Nature-Based Solutions for Water Management in Peri-Urban Areas: Barriers and Lessons Learned from Implementation Experiences

Nancy Andrea Ramírez-Agudelo *, Roger Porcar Anento, Miriam Villares and Elisabet Roca
Institute for Sustainability Science and Technology, Campus Nord, Universitat Politècnica de Catalunya BarcelonaTech, 08034 Barcelona, Spain; roger.porcar@upc.edu (R.P.A.); miriam.villares@upc.edu (M.V.); elisabet.roca@upc.edu (E.R.)
* Correspondence: andrea.ramirez.agudelo@upc.edu

Received: 6 October 2020; Accepted: 20 November 2020; Published: 24 November 2020

Abstract: Nature-based solutions (NBS) are defined by the European Commission as “actions that are inspired by, supported by, or copied from nature . . .” and that solve societal challenges and multiple benefits. As a result, NBS are often promoted as alternative responses that solve complex societal challenges such as watershed management, while delivering a systemic approach of multiple benefits for well-being, human health, and sustainable use of resources. Despite rising interest in NBS, further identification of experiences implementing NBS could advance our understanding of the operationalization of this comprehensive concept. For this purpose, we analyzed 35 peer-reviewed articles on implementation experiences of NBS for water management in peri-urban areas, on aspects related to (i) NBS problem–solution: water challenges, ecosystem services, scales, and types; (ii) NBS governance and management. From the insights of the analysis, this paper asks what lessons are learned, and which barriers are identified, from implementing NBS for water management in peri-urban areas? As a result, this study presents a detailed analysis of each aspect. We conclude by highlighting accountancy, monitoring, and communication as potential success factors for integration and development while diminishing the overall barrier of complexity, which leads to technical, institutional, economic, and social uncertainty.

Keywords: NBS; sustainable water management; ecosystem services; problem-solution; governance

1. Introduction

Societal challenges such as carbon sequestration, coastal resilience, ecosystem restoration, and watershed management underpin the need for systemic ways to address them. In this sense, nature-based solutions (NBS) enable natural processes into the technical response to address these challenges, with the aim of creating multiple benefits for society [1], well-being, human health, and the sustainable use of resources. NBS are delivering the benefits through open green spaces (e.g., urban parks), green/blue infrastructures (e.g., wetlands, river parks, rain gardens), and at a building level with elements such as green roofs or green walls. For example, addressing water challenges through NBS, i.e., flood risks, droughts, water pollution, freshwater withdrawals, or difficulties related to stormwater and urban water management, promotes the development of multifunctional landscapes, e.g., river parks that could benefit human well-being and physical and mental health. Dealing with the complex and dynamic impacts of urbanization processes and climate changes through NBS could be particularly relevant in areas that combine rural and urban dynamics, identified as peri-urban areas, peripheries, sprawls, and suburbs, among others [2].

NBS has been defined as solutions inspired and supported by nature to face societal challenges while delivering benefits that are ecological, social, and economic [3]. There are plenty of arguments
about the concept’s novelty and its operationalization within well-established concepts or ‘old tools’ as ‘natural capital’, which could limit its potential [4]. For instance, the implementation of alternative responses as NBS are ‘Low Impact Development’ (LID) in North America [5]; ‘Water Sensitive Urban Design’ (WSUD) in Australia [6]; ‘Sponge City’ in China; ‘Sustainable Urban Drainage Systems’ (SUDS) [7]; Integrated Urban Water Management (IUWM); and Edible Cities [8].

In addition, the links between NBS and other green terms framed it as an ‘umbrella’ concept [1,4,9], an aspect that was originally coined by IUCN [10] and is commonly cited [9,11–15]. The nexus of NBS with other terms has been studied by setting out how the concepts depict a metaphor [1]. Within this framing, NBS is mainly linked to terms such as ecosystem services (ES), green infrastructure (GI), and ecosystem-based adaptation (EbA) [1]. NBS promotes a comprehensive approach to contribute to human well-being, where ES are regarded as the specific benefits that humans derive from the ecosystem functions delivered through GI, as a ‘network’ of natural and semi-natural areas. Similarities among these concepts are its systemic approach to challenges [16], but differentiating in the problem-solving feature. For example, some authors have established a link between other GIs and ecosystems-based adaptation EbA, arguing that EbA is more solution-oriented than ES [9]. Whilst EbA is also associated with disaster risk reduction (DRR) to argue on its response to the impacts of urbanization processes [13], and climate changes [17], i.e. NBS for flood risk reduction.

NBS is considered to be a ‘European’ concept [1,4,9]; after being introduced by the European Commission. NBS has been supported through a definition, prioritization areas, and financing by research and development. For the first time, NBS was mentioned by the World Bank in 2008 [4]. IUCN refers to NbS in 2009 at the United Nations Framework Convention on Climate Change (COP 15) [1,4], and was adopted in 2012 as part of the IUCN program (2013–2016) [4]. In 2015, NbS was introduced as a research area within H2020, a major source of research funding for Europe, and NBS has thus ‘recently entered the scientific sphere’ [4]. Scientific publications have increased significantly since 2017, led by authors with European affiliations, albeit slightly from other locations.

NBS is a compound term in which ‘nature-based’ describes the bond with nature and natural processes [18], and the ‘solution’ refers to the feature of tackling a problem by providing multiple benefits in a resource-efficient manner [3]. This idea is exposed in a review that defines NBS while exploring the two-part concept, as based on nature and the solution feature [9]. NBGs are mainly related to urban contexts, yet in their search for a resource-efficient and adaptable solution, the challenges that NBS addresses, such as sustainable water management, also pertain to rural and peri-urban areas.

Therefore, the analysis of NBS implementation in peri-urban areas as hybrid territories combining urban and rural dynamics [2], is an opportunity for advancing on the identification of the derived barriers and lessons learned. Nevertheless, peri-urban areas are subject to variability across countries and regions [19]. In its conceptualization [20]; similar concepts to peri-urban could be fringe, peripheries, suburbs, sprawls, and territories in between, among others [2,19]. In this sense, peri-urban areas are recognized as transition spaces that have some degree of intermingling of urban and rural uses [20]. This consideration highlight the pressures of urbanization processes and climate changes in local and spatial aspects such as shifts in land cover, land use, land management, and planning [19]. Also, in the socioeconomic criteria and cultural context for its demarcation [21]; where the multifunctional character of peri-urban expose changes in socio-economic aspects between stakeholders sharing the area, which could lead to some conflicts because of different perspectives or interests.

These areas expose the place-based and social dynamics of neither-rural-nor-urban territories, which could condition the potential development of NBS. First, in terms of the spatial transition, peri-urban act as urban buffer zones, surrounding the urban boundary and limited by the rural one, e.g., comprising two boundaries, an inner (urban) and an outer (peri-urban) one [21]. Second, these areas are strategically relevant to ecosystem services (ES), integrating and responding to natural and built-up dynamics by acting as a multi-functional landscape. This relevance is based on the argument of proximity to natural landscapes of biodiversity habitats, woodlands, farmlands, and built-up areas; such as urban subdivisions and transport infrastructures [21]. Third, peri-urban
areas expose the community consensus, or the lack of it, for the support and up-take of NBS as an innovation development.

Purposely, NBS and peri-urban concepts have been used as keywords in this literature review, and the references that exposed case studies were selected as implementation experiences of ‘NBS’ for water management in ‘peri-urban areas’. The analysis followed an outline structure (i.e., social, environmental, economic, and governance) to gather the descriptors that could be supporting the comprehensive approach of NBS. Specifically, we examined NBS as a problem-solution relating to the analysis of physical and spatial aspects, and NBS governance and management to identify the actors involved and the policy instruments supporting the implementation. What lessons learned and barriers are identified in implementing NBS for water management in peri-urban areas? This article identifies the characteristics of implementing NBS in peri-urban areas as actionable knowledge in lessons learned, and the barriers as observed limitations or negative aspects. Section 2 outlines the methodology implemented, qualitative-focused multi-methods. Section 3 describes the results as NBS: problem-solution and NBS governance and management. Section 4 presents a further discussion on the analysis and significance of the barriers and lessons learned focusing on the collected evidence that could promote an advancement on the operationalization of NBS.

2. Materials and Methods

Our multi-methods research is qualitative-focused and comprises a literature review in combination with, content analysis, and descriptive research. The SLR helps to collect, examine, and integrate the different scientific contributions under the keyword combination ‘nature-based solutions’ + water + peri-urban’. An initial search of peer-reviewed articles was conducted in December 2019. Two databases have been used, Scopus and Web of Science for the search of the keywords combination. As the exclusion criteria, we used the date to limit it to sources from 2015, type to gather only articles in peer-review journals and because of language limitations, we excluded references when not written in English. As the inclusion criteria, we selected articles that explicitly expose case studies of NBS and its implementation experiences. The Systematic Literature Review (SLR) was developed with the purpose of review and analysis of ‘NBS implementation’, dealing with water management in ‘peri-urban areas’, recognizing that these terms are mainly used in the European context, while other terms are used globally for similar purposes.

A literature search using digital databases to find experiences in implementing NBS, using selected keywords presented 160 references, of which 3 references were excluded because of our lack of access or they were not written in English. Of the 157 peer-reviewed publications, we first read the title and abstract to search for the terms, “water” and “case study”; 66 references mentioned case studies and were included. The excluded 91 references were related to literature reviews, conceptual, modeling, and assessment publications. We then read the 66 articles to determine their proper fit as a case study, to conduct a more intensive review and selected 35 references (Figure 1). The examination followed an outlined structure of aspects including location, environment, economics, social dimensions, and descriptors about governance, instruments, actors involved, and its financing. To support the systematic documentation of the lessons learned and barriers highlighted in the experiences, the analysis and synthesis strategy was assisted by NVivo (Qualitative Analysis Software). In terms of the review criteria, the references excluded were out of the scope of NBS implementation; because of not using cases dealing with water or to the concept of NBS, e.g., not mentioning water in the process as input, output, or benefit, or not mentioning NBS or other green terms, such as ES, GI, EbA.

Data were gathered from 35 references published in 2016 (1), 2017 (6), 2018 (6), 2019 (15) to 2020 (7), detailed information and codes for the references are presented in Appendix A, Table A1. The references present studies in different locations, but mainly from Europe where the ‘NBS concept’ is promoted and funded, followed by Asia, America, Africa, and Oceania. Yet, it is acknowledged that due to the concepts used, the review is predominantly focused on European experiences. Besides, even if our
specific search including ‘peri-urban’ as a criterion; some case studies are linked to urban and rural areas, reinforcing the idea of interlink among built environments, beyond the administrative borders.

The analysis of NBS has been structured as (i) NBS problem–solution: Water challenges, ES, types, and scales, for the technical and spatial response; and (ii) NBS governance and management, for identifying the specific factors that support NBS implementation. As our search strategy required an iterative process to determine if the case studies were included or excluded in each criterion, the case studies mentioned in each sub-section might vary. To facilitate the analysis, each aspect is included along the results using codes and references, while detailed information on each implementation experience is presented in Appendix A. The barriers and lessons learned emerged from these insights, identifying the positive descriptions in the collected evidence of the implementation as ‘lessons learned’ or actionable knowledge; and the negative aspects as ‘barriers’ or observed limitations for operationalizing NBS as a comprehensive concept.
3. Results

The dominant discourse of NBS as a comprehensive approach is to achieve systemic interventions, delivering multiple benefits to multiple stakeholders in a resource-efficient manner [3]. As an integral feature of the concept, NBS link the problem addressed to the solution, within the aim of sustainable development—in other words, facing social, environmental, economic, and institutional barriers [9]. Thus, when referring to complex challenges, the aim for systemic interventions is to deliver results at different environmental–technical, and social levels. In this sense, we analyzed NBS implementation for water management to identify the specificities of the systemic response. The next sub-sections present NBS examined from two standing points. Our first search criteria aimed to examine the NBS problem-solving feature from the technical and spatial aspects (Section 3.1), responding to the ecological dimension of the concept. Second, the NBS governance and management (Section 3.2) to identify the socio-economic aspects that support NBS implementation.

3.1. NBS Problem-Solution: Challenges, ES, Scales, and Types

This section will explore NBS by focusing on the technical and spatial factors of NBS implementation for water challenges (Section 3.1.1), the ES delivered (Section 3.1.2), the scales of the solutions (Section 3.1.3), and types implemented (Section 3.1.4). To close this section a representation of the links among NBS types, challenges, and ecosystem services is presented. This section is complemented by Appendix A, with detailed information on each implementation experience.

3.1.1. Challenges

In terms of challenges, the experiences describe a variety of issues related directly and indirectly to water, reporting pressures on water resources, and the system management (Table 1). The direct challenges are flood risks, urban water systems management, freshwater withdrawals, climate regulation, freshwater supply, stormwater management, climate change mitigation and/or adaptation, water pollution purification/filtration, and drought/water scarcity. Indirect challenges are related to the effective-incorporation of socio-cultural services when mentioning concerns as recreation, human well-being, and social cohesion. See also Appendix A (Table A2).

The literature on NBS usually explains water challenges as results of the pressures from the climate influence and/or urbanization effects, and as causal mechanisms of interdependence among other challenges. This is observed, for example, on the hydrological impacts of urbanization processes, such as a reduction in perviousness, infiltration, and surface retention, which could be the causal mechanism for increasing storm rainfall going to a runoff, leading to floods [16]. Thus, flood risks are linked to stormwater management, not only by runoff and peak flows but also by conveying pollutants to nearby surface waters [17]. In this order of ideas, shifting natural landscape in peri-urban areas, towards an urbanized one, diminishes the natural land pervious cover, its infiltration, and its retention capacities. This shift could increase environmental risks, not only locally but also in other areas, which will require higher investments in infrastructure, services, and management over the long-term.

