resources

MDPI

Review

Key Enablers of and Barriers to the Uptake and Implementation of Nature-Based Solutions in Urban Settings: A Review

Shahryar Ershad Sarabi [1,*], Qi Han [1], A. Georges L. Romme [2], Bauke de Vries [1] and Laura Wendling [3]

[1] Information Systems in the Built Environment (ISBE) group, Department of Built Environment, Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands
[2] School of Industrial Engineering, Eindhoven University of Technology, 5612 AZ Eindhoven, The Netherlands
[3] VTT Technical Research Centre Ltd., 02150 Espoo, Finland
* Correspondence: s.ershad.sarabi@tue.nl; Tel.: +31-402-475-403

Received: 3 June 2019; Accepted: 29 June 2019; Published: 30 June 2019

check for updates

Abstract: Climate change and urbanization have resulted in several societal challenges for urban areas. Nature-based solutions (NBS) have been positioned as solutions for enhancing urban resilience in the face of these challenges. However, the body of conceptual and practical knowledge regarding NBS remains fragmented. This study addresses this gap by means of a systematic review of the literature, to define NBS as a theoretical concept; its broader significance with respect to societal challenges; the key stakeholders in NBS planning, implementation and management; and major barriers to and enablers of NBS uptake. The results of this review reveal that, despite a lack of consensus about the definition of NBS, there is a shared understanding that the NBS concept encompasses human and ecological benefits beyond the core objective of ecosystem conservation, restoration or enhancement. Significant barriers to and enablers of NBS are discussed, along with a proposed strategic planning framework for successful uptake of NBS.

Keywords: NBS; nature-based solutions; systematic review; barriers; enablers; strategic planning

1. Introduction

Climate change already significantly affects urban ecosystems [1] and this impact is expected to increase in the future [2]. In addition to climate change, rapid urbanization has accelerated the degradation of urban ecosystems via increases in the size and density of built areas, consumption of natural resources, and habitat loss [3,4]. The majority of the world's population lives in urban areas and significant further urbanization is anticipated in the next two decades [5]. By 2050, an estimated 66% of the world's population will reside in cities [6]. Conversely, urbanization is a multifaceted process that yields efficiency in the usage of space, promotes economic development, and facilitates technological innovation [3].

In the last few decades, several ecosystem-based approaches have been devised to re-nature urban areas, in an effort to enhance the resilience of urban systems [4]. The concept of nature-based solutions (NBS) is one of the more recent concepts proposed for this purpose. NBS harness natural capital to deliver ecosystem services, along with a range of other benefits, which serve to address key social, environmental, and economic challenges [7]. The initial focus of the NBS concept was on enhancing resilience in the context of climate change [8], but the broader potential for NBS to address socioeconomic challenges along with environmental issues has been increasingly recognized [7].

While NBS have been conceived as practical solutions for urban resilience [7], the uptake of the concept has been limited to date. In this respect, the NBS concept remains unclear both conceptually and practically, which fuels the idea that NBS may simply be another 'buzzword' that is easily misused [8,9]. The present review aims to map what is known about barriers to and enablers of the uptake and implementation of NBS in urban environments. To address the ambiguous nature of the NBS concept, we undertook an analysis of the existing literature on NBS, to help clarify the overarching concept of NBS as well as to identify the key barriers to and enablers of successful NBS uptake. As such, this review study contributes to building a body of knowledge on NBS, which should enable city administrators, policy makers, startups that offer NBS solutions, and many other stakeholders to overcome key barriers to the adoption and implementation of NBS. Moreover, considering the findings of the review, a strategic planning framework will be developed to support the uptake and implementation of NBS.

2. Materials and Methods

A systematic literature review was conducted to provide an overview of research to date related to the uptake of NBS. A search for publications addressing NBS as a theoretical concept, as well as NBS adoption, management, planning and implementation, was conducted in March 2019 using the Scopus search engine. Scopus was selected due to its broader coverage compared to other academic search engines [10]. The term "nature-based solutions" was used to search the "title", "keyword", and "abstract" fields of the indexed literature. The initial search yielded a total of 250 publications.

In the second step, the abstract and introduction sections were read and papers entirely focused on technical and physical dimensions of NBS (e.g., biophysical studies) were eliminated from the sample. This step served to reduce the number of reviewed publications to 68 (see also Figure 1). Additional screening of the entire text of these publications was undertaken to identify those that were relevant for our research questions regarding the barriers to and enablers of NBS. As a result, a final dataset of 41 publications was obtained.

