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Nature-Based Solutions in Urban Areas: A European Analysis

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Abstract: Currently, the world is facing resource scarcity as the environmental impacts of human intervention continue to intensify. To facilitate the conservation and recovery of ecosystems and to transform cities into more sustainable, intelligent, regenerative, and resilient environments, the concepts of circularity and nature-based solutions (NbS) are applied. The role of NbS within green infrastructure in urban resilience is recognised, and considerable efforts are being made by the European Commission (EC) to achieve the European sustainability goals. However, it is not fully evidenced, in an integrated way, which are the main NbS implemented in the urban environment and their effects. This article aims to identify the main and most recent NbS applied in urban environments at the European level and to analyse the integration of different measures as an innovative analysis based on real cases. For this purpose, this work presents a literature review of 69 projects implemented in 24 European cities, as well as 8 urban actions and 3 spatial scales of implementation at the district level. Therefore, there is great potential for NbS adoption in buildings and their surroundings, which are still not prioritized, given the lack of effective monitoring of the effects of NbS.

Keywords: nature-based solutions (NbS); ecosystem services; urban environment; blue–green infrastructure; green buildings; water management; urban regeneration; European Union

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1. Introduction

The effects of global climate change are unquestionably among the most considerable problems facing humanity today. The current model of economic development based on fossil fuels and the indiscriminate exploitation of natural resources has brought about a situation in which negative impacts are entering a critical phase. The IPCC (Intergovernmental Panel on Climate Change) Special Report, projects that global warming will reach 1.5 °C between 2030 and 2052 if it continues to increase at the current rate [1]. Reflecting this trend, numerous regional changes in climate are projected to occur, with global warming on the planet, including increasingly extreme temperatures in cities, as well as increases in the frequency, intensity, and amount of heavy rain and droughts [1].

Cities are major contributors to climate change. Today, more than half of the world's population lives in urban settlements, and the United Nations (UN) predicts that by 2050, this urban share will reach 70% [2]. At present, cities are responsible for producing 50% of global waste [3], approximately 70% of greenhouse gas (GHG) emissions [2,4], and 75% of energy and natural resource consumption [4], generating increasing pressure on rural areas and natural ecosystems to guarantee the supply of water, energy, and food, as well as for the removal of waste [5], as the world's cities occupy only 3% of the terrestrial landscape [6].

Following this trend, the likely scenario for the coming decades is a series of global challenges related to resource depletion as a result of climate change associated with increased pollution. Due to the negative impacts that global development and consumption impose on contemporary society, new global sustainability frameworks have been adopted in recent years, such as the UN 2030 Agenda for Sustainable Development and its corresponding Sustainable Development Goals (SDGs) [2]. This and other international agreements seek to establish goals, guidelines, and action models to ensure a liveable planet and a more just and sustainable society. In this context, strategic urban planning, in association with sustainability, represents a fundamental tool for the mitigation and adaptation of cities to new and emerging challenges.

As defined by the International Union for Conservation of Nature (IUCN), NbS are actions that protect, sustainably manage, and restore natural or modified ecosystems while addressing social challenges and providing benefits for both human well-being and biodiversity [7]. This mechanism, which transfers nature to cities [5], has great potential to respond to and minimize the effects of climate change in urban spaces, creating alternatives that return natural elements to the urban environment [8] that were previously disappearing with the growth and development of cities.

In order to facilitate the conservation and recovery of ecosystems and to transform cities into more sustainable, intelligent, regenerative, and resilient environments, the concepts of circular economy (CE) and nature-based solutions (NbS) are applied. NbS and the CE are interconnected, side-by-side conceptions for the development of renaturalized and circular cities [9,10].

This article presents research on the concept and application of NbS at the urban level. Recognising the NbS theme as a key element in achieving the European sustainability goals the following research question was formulated: "*What are the recent and main NbS initiatives and practices being applied in urban environments in the European Union aiming at resilience and circularity in cities?*". To answer this question, a study was carried out through applied research with a qualitative approach around textual elements and considering the predefined content analysis methodology [11]. In a logical sequence, the fundamental phases of qualitative analysis were respected: preanalysis; exploration of the material; and treatment of results, including inference and interpretation.

In the sequence of the literature review, some knowledge gaps remain regarding the effectiveness of NbS in the urban environment, with an emphasis on short-term actions and long-term sustainability goals [12]. NbS have been promoted as a key tool in the search for innovative solutions to manage natural systems and to balance benefits for nature and society. However, the concepts and their practical applications remain imprecise and fragmented due to ambiguities linked to the integration of various scientific fields and the lack of clear standards in the NbS concept [13,14]. In recent years, several attempts have been made to define and clarify the actions inspired and driven by nature, as well as the associated benefits [12–17]. Therefore, it is possible to identify that the concept and the theme of NbS are still recent and are in an evolutionary process. Many studies point to the lack of methodology for the compilation and systematic evaluation, in a comprehensive and integrative way, of NbS knowledge [18,19]. Barriers have also been identified regarding the uncertainties concerning the performance, functionality, and implementation of NbS [20]. The ecosystem approach aligned with NbS initiatives is an example of an integrated principle and concept essential to achieving social and environmental sustainability [14]. Recognising that NbS are measures that provide multiple benefits is key to ensuring that NbS interventions deliver far-reaching benefits rather than unilateral outcomes [21]. Thus, the importance of this article consists of the integration of NbS initiatives in the urban environment, considering the performance of the provided ecosystem services. In this work, we identify and present the main and most recent NbS practices implemented in urban environments at the European scale and analyse the complementarity and integration of various measures, presenting an innovative analysis based on real-world examples. This study contributes to an improved understanding of NbS and provides a synthesis of knowledge and applicability of NbS, emphasizing the complementarity of NbS measures in the urban environment.

2. Sustainability in the Built Environment

2.1. Circular Economy

An important aspect of approaching contemporary urban systems is circularity. The transition to a CE is fundamental to face environmental challenges, as cities will have to play an essential role in this economic model. CE is a concept that directly contrasts with the traditional economic model, characterized by a predominantly linear pattern. CE can be defined as a production and consumption model that includes, whenever possible, sharing, leasing, reusing, repairing, refurbishing, and recycling of existing materials and products [22] with the aim of minimizing waste and making the most of resources [5]. In this way, the product life cycle can be extended with the expectation of fostering a closed-loop market. In a circular system, the input and waste of resources, emissions, and energy consumption are minimized by decelerating and narrowing energy and material cycles [5]. This means rethinking current paradigms, aiming at a greener and more sustainable economy.

In 2020, the EC adopted the new Circular Economy Action Plan (CEAP), which constitutes one of the main elements of the European Green Deal, Europe's agenda for sustainable growth [23]. According to CEAP, the Commission has committed itself to launch a new comprehensive Strategy for a Sustainable Built Environment to increase material efficiency and reduce the climate impacts of the built environment, particularly by promoting the principles of circularity throughout the life cycle of buildings. For this purpose, the fields of energy efficiency, resource efficiency, construction, and demolition waste management should be addressed in a sustainable strategy [23]. Implementing and addressing CE principles at the various stages of a building's life cycle is of utmost importance in the transition to a circular and dynamic built environment, as the way buildings are designed is critical to how they are used and the impact they have on their surroundings [9].

2.2. Nature-Based Solutions

NbS is a new concept that started to be used at the beginning of the 21st century and was later adopted by several global institutions [24]. NbS has evolved as an "umbrella" concept [25,26] that incorporates several existing concepts and practices [27] that can be applied to the strategic dimension, spatial planning dimension, soft engineering dimension, and performance dimension (Figure 1) [25]. The most recent EC report on NbS states that this concept embodies new ways of approaching socioecological adaptation and resilience, with equal confidence in the social, environmental, and economic domains [25].

Figure 1. Overview of nature-based concepts and their relationship to existing key concepts. Adapted from [25,28].

NbS provide several beneficial ecosystem services [5,26], such as their ability to store carbon and regulate water flow [29] in order to achieve desired outcomes in urban spaces, such as disaster risk reduction, microclimate regulation, improved human health, and socially inclusive green growth [5,8,28,29].

In this sense, NbS can help in facing social and economic challenges within the sustainable development paradigm, providing benefits that meet—directly and indirectly—SDG 2, SDG 3, SDG 6, SDG 8, SDG 10, SDG 11, SDG 12, SDG 13, SDG 14, and SDG 15 [28]. Indeed, the ability to simultaneously achieve multiple SDGs is a big part of what makes NbS implementation attractive [25,30].