In fact, the literature frequently mentioned NBS for risk management, including floods, droughts, heatwaves, sea-level rise, and earthquakes. Figure 2 shows the relations between water challenges and risk management addressed in the literature. The thickness of the edges (nexus) are proportional to the number of articles that relate to both vertices (nodes). The strongest relations show more publications that relate risks to water challenges are ‘flood’, which relates to flood risk, urban water systems and pollutants purification/filtration, and “climate change” (climate change mitigation/adaptation, climate regulation and flood risk). Consequently, integrating changes in land covers and flows controls, while maintaining a certain water quality and flow, is a multi-level challenge for water management in peri-urban areas. In this sense, it is relevant to notice that water systems are also influenced by the dynamics of urban and rural systems, and decisions in other sectors as risk management.
Table 1. Nature-based solutions (NBS) Challenges description.

| Challenges                              | Description                                                                 | Codes          | References                      |
|-----------------------------------------|------------------------------------------------------------------------------|----------------|---------------------------------|
| Flood risks                             | Climate change or urbanization causing higher occurrence of flooding         | 4, 8, 10, 12, 14, 21, 22, 23, 30 | [5,7,13,17,18,22–25]            |
| Urban water systems management          | Black, gray, storm- and/or freshwater management                             | 7, 16, 20, 26, 32, 33, 34, 35 | [6,26–32]                      |
| Freshwater withdrawals                  | Related to freshwater supply/withdrawals Capacity of water bodies to regulate micro-climate, e.g., mitigation of urban heat island (UHI) and heatwaves | 4, 7, 9, 20, 29, 34, 35 | [6,25,27,28,32–34] |
| Climate regulation                      |                                                                              | 4, 6, 8, 13, 18, 24 | [8,13,18,25,35–37]            |
| Freshwater supply                       | Pollutants discharge Created as a separate category for its frequency in the case studies | 25, 27, 28, 30, 32 | [5,29,38–40]                   |
| Stormwater management                   | Flood prevention, runoff control, drainage, and filtration, etc.             | 3, 15, 31, 33 | [31,41–43]                      |
| Climate change mitigation and/or adaptation | CO2 reduction                                                                 | 12, 13, 18 | [7,8,35]                      |
| Water pollution purification/filtration | Pollutants purification/filtration Related to droughts and water scarcity | 10, 11, 16, 22, 28 | [24,26,44,13,39]               |
| Drought/Water scarcity                  |                                                                              |                |                                 |
| Effective-incorporation of Socio-cultural services | Includes recreational opportunities, esthetics, human well-being, social cohesion | 1, 2, 5, 14, 17, 18 | [8,17,45–48]                   |

Figure 2. Relation between Water challenges (left) and Risk management (right).

3.1.2. NBS and ES

NBS implementation as a solution addressing, primarily, the issues related to water challenges; has the potential of delivering multiple benefits in a resource-efficient manner and adaptable manner.
In this review, these benefits are identified through ES and its categorization of provisioning, regulating, cultural, and supporting services (Table 2). The regulating services that are frequently mentioned are the moderation of extreme events, waste-water treatment, among others. Cultural services are mainly related to recreation, mental, and physical health. Provisioning services are mainly represented through freshwater. Supporting services expose the habitat for species. See also Appendix A, Tables A3 and A4.

Table 2. Ecosystem services description.

| ES                  | Description                                           | Codes         | References                           |
|---------------------|-------------------------------------------------------|---------------|--------------------------------------|
| Provisioning Services | Food                                                  | 4, 15, 18     | [8, 25, 42]                           |
|                     | Raw materials                                         | 11            | [44]                                 |
|                     | Freshwater                                            | 8, 9, 16, 22, 25, 27, 28, 32 | [13, 18, 26, 29, 33, 38–40]          |
| Regulating Services | Local Climate Air Quality                              | 3, 5, 8, 15, 22, 24 | [13, 18, 36, 41, 42, 46]             |
|                     | Carbon sequestration and storage                       | 8, 22         | [13, 18]                             |
|                     | Moderation of extreme events                           | 2, 3, 6, 8, 10, 11, 15, 21, 22, 23, 31 | [13, 18, 22–24, 37, 41–45]          |
|                     | Waste-water treatment                                  | 1, 3, 7, 10, 11, 16, 25, 31 | [24, 26, 27, 40, 41, 43, 44, 48]     |
|                     | Erosion prevention and maintenance of soil fertility   | 7, 8          | [18, 27]                             |
|                     | Regulation of Water Flow                              | 1, 4, 9       | [25, 33, 48]                         |
| Cultural Services   | Recreation and, mental and physical health            | 1, 2, 3, 5, 8, 10, 11, 15, 22 | [13, 18, 24, 41, 42, 44–46, 48]     |
|                     | Aesthetic appreciation and inspiration for culture,    | 8, 22, 24     | [13, 18, 36]                         |
|                     | art and design                                        |               |                                      |
|                     | Spiritual experience and sense of place               | 3, 15         | [41, 42]                             |
| Supporting Services | Habitat for species                                   | 1, 3, 7, 11, 15 | [27, 41, 42, 44, 48]                 |

Although, the multiple benefits and services provided through nature are recognized; the debate in the literature is more oriented to the proper assessment of these services, and its integration into different sectors, to recognize the added value of NBS. In the policy sector, advancement by the European Commission established NBS priority areas as: the regeneration and well-being in urban areas, carbon sequestration, coastal resilience, watershed management, and ecosystem restoration, to enhance the insurance value of ecosystems and to foster sustainable use of matter and energy [3].

3.1.3. NBS Scales

NBS implementation for water management in peri-urban areas respond to different spatial scales from site to national level (Table 3). Cases are mentioned as sites (6), neighborhood (6), municipality (20), metropolitan area (7), regional–basin level (10), and national level (1). In some cases, no explicit reference was found, thus, the category ‘other’ was applied (3). Implementation experiences were mainly on a municipality scale, which is associated with the level of urban planning competencies.

Despite, the spatial scale of intervention cannot address or control the overall impact of the water challenges; it is a recognition of the limits of the NBS and the need for articulated responses at different spatial scales. This shows the role of the governance level of decision-making, that the type of NBS could determine the sectors involved, and that there must be instruments allowing the required integration of governance and management for supporting NBS implementation.
Table 3. NBS spatial scales description.

| Spatial Scale          | Codes   | References                                      |
|------------------------|---------|------------------------------------------------|
| Site                   | 2, 3, 17, 24, 31, 33 | [31,36,41,43,45,47] |
| Neighborhood           | 4, 5, 17, 32, 33, 34 | [6,25,29,31,46,47] |
| Municipality           | 1, 2, 4, 5, 8, 10, 11, 12, 13, 14, 15, 18, 19, 20, 22, 28, 29, 30, 31, 32 | [5,7,8,13,17,18,24,25,28,29,34,35,39,42–46,48,49] |
| Metropolitan area      | 4, 6, 7, 9, 16, 27, 29, | [25–27,33,34,37,38] |
| Regional (Basin level) | 9, 14, 20, 21, 23, 25, 26, 28, 31, 35 | [17,22,23,28,30,32,33,39,40,43] |
| National               | 26                  | [30]                                           |
| Other                  | 9, 24, 25            | [33,36,40]                                     |

3.1.4. NBS Types

As technical responses, different types of NBS are presented in the implementation experiences (Table 4). NBS are wetland-related approaches, such as natural wetlands, constructed wetlands, and purpose-built wetlands (15); sustainable urban drainage systems (SUDS) (11); green-roofs/walls (11); river parks (9); agroforestry (9); parks (9); permeable pavement (4); Phytorid sewage treatment (3), which is a wastewater treatment using a specific variety of plants in constructed wetlands [13]; rain gardens (3); bioswales (2); and others (24). In this review, the solutions are differentiated elements, since there is no clear boundary between what is conceptualized as SUDS in the literature. Specifically, solutions referring to SUDS for their drainage or filtration functions could be permeable pavement, rain gardens, bioswales, green roofs, detention and retention basins, wetlands.

Table 4. NBS types description.

| NBS Types                | Codes   | References                                      |
|--------------------------|---------|------------------------------------------------|
| Wetlands-related         | 2, 4, 5, 10, 11, 12, 13, 14, 16, 18, 21, 25, 29, 31, 33 | [7,8,17,23–26,31,34,35,40,43–46] |
| SUDS                     | 7, 9, 12, 13, 16, 18, 28, 29, 31, 32, 33 | [7,8,26,27,29,31,33–35,39,43] |
| Green-roofs/walls        | 3, 8, 9, 12, 13, 15, 16, 18, 28, 29, 31 | [7,8,18,26,33–35,39,41–43] |
| River parks              | 4, 5, 9, 10, 11, 13, 16, 18, 29 | [8,24–26,33–35,44,46] |
| Agroforestry             | 5, 7, 9, 13, 16, 18, 28, 29, 30 | [5,8,26,27,33–35,39,46] |
| Parks                    | 5, 7, 8, 9, 13, 16, 18, 29 | [8,18,26,27,33–35,46] |
| Permeable pavement       | 3, 8, 12, 31 | [7,18,41,43] |
| Phytorid sewage treatment| 8, 22, 25 | [13,18,40] |
| Rain garden              | 8, 31, 33 | [18,31,43] |
| Bioswales                | 12, 31 | [7,43] |
| Others                   | 1, 2, 3, 4, 6, 7, 8, 9, 17, 19, 20, 21, 22 | [5,6,13,18,22,23,25,27–33,36–38,40,41,43,45,47–49] |

NBS are not implemented independently but are combined within hybrid approaches of green, blue, and/or gray infrastructures. NBS as place-based interventions shift the approach to landscape management, compared to traditional infrastructural projects. This is done by emphasizing the link among the green (vegetation), and blue (floodable areas, water) areas; and the influence of changes in land covers, and land uses. To illustrate this aspect using flood risk management, some publications claim that the hybrid approach is the most widely used, followed by a green approach and then by a blue approach [50]. In contrast, others argue that the green approach, represented as a green storage, is modified and influenced by land cover and land-use change; thus, it is more vulnerable than the blue approach [23]. Despite its vulnerability, NBS propose a shift from the design and use of gray flood control infrastructure or NBS planning for water management [7].

In addition, other types of NBS could be regarded as linked to natural landscapes or to build-up landscapes (Table 5). The first solutions refer to integrating soil, vegetation, floodable areas, and water, while the latter is related to vegetation, floodable areas, and water.
Table 5. NBS Types and Landscapes.

| Built-up Landscapes | Vegetation | Floodable Areas | Water |
|---------------------|------------|-----------------|-------|
| Soil                | Street trees | Retention/detention basins | Ponds |
| Wildlife crossings  | Private gardens | Drainage corridors | Semi-natural waterways |
| Riparian corridors  | Coastal vegetation | Wet meadows | Floodplains |
| Natural Landscapes  | Forests     | Other water bodies |       |

To close this sub-section, NBS is represented (Figure 3) as a simplified scheme flowing from problems or challenges (left) towards a response delivering benefits (right). In the literature, the analysis of the ES supports how NBS might deliver reinforced benefits through several and simultaneous ES. Thus, this scheme exposes the problem-solving feature in the spatial and technical aspects of the NBS, as the response addressing the interconnected water challenges and delivering a multiplicity of services; rather than establishing a causal link for a fixed categorization. See also Appendix A, Tables A5 and A6.

Figure 3. NBS types, challenges, and ecosystem services.

3.2. NBS Governance and Management

This section continues the analysis of NBS by identifying the governance and management factors that are supporting NBS implementation in peri-urban areas as the policy instruments (Section 3.2.1), the involvement of stakeholders (Section 3.2.2), and financing (Section 3.2.3). This section is complemented by Appendix A, Table A7 with detailed information on each implementation experience.
### 3.2.1. Policy Instruments

Most of the implementation experiences mentioned some kind of policy instrument (27) supporting its implementation, such as projects, programs, and plans (Table 6). When analyzing the governance level of these instruments, the regulations could link supra-national regulations to national, regional, or municipal initiatives. Most instruments correspond to local regulations and initiatives at the municipal level, which complements the findings of the spatial scale of the projects (See Section 3.2.2). In the European Union context, the multi-level link is often developed under the EU Water Framework directive, which exposes the vertical coordination or agreement on NBS implementation. In addition, these regulatory frameworks cover long-term and cross-sectoral agendas, such as Sustainable Development Goals (SDGs); and sectoral documents, such as water planning, water management, risk management, and urban planning, displaying the interrelation among sectors for NBS while promoting specific supporting tools.