The selected papers were all published between 2015 and 2019, which underlines that NBS are a relatively young concept. In the final set of studies, 22 papers were empirical. Out of 41 papers, 32 were published in academic journals and 9 are chapters in books. Geographically, 23 studies address (some part of) the EU context, 15 studies are global in nature, one study is conducted in Asia, one in the US and another one in Australia.

The primary goal of the analysis was to map the diversity in conceptualizations and to explore which specific issues are studied more or less. We analyzed the papers qualitatively by full text analysis to identify how the authors have conceptualized NBS, objectives of NBS, key stakeholders in developing NBS, and the barriers and enablers for implementation and uptake of NBS (see Figure 1). We provided categories for these different dimensions and queried the set of publications based on these categories. To ensure the consistency of the data extraction and analysis we developed a data extraction spreadsheet (see Supplementary Materials).

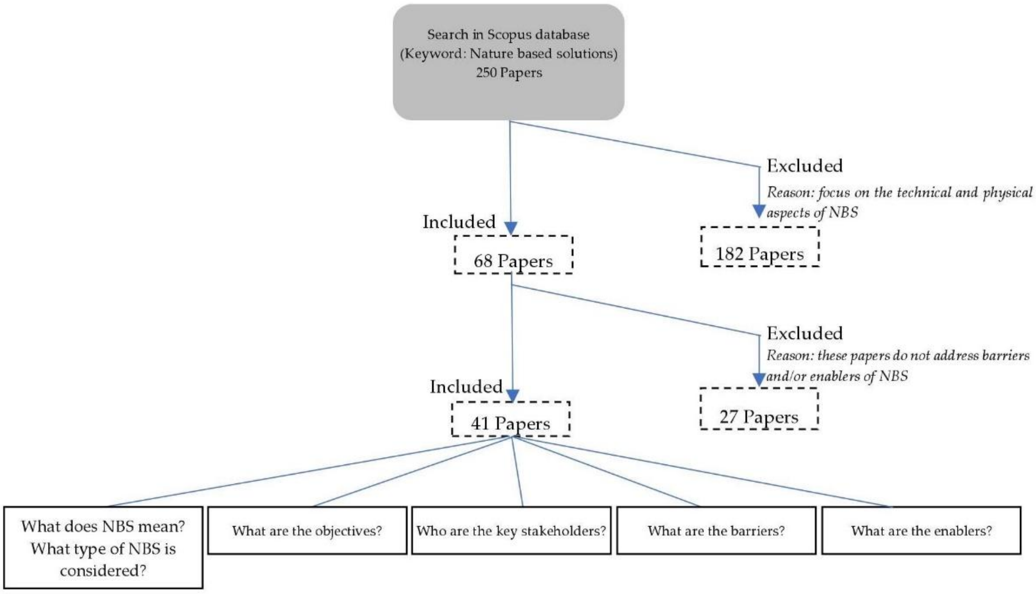

Figure 1. Representation of the review process.

3. Results

In this section, the main results are described, starting with the fundamentals of the NBS concept. Subsequently, relevant actors and the barriers to and enablers of NBS are identified.

3.1. Fundamentals of the Nature-Based Solutions Concept

As a relatively new concept, NBS is not yet clearly defined and thus there is a lack of understanding regarding what NBS are and are not; this increases the risk that the concept is misused [9]. In addition, questions can be raised regarding the necessity of the concept, its added values in comparison to alternative approaches, and the applicability of NBS to specific objectives. In this section, current definitions and typologies of NBS are first discussed, and then the necessity of the concept is investigated by exploring the added values and various objectives of implementing NBS.

3.1.1. NBS: What does it mean?

Various definitions have been proposed for NBS. Table 1 provides several examples, and thus illustrates that the definitions used tend to differ significantly, both in content and in the jargon used. There are two definitions that are often cited and may thus serve as key reference points. These definitions were proposed earlier by the International Union for the Conservation of Nature (IUCN) [11] and the European Commission (EC) [7], respectively. These two broad definitions, reproduced in the last two rows of Table 1, are both formulated to embrace a variety of approaches and interventions. IUCN's definition [11] emphasizes the importance of nature conservation and restoration, whereas the EC [7] has a broader perspective and simultaneously considers the three pillars of sustainability [12,13].

Table 1. Definitions proposed for NBS.