One of the challenges that can be addressed using NbS is the urban heat island (UHI) effect, with respect to which these solutions can be effective in mitigating air pollution and reducing air temperature in urban areas [10,31]. Systems and technologies integrated into nature-inspired construction projects (green buildings), such as green roofs and green walls—green facades, vertical gardens, or living walls—are opportunities to foster a transformation in buildings by creating effective NbS solutions [9,10,25,29], reducing thermal stress in cities, and improving air quality [28,31]. NbS also offer synergies in reducing flood and drought risks while improving water quality and quantity [29], meeting the objectives of various European regulations such as the Floods Directive and the Water Framework Directive [28,32].

In general, NbS can be grouped according to sectors and thematic areas of social importance [28,33]: (I) water management, (II) forests and forestry, (III) agriculture, (IV) urban areas, and (V) coastal areas (Table 1).

Table 1. Benefits of nature-based solutions to address climate risks in specific sectors and thematic areas.

Sectors and Areas	NbS Options	NbS Benefits	Climate Impacts
Water Management	Sustainable urban drainage systems (SUDS) Renaturalization of rivers, streams, and flood plains Restoration of ponds and lakes River buffers (vegetation strips) Water-sensitive forest management Controlled flood plains	Regulation of the water cycle Reduction in floods Improvement of the water quality Improvement of the soil quality, stability, and erosion Biodiversity Regeneration of degraded areas Recreation and aesthetic appreciation Health and quality of life	Droughts Floods
Forests and Forestry	Protection and restoration of forests Sustainable forest management Integration of trees/forests into the landscape Wetlands	Regulation of the water cycle Reduction in floods Improvement of the water quality Improvement of the soil quality, stability, and erosion Biodiversity Carbon sequestration Control of disease and pests Recreation and aesthetic appreciation Health and quality of life	Droughts Floods Fires
Agriculture	Improved soil and water management Crop-type diversification and rotation Agroforestry	Retention of water and soil retention Mitigation of heat stress Biodiversity Carbon sequestration Control of disease and pests Soil fertility	Droughts Floods Heat stress

Table 1. *Cont.*

Sectors and Areas	NbS Options	NbS Benefits	Climate Impacts
Urban Areas	Urban parks, forests, and street trees Green buildings Renaturing of abandoned areas and opportunity plots NbS for water management (bioswales, detention ponds, and rainwater harvesting) NbS for transport infrastructure (greening of streets and previous pavement and greening infrastructure) Regenerated soil Pollinator biodiversity Environmental compensation	Cooling air temperature Regulation of water runoff Improvement of the water quality Improvement of noise quality and comfort Biodiversity Carbon sequestration Regeneration of degraded areas Recreation and aesthetic appreciation Increasing the value of land and property Health and quality of life	Floods Heat stress
Coastal Areas	Rehabilitation and restoration of coastal habitats Beach regeneration, barrier islands, and beach nourishment Hybrid solutions (green dykes and vegetated levees)	Reduction in coastal flooding Stabilization of the coast Carbon sequestration Biodiversity Regeneration of degraded areas Recreation	Sea level rise Storm surges Coastal erosion

Adapted from [28,34].

The EU's ambition is to establish Europe as an inspiration and world leader in markets for NbS through research (development of a technical and scientific evidence base for NbS) and innovation (development of methods and identification of innovative best-practice approaches) [29,35]. The main objective in the field of implementation is to improve the visibility of NbS at all stages, developing demonstration sites and experiences (practical examples on a large scale) to ensure and share the relevance of these initiatives in the current market [29]. The EC has made significant efforts in promoting and disseminating NbS knowledge, experiences, and results [35] through publications, programs, and a network of NbS projects funded by Horizon 2020 (H2020 Research and Innovation Program, 2014–2020) [36]. Continuing the investments and work carried out in recent years, the EU recently launched "HORIZON Europe" (2021–2027). This is the EU's flagship research and innovation funding program (budget of EUR 95.5 billion) [37], which promises to prepare Europe to tackle climate disruption, accelerate the transition to a healthy and prosperous future, and apply solutions for resilience that will lead to the transformation of society. It also aims to accelerate soil and food health, as well as climate-neutral smart cities by 2030, among other mission areas [38]. The HORIZON Europe program emphasizes the acceptance and integration of NbS initiatives in public and private decision making [35].

2.3. Nature-Based Solutions in the Built Environment

Around the world, NbS have been developed and are being implemented to respond to current challenges and improve the quality of urbanized areas and, consequently, human health and well-being [26]. For example, in the context of the COVID-19 pandemic, NbS have been shown to provide additional health benefits, providing both physical and mental relief [39]. As a result, there has been an increase in green roof initiatives, aiding biodiversity and the expansion of urban agriculture [40]. Therefore, designing and building nature-based restorative spaces emerges as a potential response [35] in resolving public health crises [40,41].

In its annual publication, the Global Alliance for Buildings and Construction (GlobalABC) reported on the global progress of the construction and building sector towards meeting international goals with respect to climate change. According to the 2021 Global Status Report for Buildings and Construction, in 2020, the construction and operation of buildings were responsible for 37% of global energy-related carbon dioxide (CO_2) emissions, in addition to the sector's energy consumption, representing approximately 36% of global demand [42]. The document also indicates that if the effect of the COVID-19 pandemic is excluded (due to the decrease in economic activity in the period under analysis), the level of decarbonization in 2020 was only 40% of the 2050 reference path to reach the targets set out in the Paris Agreement [42]. For an alignment with the SDGs, the construction and building sector must incorporate concepts related to the CE in order to decrease the demand for building materials and reduce embodied carbon, in addition to the adoption of NbS that improve the resilience of the construction industry [43].

The use of NbS can be understood as an essential urban planning tool for cities to increase their resilience in response to climate change. In particular, in urban areas, multifunctionality makes these actions references for cities to achieve the transition from a linear to circular model, as NbS offers several benefits with respect to the main challenges highlighted in urban circularity: restoring and maintaining the water cycle (by rainwater management); water and waste treatment, recovery, and reuse; nutrient recovery and reuse; material recovery and reuse; food and biomass production; energy efficiency and recovery; and building system recovery [44].

Furthermore, the implementation of NbS in an urban environment is a central element of European strategies [25] and is directly aligned with the objectives of the 2030 Agenda [28,45] as a way to achieve sustainable cities and communities while playing an active role in the strategic implementation and fulfilment of the SDGs [28], specifically "SDG 11—Sustainable cities and communities: make cities and human settlements inclusive, safe, resilient and sustainable" and "SDG 13—Climate action: take urgent action to combat climate change and its impacts" [25,45]. In the built environment, NbS implementation can be integrated into three levels [10] characterized by:

1. Green building materials: raw natural materials taken from the biological cycle. Their processing must have minimal negative effects on the environment, with low incorporated consumption of energy, carbon, water, and chemicals. Optimal production and construction methods should allow for the safe return of nutrients to the ecosystem after the material use cycle.
2. Green building systems (systems for the greening of buildings), including green and living components integrated into structures and used for the afforestation of buildings, for example, green roofs, facade greenery, living walls, and house trees.
3. Green building sites (green urban sites): areas of land adjacent to buildings (e.g., pocket parks, urban plazas, and small community parks), which play a blue–green role in cities, emphasizing the value of open spaces with vegetation and water-sensitive urban design. These environments provide a variety of ecosystem services and reflect resilient and regenerative approaches to addressing diverse challenges such as reducing noise pollution and mitigating climate change.

Inspired and based on nature and the adoption of ecosystem principles, NbS aim to recover and regenerate natural processes and flows in the urban environment at different scales (Table 2). NbS address social challenges at a range of spatial scales—local, regional, and global [26]—which can be classified according to the level of interventions [34], representing actions from buildings or plots, including districts or neighbourhoods, to cities and beyond (other larger interventions) [46,47].

To differentiate the scale and scope of interventions, another approach used for NbS classification—for implementation in urban environments—is the proGIreg projects (funded by the EC under the Horizon 2020 programme). Specifically, NbS are classified into eight different types [48]:(1) leisure activities and clean energy on former landfills, (2) new regenerated soil, (3) community-based urban farms and gardens, (4) aquaponics, (5) green walls and roofs, (6) accessible green corridors, (7) local environmental compensation processes, and (8) pollinator biodiversity.

Table 2. Nature-based solutions and actions at different scales in urban areas.