**Table 6. Policy instruments mentioned.**

| Level         | Policy Instrument                                                                 | Scale           | Codes | References |
|---------------|----------------------------------------------------------------------------------|-----------------|-------|------------|
| International | Sendai Framework for Disaster Risk Reduction (2015-2030)                           | Global          | 22    | [13]       |
|               | Kyoto protocol                                                                    | Global          | 13    | [35]       |
|               | WaterWorld Policy Support System protection                                       | Global          | 21    | [23]       |
|               | UNESCO Biosphere Reserve“ protection                                              | Global          | 2     | [45]       |
|               | UNESCO Groundwater resource sustainability indicators                              | Global          | 26    | [30]       |
|               | UN’s SDG 17                                                                       | Global          | 20,27 | [28,38]    |
|               | UNICEF Joint Monitoring Program                                                    | Global          | 27    | [38]       |
| EU Directives | EU Water Framework Directive (2000/60/EC)                                          | Regional        | 1,10,11,14 | [17,24,44,48] |
|               | EU Flood Directive (2007/60/EC)                                                    | Regional        | 14    | [17]       |
|               | EU FP7 -Demonstrating Ecosystem Services Enabling Innovation in the Water Sector (DESSIN) | Regional        | 1     | [48]       |
|               | EU Biodiversity Strategy for 2020                                                  | Regional        | 7     | [27]       |
|               | EU Strategy on Adaptation to Climate Change“ (2013)                               | Regional        | 13    | [35]       |
|               | 6th Research Framework Program of the EU                                           | Regional        | 30    | [5]        |
| Laws/Policies | Green Highways Policy (2015)                                                       | National        | 22    | [13]       |
|               | Regional law (R.R. n.3 from 24 March 2006)                                         | Regional        | 10,11 | [24,44]    |
|               | Act No. 17/1992, Collection of Laws, On the Environment                           | National        | 13    | [35]       |
| Plans         | River basin management plan from Autorità di Bacino del Fiume Po                  | Sub-national    | 10,11 | [24,44]    |
|               | Barcelona’s Green and Biodiversity Plan (2012-2020)                              | Municipal       | 19    | [49]       |
|               | Air Quality Plan (2011-2015)                                                      | Municipal       | 19    | [49]       |
|               | Finger Plan (1947)                                                                | Municipal       | 2     | [45]       |
|               | 19 different Canadian urban or city plans                                          | Municipal       | 29    | [34]       |
|               | Italian National Plan of Adaptation to Climate Change (PNCC, 2016)               | National        | 9     | [33]       |
## Table 6. Cont.

| Level       | Policy Instrument                                                                 | Scale     | Codes | References |
|-------------|-----------------------------------------------------------------------------------|-----------|-------|------------|
| Programs    | Support Program for the Natural Area of Integrated Management of Rio Grande (ANGIRG) | Municipal | 28    | [39]       |
|             | Secretariat of the Pacific Regional Environment Program (SPREP)                    | Regional  | 35    | [32]       |
|             | China Major Science and Technology Program for Water Pollution Control and Treatment | National  | 25    | [40]       |
|             | One Water Supply, Sanitation and Hygiene (WASH) National Program (OWNP)            | National  | 32    | [29]       |
|             | Kibera Public Space Project (KPSP)                                                | Municipal | 33    | [31]       |
|             | NAIAD Project                                                                      | Municipal | 14    | [17]       |
|             | Pacific Ecosystem-based Adaptation to Climate Change (PEBACC)                     | Regional  | 35    | [32]       |
|             | Joint Innovative and Technological Research Projects from the Ministry of Science and Technology of the People’s Republic of China | National  | 25    | [40]       |
| Others      | Mapping and Assessment of Ecosystems and their Services (MAES)                    | Regional  | 7     | [27]       |
|             | Jawaharlal Nehru National Urban Renewal Mission (JNURM)                           | National  | 22    | [13]       |
|             | Atal Mission for Rejuvenation and Urban Transformation (AMRUT)                    | National  | 22    | [13]       |
|             | Greening the West initiative (GTW)                                                | Municipal | 34    | [6]        |
|             | Community-Scale Green Infrastructure (CSGI)                                        | Local     | 17    | [47]       |
|             | Piano paesaggistico regionale (PPR)                                               | Sub-national | 8   | [18]       |
|             | Piano di governo del territorio (PGT, 2012)                                        | Municipal | 8     | [18]       |
|             | Municipal Natural Assets Initiative (MNAI)                                         | Municipal | 29    | [34]       |
|             | Peri-urban Land Use Relationships–Strategies and Sustainability Assessment Tools for Urban-Rural Linkages (PLUREL) | Regional  | 30    | [5]        |
|             | Conservation Design for Subdivisions: A practical guide to create open space networks | Local     | 30    | [5]        |
|             | UK National Ecosystem Assessment (2014)                                            | National  | 16    | [26]       |
|             | Multifold instruments (mentioned for different cases)                              | Municipal | 18    | [8]        |
3.2.2. Involvement of Stakeholders

In NBS development, complex societal challenges reveal the efforts of different actors (Table 7). However, a key aspect of its implementation is the cooperation between stakeholders to address sectoral barriers, fragmentation at different governance levels, and multidisciplinary consensus. In terms of stakeholders, the categories implemented correspond to representatives of public authorities, academics and researchers, the business and private representatives, the citizens and community, including NGOs, and other water-related actors. In our review, academic and public authorities were the most mentioned actors in the case studies reviewed in this study (22), followed by the civil society (16), water-related actors (10), and business and private representatives (5).

The public sector is leading the NBS implementation effort to address the challenges described, and it takes on technical and economic leading roles. Scientific interest is reflected in the effort when research opportunities are available. The involvement of private actors and industry depends on the development of business models. The role of citizens is related to users and recipients of the benefits. However, a limitation of this study is that only peer-reviewed publications in scientific databases were considered, which may explain also the importance of the academic actors. Accordingly, further research could include the analysis of other literature sources, to complement the actors and roles.

The articles exposed different social and/or cultural values when implementing NBS. Whilst some case studies (16) involved the civil society, only one-third of them (10) explicitly mentioned its role: in the participatory process [32]; participatory modeling [17]; and personal interviews and collective meetings [41]. Also, cultural values were mentioned with terms such as recreation [13,18,24,41,42,44–46,48]; aesthetics [13,36,48]; social cohesion [42]; educational and therapeutic activities [47]; and cultural and historical heritage [18]. Local knowledge was slightly mentioned in educational activities [24]; [22], in activities to increase awareness [44]; and in bottom-up initiatives [31].

3.2.3. Financing NBS

For financing, almost half of the studies in the reviewed literature mentioned sources (Table 8). NBS is mostly funded by the public sector (14), the private sector (9), and few mentioning public–private partnerships (6). Public funding comes from local governments (municipalities), regional governments, ministries or departments of national governments or supranational institutions, such as the European Union. Research funding at the supranational level is a key aspect of this European context. Private funding comes mainly from sources such as foundations, non-profit organizations, and private corporations; or by conducting before–after simulations [43,48].

NBS has been developed as an amenity supported by public interest or through a non-profit aim, rather than through specific business models. The lack of identification of innovative business models behind NBS, reveals an open arena for identifying who is involved in the development of NBS for water management, and which roles they play. Although some references mentioned aspects related to the economic feasibility of NBS, specifically through aspects as life-cycle costs, cost-benefit analysis, or operating and maintenance costs, there were not included as part of this study; but, it should be covered in research by others. In fact, the economic feasibility of NBS is a barrier in its implementation, especially for avoiding uncertainty in its operationalization.
Table 7. Actors mentioned in the case studies.

| Actors                          | Description                                                                 | Codes                  | References                                                                 |
|---------------------------------|-----------------------------------------------------------------------------|------------------------|---------------------------------------------------------------------------|
| Public authorities              | Local governments (municipalities, planning authorities, etc.), regional governments, ministries or departments, national governments or even supra-national institutions. | 2, 7, 8, 9, 10, 11, 13, 14, 15, 16, 18, 19, 22, 25, 26, 28, 29, 30, 32, 33, 34, 35 | [5,6,8,13,17,18,26,27,29–35,39,40,42,44,45,49,51] |
| Civil society                   | Citizen associations, community groups, advocacy organizations, environmental associations, friend groups, volunteers, NGOs, etc. | 7, 10, 11, 13, 14, 15, 16, 17, 18, 22, 28, 29, 32, 33, 34, 35 | [6,8,13,17,24,26,27,29,31,32,34,35,39,42,44,47] |
| Academic and research bodies   | Scientific and technical experts, consultants, university departments, research groups, etc. | 1, 3, 4, 6, 7, 8, 9, 10, 11, 12, 13, 15, 18, 20, 21, 22, 23, 25, 26, 27, 28, 31 | [7,8,13,18,22–25,27,28,30,33,35,37–44,48] |
| Water-related actors            | Water management authorities, water utilities, hydro-geologists, water-sources investors, etc. | 3, 5, 10, 11, 22, 25, 26, 27, 32, 34 | [6,13,24,29,30,38,40,41,44,46] |
| Industry, business and private sector | Private landscaper, wastewater treatment companies, water vendors, etc. | 5, 15, 16, 22, 26 | [13,26,30,42,46] |

Table 8. Funding sources mentioned in the case studies.

| Financing Source | Countries                                                                 | Codes                  | References                                                                 |
|------------------|---------------------------------------------------------------------------|------------------------|---------------------------------------------------------------------------|
| Public sector    | Italy, Poland, Slovakia; Slovenia, United Kingdom, Spain, China, India, Ethiopia, Tanzania, Australia, Vanuatu | 8, 10, 11, 13, 14, 16, 19, 22, 25, 32, 34, 35 | [6,13,17,18,24,26,29,32,35,40,44,49] |
| Private sector   | Italy, Poland, Slovakia, Spain, China, India, Bolivia, Ethiopia, Tanzania | 10, 11, 13, 19, 22, 28, 32 | [13,24,29,35,39,44,49] |
| Public-Private partnerships | Italy, Poland, Slovakia, India, China, Ethiopia, Tanzania | 10, 11, 13, 22, 26, 32 | [13,24,29,30,35,44] |
In summary, the results in this section indicate that implementation experiences of NBS in peri-urban areas are addressing different challenges, at different spatial scales, but mainly at the municipal level, and are executed through several types as hybrid approaches. The governance and management aspects of the cases suggest that NBS is linked to municipal, metropolitan and regional basin scales, i.e., by interventions across administrative borders, and delivered through agreements and consensus supported by policy instruments. The recognition of the actors involved indicates the leading role of public authorities, although, in some cases, other actors as academia and industry are involved. Funding schemes executed by privates are rarely mentioned. Finally, the implementation of NBS could be considered a process of a participatory nature. NBS as a socio-technical innovation needs to advance in the economic aspects. As a further barrier, none of the case studies examined referred to the gender perspective, which could be seen as a knowledge gap in sustainable development and the NBS–well-being relationship. The next section, therefore, moves from these insights on to discuss the barriers and lessons identified.

4. Discussion

This paper analyzes NBS for water management in peri-urban areas, using peer-reviewed literature on the implementation experiences, with a detailed view on specific spatial and technical aspects; and more general information on the governance, and management aspects. It supports in particular a previously cited barrier of NBS: there is still a need for NBS to be operationalized to be able to collect evidence on its effectiveness [16]. The added value of NBS in terms of measuring the technical performance is presented in the literature through the recognition of ES, although, the debate is more oriented on the assessments, classifications, and scenario planning. In this review, the added value of NBS in the management and governance focused on the policy instruments and involvement of stakeholders, and economic aspects are only examined by the funding sources; but is an aspect to be researched by others, since it is equally relevant for informed cost-benefits, assessments on life-cycle costs, or operating and maintenance costs.

What lessons were learned, and which barriers were identified, by implementing NBS for water management in the peri-urban?

4.1. Lessons Learned

Water challenges expose pressures due to climate, risks, and urbanization. These challenges are interdependent, dynamic, and linked to the quality and quantity of the resource, revealing the complexity of water management in peri-urban areas. A common aspect is addressing water challenges through a mix of green/blue, green(gray), and green/blue(gray) infrastructure approaches. NBS in the peri-urban area ranges from macroscales, such as river basins and agroforestry, to buildings as a microscale. Although there is not a fixed spatial scale, it is understood that peri-urban areas could tend to municipal levels for their planning competencies or bigger scales for implementations linking rural and urban systems. The multiple benefits delivered could be regarded as interrelated services, influencing different fields as landscape management; risks and climate regulation; recreation, physical and mental health, and well-being [35]. This approach is open to contextualization as various GI and ES are mentioned when referring to implementation experiences, e.g., in the use of NBS or other green terms such as GI, ES, Eb; also, its open to adaptation, since NBS could be known under other terms such as LID, WSUD, SUDS, IUWM.

NBS deliver structural physical changes, exposed as spatial elements enhancing water management in different material manners while being resource-efficient. These changes result from integrating different fields, instruments, and mechanisms to promote shifts in the practices of cross-sectoral expertise, e.g., infrastructure design and water management. These new practices shift different domains, for example in landscape management [11], to support built-up landscapes or natural landscapes; as well as improvements in the spatial resources, risk management, and social well-being. Specific examples are the identification of flood-prone areas and influencing factors for flood occurrence,
such as distance, slope, and land cover [22]; design green infrastructure for increasing awareness of previously unnoticed natural features, such as sudden incidental nature experiences [45]; and improve multi-functionality of the urban green space [41].

NBS as an alternative practice, to enhance the dominant culture of gray infrastructure with interventions and experiments of blue and green approaches, could increase the potential of a peri-urban area to support human well-being. NBS implementation can deliver multiple benefits at multiple aspects; depending on the involvement and support of different levels of responsibility, territorial scales, and sectors. The operationalization of NBS could be enhanced by developing frameworks for capturing its comprehensive approach, considering it as a process, and including the multiple dimensions of its solution (e.g., spatial, technical, ecological, social, economic, etc.).

Finally, accountancy on the multi-functionality and the benefits delivered could be a critical success factor to involve cross-disciplinary approaches into NBS for water management. In this sense, monitoring NBS as a process is crucial for integrating the different scales of NBS: the spatial scale of the implementation, the scale of the challenge, and the scale of the impacts. Besides, communication about NBS could support the involvement of different actors, and the integration of sector, at different levels of decision-making to improve infrastructure planning and assessments of multiple benefits.