NBS are ...	Reference
"any transition to a use of ecosystem services with decreased input of non-renewable natural capital and increased investment in renewable natural processes."	Maes and Jacobs [14], p. 123
"multifunctional green interventions delivering upon the social, economic and environmental pillars of sustainable development."	van der Jagt et al. [15], p. 265

Table 1. *Cont.*

NBS are . . .	Reference
"soft engineering approaches that are aimed at increasing the resilience of territories and societies affected by meteorological events and therefore reducing the economic, functional, cultural, and social damage disruption that such events cause."	Short et al. [16], p. 242
"actions that alleviate a well-defined societal challenge (challenge-orientation), employ ecosystem processes of spatial, blue and green infrastructure networks (ecosystem processes utilization), and are embedded within viable governance or business models for implementation (practical viability)."	Albert et al. [12], p. 12
"conscious use of nature to help urban inhabitants address various environmental, social and economic challenges."	Kronenberg et al. [17], p. 295
"actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits."	Cohen-Shacham et al. [11], p. 2
"Nature-based solutions are actions inspired by, supported by or copied from nature and which aim to help societies address a variety of environmental, social and economic challenges in sustainable ways."	EC [7], p.5

To clarify which perspective is more common, we classified the publications reviewed into two groups in Table 2. The first group of publications conceptualizes NBS as actions that are designed to conserve and restore nature, placing biodiversity at the heart of the NBS concept (in line with IUCN's definition), whilst the second group of publications conceptualize NBS as actions designed to address environmental, social and economic challenges simultaneously by maximizing generation of ecosystem services (the definition from the EC). Table 2 shows that nine studies are in line with the former definition and 27 were based on the latter definition. The other publications did not exhibit an explicit inclination toward one of the two viewpoints.

Table 2. Groups for defining NBS.

NBS as . . .	Focus	Number of Papers	References
Solutions to major societal challenges while improving natural capital and biodiversity	Nature conservation and restoration	9	[16,18–25]
Solutions which meet environmental, economic and social objectives simultaneously	Sustainable development	27	[8,12–15,17,26–46]

The result of this analysis shows that the sustainability perspective is more common among the reviewed publications. In other words, NBS are more often considered as solutions that provide benefits to the environment and humans simultaneously rather than focusing on nature conservation and restoration. This result is aligned with the views of Nesshöver et al. [13] who suggest that NBS do not inherently conserve nature or enhance the biodiversity, and that the specific aim of NBS development should be explicitly recognized in NBS projects. This is important as the provision of ecosystem services is not always positively correlated with biodiversity enhancement outcomes [8].

Another way to map the territory of NBS is to cluster solutions based on the level of ecosystem intervention, drawing on the typology proposed by Eggermont et al. [9]. These authors identified three types of NBS: Type 1 are NBS with minimal or no interventions including protection and conservation, urban planning and monitoring strategies; type 2 are management approaches to develop sustainable ecosystems and optimize the generation of chosen ecosystem services, like integrated water resource management plans or installation of apiaries, and; type 3 include highly intensive management approaches, including those aiming at the creation of entirely new ecosystems, which constitutes the most visible type of solution in the area of NBS. We analyzed the set of publications to assess which type of NBS was referenced and used in each publication. Table 3 shows which studies refer to one of the three types defined above or to multiple types.

Table 3. Types of NBS.

Types of NBS	Number of Articles	References
Type 3	19	[15,17,23,25–30,32–34,38,40,43,44,47,48]
Type 2	3	[16,35,36]
Type 1	2	[18,20]
Multiple types	11	[9,12,13,19,22,24,31,37,41,46,49]

Table 3 points out that type 3 of NBS, characterized by a high level of managerial intervention, has received most attention in the literature. In fact, actions involving less managerial interventions were only rarely identified as NBS (see type 1 and 2 in Table 3). In addition, publications that address multiple types of NBS primarily deal with types 2 and 3. The focus of the reviewed literature on type 3 and to a lesser extent type 2, implies a greater alignment with the three-pillar sustainability perspective underpinning the EC's definition of NBS [9]. However, this focus in the publications reviewed may result from a reporting bias; for instance, type 1 of NBS is possibly reported less in scientific publications than in popular publications or on social media.

The EC's phrase "actions inspired by, supported by or copied from nature", a key element of their NBS definition [7], has added to the confusion. Krauze and Wagner [37] attempted to clarify this phrase from the perspective of ecohydrology, by describing the notion of 'mimicking nature' as "introducing biophysical structures into blue-green infrastructure and urban-green infrastructure", and 'manipulating nature' as the "introduction of agents external to the indigenous system". In addition, Krauze and Wagner [37] classified NBS based on city management zones. According to this framework, the role of NBS changes from preserving nature to enabling nature as the location of NBS moves from outer parts of the cities toward the city center. By combining the NBS typology of Eggermont et al. [9] with Krauze and Wagner's [37] framework, one can argue that the shift from type 1 to type 3 of NBS converges with a decreasing emphasis on the 'natural' character of the urban environment and an increasing emphasis on the proximity of NBS to the city center (Figure 2). This is not to say that type 1 NBS cannot be found in the inner parts of a city, but the general pattern observed is that the level of managerial intervention required in NBS increases when moving (closer) to the center of an urban area. Figure 2 illustrates the change in perspective of NBS from nature-oriented to a sustainability orientation.