Scale	Actions and Interventions
Micro: Building or plot	Previous pavement Urban meadow Private garden Regreening spaces between buildings Actions in community courtyards Shelter for auxiliary fauna (insects and earthworms) Green facades and vertical gardens Sustainable urban drainage systems Green roof and meadow Combined solutions—green roof with renewable energy Rooftop farming and in-height orchards
Meso: District or neighbourhood	Street furniture Previous pavement Comfortable urban places Urban microclimates (public fountains and lakes) Green wharf Spontaneous flora Street trees Community garden Allotment gardens Urban parks Permeable riverbanks and waterbodies Renaturing of abandoned areas and opportunity plots
Macro: City and beyond	Urban farming Constructed wetlands Green street networks Urban forests Ecological corridors Urban planning Renaturing of rivers and streams Controlled flood plains

Adapted from: [34,46,47].

3. Materials and Methods

An initial literature search of 69 case studies was carried out in the Oppla repository (https://oppla.eu/ (accessed on 5 September 2022)), a platform that serves as an EU information centre for knowledge and exemplary NbS cases; proGIreg (https://progireg.eu/ (accessed on 20 September 2022)) "Living Labs" projects for the implementation of innovative NbS in pioneering and strategic cities with the potential for the development of "productive Green Infrastructure for post-industrial urban regeneration"; and CLEVER Cities (https://clevercities.eu/ (accessed on 30 September 2022)) nature-based intervention projects in key city regions to promote urban regeneration. With this selection, it was possible to analyse case studies in different places in Europe, making it possible to enrich the research due to the diversity of realities. Altogether, these are projects with a particular focus on thematic coverage of the urban implementation of NbS and have received funding from the EU's Horizon 2020 innovation action programme.

Through the applied methodology, it was possible to analyse projects for 24 different European cities. The reported solutions and the knowledge acquired about NbS in different locations in the EU were analysed and acquired through the investigation of empirical knowledge, and data collection was performed through indirect and online observation and made available for public access.

The second stage of the research is to enrich the initial stage and to assist in the construction of scientific knowledge about the main strategies and current interventions with respect to urbanization in the implementation and development of more resilient and environmentally sustainable cities, consisting of the selection of keywords and adequate databases to search. The keywords used in the research were: "nature-based solutions" and the name of the cities under analysis (24 mentioned above). The sets were sequentially combined in "Scopus" and "Web of Science" by searching the "All fields" scope using the Boolean operator "AND" between sets of keywords. Then, some criteria were defined to narrow down the information, as presented below: (1) date: only articles published in the last five years were included; (2) source type: only peer-reviewed journals were considered; and (3) language: only articles written in English were included in the study. In terms of eligibility criteria, any article that provided relevant information regarding NbS in the city under study was included in the analysis, i.e., information was accepted indifferently from interested parties (for example, research institutions, local organisations, or public authorities) at all scales (building, district, or city) and during each stage of urban development (planning, design, implementation, or management).

All textual materials were gathered, compiled, and consolidated (from September to November 2022) to provide an overview of recurring NbS themes. This task was aided by the development of an Excel datasheet, which included the following elements: location and country, period or project end projections, title/name of project/program, main objectives, main impacts, project name or name of NbS actions, the spatial scale of NbS implementation, classification of types of urban actions for NbS, types of ecosystem services, classification of ecosystem services, types of benefits, and classification of multiple benefits in the implementation of NbS actions. Then, the qualitative information was synthesized and refined.

As it is a new concept, there is no unique and unambiguous identification and classification method for NbS [34]. Given the lack of standardized criteria and taking the urban context of adaptation to climate change in nature-based planning into account, it was considered appropriate to classify NbS actions implemented in an urban environment through a methodology defined by the Naturvation project (funded by the EU's Horizon 2020 research and innovation programme) [49] and the categories shown in Table 1. Therefore, eight different types of NbS classification were established for the urban sustainability challenges of a city, district, or building, namely (1) blue infrastructure, (2) community gardens and allotments, (3) green areas for water management, (4) green buildings, (5) infrastructure with green features, (6) parks and urban forests, (7) renaturing of abandoned areas and opportunity plots, and (8) urban gardens and green spaces between buildings. For the differentiation of the spatial scale, on which the impacts of NbS were evaluated, together with the type of NbS adopted and the dimension (micro, meso, or macro) in which it is implemented, and respecting the classification shown in Table 2, the following scenarios were established: (1) district or neighbourhood; (2) regional, metropolitan, or urban; and (3) street, plot, or building. Regarding the categorization of the different urban ecosystem services and multiple benefits in the implementation of NbS actions, when not made available by the program, this factor was evaluated according to the EC manuals published by and available from the "Publications Office of the European Union" [50–52].

4. Results

As the focus of the research—current initiatives to implement NbS in urban areas in the European panorama—it was possible to analyse case studies in the following cities: Amsterdam (The Netherlands), Bari (Italy), Berlin (Germany), Bilbao (Spain), Bristol (United Kingdom), Budapest (Hungary), Dresden (Germany), Dublin (Ireland), Dortmund (Germany), Edinburgh (United Kingdom), Genk (Belgium), Hamburg (Germany), Linz (Austria), Lisbon (Portugal), Ljubljana (Slovenia), London (United Kingdom), Milan (Italy), Oradea (Romania), Poznan (Poland), Rotterdam (The Netherlands), Szeged (Hungary), Turin (Italy), Utrecht (The Netherlands), and Zagreb (Croatia). The first step was to analyse the country of origin of each study (Figure 2). The colours in Figure 2 indicate the countries and the respective number of cities analysed. The most representative country was Germany, with four cities, followed by Italy, The Netherlands, and the United Kingdom, with three cities each, and Hungary, with two cities. The remaining countries include only one city under study.

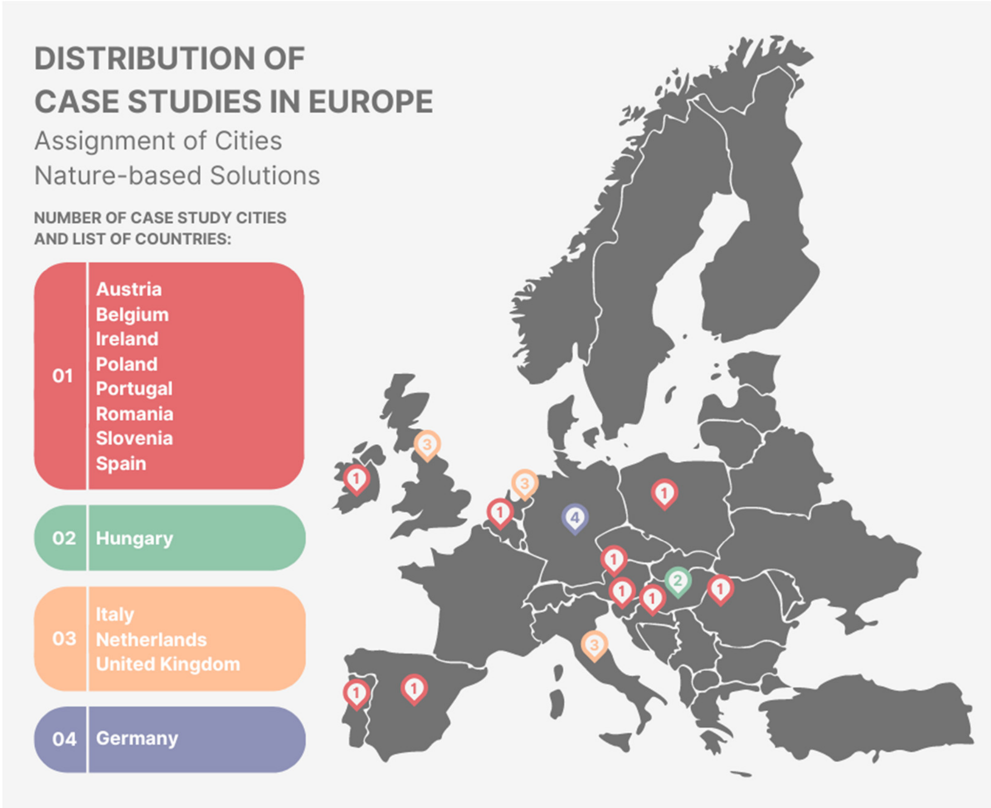

Figure 2. Spatial distribution of cities by country.

Following the preliminary analysis, Figure 3 represents the distribution of the number of NbS projects implemented by European countries. The most representative countries are Italy and the United Kingdom, followed by Germany and The Netherlands.