4.2. Barriers

NBS cannot control the overall impact of water challenges [32], nor can it meet all needs (e.g., high runoff volumes, high contaminant loads, etc.), that could be related to high technical uncertainty [43]. To avoid uncertainty, systemic implications of NBS require taking into account the benefits, services, and the potential risks or unintended consequences of their up-take [14]. Limitations to this purpose could be financial but could also extend to the lack of technological capacity or deficiency in infrastructure, as shown by the region-wide gap in groundwater monitoring systems and data [38]; or that affect institutional capacity [29,31]. These also affect the NBS market uptake and the creation of alternative business models and practices that support it, and thus, limiting partnerships and involvement. For instance, market uptake of NBS benefits as a field still requires legal regulations [8].

Even if NBS implementation involves different stakeholders, the promoting role is mainly done, and funded, by the public sector. The lack of interactions among the different actors involved compromises the perception of NBS, which could be negative for aspects such as costs, benefits in the short- and long-term, and impact of the solution [52]. This could lead to difficulties due to inhabitant resistance to changes [29,35], passive involvement, and insignificant increase of social cohesion [8], fear of the unknown, and uncertainty [16,17]. Some NBS functions could lead to disservices, which are perceived negatively or affect safety perceptions, i.e., fire risks on green spaces or drowning risks in SUDS [31]. In this sense, the cases revealed how social dynamics in terms of behavior and practices are shaped through socio-cultural values, traditions, and perceptions [16,31]; and how they influence the uptake and use of NBS [26]. Study cases revealed that NBS increases individual and public awareness for lifestyle shifts [8]. Major aspects to consider for precaution in implementing NBS are displacement, gentrification commodification, social justice regarding access to nature and human well-being, among others [1,11,16].

A common aspect of the lessons learned and barriers is the knowledge demand, associated with the NBS uptake or decision-making for long-term and co-benefits [16], and on its effectiveness for comparison to conventional approaches. Therefore, NBS as a process should also be open to monitoring, i.e., for its maintenance and operation, and for examining ES and disservices. A crucial factor is to account for NBS perceptions throughout its implementation, e.g., costs, benefits; while acknowledging that both positive and negative perceptions need to be managed [32].

Limitations of this review are related to the use of European promoted terms; the lack of economic aspects related to cost-benefits, maintenance, and operation, and that none of the case studies examined referred to the gender perspective, which could be seen as a knowledge gap in the NBS–well-being
relationship. To provide greater insight into the novelty and comprehensive approach of NBS, further research could work on these gaps.

5. Conclusions

NBS address different water challenges, produced by urbanization processes, changes in climate, and risks while allowing the delivery of other services. Through a systematic review, in combination with content analysis, and descriptive research, this study examined 35 articles of experiences with NBS implementation in peri-urban areas. The review presented NBS from two standing points, first from the spatial scale and technical aspects of its problem-solving feature, to respond to the ecological dimension of the concept. Second, from the governance and management, to identify the socio-economic factors that support its implementation.

Based on the insights of this analysis, we identified lessons learned and barriers. Mainly, accountancy, monitoring, and communication could be a potential success factor in NBS for water management. In this sense, accountancy to involve cross-disciplinary approaches on the multi-functionality and the benefits delivered. Monitoring on NBS as a process for integrating the different scales of NBS: the spatial scale of the implementation, the scale of the challenge, and the scale of the impacts. Communication about NBS could help to implicate different actors at different levels of decision-making. In a second order, this work identified that NBS could deliver multiple benefits, regardless of the type, scale, and location. However, in its implementation as a systemic response, its benefits are usually acknowledged as ES, which are integrated at multiple spatial scales and social aspects beyond the green infrastructure (GI). Since NBS cannot meet all needs, neither control the overall impact of water challenges, its implementation should be supported on different levels of responsibility, territorial scales, and sectors. This means that physical changes in water management should be supported on social consensus established among different stakeholders, sectors, and organizations.

Yet, a major barrier for NBS implementation is the complexity of a comprehensive approach, which leads to technical, institutional, economic, and social uncertainty. Limitations could be the lack of technological capacity or deficiency in infrastructure, as shown by the region-wide gap in groundwater monitoring systems and data [38]. Even if public authorities are playing a vital role in the promotion of NBS, by funding it, promoting research and policies; limitations could be related to the institutional capacity [29,31]; and extend to economic aspects, e.g., to promote legal regulations required for the market uptake of NBS benefits [8]. This weakness in the creation of alternative business models and practices could restrain partnerships and the support of NBS by private actors. Further NBS uptake is depending on the enhancement of technical, institutional, and financial capacities, but also on the involvement of the different actors, including lay citizens. In fact, the interaction between the different actors involved could promote greater advances to actionable knowledge, perspectives, and discourses on this solution.

Nevertheless, the effort in identifying the systemic implications of NBS, in terms of benefits, services, potential risks, and unintended consequences aids to manage the negative perceptions around NBS implementation, which could be an advancement for overcoming alternative practices as NBS. In this sense, water management requires addressing its related challenges and social aspects in an integrated way. The cases reviewed have implemented NBS as an environmental and socio-technical system, which provides a feasible approach to managing water challenges and their associated pressures. As our research focused on NBS for water management in peri-urban areas, it is limited in identifying meaningful influential factors among NBS types, ES, or built-up context. Water management in peri-urban areas could be further explored to understand the influence of urban boundaries on NBS types.

As a systematic review, this paper has different limitations. First, ‘NBS’ and ‘peri-urban’ terms used in inclusion criteria are mostly used in Europe. Although, other relevant experiences may be found under similar concepts for NBS such as LID, WSUD, SUDS, IUWM, or to peri-urban areas as suburbs, fringe, peripheries, suburbs, sprawls, etc. Second, the literature selected only covered
peer-reviewed articles, and there may be significant evidence of experiences, lessons, and barriers, in other bodies of literature as NBS is in the intersection of science-policy-innovation. Third, our analysis has a wide-spread view of the implementation of NBS reported in the scientific literature, which usually focuses deeply on a specific discipline, therefore further analysis could advance in the operationalization of NBS in terms of frameworks for capturing its comprehensive approach. Further analysis could contrast this 'NBS in peri-urban areas' to other bodies of literature, including other terms, and explore this alternative approach from complementary concerns as the economic aspects (e.g., cost-benefits, life-cycle costs, operating and maintenance costs).

Despite these limitations, this review offers a widespread overview of the comprehensive approach of NBS regarding implementation experiences of NBS for water management in peri-urban areas. The contribution of this paper is the analysis of NBS in its different aspects throughout the implementation, identifying the lessons learned and barriers behind them. The results are describing each of the aspects analyzed in the selected references, to provide an overview of what is considered the problem-solving feature of NBS. Furthermore, complementary information of the cases (location, challenges, ES, types, scales) is used to report the specificities of the implementation experiences. There are still many opportunities and knowledge gaps to facilitate NBS operationalization, such as the different narratives around NBS and the local search for collaborations as processes that not only reveal the technical effectiveness of the challenges addressed but also the advances to the solution as a fixed vision or as a cross-boundary scheme that requires cross-sectoral dialogues.

Author Contributions: Conceptualization, N.A.R.-A., R.P.A., M.V. and E.R.; methodology, N.A.R.-A., R.P.A., M.V. and E.R.; validation, M.V. and E.R.; formal analysis, N.A.R.-A. and R.P.A.; investigation, N.A.R.-A., R.P.A. and E.R.; writing—original draft preparation, N.A.R.-A., R.P.A.; writing—review and editing, N.A.R.-A., E.R.; visualization, N.A.R.-A., R.P.A.; supervision, E.R.; funding acquisition, M.V. and E.R. All authors have read and agreed to the published version of the manuscript.

Funding: This research was partially funded by the Spanish Ministry of Science and Innovation, grant number PCI2019-103674 (MCIU/AEI/FEDER).

Acknowledgments: This paper is a product of the project Nature-Based Solutions for Water Management in the Peri-Urban: Linking Ecological, Social and Economic Dimensions (NATWIP), a project funded under the 2018 Joint Call of Water JPI. We are grateful to the NATWIP Consortium for their contributions to the refinement of this research, especially to Sarah Hale (NGI) & Lina Suleiman (KTH). This version is integrating valuable insights from the fruitful discussions within the NATWIP meetings. We would like to thank Gerard Martinez Görgig for the support during the selection of references for its formal analysis.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses or interpretation of data; in the writing of the manuscript; or in the decision to publish results.

Appendix A

| Code | Country | Location | Title | Authors | Year |
|------|---------|----------|-------|---------|------|
| 1    | Denmark | Aarhus   | Making the ecosystem services approach operational: A case study application to the Aarhus River, Denmark. | Riegels, N.; Lynggaard-Jensen, A.; Krosgaard Jensen, J.; Gerner, N.V.; Anzaldua, G.; Mark, O.; Butts, M.; Birk, S. Beery, T.H.; Raymond, C.M.; Kyttä, M.; Olafsson, A.S.; Plieninger, T.; Sandberg, M.; Stenseke, M.; Tengö, M.; Jönsson, K.I. | 2020 |
| 2    | Denmark | Copenhagen Kristianstad | Fostering incidental experiences of nature through green infrastructure planning. | | 2017 |
| Code | Country  | Location        | Title                                                                 | Authors                                      | Year |
|------|----------|-----------------|-----------------------------------------------------------------------|----------------------------------------------|------|
| 3    | France   | Villeurbanne    | Improving the multi-functionality of urban green spaces: Relations between components of green spaces and urban services. Resilient landscapes in Mediterranean urban areas: Understanding factors influencing forest trends. Assessing nature-based recreation to support urban green infrastructure planning in Trento (Italy). Regulating Ecosystem Services and Green Infrastructure: assessment of Urban Heat Island effect mitigation in the Municipality of Rome, Italy. Local scale prioritisation of green infrastructure for enhancing biodiversity in Peri-Urban agroecosystems: A multi-step process applied in the Metropolitan City of Rome (Italy). Integrating green infrastructure into spatial planning regulations to improve the performance of urban ecosystems. Insights from an Italian case study. Mapping urban resilience for spatial planning. A first attempt to measure the vulnerability of the system. Going green? Ex-post valuation of a multipurpose water infrastructure in Northern Italy. | Belmeziti, A.; Cherqui, F.; Kaufmann, B.; Tomao, A.; Quatrini, V.; Corona, P.; Ferrara, A.; Laforteza, R.; Salvati, L.; Cortinovis, C.; Zulian, G.; Geneletti, D.; Marando, F.; Salvatori, E.; Sebastiani, A.; Fusaro, L.; Manes, F.; Capotorti, G.; De Lazzari, V.; Ortí, M.A.; Ronchi, S.; Arcidiacono, A.; Pogliani, L.; Brunetta, G.; Salata, S.; Reynaud, A.; Lanzanova, D.; Liquete, C.; Grizzetti, B. | 2018 |