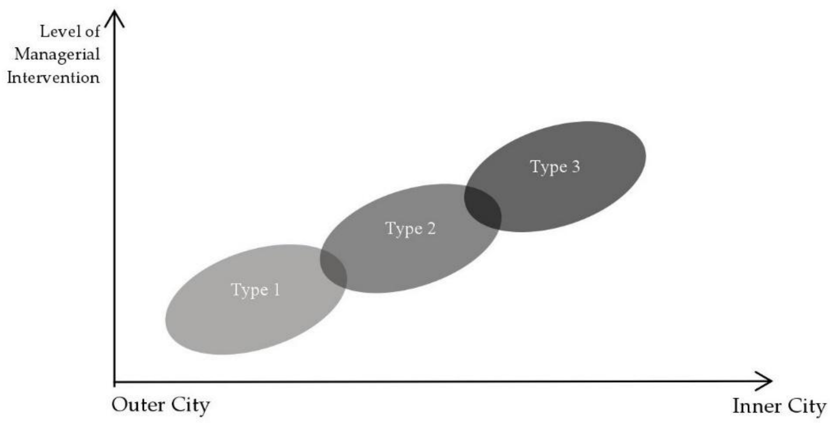

Figure 2. Schematic representation of range of NBS (Type1: NBS to improve use or protection of natural ecosystems, Type2: NBS to improve managed ecosystem sustainability or function, Type3: Design and management of newly-created ecosystems); adapted from [9] and [37].

In the reviewed publications, in particular those referring to type 3 NBS, other terms such as blue-green infrastructure and ecological engineering, were occasionally used interchangeably with NBS. This highlights the need to more explicitly characterize how NBS and the processes through which they are created, implemented and managed, differ from other theoretical concepts or actions designed to achieve similar socioecological objectives.

3.1.2. Why are NBS Important? What are the Objectives for Developing NBS?

Nature-based solutions are gaining increasing attention from scientists and practitioners as potential solutions to enhance ecological, social and economic urban resilience [13,48]. The multiple co-benefits of NBS support increasing resilience of urban socioecological systems through the creation and enhancement of the system's capacity to accommodate and adapt to disturbances such as flooding, heatwaves, coastal erosion, etc. [48]. While, renaturing urban areas to enhance urban ecological resilience and sustainability is not a new concept [21], there are specific factors that make NBS an innovative concept. For instance, Pauleit et al. [21] introduced NBS as a multidisciplinary umbrella concept that combines the lessons learned from previous ecosystem-based approaches, and Nesshöver et al. [13] emphasized the transdisciplinary nature of the NBS concept. As discussed in both studies, NBS not only combine different bodies of knowledge, but also incorporate knowledge of actors from multiple levels, especially citizens who have context-based knowledge. Davies and Lafortezza [45] mentioned the focus of NBS on applicability of solutions as an important added value. Overall, cross-sectoral multifunctionality is the main factor that makes NBS interesting for stakeholders and a strong investment option for sustainable urban development [8,9,13,15,27,36].

Based on an analysis of 20 case studies in European cities, Raymond et al. [27] proposed ten challenge areas to which NBS can contribute. These challenge areas are: climate change mitigation and adaptation; water management; coastal resilience; green space management; air quality; urban regeneration; participatory planning and governance; social justice and social cohesion; public health and well-being; and economic opportunities and green jobs. An analysis of the empirical studies (i.e., 22 of the 40 publications) serves to identify which challenges have been addressed in the literature (see Table 4).

Table 4. Objectives for developing NBS.