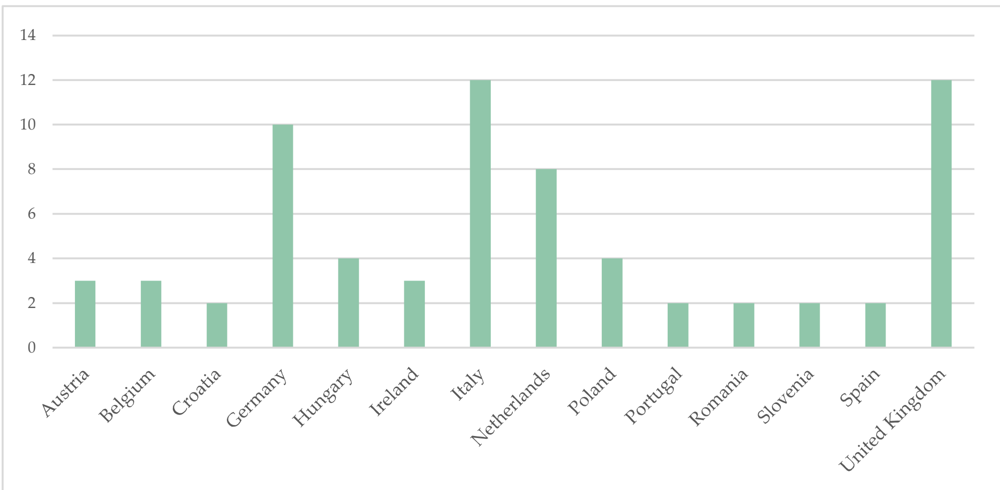

Figure 3. Number of NbS Projects by European countries.

Table 3 presents a complete list of cities with exploratory cases and experimental applications related to NbS. This list includes the identification data, main objectives, and impacts of specific and/or combined NbS initiatives and actions that support urban circular thinking and the use NbS concepts in the built environment. In the last column, the articles are identified after the selection of data and comprehensive information under the research objective and methodology implemented.

Table 3. List of cities and their projects.

Location	Name of Project/Program	Main Objectives	Main Impacts	Project Name or Name of NbS Actions	Supporting References
Amsterdam, The Netherlands	NbS for greening the city and increasing resilience	Create a creative and varied city with an integrated public transport network, high-quality urban planning, and investment in recreational green spaces, water, and renewable energy	Green spaces created/renovated; reduced flood risks; increased social awareness and political support for water diplomacy and climate change adaptation	City Parks Green Neighbourhoods Greening the city Green corridors Deltaplan	[53–56]
Bari, Italy	NbS for greening the urban space	Improve urban quality and green areas, reduce the urban heat island effect, and manage stormwater	Health benefits, mitigation of the urban heat island effect, air purification, restoration/maintenance of habitats and biodiversity, water flow regulation, and reduced impacts of heavy precipitation events	Operation Zero Degradation: Revitalizing residual urban areas as green spaces Shagree: the Green shadows programme Lama Balice Nature Park	[53]
Berlin, Germany	NbS for urban green connectivity and biodiversity	Create connectivity across the city and a 'greenbelt' as a border boundary for urban growth and protection against urban sprawl	Green adaptation to climate change, increasing urban resilience, green/blue connectivity and functionality, biodiversity, cultural wealth, water infiltration/storage, NbS social learning, and health benefits	BENE (urban greening) Green Moabit (rainwater management) Mischwaldprogramm (mixed forests) Transforming vacant urban areas into green spaces School gardens (Urban Living Lab) Twenty green walks Prinzessinnengarten (nomadic gardening)	[53,57–59]
Bilbao, Spain	NbS for dealing with extreme temperature and rainfall events	Make the city more resilient towards cold spells, heat waves, and frequent floods	Mitigation and adaptation to climate change in urban planning, social and economic cohesion, well-being, health, and a more attractive city	Zorrotzaurre project (new floodproof district) Bilbao Greenbelt Expansion (expansion and connection of green areas)	[53]
Bristol, United Kingdom	NbS for a sustainable future	Create a socially inclusive environment with facilities for sport and recreation and a natural environment with urban regeneration and renewal through green networks to minimize and mitigate climate change	Protect, provide, enhance, and expand green infrastructure; promote healthy lifestyles and social inclusion; and increase connectivity with nature	Green infrastructure Green areas for flood management	[53]
Budapest, Hungary	NbS for climate resilience and pollution control	Protection of and increase in the number of green areas, ensuring ecological connectivity and the development of 'smart' and environmentally conscious cities	Urban biodiversity, better water management (water retention), better air quality, social cohesion, public awareness of nature, health, and recreational benefits	Pocket parks Urban gardens Renewing city parks Preserving forests on the outskirts and existing green areas	[53]

Table 3. *Cont.*

Location	Name of Project/Program	Main Objectives	Main Impacts	Project Name or Name of NbS Actions	Supporting References
Dresden, Germany	NbS for sustainable urban transition	A compact city to accommodate more development and include a network of functional green spaces	Bottom-up initiatives for community gardens for diverse environmental, social, and economic benefits; a better quality of urban life; urban renewal; and increased city attractiveness	Living lab: transforming former allotment gardens into community gardens Urban landscape plan: ecological network	[53]
Dublin, Ireland	NbS for a more sustainable city by 2030	Create a sustainable and resilient city based on economy, environment, and equity	Providing an attractive place to live, work, and visit; air and water regulation; climate adaptation; and pollution reduction	Sustainable urban drainage Green infrastructure Green roofs and green walls	[53,60,61]
Dortmund, Germany	The Living Lab: From the Duesenberg to the Huckarde district	Strengthen high-quality green infrastructure and industries with a focus on urban agriculture and improved quality	Reconstruction of derelict land previously used by industry for residential areas and green leisure areas, increasing natural potential with a greenbelt	Renaturing landfill sites Urban farming and gardening on post-industrial sites Connecting Huckarde with River Emscher and Duesenberg Aquaponics as soil-less agriculture Pollinator biodiversity and citizen science	[62]
Edinburgh, United Kingdom	NbS enhancing health, wealth, and sustainability	Create a low-carbon, resource-efficient city, providing a resilient local economy and vibrant, thriving communities	New business and knowledge opportunities, public awareness, green infrastructure connectivity, biodiversity, cultural wealth, ownership, water management, and climate adaptation	Pollinator Pledge Granton Community Gardeners Duddingston Field Group	[53]
Genk, Belgium	NbS bridging green and industrial heritage	Use Genk's natural and human capital for sustainable value creation	Social cohesion, economic opportunities, green jobs, and transition to sustainability	Urban farming—Modeltuin Genk Noord Green Corridor—Stiemerbeek Valley Bee Plan—Bijenplan and Heempark	[53,63]
Hamburg, Germany	Hamburg's CLEVER Action Lab: Neugraben-Fischbek	Promote sustainable and socially integrative urban renewal through NbS and demonstrate the capacity and potential of these solutions in terms of technical, social, and economic innovation	Ecologically regenerated and healthier urban environments with greater social cohesion, more economic opportunities, and greater environmental quality	Green corridor Green roofs and green facades School playgrounds/yards	[64–68]
Linz, Austria	NbS as a motor for urban growth	Enhancing and protecting urban green areas as a way to increase the attractiveness of the city and position it as an important location for regional and international business	Recreation; biodiversity; microclimate; traffic noise control; stormwater management; and a high-quality urban landscape for real estate value, air quality, and pollution reduction	Landschaftspark Bindermichl-Spallerhof SolarCity Urban greening strategy	[53]