Table A1. Cont.
| Code | Country       | Location          | Title                                                                 | Authors                                      | Year |
|------|---------------|-------------------|----------------------------------------------------------------------|----------------------------------------------|------|
| 11   | Italy         | Gorla Maggiore    | Integrated valuation of a nature-based solution for water pollution control. Highlighting hidden benefits. Planning for spatial equity—A performance based approach for sustainable urban drainage systems. The green infrastructure in cities as a tool for climate change adaptation and mitigation: Slovakian and polish experiences. Engaging stakeholders in the assessment of NBS effectiveness in flood risk reduction: A participatory System Dynamics Model for benefits and co-benefits evaluation. Creating urban green infrastructure where it is needed—A spatial ecosystem service-based decision analysis of green roofs in Barcelona. | Liquete, C.; Udias, A.; Conte, G.; Grizzetti, B.; Masi, F. La Rosa, D.; Pappalardo, V. Belčaková, I.; Świader, M.; Bartyňa-Zielińska, M. Pagano, A.; Pluchinotta, I.; Pengal, P.; Cokan, B.; Giordano, R. Langemeyer, J.; Wedgwood, D.; McPhearson, T.; Baró, F.; Madsen, A.L.; Barton, D.N. Bricker, S.H.; Banks, V.J.; Galik, G.; Tapete, D.; Jones, R. Jerome, G.; Mell, I.; Shaw, D. | 2016 2020 2019 2019 2019 2020 2017 2017 |
| 12   | Italy         | Avola             |                                                                      |                                              |      |
| 13   | Poland        | Wroclaw           | The green infrastructure in cities as a tool for climate change adaptation and mitigation: Slovakian and polish experiences. Engaging stakeholders in the assessment of NBS effectiveness in flood risk reduction: A participatory System Dynamics Model for benefits and co-benefits evaluation. | Belčaková, I.; Świader, M.; Bartyňa-Zielińska, M. |
| 14   | Slovenia       | Ljubljana         | A participatory System Dynamics Model for benefits and co-benefits evaluation. Creating urban green infrastructure where it is needed—A spatial ecosystem service-based decision analysis of green roofs in Barcelona. | Pagano, A.; Pluchinotta, I.; Pengal, P.; Cokan, B.; Giordano, R. Langemeyer, J.; Wedgwood, D.; McPhearson, T.; Baró, F.; Madsen, A.L.; Barton, D.N. |
| 15   | Spain          | Barcelona         | Accounting for groundwater in future city visions. Re-defining the characteristics of environmental volunteering: Creating a typology of community-scale green infrastructure. Edible city solutions—one step further to foster social resilience through enhanced socio-cultural ecosystem services in cities. Nature-based solutions for urban landscapes under post-industrialization and globalization: Barcelona versus Shanghai. | Jerome, G.; Mell, I.; Shaw, D. Säumel, I.; Reddy, S.E.; Wachtel, T. |
| 16   | United Kingdom | London            |                                                                      |                                              |      |
| 17   | United Kingdom | Liverpool         |                                                                      |                                              |      |
| 18   | Germany        | Andernach         |                                                                      |                                              |      |
|      | Germany        | Heidelberg        |                                                                      |                                              |      |
|      | Netherlands    | Rotterdam         |                                                                      |                                              |      |
|      | Norway         | Oslo              |                                                                      |                                              |      |
|      | Cuba           | Havana            |                                                                      |                                              |      |
| 19   | Spain          | Barcelona         |                                                                      |                                              |      |
|      | China          | Shanghai          |                                                                      |                                              |      |
| Code | Country | Location | Title                                                                 | Authors                                                                                                    | Year  |
|------|---------|----------|----------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-------|
| 20   | Portugal United Kingdom Iran | Xarrama Shazand Foyle | Health comparative comprehensive assessment of watersheds with different climates. | Hazbavi, Z.; Keesstra, S.D.; Nunes, J.P.; Baartman, J.E.M.; Gholamalifard, M.; Sadeghi, S.H.                           | 2018  |
| 21   | United Kingdom Colombia Ecuador India | London Bogotá Guayaquil Chennai | Evaluating natural infrastructure for flood management within the watersheds of selected global cities. Ecosystem based Disaster Risk Reduction approaches (EbDRR) as a prerequisite for inclusive urban transformation of Nagpur City, India. | Gunnell, K.; Mulligan, M.; Francis, R.A.; Hole, D.G.                                                                 | 2019  |
| 22   | India Nagpur City | | A comparison of statistical methods and multi-criteria decision making to map flood hazard susceptibility in Northern Iran. Influence of blue infrastructure on lawn thermal microclimate in a subtropical green space. Embedded reservoir and constructed wetland for drinking water source protection: Effects on nutrient removal and phytoplankton succession. | Dhyani, S.; Lahoti, S.; Khare, S.; Pujari, P.; Verma, P.                                                                 | 2018  |
| 23   | Iran | | | Arabameri, A.; Rezaei, K.; Cerdà, A.; Conoscenti, C.; Kalantari, Z. |                                                                                                             | 2019  |
| 24   | China Shanghai | | | Yang, C.; Nan, J.; Yu, H.; Li, J.                                                                                   | 2020  |
| 25   | China Jiangsu | | | |                                                                                                               | 2020  |
| 26   | China Cambodia Indonesia Lao PDR Myanmar Timor Leste Vietnam | | Groundwater depletion and contamination: Spatial distribution of groundwater resources sustainability in China. Groundwater as a source of drinking water in southeast Asia and the Pacific: A multi-country review of current reliance and resource concerns. Planting waterscapes: Green infrastructures, landscape and hydrological modeling for the future of Santa Cruz de la Sierra, Bolivia. | Jia, X.; O’Connor, D.; Hou, D.; Jin, Y.; Li, G.; Zheng, C.; Ok, Y.S.; Tsang, D.C.W.; Luo, J. | 2019  |
| 27   | Bolivia Santa Cruz de la Sierra | |                                                                                                                 | Carrard, N.; Foster, T.; Willetts, J.                                                                            | 2019  |
| 28   | Bolivia Santa Cruz de la Sierra | |                                                                                                                 | Castelli, G.; Foderi, C.; Guzman, B.H.; Ossoli, L.; Kempff, Y.; Bresci, E.; Salbitano, F.                      | 2017  |
| Code | Country | Location | Title                                                                 | Authors                                                                 | Year |
|------|---------|----------|----------------------------------------------------------------------|------------------------------------------------------------------------|------|
| 29   | Canada  | -        | The use of ecosystem services concepts in Canadian municipal plans.   | Thompson, K.; Sherren, K.; Duinker, P.N.                               | 2019 |
| 30   | United States | Texas | Subdivision design and landscape structure: Case study of The Woodlands, Texas, US. | Kim, J.                                                               | 2019 |
| 31   | United States | Ethiopia | Guide for using green infrastructure in urban environments for stormwater management. | McFarland, A.R.; Larsen, L.; Yeshitela, K.; Engtida, A.N.; Love, N.G. | 2019 |
| 32   | Ethiopia | Tanzania | Examining urban water management practices—Challenges and possibilities for transitions to sustainable urban water management in Sub-Saharan cities. Hybrid infrastructures, hybrid governance: New evidence from Nairobi (Kenya) on green-blue-grey infrastructure in informal settlements: “Urban hydroclimatic risks in the 21st century: Integrating engineering, natural, physical and social sciences to build. The role of water utilities in urban greening: A case study of Melbourne, Australia. Devising urban ecosystem-based adaptation (EbA) projects with developing nations: A case study of Port Vila, Vanuatu. | Herslund, L.; Mguni, P.; Mulligan, J.; Bukachi, V.; Clause, J.C.; Jewell, R.; Kirimi, F.; Odbert, C.; Pedersen Zari, M.; Blaschke, P.M.; Jackson, B.; Komugabe-Dixson, A.; Livesey, C.; Loubser, D.I.; Martinez-Almoyna Gual, C.; Maxwell, D.; Rastandeh, A.; Renwick, J.; et al. | 2019 |
| 34   | Australia | Melbourne |                                                                       | Furlong, C.; Phelan, K.; Dodson, J.                                     | 2018 |
| 35   | Vanuatu | Port Vila |                                                                       | Pedersen Zari, M.; Blaschke, P.M.; Jackson, B.; Komugabe-Dixson, A.; Livesey, C.; Loubser, D.I.; Martinez-Almoyna Gual, C.; Maxwell, D.; Rastandeh, A.; Renwick, J.; et al. |

Table A1. Cont.
### Table A2. List of cases with challenges and descriptions.

| Code | Challenges | Description |
|------|------------|-------------|
| 1    | Effective-incorporation of socio-cultural services | River restoration (to improve recreation and aesthetic aspects) |
| 2    | Incidental experience of nature | Stormwater management |
| 3    | Stormwater management | Stormwater management |
| 4    | Freshwater withdrawals | Regulating impacts on water through forests |
| 5    | Nature-based recreational systems | Climate regulation |
| 6    | (Not specific for water NBS) | Climate regulation |
| 7    | Preservation and improvement of ES and landscape (water included) | Urban water systems management |
| 8    | Flooding, urban heat island effect | Flood risks |
| 9    | Identification of vulnerability | Water pollution purification/filtration |
| 10   | Flood risk and water pollution | Flooding, urban heat island effect |
| 11   | Water pollution control | Climate change mitigation and/or adaptation Flood risks |
| 12   | Flood risk due to climate change and urbanization processes | Climate change mitigation and/or adaptation Flood risks |
| 13   | Blue-green infrastructure | Climate regulation |
| 14   | Capability of NBS to produce co-benefits (nature conservation, community well-being, etc.) besides supporting risk reduction (flood risk reduction) | Essential services |
| 15   | Stormwater runoff control | Stormwater management |
| 16   | Groundwater Management | Water pollution purification/filtration |
| 17   | Not related to water (but interesting for community-scale engagement) | Effective-incorporation of socio-cultural services Climate change mitigation and/or adaptation Flood risks |
| 18   | Edible Cities | Socio-cultural services Climate regulation |
| 19   | Urban environmental challenges that arise as a city rapidly urbanizes | (not specific for water NBS) |
| 20   | Watershed health assessment. | Urban water systems management |
| 21   | Flood risk | Flood risks |
| 22   | Ecosystem-based Disaster Risk Reduction (EbDRR): water shortage, floods and increasing temperature | Drought/Water scarcity Climate regulation |
| 23   | Flood hazard | Flood risks |
| 24   | Thermal microclimate regulation | Climate regulation |
| 25   | Preservation of drinking water | Freshwater supply |
| 26   | Water Management | Urban water systems management |
| 27   | Drinking water source | Freshwater supply |
| 28   | decline in water supply for the city | Drought/Water scarcity |
| 29   | Application of Ecosystem Services | Freshwater supply Flood risks |
| 30   | Flood risk, water supply | Freshwater supply |
| 31   | Stormwater management | Stormwater management |
Table A2. Cont.

| Code | Challenges | Description |
|------|------------|-------------|
| 32   | Urban water systems management Freshwater supply | Water management and supply |
| 33   | Stormwater management | Stormwater management and wastewater drainage |
| 34   | Urban water systems management Freshwater withdrawals | Water utilities to ensure water security |
| 35   | Urban water systems management Freshwater withdrawals | Water security; Coastal ecosystems regeneration; Integrated urban water systems (stormwater, greywater, blackwater, drinking water) |

Table A3. Structure of ES and description (TEEB) and main aspects identified.

| ES | Description | Aspects Identified | Codes |
|----|-------------|--------------------|-------|
| Food | Food production | Food supply | 4 |
| Food | Food production | 15 |
| Food | Improve (edible cities) | 18 |
| Raw materials | Raw materials production | Wood extraction | 11 |
| Freshwater | Rain water harvesting | Water yield | 8 |
| Freshwater | Rain water harvesting | Control and assure water supply | 9 |
| Freshwater | Rain water harvesting | Water supply | 16; 32 |
| Medicinal Resources | Not identified | Mitigate urban heat island effect | 3 |
| Medicinal Resources | Not identified | Climate regulation | 6 |
| Medicinal Resources | Not identified | (Cooling Capacity of Green Infrastructure elements obtained from land surface temperature) | |
| Local Climate Air Quality | Climate regulation | Microclimate adaptation | 8 |
| Local Climate Air Quality | Climate regulation | Thermal regulation | 15 |
| Local Climate Air Quality | Climate regulation | Microclimate regulation (reduced UHI) | 22 |
| Local Climate Air Quality | Climate regulation | Cooling capacity | 24 |
| Carbon sequestration and storage | Carbon sequestration | Carbon sequestration (carbon sink) | 8 |
| Carbon sequestration and storage | Carbon sequestration | Carbon sequestration | 22 |
| Carbon sequestration and storage | Carbon sequestration | Water level fluctuation | 2 |
| Carbon sequestration and storage | Carbon sequestration | Reduce water volume, retain peak flow, recharge groundwater | 3 |
| Flood protection | Flood protection | 7; 11 |
| Flood protection | Flood protection | 10 |
| Flood protection | Flood prevention | 21 |
| Flood protection | Flood prevention | 23 |
| Flood protection | Flood prevention | 8 |
| Flood protection | Flood prevention | (runoff mitigation, stormwater management) | |
| Stormwater runoff control | Stormwater runoff control | 15 |
| Stormwater runoff control | Stormwater runoff control | Decelerate rainwater runoff and minimizing flood peaks | 22 |
| Stormwater runoff control | Stormwater runoff control | Runoff mitigation | 31 |
Table A3. Cont.

| ES                                      | Description                                                                 | Aspects Identified                                                                 | Codes |
|-----------------------------------------|-----------------------------------------------------------------------------|----------------------------------------------------------------------------------|-------|
| Waste-water treatment                   | Pollution control                                                           | Bio-remediation; filtration, sequestration, storage and accumulation; dilution   | 1     |
|                                        |                                                                             | To trap (filter) pollution                                                       | 3     |
|                                        |                                                                             | Water quality regulation                                                         | 7     |
|                                        |                                                                             | Pollution control                                                                | 10    |
|                                        |                                                                             | Water purification                                                               | 11    |
|                                        |                                                                             | Dilute and attenuate contaminants                                                | 16    |
|                                        |                                                                             | Nutrients and phytoplankton concentration in water, in order to assure water quality. | 25    |
|                                        |                                                                             | Pollutant removal                                                                | 31    |
| Erosion prevention and maintenance of   | Erosion prevention                                                           | Erosion control; soil fertility regulation;                                       | 7     |
| soil fertility                          |                                                                             | Sediment retention; soil erosion prevention                                       | 8     |
| Regulation of Water Flow                | Regulation of Water Flow                                                    | Hydrological cycle and water flow                                                | 1     |
|                                        |                                                                             | Forests and others regulating ES protection.                                     | 4     |
|                                        |                                                                             | Control water vulnerabilities                                                     | 9     |
| Pollination                            | Pollination support                                                         | Pollination support                                                              | 7     |
| Biological control                     |                                                                             | Physical and experiential interactions                                           | 1     |
|                                        |                                                                             | Pleasure and recreational activities, cultural activities, serve as pathway/barrier, nature observation | 3     |
|                                        |                                                                             | Applications, for the spatially-explicit assessment of ecosystem services, but increasingly applied to assess potential and opportunities for nature-based recreation | 5     |
| Recreation and, mental and physical    |                                                                             | Outdoor recreation (pedestrian and cycling paths)                                | 8     |
| health                                  |                                                                             | Recreational use                                                                 | 10    |
|                                        |                                                                             | Recreation                                                                      | 11    |
|                                        |                                                                             | Recreational opportunities                                                       | 15    |
|                                        |                                                                             | Recreational prospects                                                           | 22    |
|                                        |                                                                             | Mental well-being                                                               | 2     |
|                                        |                                                                             | Social well-being                                                               | 2     |
|                                        |                                                                             | Relief from everyday stress                                                      | 22    |
|                                        |                                                                             | Promotion of health behaviors (physical activity)                                | 2     |
| Cultural Services                       |                                                                             | Aesthetic and cultural values                                                    | 22    |
|                                        |                                                                             | Aesthetic value                                                                 | 24    |
|                                        |                                                                             | Cultural and historical heritage                                                 | 8     |
|                                        |                                                                             | Form social ties                                                                | 3     |
|                                        |                                                                             | Facilitation of social cohesion                                                 | 15    |
| Aesthetic appreciation and inspiration  | Aesthetics                                                                   |                                                                           |       |
| for culture, art and design             |                                                                             |                                                                           |       |
| Spiritual experience and sense of place | Cultural and historical heritage                                             |                                                                           |       |
| Tourism                                | Aesthetics                                                                   |                                                                           |       |
|                                        |                                                                             |                                                                           |       |
|                                        |                                                                             |                                                                           |       |
### Table A3. Cont.

