs at the site level. *Ecosystem Services* 2017;**26**:17–26
44. Sun F, Xiang J, Tao Y *et al.* Mapping the social values for ecosystem services in urban green spaces: integrating a visitor-employed photography method into SolVES. *Urban Forestry & Urban Greening* 2019;**38**:105–13
45. Mitchell R, Popham F. Effect of exposure to natural environment on health inequalities: an observational population study. *The Lancet* 2008;**372**:1655–60
46. Helen H, Gasparatos A. Ecosystem services provision from urban farms in a secondary City of Myanmar, Pyin Oo Lwin. *Agriculture (Basel)* 2020;**10**:140
47. Säumel I, Hogrefe J, Battisti L *et al.* The healthy green living room at one's doorstep? Use and perception of residential greenery in Berlin, Germany. *Urban Forestry & Urban Greening* 2021;**58**:1–13. https://doi.org/10.1016/j.ufug.2020.126949
48. Ngulani T, Shackleton CM. Use of public urban green spaces for spiritual services in Bulawayo, Zimbabwe. *Urban Forestry & Urban Greening* 2019;**38**:97–104
49. Poe MR, McLain RJ, Emery M *et al.* Urban Forest justice and the rights to wild foods, medicines, and materials in the City. *Human Ecology* 2013;**41**:409–22
50. Pinto L, Ferreira CSS, Pereira P. Environmental and socioeconomic factors influencing the use of urban green spaces in Coimbra (Portugal). *Science of the Total Environment* 2021;**792**:1–15. https://doi.org/10.1016/j.scitotenv.2021.148293
51. Dadvand P, Nieuwenhuijsen MJ, Esnaola M *et al.* Green spaces and cognitive development in primary schoolchildren. *Proceedings of the National Academy of Sciences of the United States of America* 2015;**112**:7937–42
52. Kuldna P, Poltimäe DH, Tuhkanen H. Perceived importance of and satisfaction with nature observation activities in urban green areas. *Journal of Outdoor Recreation and Tourism* 2020;**29**:1–8. https://doi.org/10.1016/j.jort.2019.100227
53. Vujcic M, Tomicevic-Dubljevic J, Grbic M *et al.* Nature-based solution for improving mental health and wellbeing in urban areas. *Environmental Research* 2017;**158**:385–92
54. Soga M, Cox D, Yamaura Y *et al.* Health benefits of urban allotment gardening: improved physical and psychological wellbeing and social integration. *IJERPH* 2017;**14**:71
55. Tan CLY, Chang C-C, Nghiem LTP *et al.* The right mix: residential urban green-blue space combinations are correlated with physical exercise in a tropical city-state. *Urban Forestry & Urban Greening* 2021;**57**:1–12. https://doi.org/10.1016/j.ufug.2020.126947
56. Zhang W, Yang J, Ma L *et al.* Factors affecting the use of urban green spaces for physical activities: Views of young urban residents in Beijing. *Urban Forestry & Urban Greening* 2015;**14**:851–857. https://doi.org/10.1016/j.ufug.2015.08.006
57. Enssle F, Kabisch N. Urban green spaces for the social interaction, health and wellbeing of older people— an integrated view of urban ecosystem services and socio-environmental justice. *Environmental Science & Policy* 2020;**109**:36–44
58. Egerer MH, Philpott SM, Bichier P *et al.* Gardener wellbeing along social and biophysical landscape gradients. *Sustainability* 2018;**10**:1–14. https://doi.org/10.3390/su10010096
59. Dadvand P, Hariri S, Abbasi B *et al.* Use of green spaces, self-satisfaction and social contacts in adolescents: a population-based CASPIAN-V study. *Environmental Research* 2019;**168**:171–7
60. Valente D, Pasimeni MR, Petrosillo I. The role of green infrastructures in Italian cities by linking natural and social capital. *Ecological Indicators* 2020;**108**:1–8. https://doi.org/10.1016/j.ecolind.2019.105694
61. Ngiam RWJ, Lim WL, Matilda Collins C. A balancing act in urban social-ecology: human appreciation, ponds and dragonflies. *Urban Ecosystem* 2017;**20**:743–58
62. McClintock N, Mahmoudi D, Simpson M *et al.* Socio-spatial differentiation in the Sustainable City: a mixed-methods assessment of residential gardens in metropolitan Portland, Oregon, USA. *Landscape and Urban Planning* 2016;**148**:1–16
63. Connop S, Vandergert P, Eisenberg B *et al.* Renaturing cities using a regionally-focused biodiversity-led multifunctional benefits approach to urban green infrastructure. *Environmental Science & Policy* 2016;**62**:99–111
64. Home R, Lewis O, Bauer N *et al.* Effects of garden management practices, by different types of gardeners, on human wellbeing and ecological and soil sustainability in Swiss cities. *Urban Ecosystem* 2019;**22**:189–99
65. Russo A, Cirella GT. Edible green infrastructure for urban regeneration and food security: case studies from the Campania region. *Agriculture* 2020;**10**:358
66. Derkzen ML, Nagendra H, Van Teeffelen AJA *et al.* Shifts in ecosystem services in deprived urban areas: understanding people's responses and consequences for wellbeing. *E&S* 2017;**22**:art51
67. von Hoffen LP, Säumel I. Orchards for edible cities: cadmium and lead content in nuts, berries, pome and stone fruits