Table 3. *Cont.*

Location	Name of Project/Program	Main Objectives	Main Impacts	Project Name or Name of NbS Actions	Supporting References
Lisbon, Portugal	NbS enhancing resilience through urban regeneration	Increase resilience through urban regeneration and increase the importance of preserving natural, forestry, agricultural, and cultural heritage	Better ecological flows and landscape functions; green infrastructure to adapt to climate change, improve drainage, control air and water pollution, and promote leisure, contributing to healthy lifestyles and an attractive city	Green corridors and street trees Urban agriculture	[53,57,69–73]
Ljubljana, Slovenia	NbS for urban regeneration and well-being	Protect and enhance the city's natural environment	Mitigation of the urban heat island effect, accessibility for pedestrians and cyclists, gardens for recreation and leisure, and restoration of the river with an ecological corridor	Green areas (including agricultural allotments) Urban ecological zone Restoration of the river Ljubljanica (Ljubljanica Connects)	[53,56,74–77]
London, United Kingdom	NbS for a leading sustainable city	Increase green space, improve air quality, reduce the UHI effect (heat island), and prevent flash floods through climate change adaptation and mitigation	Opportunity to develop and market green skills; NbS can mitigate heat stress, flood risk, and air quality issues	Green roofs (London/Barking Riverside) Natural water retention measures—River Quaggy Brownfield restoration, Barking Riverside Olympic Park—biosolar roofs Beetle Bump, University of East London campus	[53,64,73,78,79]
	London's CLEVER Action Lab: Thamesmead	Provide opportunities to connect with natural landscapes, economic opportunities, social cohesion, and citizen well-being and advance NbS research and urban regeneration	Quality green spaces working together with education and community networks; connection with nature; social, economic, and environmental impact	Connecting people and places "Healthy Streets"—Parkview, South Thamesmead Greening Unusual and Underused Spaces—South Thamesmead Activating Southmere Lake—Southmere, South Thamesmead	
Milan, Italy	NbS for urban regeneration	Green infrastructure is the best way to achieve environmental goals; promote social development and improve social well-being	Social cohesion; promotion of multipurpose green infrastructure; offering inhabitants agricultural, forestry, cultural, and recreational activities	Parco Agricolo Sud (periurban agriculture and nature conservation) Urban gardening Bosco Verticale (vertical forest) Gorla Maggiore Water Park	[53,56,64,73,80–88]
	CLEVER Cities Milan	Experimenting with innovative green and NbS infrastructure for city regeneration, climate change mitigation, and building a better future for citizens	Diffusion of green roofs and facades; support for experimental projects; development of public green areas with innovative and shared methods in terms of planning, management, maintenance, and monitoring; and the experimental integration of green spaces into railway infrastructure	Green roofs and walls: 'Rinverdiamo Milano'—Let's re-green Milan Development of public green areas: A new park for Giambellino 129 A new green hub for Tibaldi station	

Table 3. *Cont.*

Location	Name of Project/Program	Main Objectives	Main Impacts	Project Name or Name of NbS Actions	Supporting References
Oradea, Romania	Improving the quality of life with NbS	Improve the quality of life of citizens, prioritizing increased leisure opportunities	Active utilization of new areas with improved recreation, increased connectivity, and more biodiversity; improved air quality and climate conditions; new employment and business opportunities; and positive cooperation in public–private partnerships	Green area rehabilitation and development of green infrastructure Creation of outdoor leisure areas Lake creation	[53]
Poznan, Poland	NbS for a friendly, mobile city	Transforming into a green city and improving the quality of life of all inhabitants in such a way that they have a stake in cocreating the city	Green wedge system with high cooling capacity, the transformation of parking lots into green areas, riverside areas with seasonal beaches for leisure, high tourist potential, and new housing projects close to green areas	Maintaining the green wedge system Planting 18,000 trees on the roadside and using transitional green elements; Transforming car parks into green areas Community gardens Creating seasonal beaches	[53,58,63,70,89–91]
Rotterdam, The Netherlands	NbS for building a waterproof city	Make the city 100% weatherproof by 2025, with a focus on adaptive measures including rainwater capture and delayed drainage	Blue–green corridors to facilitate natural hydrological processes, increased biodiversity, and improved quality of life	Water storage capacity Deltaplan Tidal park programme—Esch, Mallegat	[53,92–94]
Szeged, Hungary	NbS for urban regeneration and adaptation to climate change	Improve the quality of green areas, restore natural habitats and ecological corridors for social and recreational purposes, and mitigate the impacts of climate change	More recreational environments and public awareness, more stable biodiversity and ecosystems, and better air and soil quality	Green area rehabilitation Green infrastructure development Urban gardening	[53,81,85]
Turin, Italy	The Living Lab: Mirafiori Sud	Strengthen green infrastructure in areas previously dominated by industry; improve urban quality, social, and economic issues through NbS implementation; involve citizens in activities; and promote NbS-based business models	Introduction of more green space, contribution to education in schools, the inclusion of disadvantaged social groups, support for new entrepreneurship and new green jobs, and NbS regulation	New soil and plant species for urban forestry (Parco Sangone) Greenway and cycling corridor (Sangone river) Urban farming and gardening Pollinator-friendly green spaces Aquaponics tests Green roofs and walls	[62,95–97]
Utrecht, The Netherlands	NbS for urban resilience and citizens' well-being	Promoting healthy urban living, an integrated and systemic urban life that combines the cleanest local approach, recreation, and noise reduction	A water system for diverse ecosystem services, street trees, and street vegetation contributes to quality of life through the realization of a comprehensive green structure based on historical–cultural, spatial, environmental, and ecological values	Central station—a 'Smart Sustainable District' Leidsche Rijn—sustainable urban drainage systems City trees and greenery	[53,98–100]

Table 3. *Cont.*

Location	Name of Project/Program	Main Objectives	Main Impacts	Project Name or Name of NbS Actions	Supporting References
Zagreb, Croatia	The Living Lab: Sesvete	Strengthening green infrastructure in areas previously dominated by industry, social inclusion, supporting new entrepreneurship and new green jobs, and introducing NbS as a catalyst in urban regeneration	New public spaces and the introduction of NbS to sustainable urban planning, strengthening urban resilience, wellness programs (recreation and sports areas), community activities, and bioclimatic building principles	Urban gardens and green areas (educational area) Aquaponic testing New connecting cycle path (urban gardens and neighbourhood) Green roofs and/or green walls in historic buildings (former factories)	[62]

Figure 4 presents the unfolding of NbS actions classified as interventions in an urban environment. A total of 69 projects (singular or combined) were identified, corresponding to 185 actions implemented in the 24 cities under analysis. The large number of actions compared to the number of samples (cities and projects) is because, in most cases, nature-based interventions fall into more than one domain. This holistic and integrative nature of NbS has been highlighted in the literature, emphasizing its multifunctionality as the main advantage over traditional (grey) infrastructure-based solutions [101]. For example, in Budapest, in the creation of pocket parks as an initiative to increase the number of green areas in a district of the city, they are multifunctional; that is, they provide spaces for small-scale food production and the possibility of recreation and community sharing through gardening, assisting in water retention and the region's microclimate [53]. In this case, the project is characterized by all relevant types of NbS, namely "infrastructure with green features", "parks and urban forests", "community gardens and allotments", and "green areas for water management".

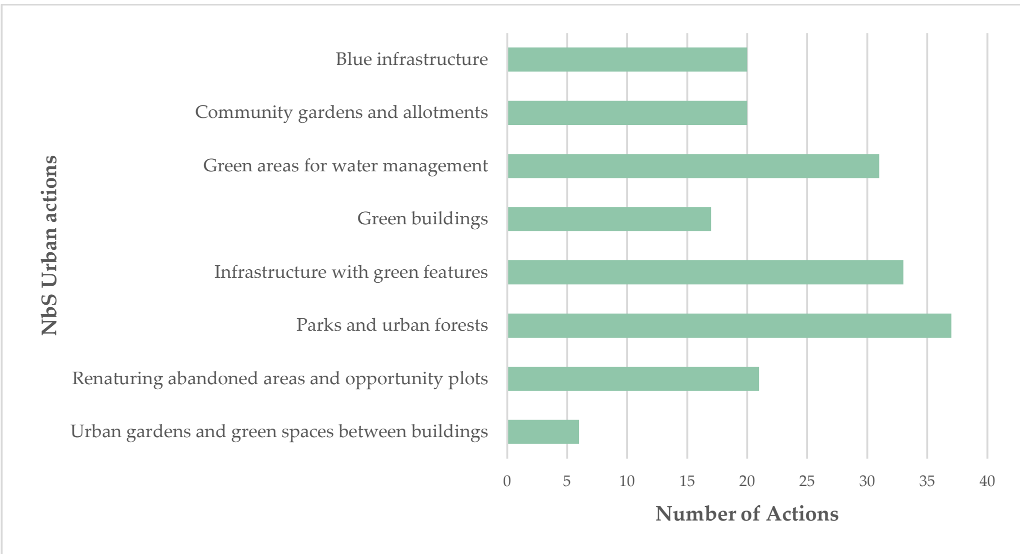

Figure 4. Distribution of NbS urban actions.

The types of NbS most represented in the built environment are "infrastructure with green features" (18%), "parks and urban forests" (20%), and "green areas for water management" (17%). On the other hand, the least represented is "urban gardens and green spaces between buildings" (3%).

Figure 5 represents the spatial distribution of NbS implementation scales in urban space. Analysis shows that the NbS implemented on the "district or neighbourhood" scale correspond to 43% of the total sample, followed by "regional, metropolitan, or urban" and "street, plot, or building", representing 35% and 22%, respectively.