| ES                          | Description                        | Aspects Identified                      | Codes |
|-----------------------------|-------------------------------------|----------------------------------------|-------|
| Supporting Services         | Habitat for species                 | Natural habitat/shelter                | 3     |
|                             |                                     | Maintenance of genetic diversity       | Not identified |

### Table A4. List of cases with Ecosystem services.

| Code | Provisioning Services | Regulating Services                                      | Cultural Services                                      | Supporting Services |
|------|-----------------------|----------------------------------------------------------|--------------------------------------------------------|---------------------|
| 1    |                       | Waste-water treatment                                     | Recreation and, mental and physical health             | Habitat for species |
|      |                       | Regulation of Water Flow                                  |                                                        |                     |
| 2    |                       | Moderation of extreme events                              | Recreation and, mental and physical health             | Habitat for species |
|      |                       | Local Climate Air Quality                                 | Recreation and, mental and physical health             |                     |
| 3    |                       | Moderation of extreme events                              | Spiritual experience and sense of place                | Habitat for species |
|      |                       | Waste-water treatment                                     |                                                        |                     |
| 4    | Food                  |                                                          | Recreation and, mental and physical health             |                     |
| 5    |                       |                                                          |                                                        |                     |
| 6    |                       | Local Climate Air Quality                                 | Recreation and, mental and physical health             |                     |
|      |                       | Moderation of extreme events                              |                                                        |                     |
|      |                       | Waste-water treatment                                     |                                                        |                     |
| 7    |                       | Erosion prevention and maintenance of soil fertility      | Recreation and, mental and physical health             | Habitat for species |
|      |                       | Pollination                                               |                                                        |                     |
|      |                       | Local Climate Air Quality                                 |                                                        |                     |
|      |                       | Carbon sequestration and storage                          |                                                        |                     |
| 8    | Freshwater            | Moderation of extreme events                              | Aesthetic appreciation and inspiration for culture, art and design |                     |
|      |                       | Erosion prevention and maintenance of soil fertility      |                                                        |                     |
| 9    | Freshwater            |                                                          |                                                        |                     |
| 10   |                       | Moderation of extreme events                              | Recreation and, mental and physical health             |                     |
|      |                       | Waste-water treatment                                     |                                                        |                     |
| 11   | Raw materials         | Moderation of extreme events                              | Recreation and, mental and physical health             | Habitat for species |
|      |                       | Waste-water treatment                                     |                                                        |                     |
| 15   | Food                  |                                                          | Recreation and, mental and physical health             | Habitat for species |
|      |                       | Local Climate Air Quality                                 |                                                        |                     |
| 16   | Freshwater            |                                                          | Spiritual experience and sense of place                |                     |
| 18   | Food                  | Waste-water treatment                                     |                                                        |                     |
| 21   |                       | Moderation of extreme events                              |                                                        |                     |
Table A4. Cont.

| Code | Provisioning Services | Regulating Services          | Cultural Services                                      | Supporting Services                                      |
|------|-----------------------|------------------------------|--------------------------------------------------------|---------------------------------------------------------|
| 22   | Freshwater            | Local Climate Air Quality    | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
|      |                       | Carbon sequestration and storage |                                         |                                                         |
| 23   | Freshwater            | Local Climate Air Quality    | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
|      |                       | Carbon sequestration and storage |                                         |                                                         |
| 24   | Freshwater            | Waste-water treatment        | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
| 25   | Freshwater            | Waste-water treatment        | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
| 27   | Freshwater            | Waste-water treatment        | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
| 28   | Freshwater            | Waste-water treatment        | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
| 31   | Freshwater            | Waste-water treatment        | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |
| 32   | Freshwater            | Waste-water treatment        | Recreation and, mental and physical health             | Aesthetic appreciation and inspiration for culture, art and design |

Table A5. Summary of NBS types, challenges and Ecosystem Services.

| Code | NBS Types    | Challenges                                      | Ecosystem Services                                      |
|------|--------------|-------------------------------------------------|---------------------------------------------------------|
| 1    | Other        | Effective-incorporation of socio-cultural services | Waste-water treatment                                   |
|      |              |                                                 | Regulation of Water Flow                                 |
|      |              |                                                 | Recreation and, mental and physical health              |
|      |              |                                                 | Habitat for species                                     |
| 2    | Wetland      | Effective-incorporation of socio-cultural services | Moderation of extreme events                            |
|      | Other        |                                                 | Recreation and, mental and physical health              |
|      |              |                                                 | Local Climate Air Quality                               |
|      |              |                                                 | Moderation of extreme events                            |
| 3    | Permeable pavement Other | Stormwater management                  | Waste-water treatment                                   |
|      |              |                                                 | Recreation and, mental and physical health              |
|      |              |                                                 | Local Climate Air Quality                               |
|      |              |                                                 | Spiritual experience and sense of place                 |
|      |              |                                                 | Habitat for species                                     |
| 4    | River park   | Flood risks                                    | Food                                                    |
|      | Wetland      | Freshwater withdrawals                         | Regulation of Water Flow                                 |
|      | Other        | Climate regulation                             |                                                         |
|      | River park   |                                                 |                                                         |
|      | Agroforestry | Effective-incorporation of socio-cultural services | Recreation and, mental and physical health              |
|      | Park         |                                                 |                                                         |
|      |              |                                                 |                                                         |
| 6    | Other        | Climate regulation                             | Local Climate Air Quality                               |
|      | SUDS         |                                                 | Moderation of extreme events                            |
|      |              |                                                 | Waste-water treatment                                   |
| 7    | Agroforestry | Urban water systems management                  | Erosion prevention and maintenance of soil fertility    |
|      | Park         |                                                 | Pollination                                              |
|      | Other        | Freshwater withdrawals                         | Habitat for species                                     |
|      |              |                                                 | Freshwater                                              |
|      |              |                                                 | Local Climate Air Quality                               |
|      |              |                                                 | Carbon sequestration and storage                        |
|      |              |                                                 | Moderation of extreme events                            |
| 8    | Green roof/wall Park Rain | Flood risks                                 | Erosion prevention and maintenance of soil fertility    |
|      |              |                                                 | Recreation and, mental and physical health              |
|      |              |                                                 | Aesthetic appreciation and inspiration for culture, art and design |
Table A5. Cont.

| Code | NBS Types          | Challenges                      | Ecosystem Services                       |
|------|--------------------|---------------------------------|------------------------------------------|
| 9    | SUDS               |                                 | Freshwater withdrawals                   |
|      | Green roof/wall    |                                 | Regulation of Water Flow                 |
|      | River park         |                                 | Moderation of extreme events             |
|      | Agroforestry       |                                 | Waste-water treatment                    |
|      | Park               |                                 | Recreation and, mental and physical health|
|      | Other              |                                 | Raw materials production                |
|      |                    |                                 | Climate change mitigation and/or adaptation|
|      |                    |                                 | Flood risks                              |
| 10   | SUDS               |                                 | Climate change mitigation and/or adaptation|
|      | River park         | Water pollution purification/ filtration | Waste-water treatment Recreation and, mental and physical health |
|      | Wetland            | Flood risks                     | Raw materials production                |
|      |                    |                                 | Modation of extreme events               |
| 11   | SUDS               |                                 | Climate change mitigation and/or adaptation|
|      | River park         | Water pollution purification/ filtration | Waste-water treatment Recreation and, mental and physical health |
|      | Wetland            | Flood risks                     | Raw materials production                |
|      |                    |                                 | Modation of extreme events               |
| 12   | SUDS               | Climate change mitigation and/or adaptation | Climate change mitigation and/or adaptation|
|      | Wetland            | Flood risks                     | Flood risks                              |
|      | Bioswale           |                                 | -                                        |
|      | Permeable pavement |                                 | -                                        |
|      | SUDS               |                                 | -                                        |
| 13   | SUDS               | Climate change mitigation and/or adaptation | Flood risks                              |
|      | River park         | Climate regulation              | -                                        |
|      | Agroforestry       |                                 | -                                        |
|      | Wetland            |                                 | -                                        |
|      | Park               |                                 | -                                        |
| 14   | Wetland            | Flood risks                     | -                                        |
|      |                    | Effective-incorporation of socio-cultural services | Food                                    |
|      |                    |                                 | Local Climate Air Quality                |
|      |                    |                                 | Recreation and, mental and physical health |
|      |                    |                                 | Spiritual experience and sense of place  |
|      |                    |                                 | Habitat for species                      |
| 15   | SUDS               | Stormwater management           | -                                        |
|      | Green roof/wall    |                                 | Food                                    |
|      |                    |                                 | Local Climate Air Quality                |
|      |                    |                                 | Recreation and, mental and physical health |
|      |                    |                                 | Spiritual experience and sense of place  |
|      |                    |                                 | Habitat for species                      |
| 16   | SUDS               | Water pollution purification/ filtration | Freshwater                               |
|      | River park         |                                 | Waste-water treatment                    |
|      | Agroforestry       |                                 | -                                        |
|      | Wetland            |                                 | -                                        |
|      | Park               |                                 | -                                        |
| 17   | Other              | Effective-incorporation of socio-cultural services | -                                        |
|      |                    | Climate change mitigation and/or adaptation | -                                        |
|      |                    | adaptation                      | -                                        |
| 18   | Other              | Effective-incorporation of socio-cultural services | Food                                    |
|      | SUDS               | Climate regulation              | Climate regulation                       |
|      | Green roof/wall    |                                 | -                                        |
|      | River park         |                                 | -                                        |
|      | Agroforestry       |                                 | -                                        |
|      | Wetland            |                                 | -                                        |
|      | Park               |                                 | -                                        |
| 19   | Other              | (not specific for water NBS)    | -                                        |
|      |                    | Urban water systems management  | -                                        |
|      |                    | Freshwater withdrawals         | -                                        |
| 20   | Other              | Flood risks                     | -                                        |
| 21   | Wetland            | Flood risks                     | -                                        |
|      | Other              |                                 | -                                        |
### Table A5. Cont.

| Code | NBS Types      | Challenges             | Ecosystem Services                                      |
|------|----------------|------------------------|---------------------------------------------------------|
| 22   | Phytorid treatment Other | Flood risks, Drought/Water scarcity, Climate regulation | Freshwater, Local Climate Air Quality, Carbon sequestration and storage, Recreation and, mental and physical health, Aesthetic appreciation and inspiration for culture, art and design |
| 23   | Other           | Flood risks            | Moderation of extreme events, Local Climate Air Quality Aesthetic appreciation and inspiration for culture, art and design |
| 24   | Other           | Climate regulation     | -                                                       |
| 25   | Wetland Phytorid treatment Other | Freshwater supply | Waste-water treatment |
| 26   | Other           | Urban water systems management | -                                                       |
| 27   | Other           | Freshwater supply      | Freshwater                                             |
| 28   | Green roof/wall Agroforestry SUDS SUDS Green roof/wall River park | Drought/Water scarcity, Freshwater supply | Freshwater                                             |
| 29   | Agroforestry Wetland Park | Freshwater withdrawals | -                                                       |
| 30   | Agroforestry Other SUDS Green roof/wall Wetland River park | Flood risks, Freshwater supply | -                                                       |
| 31   | Rain garden Bioswale Permeable pavement Other | Stormwater management | Moderation of extreme events, Waste-water treatment |
| 32   | SUDS Other SUDS | Urban water systems management, Freshwater supply | Freshwater                                             |
| 33   | Wetland Rain garden Other | Stormwater management | -                                                       |
| 34   | Rain garden Other | Urban water systems management | -                                                       |
| 35   | Other           | Urban water systems management, Freshwater withdrawals Urban water systems management | -                                                       |
### Table A6. Summary of NBS types and scales with descriptions.