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

harvested within the inner city neighbourhoods in Berlin, Germany. *Ecotoxicology and Environmental Safety* 2014;**101**:233–9
68. Polko P, Kimic K. Gender as a factor differentiating the perceptions of safety in urban parks. *Ain Shams Engineering Journal* 2022;**13**:1–12. https://doi.org/10.1016/j.asej.2021.09.032
69. Branas CC, Cheney RA, MacDonald JM *et al.* A difference-in-differences analysis of health, safety, and greening vacant urban space. *American Journal of Epidemiology* 2011;**174**:1296–306
70. Piaggio M. The value of public urban green spaces: measuring the effects of proximity to and size of urban green spaces on housing market values in San José, Costa Rica. *Land Use Policy* 2021;**109**:1–12. https://doi.org/10.1016/j.landusepol.2021.105656
71. Battisti L, Pille L, Wachtel T *et al.* Residential greenery: state of the art and health-related ecosystem services and disservices in the city of Berlin. *Sustainability.* 2019;**11**:1–20. https://doi.org/10.3390/su11061815
72. Higgins SL, Thomas F, Goldsmith B *et al.* Urban freshwaters, biodiversity, and human health and wellbeing: setting an interdisciplinary research agenda. *WIREs Water* 2019;**11**:1–13. https://doi.org/10.1002/wat2.1339
73. Lyu R, Clarke KC, Zhang J *et al.* The impact of urbanization and climate change on ecosystem services: a case study of the city belt along the Yellow River in Ningxia, China. *Computers, Environment and Urban Systems* 2019;**77**:1–12. https://doi.org/10.1016/j.compenvurbsys.2019.101351
74. Day JW, Gunn JD, Burger JR. Diminishing opportunities for sustainability of coastal cities in the Anthropocene: a review. *Frontiers in Environmental Science* 2021;**9**:1–15. https://doi.org/10.3389/fenvs.2021.663275
75. De Visser S, Scherer L, Huijbregts M *et al.* Characterization factors for the impact of climate change on freshwater fish species. *Ecological Indicators* 2023;**150**:1–9. https://doi.org/10.1016/j.ecolind.2023.110238
76. Langeveld JG, Cherqui F, Tscheikner-Gratl F *et al.* Asset management for blue-green infrastructures: a scoping review. *Blue-Green Systems* 2022;**4**:272–90
77. Bally F, Coletti M. Civil society involvement in the governance of green infrastructure: an analysis of policy recommendations from EU-funded projects. *Journal of Environmental Management* 2023;**342**:1–11. https://doi.org/10.1016/j.jenvman.2023.118070
78. Haase A, Koprowska K, Borgström S. Green regeneration for more justice? An analysis of the purpose, implementation, and impacts of greening policies from a justice perspective in Łódź stare Polesie (Poland) and Leipzig's inner east (Germany). *Environmental Science & Policy* 2022;**136**:726–37
79. Triguero-Mas M, Anguelovski I, García-Lamarca M *et al.* Natural outdoor environments' health effects in gentrifying neighborhoods: disruptive green landscapes for underprivileged neighborhood residents. *Social Science & Medicine* 2021;**279**:113964. https://doi.org/10.1016/j.socscimed.2021.113964
80. Haase D, Kabisch S, Haase A *et al.* Greening cities—to be socially inclusive? About the alleged paradox of society and ecology in cities. *Habitat International* 2017;**64**:41–8
81. Roebeling P, Fidélis T, Grossi D *et al.* Balancing social and economic impacts of nature-based solutions for storm water managemen. In: *Novatech 2016 Proceedings. Presented at the NOVATECH 2016 – 9th International Conference on Planning and Technologies for Sustainable Management of Water in the City*, 2016, 228–37
82. Cole HVS, Triguero-Mas M, Connolly JJT *et al.* Determining the health benefits of green space: does gentrification matter? *Health & Place* 2019a;**57**:1–11
83. Pearsall H, Eller JK. Locating the green space paradox: a study of gentrification and public green space accessibility in Philadelphia, Pennsylvania. *Landscape and Urban Planning* 2020;**195**:1–12. https://doi.org/10.1016/j.landurbplan.2019.103708
84. Anguelovski I, Connolly JJ, Garcia-Lamarca M *et al.* New scholarly pathways on green gentrification: what does the urban 'green turn' mean and where is it going? *Progress in Human Geography* 2019;**43**:1064–86