Objectives	Number of Papers	References
Climate Change Mitigation and Adaptation	10	[12,17,20,24,26,35,38,41,43,50]
Water Management	14	[12,16–18,20,22–24,26,29,38,39,41,50]
Coastal Resilience	2	[18,23]
Green Space Management	7	[15,20,34,35,43,44,49]
Air Quality	4	[17,38,46,49]
Urban Regeneration	8	[15,24,26,31,35,44,46,49]
Participatory Planning and Governance	8	[15,16,26,31,35,39,46,49]
Social Justice and Social Cohesion	9	[15,16,26,31,35,39,43,46,49]
Public Health and Well-being	10	[15,17,26,29,31,34,35,39,43,49,51]
Economic Opportunities and Green Jobs	5	[15,16,20,29,43]

Among the biophysical challenges identified by Raymond et al. [27], the NBS literature focuses primarily on water management and enhancing water resilience. In this area, the role of NBS is mainly to improve connectivity of the water cycle, increase water retention and infiltration, and manage surface run-off. The contribution of NBS to climate change adaptation and carbon sequestration is also cited frequently. Moreover, our analysis reveals considerable attention to the socioeconomic benefits of NBS. Several of the reviewed publications provide evidence for the potential of NBS to bring stakeholders together and initiate social innovations [15,24,35,46]. In particular, NBS have been noted to be highly effective in enhancing ecosystem stewardship and sense of place among affected populations, especially vulnerable people and low-income groups who are typically under-represented [26]. This benefit is especially acknowledged in relation to urban gardens and urban agricultural areas, where citizens directly participate in the management, maintenance and monitoring of NBS [15,35,36,49]. The role of NBS in providing health and well-being benefits such as improved mental health, e.g., [51], and encouraging healthy and dynamic life styles, e.g., [39] were also emphasized in the reviewed publications. While the EC [7] maintains a particular focus on the potential of NBS to create job opportunities, this benefit is hardly or not considered in any of the reviewed studies. The economic benefits of NBS are typically limited to the cost effectiveness of specific solutions, e.g., [29] and the job creation potential of NBS is only explicitly articulated in the context of urban agriculture [15,36]. Notably, the results of this analysis might possibly have been more in favor of biophysical challenge areas, if we would have included studies drawing on a more technical perspective. Nonetheless, our review clearly shows that the concept of NBS emphasizes the importance of enhancing both social and ecological resilience in urban areas.

In sum, by mapping the concept and objectives of NBS, this section served to clarify that the scope of NBS goes beyond nature conservation, and the NBS concept equally emphasizes its potential benefits to social and ecological resilience. In the next section, the NBS concept is discussed from a more practical perspective.

3.2. Nature-Based Solutions in Action

In this section, we analyze the key actors in developing NBS, and explore the barriers and enablers of NBS identified in the selected papers.

3.2.1. Who are the Key Actors?

Review of the selected NBS literature identified four levels of actors relevant for NBS development (Table 5). Micro-level actors include citizens, landowners, business owners, citizen groups, and non-governmental organizations (NGOs). Meso-level actors work at the city level, and include municipal departments, water boards and similar local actors. The macro-level actors work at regional, national and international levels, and include regional and national authorities, and international organizations. Transboundary actors transcend these geographical levels and organizational boundaries, by fostering relationships and networks among producers and users of NBS.

Table 5. Stakeholders in NBS development.

Actors	Number of Papers	References
Micro	28	[8,13,15–17,20,22,24,26–36,40,44–46,48–50,52]
Meso (city level)	27	[8,13,15–17,20,22,24,26–29,31–36,40,43–46,48–50,52]
Macro (regional, national or international)	12	[14–17,20,23,28,33,36,40,43,52]
Transboundary	7	[15–17,26,31,45,50]

Meso-level and micro-level actors are the most recognized groups in the reviewed literature and are typically identified as the key actors for uptake and implementation of NBS. Micro-level actors constitute the most diverse category of actors and are the primary beneficiaries of NBS [36]. The role of this group also varies in different cases from end-users with little decision-making power (top-down management) to the initiators of NBS innovations with genuine power to make decisions (bottom-up management) [26,31]. Micro-level actors are core to the NBS concept and contribute essential contextual knowledge and experience to management actions. This group of actors are usually active in the level of parcels or single NBS elements e.g., [15,26], with short-term goals and actions [8]. The role of meso-level actors (municipal departments) can vary in different contexts from initiators of NBS e.g., [35], to monitoring, supervisory, and supportive roles e.g., [15]. This group of actors are identified as critical mainly due to their role in providing the required institutional context and providing land and financial support for development of NBS e.g., [26]. The benefits that this group receives from NBS include improving the image of the city and increasing municipal income e.g., [44]. This group of actors are active at the city scale and are characterized with longer-term perspectives in comparison to the micro-level actors. Among macro-level actors, the role of the EC is emphasized [33,36], especially for providing incentives to accelerate the transition toward NBS e.g., [17], along with a framework for NBS demonstration and knowledge exchange [33]. National and regional level actors are also mentioned as effective stakeholders, particularly through provision of an appropriate institutional context [23,28,43].