| Code | NBS Types     | Elements Description                                                                 | Scales       | Description                              |
|------|---------------|--------------------------------------------------------------------------------------|--------------|------------------------------------------|
| 1    | Other         | not specified (1) wetland, river, wet meadows case;                                | Municipality |                                          |
| 2    | Wetland Other | (2) green cycling lanes (surrounded of green and blue infrastructure)                | Site         | Municipality                             |
|      | Green roof/wall| Trees (lone trees, afforestation), shrub (lone shrub, hedge, massif),              | Site         | University campus                       |
|      | Permeable     | herbaceous (grass, lawn, meadow), mineral (permeable/impermeable surface), temporary |              |                                          |
|      | pavement      | water body, green roof . . .                                                         |              |                                          |
| 3    | River park    | Forests                                                                              | Neighborhood | Municipality                             |
|      | Other         | Other not specified (e.g., green permeable pavement, rain gardens, parks, green roofs, | Municipality |                                          |
|      | Wetland       | wildlife crossings, Phyto-remediation/Phyto-depuration, acoustic green barrier, etc.) |              |                                          |
| 4    | Wetland       | Green infrastructure (GI): street trees, urban forest, peri-urban forest, water bodies . . . | Metropolitan Area |                                          |
| 5    | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 6    | Other         | Other                                                                                 | Metropolitan Area |                                          |
| 7    | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 8    | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
|      | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
|      | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 9    | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 10   | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 11   | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 12   | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| 13   | Wetland       | Other                                                                                 | Metropolitan Area |                                          |
| Code | NBS Types          | Elements Description                                                                 | Scales                        | Description                               |
|------|--------------------|---------------------------------------------------------------------------------------|-------------------------------|-------------------------------------------|
| 14   | Wetland            | River restauiration; Retention area effectiveness; Wetlands restauiration; Watershed  | Municipality:                |                                            |
|      |                    | restauiration; Opening floodplains; River meandering                                   | Regional (Basin level)        | Ljubljana, Slovenia                        |
|      |                    |                                                                                      |                               | Glinšćica river                           |
| 15   | Green roof/wall    |                                                                                      | Municipality                  |                                            |
|      | SUDS               |                                                                                      |                               |                                            |
|      | Green roof/wall    |                                                                                      | Metropolitan Area             |                                            |
| 16   | River park         |                                                                                      |                               |                                            |
|      | Agroforestry       |                                                                                      |                               |                                            |
|      | Wetland Park       |                                                                                      |                               |                                            |
| 17   | Other              |                                                                                      | Site                          | Community scale GI                        |
|      | SUDS               |                                                                                      | Neighborhood                  |                                            |
|      | Green roof/wall    |                                                                                      | Municipal                   |                                            |
|      | SUDS               |                                                                                      | Metropolitan Area             |                                            |
|      | River park         |                                                                                      |                               |                                            |
|      | Agroforestry       |                                                                                      |                               |                                            |
|      | Wetland Park       |                                                                                      |                               |                                            |
| 19   | Other              |                                                                                      | Municipal                   |                                            |
|      | Other              |                                                                                      | Municipal                   |                                            |
|      | Other              |                                                                                      | Regional                     |                                            |
|      | Other              |                                                                                      | Regional (Basin level)        |                                            |
| 21   | Wetland            | Floodplains, waterbodies, canopy, wetlands, soil                                     | Regional (Basin level)        |                                            |
|      | Other              | Phytorid waste-water treatment technology (plants with filtration and treatment     |                               |                                            |
|      |                    | capability in constructed wetlands)                                                 |                               |                                            |
| 22   | Phytorid treatment | Other                                                                                 | Municipality                  |                                            |
| 23   | Other              | Terrain analysis to help planners and stakeholders to control flood hazard.           | Regional (Basin level)        |                                            |
| 24   | Other              | Pond                                                                                   | Site                          | Patch scale (lawn in an urban park)       |
|      |                    |                                                                                      | Other                         |                                            |
| 25   | Wetland            | Conservation and control of Phytoplankton’s nutrients absorption and how it affects  | Regional (Basin level)        | Lake                                      |
|      | Phytorid treatment | the quality of water                                                                   | Other                         |                                            |
|      | Other              |                                                                                      | Regional                     |                                            |
|      |                    |                                                                                      | National                     |                                            |
|      |                    |                                                                                      | Metropolitan Area             |                                            |
| 26   | Other              |                                                                                      | Regional (Basin level)        |                                            |
| 27   | Other              |                                                                                      | National                     |                                            |
|      | SUDS               |                                                                                      | Metropolitan Area             |                                            |
| 28   | Green roof/wall    |                                                                                      | Municipal                   |                                            |
|      | Agroforestry       |                                                                                      | Metropolitan Area             |                                            |
|      | SUDS               |                                                                                      | Regional                     |                                            |
|      | Green roof/wall    |                                                                                      | Regional (Basin level)        |                                            |
| 29   | River park         |                                                                                      | Municipal                   |                                            |
|      | Agroforestry       |                                                                                      | Metropolitan Area             |                                            |
|      | Wetland Park       |                                                                                      |                               |                                            |
| 30   | Agroforestry       | Soil                                                                                   | Municipal                   |                                            |
|      | Other              |                                                                                      |                               |                                            |
### Table A6. Cont.

| Code | NBS Types | Elements Description | Scales | Description |
|------|-----------|----------------------|--------|-------------|
| 31   | SUDS      | Retention basins; rainwater harvesting; constructed wetlands; detention basins; bioswales; rain gardens; green roofs; permeable pavements | Site   | Municipality |
|      | Green roof/wall Wetland |                       | Regional | (Basin level) |
|      | Rain garden  |                       |         |              |
|      | Bioswale  |                       |         |              |
|      | Permeable pavement  |                       |         |              |
|      | Other  |                       |         |              |
| 32   | SUDS      | Water harvesting, stormwater drainage, building gabions, planting next to the river | Neighborhood | Municipality |
|      | Other  |                       |         |              |
| 33   | Wetland  | bio-filtration | Site | Neighborhood |
|      | Rain garden  |                       |         | local community scale |
|      | Other  |                       |         |              |
| 34   | Other  | (1) Transformation of concrete drainage channel into semi-natural waterway; (2) Planting trees along waterways, drainage corridors and parks; (3) Transformation of Sewer reserve into linear park and bike track Riparian corridor regeneration; Restauration and protection of coastal vegetation; Intensification of peri-urban home garden; Urban trees and vegetation | Neighborhood |              |
| 35   | Other  |                       | Regional | (Basin level) |

### Table A7. Summary of cases with location, spatial scale, instruments scales and actors involved.

| Code | Country | Location | Spatial | Policy Instruments | Actors |
|------|---------|----------|---------|--------------------|--------|
| 1    | Denmark | Aarhus   | Municipality | Regional         | Public authorities |
|      |         |          |          | Global            | Academic and research bodies |
| 2    | Denmark | Copenhagen | Kristianstad | Site             | Academic and research bodies |
|      |         |          | Municipality | Site             | Water-related actors |
| 3    | France  | Villeurbanne |          | Neighborhood      | Academic and research bodies |
|      |         |          | Municipality | Metropolitan Area | Water-related actors |
| 4    | Greece  | Athens   | Neighborhood | Municipality      | Academic and research bodies |
|      |         |          | Metropolitan Area | Metropolitan Area | Industry, business and private sector |
| 5    | Italy   | Trento   | Neighborhood | Municipality      | Academic and research bodies |
| 6    | Italy   | Rome     | Metropolitan Area | Regional | Civil society |
| 7    | Italy   | Rome     | Metropolitan Area | Regional | Academic and research bodies |
|      |         |          |               | Sub-national     | Public authorities |
|      |         |          |               | Municipal        | Academic and research bodies |
| 8    | Italy   | Rescaldina | Municipality | Metropolitan Area | Public authorities |
|      |         |          | Regional (Basin level) | National | Academic and research bodies |
| 9    | Italy   | Moncalieri | Other | Metropolitan Area | Public authorities |
|      |         |          | Regional (Basin level) | National | Academic and research bodies |
| Code | Country         | Location              | Spatial              | Policy Instruments          | Actors                                      |
|------|----------------|-----------------------|----------------------|----------------------------|---------------------------------------------|
| 10   | Italy          | Gorla Maggiore        | Municipality         | Regional                   | Public authorities                         |
|      |                |                       |                      | Sub-national               | Civil society                              |
|      |                |                       |                      |                            | Academic and research bodies               |
|      |                |                       |                      |                            | Water-related actors                       |
| 11   | Italy          | Gorla Maggiore        | Municipality         | Regional                   | Public authorities                         |
|      |                |                       |                      | Sub-national               | Civil society                              |
|      |                |                       |                      |                            | Academic and research bodies               |
|      |                |                       |                      |                            | Water-related actors                       |
|      |                |                       |                      |                            | Academic and research bodies               |
| 12   | Italy          | Avola                 | Municipality         | Global                     | Public authorities                         |
|      |                |                       |                      | Regional                   | Civil society                              |
|      |                |                       |                      | National                   | Academic and research bodies               |
|      |                |                       |                      | Municipal                  |                                            |
| 13   | Poland         | Wroclaw               | Municipality         | Regional                   | Public authorities                         |
|      | Slovakia       | Bratislava             |                      | National                   | Civil society                              |
|      |                |                       |                      | Municipal                  | Academic and research bodies               |
|      |                |                       |                      |                            |                                            |
| 14   | Slovenia        | Ljubljana             | Municipality         | Regional                   | Public authorities                         |
|      |                |                       |                      | (Basin level)              | Civil society                              |
|      |                |                       |                      |                            |                                            |
| 15   | Spain          | Barcelona             | Municipality         |                           | Public authorities                         |
|      |                |                       |                      |                            | Civil society                              |
|      |                |                       |                      |                            | Academic and research bodies               |
|      |                |                       |                      |                            | Industry, business and private sector      |
| 16   | United Kingdom | London                | Metropolitan Area    | Sub-national               | Public authorities                         |
|      |                |                       |                      | National                   | Civil society                              |
|      |                |                       |                      |                            |                                            |
| 17   | United Kingdom | Liverpool             | Site Neighborhood    | Local                      | Public authorities                         |
|      | Germany        | Andernach             |                      |                            | Civil society                              |
|      | Germany        | Heidelberg            |                      |                            |                                            |
| 18   | Netherlands     | Rotterdam             | Municipality         | Municipal                  | Public authorities                         |
|      | Norway         | Oslo                  |                      |                            | Civil society                              |
|      |                | Havana                |                      |                            | Academic and research bodies               |
| 19   | Spain          | Barcelona             | Municipality         | Municipal                  | Public authorities                         |
|      | China          | Shanghai              |                      |                            | Civil society                              |
|      | China          | Shanghai              |                      |                            | Academic and research bodies               |
|      | Portugal        | Xarrama               | Municipality         | Municipal                  | Public authorities                         |
|      |                | Foyle                 |                      |                            | Civil society                              |
|      |                | Shazand               |                      |                            | Academic and research bodies               |
| 20   | United Kingdom | London                | Regional             | Global                     | Academic and research bodies               |
|      | Iran           | Bogotá                | (Basin level)        |                            |                                            |
|      |                | Guayaquil             |                      |                            |                                            |
|      |                | Chennai               |                      |                            |                                            |
| 21   | United Kingdom | Colombia              | Regional             | Global                     | Public authorities                         |
|      | Ecuador        | Guayaquil             | (Basin level)        |                            | Civil society                              |
|      |                | Chennai               |                      |                            | Academic and research bodies               |
|      | India          | Nagpur City           | Municipality         | Global                     | Public authorities                         |
|      |                |                       |                      | National                   | Civil society                              |
|      |                |                       |                      |                            | Academic and research bodies               |
|      |                |                       |                      |                            | Water-related actors                       |
| 23   | Iran           |                       | Regional             | Global                     | Academic and research bodies               |
|      |                |                       | (Basin level)        |                            |                                            |
| 24   | China          | Shanghai              | Site Other           | Global                     | Public authorities                         |
|      |                |                       | Regional             |                            | Academic and research bodies               |
|      |                |                       | (Basin level)        |                            | Water-related actors                       |
| 25   | China          | Jiangsu               | National             | Global                     | Public authorities                         |
|      |                |                       |                      |                            | Academic and research bodies               |
|      |                |                       |                      |                            | Water-related actors                       |
| Code | Country          | Location      | Spatial                  | Policy Instruments | Actors                                      |
|------|------------------|---------------|--------------------------|--------------------|---------------------------------------------|
| 26   | China            | -             | Regional (Basin level)   | Global             | Academic and research bodies                |
|      |                  |               | National                 |                    | Water-related actors                        |
|      |                  |               |                          |                    | Industry, business and private sector       |
| 27   | Cambodia         | -             | Metropolitan Area        | Global             | Academic and research bodies                |
|      | Indonesia        | Lao PDR       |                          |                    | Water-related actors                        |
| 28   | Bolivia          | Santa Cruz de la Sierra | Municipalité | Municipal | Public authorities                          |
|      |                  |                | Regional (Basin level)   |                    | Civil society                               |
| 29   | Canada           | -             | Municipalité             | Municipal          | Academic and research bodies                |
|      |                  |                | Metropolitan Area        |                    | Public authorities                          |
|      |                  |                |                          |                    | Civil society                               |
| 30   | United States    | Texas         | Municipalité             | Regional           | Academic and research bodies                |
|      |                  |                |                          | Municipal          | Public authorities                          |
|      |                  |                |                          |                    | Civil society                               |
|      |                  |                |                          |                    | Water-related actors                        |
| 31   | United States    | Detroit       | Site                     | Regional           | Public authorities                          |
|      | Ethiopia         | Addis Ababa   | Municipalité             | (Basin level)      | Civil society                               |
| 32   | Ethiopia         | Addis Ababa   | Neighborhood             | Municipal          | Water-related actors                        |
|      | Tanzania         | Dar es Salaam |                          |                    | Public authorities                          |
|      |                  |                |                          |                    | Civil society                               |
| 33   | Kenya            | Nairobi       | Site                     | Neighborhood       | Public authorities                          |
|      |                  |                |                          |                    | Civil society                               |
| 34   | Australia        | Melbourne     |                          | Municipal          | Water-related actors                        |
| 35   | Vanuatu          | Port Vila     | Neighborhood             | Regional           | Public authorities                          |
|      |                  |                | (Basin level)            |                   | Civil society                               |

References
1. Escobedo, F.J.; Giannico, V.; Jim, C.Y.; Sanesi, G.; Lafortezza, R. Urban forests, ecosystem services, green infrastructure and nature-based solutions: Nexus or evolving metaphors? Urban For. Urban Green. 2019, 37, 3–12. [CrossRef]
2. Wandl, D.I.A.; Nadin, V.; Zonneveld, W.; Rooij, R. Beyond urban-rural classifications: Characterising and mapping territories-in-between across Europe. Landsc. Urban Plan. 2014, 130, 50–63. [CrossRef]
3. Bauduceau, N.; Berry, P.; Cecchi, C.; Elmqvist, T.; Fernández, M.; Hartig, T.; Krull, W.; Mayerhofer, E.; Sandra, N.; Noring, L.; et al. Towards an EU Research and Innovation Policy Agenda for Nature-Based Solutions & Re-Naturing Cities: Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities; Publications Office of the EU: Luxembourg, 2015; 76p. [CrossRef]
4. Hanson, H.I.; Wickenberg, B.; Alkan Olsson, J. Working on the boundaries—How do science use and interpret the nature-based solution concept? Land Use Policy 2019, 104302. [CrossRef]
5. Kim, J. Subdivision design and landscape structure: Case study of The Woodlands, Texas, US. Urban For. Urban Green. 2019, 38, 232–241. [CrossRef]
6. Furlong, C.; Phelan, K.; Dodson, J. The role of water utilities in urban greening: A case study of Melbourne, Australia. Util. Policy 2018, 53, 25–31. [CrossRef]
7. La Rosa, D.; Pappalardo, V. Planning for spatial equity—A performance based approach for sustainable urban drainage systems. Sustain. Cities Soc. 2020, 53. [CrossRef]
8. Säumel, I.; Reddy, S.E.; Wachtel, T. Edible city solutions—one step further to foster social resilience through enhanced socio-cultural ecosystem services in cities. *Sustainability* 2019, 11, 972. [CrossRef]

9. Dorst, H.; van der Jagt, A.; Raven, R.; Runhaar, H. Urban greening through nature-based solutions – Key characteristics of an emerging concept. *Sustain. Cities Soc.* 2019, 49, 101620. [CrossRef]

10. Cohen-Shacham, E.; Walters, G.; Janzen, C.; Maginnis, S. (Eds.) *Nature-Based Solutions to Address Global Societal Challenges*; IUCN: Gland, Switzerland, 2016; Volume xiii.