85. Amdur RJ, Yeung A. Equality, equity, and diversity: definitions and basic concepts. *Practical Radiation Oncology* 2021;**11**:238–40
86. Bremer LL, Keeler B, Pascua P *et al.* Nature-based solutions, sustainable development, and equity. In: *Nature-Based Solutions and Water Security*. Elsevier, 2021, 81–105
87. McDermott M, Mahanty S, Schreckenberg K. Examining equity: a multidimensional framework for assessing equity in payments for ecosystem services. *Environmental Science & Policy* 2013;**33**:416–27
88. Pascual U, Phelps J, Garmendia E *et al.* Social equity matters in payments for ecosystem services. *Bioscience* 2014a;**64**:1027–36
89. Amorim Maia AT, Calcagni F, Connolly JJT *et al.* Hidden drivers of social injustice: uncovering unequal cultural ecosystem services behind green gentrification. *Environmental Science & Policy* 2020;**112**:254–63
90. Sun W, Ren J, Zhai J *et al.* 'Just green enough' in urban renewal: a multifunctional and pragmatic approach in realizing multiscale urban green space optimization in built-up residential areas. *Urban Forestry & Urban Greening* 2023;**82**:1–13. https://doi.org/10.1016/j.ufug.2023.127891
91. Chen Y, Xu Z, Byrne J *et al.* Can smaller parks limit green gentrification? Insights from Hangzhou, China. *Urban Forestry & Urban Greening* 2021;**59**:1–19. https://doi.org/10.1016/j.ufug.2021.127009
92. Anguelovski I, Connolly J, Brand AL. From landscapes of utopia to the margins of the green urban life: for whom is the new green city? *City* 2018;**22**:417–36
93. Kotsila P, Anguelovski I, Baró F *et al.* Nature-based solutions as discursive tools and contested practices in urban nature's neoliberalisation processes. *Environment and Planning E: Nature and Space* 2021;**4**:252–74
94. Byrne J, Ambrey C, Portanger C *et al.* Could urban greening mitigate suburban thermal inequity?: the role of residents' dispositions and household practices. *Environmental Research Letters* 2016;**11**:1–16. https://doi.org/10.1088/1748-9326/11/9/095014
95. Kato-Huerta J, Geneletti D. Environmental justice implications of nature-based solutions in urban areas: a systematic review of approaches, indicators, and outcomes. *Environmental Science & Policy* 2022;**138**:122–33
96. Wolch J, Wilson JP, Fehrenbach J. Parks and park funding in Los Angeles: an equity-mapping analysis. *Urban Geography* 2005;**26**:4–35
97. VanderWilde C. Striving for just green enough. *Ágora* 2017;**11**:62–66
98. Wolch JR, Byrne J, Newell JP. Urban green space, public health, and environmental justice: the challenge of making cities 'just green enough. *Landscape and Urban Planning.* 2014;**125**:234–44
99. Bulkeley H, Coenen L, Frantzeskaki N *et al.* Urban living labs: governing urban sustainability transitions. *Current Opinion in Environmental Sustainability* 2016;**22**:13–7
100. Leminen S, Nyström A-G, Westerlund M. A typology of creative consumers in living labs. *Journal of Engineering and Technology Management* 2015;**37**:6–20

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024

101. Castán Broto V, Bulkeley H. A survey of urban climate change experiments in 100 cities. *Global Environmental Change* 2013;**23**: 92–102
102. Cousins JJ. Justice in nature-based solutions: research and pathways. *Ecological Economics* 2021;**180**:1–11. https://doi.org/10.1016/j.ecolecon.2020.106874
103. Bloom H. The bacterial roots of the new autocracies: an essay on "biopolitics". *Biosystems* 2020;**196**:1–6. https://doi.org/10.1016/j.biosystems.2020.104168
104. Li L, Uyttenhove P, Van Eetvelde V. Planning green infrastructure to mitigate urban surface water flooding risk—a methodology to identify priority areas applied in the city of Ghent. *Landscape and Urban Planning* 2020;**194**:103703. https://doi.org/10.1016/j.landurbplan.2019.103703
105. Pereira SC, Marta-Almeida M, Carvalho AC *et al.* Extreme precipitation events under climate change in the Iberian Peninsula. *International Journal of Climatology* 2020;**40**: 1255–78

Downloaded from https://academic.oup.com/ooih/article/doi/10.1093/ooih/ouad004/7322050 by Library of the Law University of Lithuania user on 30 April 2024