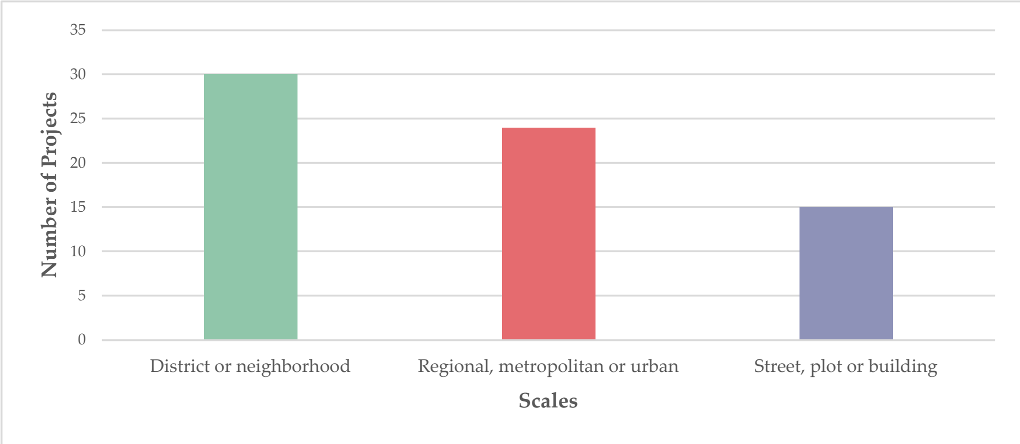

Figure 5. Spatial scale NbS of implementation.

From the classification of different urban ecosystem services and multiple benefits in the implementation of NbS actions, according to which 69 projects were analysed, it was possible to compile the data and represent them through Figures 6–9.

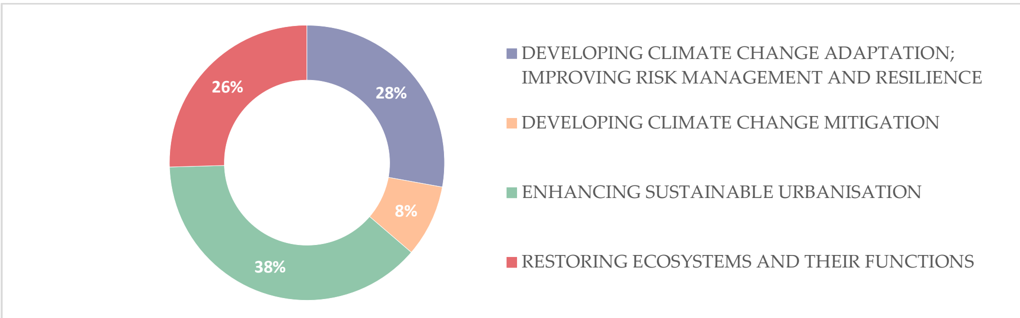

Figure 6. Distribution of the multiple benefits of NbS.

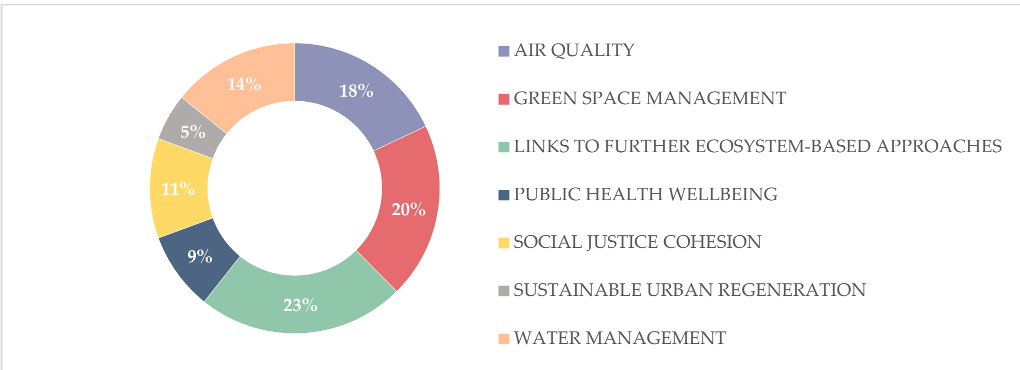

Figure 7. Distribution of NbS ecosystem services.

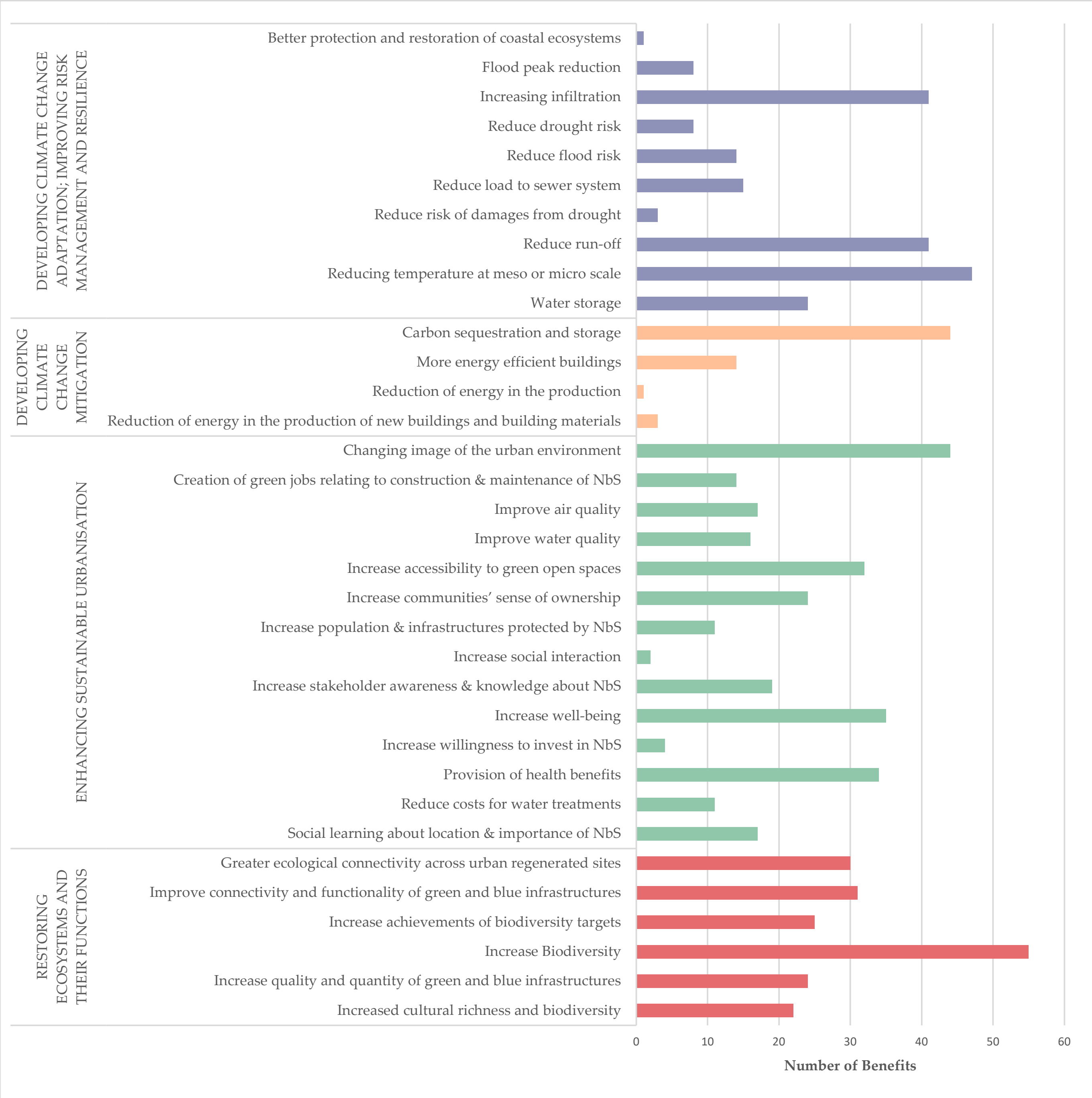

Figure 8. Multiple benefits NbS.