11. Albert, C.; Schröter, B.; Haase, D.; Brillinger, M.; Henze, J.; Herrmann, S.; Gottwald, S.; Guerrero, P.; Nicolas, C.; Matzdorf, B. Addressing societal challenges through nature-based solutions: How can landscape planning and governance research contribute? *Landsc. Urban Plan.* 2019, 182, 12–21. [CrossRef]

12. Dallimer, M.; Martin-Ortega, J.; Rendon, O.; Afionis, S.; Bark, R.; Gordon, I.J.; Paavola, J. Taking stock of the empirical evidence on the insurance value of ecosystems. *Ecol. Econ.* 2020, 167. [CrossRef]

13. Dhyani, S.; Lahoti, S.; Khare, S.; Pujari, P.; Verma, P. Ecosystem based Disaster Risk Reduction approaches (EbDRR) as a prerequisite for inclusive urban transformation of Nagpur City, India. *Int. J. Disaster Risk Reduct.* 2018, 32, 95–105. [CrossRef]

14. Gómez Martin, E.; Máněz Costá, M.; Schwerdtner Máněz, K. An operationalized classification of Nature Based Solutions for water-related hazards: From theory to practice. *Ecol. Econ.* 2020, 167. [CrossRef]

15. Loiseau, E.; Saikku, L.; Antikainen, R.; Droste, N.; Hansjürgens, B.; Pitkänen, K.; Leskinen, P.; Kuikman, P.; Thomsen, M. Green economy and related concepts: An overview. *J. Clean. Prod.* 2016, 139, 361–371. [CrossRef]

16. Kabisch, N.; Frantzeskaki, N.; Pauleit, S.; Naumann, S.; Davis, M.; Artmann, M.; Haase, D.; Knapp, S.; Korn, H.; Sundell, P.; Thomsen, M. Green areas and related concepts: A systematic review of the literature. *J. Clean. Prod.* 2016, 21, art39. [CrossRef]

17. Pagano, A.; Pluchinotta, I.; Pengal, P.; Cokan, B.; Giordano, R. Engaging stakeholders in the assessment of NBS effectiveness in flood risk reduction: A participatory System Dynamics Model for benefits and co-benefits evaluation. *Sci. Total Environ.* 2019, 690, 543–555. [CrossRef] [PubMed]

18. Ronchi, S.; Arcidiacono, A.; Pogliani, L. Integrating green infrastructure into spatial planning regulations to improve the performance of urban ecosystems. Insights from an Italian case study. *Sustain. Cities Soc.* 2020, 53. [CrossRef]

19. Shaw, B.J.; van Vliet, J.; Verburg, P.H. The peri-urbanization of Europe: A systematic review of a multifaceted process. *Landsc. Urban Plan.* 2020, 196. [CrossRef]

20. Wandl, A.; Magoni, M. Sustainable Planning of Peri-Urban Areas: Introduction to the Special Issue. *Plan. Pract. Res.* 2017, 32, 1–3. [CrossRef]

21. Mortoja, M.G.; Yigitoanlar, T.; Mayere, S. What is the most suitable methodological approach to demarcate peri-urban areas? A systematic review of the literature. *Land Use Policy* 2020, 95, 104601. [CrossRef]

22. Arabameri, A.; Rezaei, K.; Cerdà, A.; Conoscenti, C.; Kalantari, Z. A comparison of statistical methods and multi-criteria decision making to map flood hazard susceptibility in Northern Iran. *Sci. Total Environ.* 2019, 660, 443–458. [CrossRef]

23. Gunnell, K.; Mulligan, M.; Francis, R.A.; Hole, D.G. Evaluating natural infrastructure for flood management within the watersheds of selected global cities. *Sci. Total Environ.* 2019, 670, 411–424. [CrossRef] [PubMed]

24. Reynaud, A.; Lanzanova, D.; Lique, C.; Grizzetti, B. Going green? Ex-post valuation of a multipurpose water infrastructure in Northern Italy. *Ecosyst. Serv.* 2017, 27, 70–81. [CrossRef] [PubMed]

25. Tomao, A.; Quatrini, V.; Corona, P.; Ferrara, A.; Laforcella, R.; Salvati, L. Resilient landscapes in Mediterranean urban areas: Understanding factors influencing forest trends. *Environ. Res.* 2017, 156, 1–9. [CrossRef]

26. Bricker, S.H.; Banks, V.J.; Galik, G.; Tapete, D.; Jones, R. Accounting for groundwater in future city visions. *Land Use Policy* 2017, 69, 618–630. [CrossRef]

27. Capotorti, G.; De Lazzari, V.; Orti, M.A. Local scale prioritisation of green infrastructure for enhancing biodiversity in Peri-Urban agroecosystems: A multi-step process applied in the Metropolitan City of Rome (Italy). *Sustainability* 2019, 11, 3322. [CrossRef]

28. Hazbavi, Z.; Keesstra, S.D.; Nunes, J.P.; Baartman, J.E.M.; Gholamalifard, M.; Sadeghi, S.H. Health comparative comprehensive assessment of watersheds with different climates. *Ecol. Indic.* 2018, 93, 781–790. [CrossRef]
29. Herslund, L.; Mguni, P. Examining urban water management practices—Challenges and possibilities for transitions to sustainable urban water management in Sub-Saharan cities. *Sustain. Cities Soc.* **2019**, *48*, 101573. [CrossRef]

30. Jia, X.; O’Connor, D.; Hou, D.; Jin, Y.; Li, G.; Zheng, C.; Ok, Y.S.; Tsang, D.C.W.; Luo, J. Groundwater depletion and contamination: Spatial distribution of groundwater resources sustainability in China. *Sci. Total Environ.* **2019**, *672*, 551–562. [CrossRef]

31. Mulligan, J.; Bukachi, V.; Clause, J.C.; Jewell, R.; Kirimi, F.; Odbert, C. Hybrid infrastructures, hybrid governance: New evidence from Nairobi (Kenya) on green-blue-grey infrastructure in informal settlements: “Urban hydroclimatic risks in the 21st century: Integrating engineering, natural, physical and social sciences to build. *Anthropocene* 2020, *29*. [CrossRef]

32. Pedersen Zari, M.; Blaschke, P.M.; Jackson, B.; Komugabe-Dixon, A.; Livesey, C.; Loubser, D.I.; Martinez-Almoyna Gual, C.; Maxwell, D.; Rastandeh, A.; Renwick, J.; et al. Devising urban ecosystem-based adaptation (EbA) projects with developing nations: A case study of Port Vila, Vanuatu. *Ocean Coast. Manag.* **2020**, *184*. [CrossRef]

33. Brunetta, G.; Salata, S. Mapping urban resilience for spatial planning—A first attempt to measure the vulnerability of the system. *Sustainability* 2019, *11*, 2331. [CrossRef]

34. Thompson, K.; Sherren, K.; Duinker, P.N. The use of ecosystem services concepts in Canadian municipal plans. *Ecosyst. Serv.* **2019**, *38*, 100950. [CrossRef]

35. Belčáková, I.; Świader, M.; Bartyňa-Zielińska, M. The green infrastructure in cities as a tool for climate change adaptation and mitigation: Slovakian and polish experiences. *Atmosphere* 2019, *10*, 552. [CrossRef]

36. Fung, C.K.W.; Jim, C.Y. Influence of blue infrastructure on lawn thermal microclimate in a subtropical green space. *Sustain. Cities Soc.* **2020**, *52*. [CrossRef]

37. Marando, F.; Salvatori, E.; Sebastiani, A.; Fusaro, L.; Manes, F. Regulating Ecosystem Services and Green Infrastructure: Assessment of Urban Heat Island effect mitigation in the Municipality of Rome, Italy. *Ecol. Modell.* **2019**, *392*, 92–102. [CrossRef]

38. Carrard, N.; Foster, T.; Willetts, J. Groundwater as a source of drinking water in southeast Asia and the Pacific: A multi-country review of current reliance and resource concerns. *Water* 2019, *11*, 1605. [CrossRef]

39. Castelli, G.; Foderi, C.; Guzman, B.H.; Ossoli, L.; Kempff, Y.; Bresci, E.; Salbitano, F. Planting waterscapes: Green infrastructures, landscape and hydrological modeling for the future of Santa Cruz de la Sierra, Bolivia. *Forests* 2017, *8*, 437. [CrossRef]

40. Yang, C.; Nan, J.; Yu, H.; Li, J. Embedded reservoir and constructed wetland for drinking water source protection: Effects on nutrient removal and phytoplankton succession. *J. Environ. Sci. (China)* **2020**, *87*, 260–271. [CrossRef]

41. Belmeziti, A.; Cherqui, F.; Kaufmann, B. Improving the multi-functionality of urban green spaces: Relations between components of green spaces and urban services. *Sustain. Cities Soc.* **2018**, *43*, 1–10. [CrossRef]

42. Langemeyer, J.; Wedgwood, D.; McPhearson, T.; Baró, F.; Madsen, A.L.; Barton, D.N. Creating urban green infrastructure where it is needed—A spatial ecosystem service-based decision analysis of green roofs in Barcelona. *Sci. Total Environ.* **2020**, *707*. [CrossRef]

43. McFarland, A.R.; Larsen, L.; Yeshitela, K.; Engida, A.N.; Love, N.G. Guide for using green infrastructure in urban environments for stormwater management. *Environ. Sci. Water Res. Technol.* **2019**, *5*, 643–659. [CrossRef]

44. Liquete, C.; Udias, A.; Conte, G.; Grizzetti, B.; Masi, F. Integrated valuation of a nature-based solution for water pollution control. Highlighting hidden benefits. *Ecosyst. Serv.* **2016**, *22*, 392–401. [CrossRef]

45. Beery, T.H.; Raymond, C.M.; Kyttä, M.; Olafsson, A.S.; Plenininger, T.; Sandberg, M.; Stenseke, M.; Tengö, M.; Jönsson, K.I. Fostering incidental experiences of nature through green infrastructure planning. *Ambio* 2017, **46**, 717–730. [CrossRef] [PubMed]

46. Cortinovis, C.; Zulian, G.; Geneletti, D. Assessing nature-based recreation to support urban green infrastructure planning in Trento (Italy). *Land* **2018**, *7*, 112. [CrossRef]

47. Jerome, G.; Mell, I.; Shaw, D. Re-defining the characteristics of environmental volunteering: Creating a typology of community-scale green infrastructure. *Environ. Res.* **2017**, *158*, 399–408. [CrossRef]

48. Riegeletal.; Lynggaard-Jensen, A.; Krogsdaa,J.; Gerner, N.V.; Anzaldua, G.; Mark, O.; Butts, M.; Birk, S. Making the ecosystem services approach operational: A case study application to the Aarhus River, Denmark. *Sci. Total Environ.* **2020**, *707*. [CrossRef]
49. Fan, P.; Ouyang, Z.; Basnou, C.; Pino, J.; Park, H.; Chen, J. Nature-based solutions for urban landscapes under post-industrialization and globalization: Barcelona versus Shanghai. *Environ. Res.* 2017, 156, 272–283. [CrossRef]

50. Sahani, J.; Kumar, P.; Debele, S.; Spyrou, C.; Loupis, M.; Aração, L.; Porcù, F.; Shah, M.A.R.; Di Sabatino, S. Hydro-meteorological risk assessment methods and management by nature-based solutions. *Sci. Total Environ.* 2019, 696. [CrossRef]

51. Grizzetti, B.; Lanzanova, D.; Liquete, C.; Reynaud, A.; Cardoso, A.C.C. Assessing water ecosystem services for water resource management. *Environ. Sci. Policy.* 2016, 61, 194–203. [CrossRef]

52. Raymond, C.M.; Frantzeskaki, N.; Kabisch, N.; Berry, P.; Breil, M.; Nita, M.R.; Geneletti, D.; Calfapietra, C. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environ. Sci. Policy.* 2017, 77, 15–24. [CrossRef]

**Publisher's Note:** MDPI stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (http://creativecommons.org/licenses/by/4.0/).