An important group of actors whose role is emphasized in the literature reviewed are transboundary actors, also known as change agents or knowledge brokers. These actors are important as their actions diffuse knowledge of NBS among multiple stakeholders and facilitate mainstreaming the concept into urban planning practices, by engaging disparate groups to form networks centered on NBS [16,45]. Depending on the context, different actors can play this role. For example, NGOs and scientists functioned as transboundary actors in a Polish green roof initiative [17], whereas a project officer, appointed by the local district council, played this role in the case of a NBS project focused on flood management in the UK [16]. Frantzeskaki et al. [31] argued that the role of transboundary actors is central to NBS innovation diffusion.

3.2.2. Barriers to Successful Development of NBS

We analyzed the reviewed NBS literature to recognize the barriers mentioned for successful implementation and uptake of NBS. Six major barriers were identified. The results are presented in Table 6.

Table 6. Barriers to successful development and uptake of NBS.

Barriers	Number of Papers	References
Inadequate financial resources *	9	[22,24,27,31,32,34,36,39,40]
Path dependency *	7	[8,17,31,40,43,45,50]
Institutional fragmentation *	6	[8,22,31,34,50,52]
Inadequate regulations *	6	[17,20,22,36,40,52]
Uncertainty regarding implementation process and effectiveness of the solutions ***	18	[8,9,12,13,15–18,20,22–25,27,28,31,32,35,37,39–41,52]
Limited land and time availability **	7	[12,23,27,31,36,37,52]

* = socio-institutional barriers, *** = hybrid barriers (both socio-institutional and biophysical), and ** = biophysical barriers.

Inadequate financial resources can be a significant barrier to NBS implementation. Specific funding opportunities to facilitate the implementation of NBS are limited. In addition, many of the co-benefits associated with NBS can be realized only in the long-term whereas funding schemes tend to be short-term in nature [31]. Municipalities have limited resources, and autonomy in deciding how to allocate the expenditures [32]. Sole reliance on governmental and municipal resources to finance solutions places a great deal of pressure on these institutions and highlights the critical need for additional exploration of economic opportunities related to NBS in order to encourage private investment [24].

The other identified barrier to uptake and implementation of NBS is the so-called 'path dependency' of organizational decision making, which confines decision makers by their active memory based on past experiences and often leads to resistance to change [45]. This barrier can be linked to what Kabisch et al. [8] referred to as the 'paradigm of growth'. Urban stakeholders are accustomed to using gray infrastructure for addressing challenges and enhancing the built-up areas for the purpose of economic growth. Changing the mindset of stakeholders toward NBS can be a difficult process, and breaking the 'path dependence' requires changing individual and societal behavior [43].

Institutional fragmentation ('sectoral silos') is another important barrier mentioned in the literature. Different departments usually work in line with their own vision, legal frameworks and procedures, and use their own sectoral language [31]. Different responsibilities distributed among multiple agencies and departments are a barrier for the production of benefits from NBS, and limit the opportunities for incorporating novelty in the NBS planning and management process [52]. The split among responsibilities can cause confusion about who is the owner, and who should operate and maintain the NBS in the long-term [50].

Regulations supporting NBS implementation are scattered [52]. In general, the prevailing regulations have been developed from gray infrastructures as the main, or only available, option to address given challenges. In other cases, the principle of ecosystem protection may not underpin regulations, or legislation may not encompass all environmental components, as is the case in China where farm ponds are not covered in the environmental regulations [20]. On occasion, even when appropriate regulations and policies exist, a lack of law enforcement can limit the uptake of solutions [22].

Lack of information, or the uncertainty regarding NBS implementation processes and benefits, is frequently mentioned in the literature as a critical barrier limiting the uptake of NBS by decision makers. As innovations dealing with complex social-ecological systems, NBS are characterized by multiple uncertainties [8]. The lack of comprehensive information regarding the creation, implementation and management of NBS as well as the dearth of evidence regarding NBS effectiveness across widespread spatial and temporal scales may lead to a great deal of uncertainty, particularly among the public [37], or even invoke conflict among actors [22,35]. The body of knowledge regarding NBS has remained largely academic [52], with limited diffusion which has negatively affected the level of acceptance of NBS by the public [16,22].