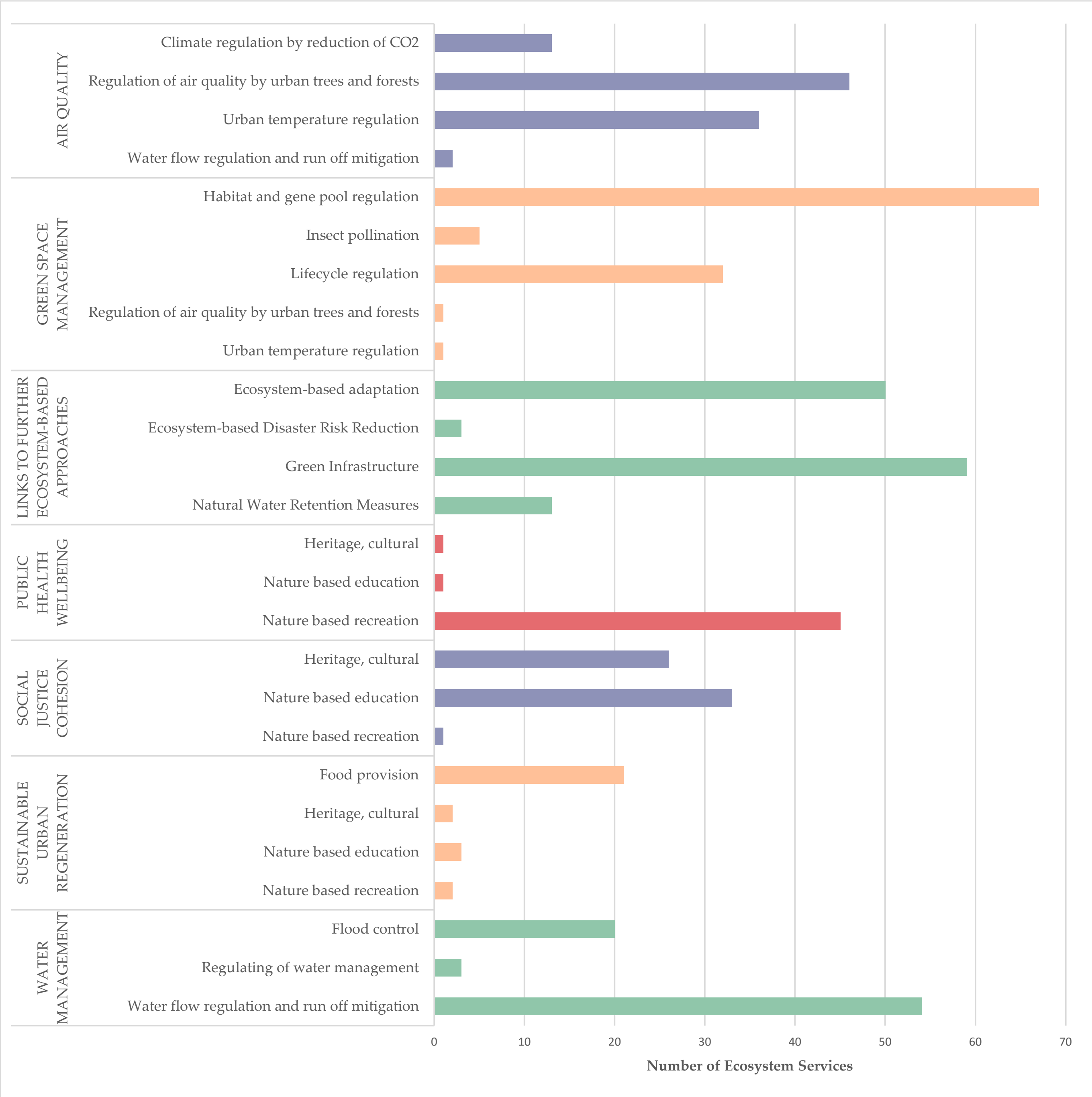

Figure 9. NbS ecosystem services.

The most prevalent NbS challenges addressed in the survey concern issues of increasing sustainable urbanization (38%), followed, in equivalence, by developing climate change adaptation and improving risk management and resilience (28%) and restoring ecosystems and their functions (26%). Challenges related to the development of climate change mitigation were less common among the analysed case studies, corresponding to 8% of NbS projects. In particular, the types of benefits most highlighted were "increasing infiltration", "reduce run-off", "reducing the temperature at meso or micro-scale", "carbon sequestration and storage", "changing image of the urban environment", and "increase biodiversity".

The last type of characterization (ecosystem services provided) includes five different categories, where, according to the results of the analyses, the most frequently provided services among the analysed NbS are related the interaction of more ecosystem-based approaches (23%), for example, natural water retention measures (NWRM) and ecosystem-based disaster risk reduction (Eco-DRR); green space management (20%); and air quality (18%). Fewer ecosystem services related to sustainable urban regeneration were provided, corresponding to 5% of NbS projects. In particular, most case studies offer services equivalent to “water flow regulation and runoff mitigation”, “green infrastructure”, “ecosystem-based adaptation”, and “habitat and gene pool regulation”, designating the crucial role of these practices for the environment.

5. Discussion

The EU has been actively engaged with the research community to better address NbS knowledge and technology gaps through its framework programs and its research and innovation strategy, namely Horizon 2020 and HORIZON Europe. Reflecting on its leading role in the spread of NbS [18,35], the EC, through its funded programs, is focused on the development and availability of a knowledge base on NbS. Indeed, many European cities and regions have undertaken NbS-inspired initiatives to address a range of societal challenges through the delivery of essential ecosystem services. This is evident in fourteen countries represented by the total sample of case studies analysed with different scenarios and applications of NbS in the urban environment.

The articles from eligible scientific journals, in their entirety, did not show similarities with the present study, confirming that the NbS theme is still evolving and that there is a lack of methods for systematic, comprehensive, and integrative compilation and assessment of NbS knowledge [18,19]. It is noted that much of the ongoing efforts are focused on addressing NbS solutions in unique ways for the evapotranspiration performance of vertical vegetation systems [57], for the emotional reaction to urban vegetation [82], for CO_2 reduction in a hermetic museum environment [83], or for its potential to attract young generations [95]. These approaches are important to answer several critical gaps in NbS knowledge; however, barriers have been identified regarding uncertainties in terms of the performance, functionality, and implementation of NbS [20]. Therefore, an integrated approach to the provided ecosystem services is fundamental, assigning the crucial role of NbS practices to the environment and mitigation of climate change impacts, as well as the performance of NbS related to the identified challenges [19].

During the second stage of the research (consultation of the “Scopus” and “Web of Science” databases), a considerable number of cities were not addressed and cited in published articles on NbS under penalty of the exclusion and eligibility criteria previously defined in the Methodology section. Thus, it was not possible to find articles that contained relevant information for the analysis of NbS actions in the following cities: Bari, Bilbao, Bristol, Budapest, Dortmund, Dresden, Edinburgh, Linz, Oradea, and Zagreb. The rest of the documents were important for classifying the different NbS actions, their benefits, and ecosystem services associated with the urban environment.

Urban environments are associated with a significant number of actions that focus on changing green infrastructure towards multifunctionality and improved quality, whereas actions to support citizens in its use are lacking [89]. Nature-based interventions require a collaborative approach to their planning and implementation [93]. The urban environment constitutes opportunities for the participation of citizens and society actors in the formation and planning of green spaces [54], with a significant importance of being at the centre of policy formulation [71]. Therefore, the implementation of NbS in urban contexts requires the cooperation of different public and private actors to manage these processes, directly contributing to learning among the participants, as evidenced in Hamburg within the scope of the CLEVER Cities project [68].

In the city of Milan, after the adoption of NbS, a study pointed out the importance of NbS interventions in citizens’ perceptions of their well-being, general health, and a strong sense of belonging to the neighbourhood [80]. These benefits correspond to the increase in sustainable urbanization, as evidenced in the results presented for the multiple NbS benefits.

Studies have identified that knowledge about indicators is needed to monitor and evaluate the implementation of NbS [60,65], with the aim of transformation into a strategic green–blue link in cities, although this remains a considerable challenge to overcome [63]. Different approaches to urban planning, particularly the use and guarantee of effective NbS, shape the design of cities that are more resilient to the effects of climate change in terms of increasing the density of green areas and ensuring permeability, influencing cooling capacity [88], and the impact of floods during extreme weather events [97]. Therefore, it is of great importance to integrate ecological components into a real dynamic green infrastructure [86] throughout the design process when implementing NbS [92,102].

NbS represent an effective tool to improve ecosystem services, value environmental and sociocultural issues [84], and offer integrated benefits with environmental and water management practices [71]. Actions such as "blue infrastructure" and "green areas for water management" have been implemented in the urban environment. The highlighted benefits include "improve connectivity and functionality of green and blue infrastructures", "reduce run-off", and "increasing infiltration". With respect to the provided ecosystem services, the highlights are "water flow regulation and runoff mitigation", "flood control", and "natural water retention measures".

Many studies emphasize the potential and effectiveness of NbS adoption in urban water management [66,74–77,96,98]. The activities proposed for Hamburg, among others, focus on the management of rainwater, which will be used in irrigation systems for plantation areas, increasing the efficiency of rainwater reuse [66]. Similarly, the Leidsche Rijn water system in Utrecht is a sustainable, nature-based, closed-loop surface water system providing clean, clear surface water and supporting biodiversity and climate adaptation. The system includes NbS components in urban infrastructure regimes such as bioswales, ecological water banks, a network of canals, buffer lakes, dams with water gates, water pump stations, and permeable paving [98]. Ljubljana stands out in terms of land use planning and urban water management in the city, with retention areas that are attractive for leisure activities and have a positive impact on the microclimate [76]. Efficient waste management in Ljubljana is an example of the promotion of circularity through the processing of biological waste and mixed waste. Ljubljana Regional Center for Waste Management (RCERO) facilities are capable of producing green electricity from renewable sources of biogas composed of biological waste and electricity and heat [74,75].

Another potential for the implementation of NbS in an urban environment is the possibility of transforming abandoned land into strategic areas promoting green infrastructure and urban regeneration [79]. Many projects, such as post-industrial districts that host living laboratories [62,87], enable the development, testing, and implementation of NbS. This potential is readily identified in the Results. "Renaturing abandoned areas and opportunity plots" is prominent among interventions in urban environments and has a great influence on ecosystem services of "ecosystem-based adaptation" and the benefits of "greater ecological connectivity across urban regenerated sites" and "changing image of the urban environment".

Large green spaces with NbS have the potential to increase the volume of business, increasing revenues, in addition to creating a pleasant feeling of usability of the space for the population [81]. Vegetation contributes to real estate appreciation in the built environment, for example, in housing projects, reflecting economic benefits for the community [90]. It is worth noting that NbS actions in the social body, such as gardens in subdivisions or community gardens, are important and multifunctional areas in cities [91] that promote social cohesion and equity in the neighbourhood [99].

Although it is not the focus of this research, it is worth noting that a major advantage of implementing NbS is their high cost–benefit ratio over traditional solutions [25,28,29], as they are solutions that represent a flexible approach to sustainable inclusive growth at an affordable cost [8]. Thus, NbS represent an important tool for the development of a regenerative, shared, and circular economy in cities.

A study of the identification of NbS shares in the city of Amsterdam addressed NbS classification according to the level of applied technology (this reinforces the existence of other NbS classification methods). An example of high-tech NbS classification is the intervention of a tree-lined central square (IJburg Island), with great efforts due to the enormous amount of vegetation and the creation of a water retention system. On the other hand, an urban park (Roofpark Orly Square) classified as low-tech NbS transformed a grey space into a green space, with the intention of retaining rainwater and capillary irrigation [55]. Another example of low-tech NbS is urban gardens characterized by low-impact solutions, particularly in Lisbon, where the cost of gardening is lower than in other European regions [70].

However, with respect to differences in classification, many articles approached the initiatives in an urban environment with the same logic adopted in the present work. Research shows positive results of microscale interventions, for example, green roofs generate benefits in food production, energy savings (10-30%), and rainwater storage for cultivation and local cooling [56]. Among NbS solutions, facade vegetation and green roofs on buildings play an important role in temperature regulation, with improvements in thermal load, thermal comfort, and thermal storage of the building [67], as well as in reducing the harmful effects of heat waves on human health [85]. Therefore, buildings play an important part in these processes, not just in terms of carbon reduction but also in terms of adaptability and resilience in urban areas [103]. Furthermore, when deployed on a large scale, green roofs show great potential to develop a robust flood control network [60,103] and reduce runoff [67], in addition to potential to increase biodiversity [100]. Tree planting along streets or in urban parks has the greatest impact on heat mitigation and "greenness" (benefits in terms of restoration and mental health related to the amount of natural and seminatural areas that people experience in their surroundings, either by seeing them or directly accessing them) [100]. Small gardens also demonstrate cooling potential, as evidenced in the heavily urbanized region of Lisbon [69].

With great potential for the urban environment, as mentioned above, the actions of "green buildings" and "urban gardens and green spaces between buildings", characterized by the same scale of implementation, represent actions with less frequency in the sample of the analysed case studies. This may mean that large European investments in NbS initiatives in the urban environment occur in projects with larger scales of implementation.

On a mesoscale, studies reported projected in the city of Amsterdam, with an alternative of ditches and filter strips (water decelerating green strip), which allows for local cooling and reduced runoff and storage capacity [56]. In Ljubljana, public orchards and nectar gardens with the planting of fruit trees (mesoscale) have increased livelihoods in the city by providing additional green areas, creating recreational areas, and generating a local cooling effect during hot summer periods [56]. This scale of implementation corresponds to most actions in an urban environment, representing approximately 45% of the total cases analysed. The actions of "parks and urban forests" and "community gardens and allotments" are highly correlated with the mesoscale.

With the adoption of macroscale solutions, for example the Gorla Maggiore Water Park, there was the possibility of peak flow reduction of 86% (downstream flooding) [56]. Another example is the city of Lisbon (European Green Capital 2020), which has a network of green corridors that are part of the urban green infrastructure and actively contribute to ecological connectivity [72]. Another highlight is in Rotterdam, which is an example of a multicultural and resilient city with major green initiatives and movements (urban agriculture combined with sustainable water management systems) [94].

The application of NbS has proven to be a valuable measure to improve climate resilience and citizens' quality of life, as well as environmental justice and social coherence [67]. Urban spaces have great potential for green infrastructures [76,78], although this potential has not yet been fully discovered or used [58].

In many vulnerable regions, harnessing the power of nature is a promising and cost-effective strategy to strengthen climate resilience while promoting shared social, economic, and sustainable prosperity. Ongoing efforts are noted in Europe in scaling up and integrating NbS for mitigation of and adaptation to climate challenges, with the development of resilience in cities aiming at sustainability. Similarly, some countries in North America and East Asia have steadily advanced the use of NbS in urban planning. References to the use of NbS to combat climate change and reduce environmental degradation can be found political agendas in the United States [104], as well as in Chinese government statements supporting such solutions aimed at combating the causes of climate change [105].

To realize their full potential, NbS should be developed with reference to the expertise of all relevant stakeholders so that these solutions contribute to achieving all dimensions of sustainability in urban space. It is worth highlighting the importance of adding several NbS issues to scientific and policy agendas to address climate change adaptation and mitigation measures. With respect to the development of the present study, it is important to remark that the partners in the 69 analysed projects, beyond researchers from universities and companies, include local authorities. All projects implemented in municipalities demonstrate a real concern and interest in changing and improving the urban environment through NbS. Thus, local governments are increasing the interest and implementation of these types of innovative solutions inspired and driven by nature to face current and future challenges due to the consequences of climate change, making the urban environment more resilient.

6. Conclusions

Given the complexity of urban development and climate change, the pressure on natural resources is expected to continue. As a consequence, public agents in particular have to develop and implement long-term solutions for the sustainable and resilient development of cities based on new technologies and the establishment of development policies. Additionally, the ways of building and applying the concept of NbS, which encompasses solutions that provide a series of ecosystem services and multiple challenges and benefits, whether built permanently or environmentally, are expected to increase. Furthermore, the EU intends to continue its investment in the theorizing and operationalization of NbS, which is expected to increase with the HORIZON Europe program.

From the analysis of the results, it is possible to identify the implementation of urban actions for the development of urban parks and forests, the promotion of green areas for water management, and interventions of existing infrastructure with resources. The results also refer to the need to increase incentives for interventions in nature at a local scale, namely initiatives that promote the greening of buildings. This is essential to improve the local climate (mitigation of the heat island effect), to retain and reduce rainwater runoff, to increase biodiversity, and to improve human well-being through, for example, energy-parity solutions, such as the construction of a thermal cover to contribute to the thermal comfort of buildings through improved thermal insulation and increased potential performing in terms of energy.

The main goal of this article is to identify and present the main and most recent NbS practices applied in urban environments in the European panorama to support the analysis of the complementarity and integration of different measures, as an innovative analysis based on real cases. This study represents a systematic, comprehensive, and integrative compilation and assessment of NbS knowledge, highlighting the complementarity of NbS measures in the urban environment and the need for further research on this topic. NbS research on urban water and sewage networks is expected to continue, with the aim of reducing their inefficacity and improving both sustainability and performance on the path of urban greening.

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