Limited space (land) and time are additional barriers mentioned in the reviewed literature. In general, NBS require more land and time to provide the expected benefits than conventional gray infrastructure approaches [23]. Limited available space, especially in urban areas, can restrict development of NBS. This barrier is particularly apparent in the inner parts of the city where land is a scarce and expensive resource [37]. In many cases, the benefits of NBS may be fully realized only in the long-term, limiting their acceptance to local level actors with shorter-term agendas. The successful implementation of NBS requires long-term collaborative efforts among multiple stakeholders [12], thus there is a need to view NBS and the benefits delivered from a longer-term perspective.

3.2.3. Enablers for Successful Development of NBS

Previously we have discussed the multiple functions that NBS provides and the barriers for developing these solutions. However, to realize the multifunctionality of NBS and to address the barriers, various approaches, mechanisms, or actions can be adopted. Several enablers have been mentioned in the reviewed literature (Table 7).

Table 7. Enablers for successful implementation of NBS.

Enablers	Number of Papers	References
Partnership among stakeholders *	27	[8,9,12,13,15–17,19,20,22,24,26–28,30–36,43,45,46,48–50]
Knowledge sharing mechanisms and technologies *	9	[8,13,20,23,27,33,35,43,45]
Economic instruments *	9	[14,15,32,33,36,39,40,44,52]
Plans, acts and legislations *	9	[15,20,28,35,36,43–45,49]

Table 7. *Cont.*

Enablers	Number of Papers	References
Education and training *	8	[16,20,27,31,36,43,45,50]
Effective monitoring and Valuation systems for implementation process and benefit ***	16	[8,9,12–14,16,19,20,26–29,32–34,42]
Open innovation and Experimentation ***	5	[15,16,26,31,34]
Combining NBS with other urban elements and gray infrastructures **	8	[12,22,23,27,28,37,43,45]
Appropriate planning and design **	5	[26,30,34,37,48]

* = socio-institutional enablers, *** = hybrid enablers (both socio-institutional and biophysical), and ** = biophysical enablers.

The most frequently identified socio-institutional enabler is the partnership among stakeholders and organizations from multiple levels (vertical cooperation) as well as from the same level (horizontal cooperation). NBS are designed to deal with challenges that are affected by or affect multiple stakeholders, and partnerships are required to ensure the generation of multiple benefits [15]. Nesshöver et al. [13] identified three specific benefits that partnerships with stakeholders can bring to the NBS development process: 1) 'Substantive' benefits by providing local perspectives and improving the planning; 2) 'instrumental' benefits to bring support for the plan, and; 3) 'normative' benefits by increasing the legitimacy of the process. Through face-to-face partnerships, stakeholders can generate shared visions of and understanding of the solutions and nature [16], while open dialogue can foster greater acceptance of NBS, and break the 'path dependence' [22].

Partnerships with local actors especially community groups can encourage trust, while facilitating ecosystem stewardship and social learning as critical factors for socioecological resilience [24,35]. Citizens can empower the NBS planning and management process by their local knowledge and catalyze the "tailoring to local context" of NBS, which substantially increases the likelihood of a successful outcome [31]. Several successful examples of partnerships with NGOs can be found among papers. For instance, a partnership between an NGO and municipality led to development of the first community garden in Szeged [15]. The private sector can also bring substantial benefits, mainly due to limited technical and financial resources of municipalities [32]. The private sector can offer essential support to the NBS implementation process by sharing experience during project implementation as well as through the contribution of financial resources. Public-private partnerships (PPP) are encouraged as they combine the top-down regulation of the government sector with the flexibility of the private sector [24]. Partnerships between businesses and other urban stakeholders is key to showcase the potential and value of NBS for economic prosperity and human well-being. Partnerships and collaborations should also form among departments and institutions. Support of a single department that derives benefits from NBS implementation and is directly responsible for developing the solutions is insufficient in the long term. In particular, due to the multidisciplinary nature of NBS multiple departments that receive benefits from the NBS should be involved in the projects [32]. Frantzeskaki [26] emphasized an inclusive narrative of the mission for NBS to bridge the knowledge across different city departments.

There are different approaches mentioned to facilitate partnership among stakeholders. As van Ham and Klimmek [24] mention, the key to successful partnerships is developing a shared understanding of NBS and their benefits. Using place-based approaches to engage the local actors [35], or any initiative similar to the Million Trees NYC project in New York [43], serves to generate a shared understanding. The role of the transboundary actors in providing this shared understanding is important, as they can speak the language of different groups and connect them with one another [31].

The level of partnership varies in different cases and contexts with different property types [46]. There are cases like communal gardens, characterized by self-governance, where micro-level actors (e.g., citizens, gardeners, etc.) manage the ecosystem, and the role of the municipality is mentioned as the provider of land and the required institutional context [15]. In contrast, in cases of allotment gardens the green areas have been developed using a more top-down form of governance [46]. NBS with relatively more inclusive systems of property management, including engagement of varied groups of people, is believed to facilitate social learning and generation of ecosystem stewardship [46].

Knowledge sharing mechanisms and technologies are also identified as important enablers for NBS development. These technologies in urban areas are typically used for sharing ideas, getting feedback or mapping NBS issues. They enable the involvement of bigger groups of stakeholders and are faster and cheaper than physical partnerships. For instance, using e-governance, the city of Melbourne has supported successful implementation of place-making strategies through effective incorporation of citizens' knowledge in the planning process [35], or in the case of Tempelhof park in Berlin where consultation through an online platform served to engage 68,000 users and around 2500 idea contributors participated in the planning process [24].

Sharing experiences and lessons learned among different contexts using knowledge sharing technologies has also been mentioned as an enabler. For instance, knowledge repositories like Oppla (http://oppla.eu/) and ThinkNature (https://think-nature.eu/) or the Natural Infrastructure for Business platform (https://naturalinfrastructureforbusiness.org/) are instrumental in sharing experiences and best practices in implementing NBS [33], which in turn may promote investments in natural infrastructure [24].

In several cases, the use of economic instruments and incentives has been referred to as an enabler. Droste et al. [32] introduced three types of economic instruments including, price instruments, quantity instruments, and fiscal instruments. The first two instruments focus on the private actors by changing the fees and charges of using ecosystem services (price-based instruments), or limiting the activities affecting the nature (quantity instruments). The third one focuses on the decision makers in the public sector by creating incentives for developing green infrastructures and NBS through the inclusion of ecological criteria in fiscal transfer processes. Using economic instruments can encourage stakeholders to uptake and implement NBS as the alternative that can provide the best value for money to them. The economic instruments can also be in form of grants, like in the case of Szeged where a European grant aid enabled an NGO to initiate a community garden [15].

Plans, programs and legislations can be a barrier as well as an enabler. The role of meso- and macro-level actors is central in providing supportive and clear legislation. For example, the Edinburgh's Community Empowerment Act 2015 empowered the community to manage public lands [15] and legislation, such as the EU flood directive which appears to support NBS development [23]. At a local level, legislation similar to the strategic green infrastructure plan developed by the Barcelona city council [49] can facilitate mainstreaming the NBS concept by considering its social-ecological system perspective. Other examples of legislation as an enabler of NBS implementation include the Federal Law in Switzerland where agencies are required to apply the 'Swiss Landscape Concept' [28], and the "National Planning Policy Framework" in the UK that embraced sustainable urban drainage (SUD) legislation requiring municipalities to implement SUDs in residential developments with ten or more homes and in major commercial and mixed use developments [52].

Education and training programs for stakeholders from different institutional scales including citizens, and professionals is also mentioned as an enabler to decrease the uncertainties regarding the functionality of solutions and to provide public support for NBS. As Davies and Lafortezza [45] mention, training programs on NBS should be scaled up and equal study time, as is currently dedicated to gray infrastructure, should be dedicated to NBS education. Besides infrastructure professionals, educating the public through formal education in classrooms, and informal education through newspapers, television, radio, and the internet can facilitate uptake of the NBS concept [20].

Evaluation of the multiple benefits yielded by NBS, especially the social benefits, has not been fully developed to date [16]. Effective evaluation systems, or development of a standardized system of NBS evaluation considering the spatio-temporal dynamics of benefits, have been mentioned as an enabler to facilitate increased uptake of NBS [42]. At present, the most commonly accepted evaluation framework for NBS is EKLIPSE [27] developed by an expert working group under the auspices of the European Commission [33]. The EKLIPSE framework uses the ten challenges outlined by Raymond et al. [27] as the basis for evaluating NBS benefits. The innovative aspect of this framework is that synergies and tradeoffs among the challenges are considered as an important part of the assessment process. Nesshöver et al. [13] emphasized the necessity of nested multiscale assessment systems, as different NBS, and functions operating at different spatio-temporal scales. In addition, Thorslund et al. [18] emphasize the importance of viewing interactions among NBS from a broader scale. Several examples of methods to look at NBS from larger scales have been mentioned. For instance, Chen et al. [20] refer to inventory mapping as a method to monitor farm ponds on a larger scale. Other approaches considered useful for assessment and evaluation of NBS performance include multi-criteria analysis for integrated evaluation of NBS methods considering social, environmental and economic aspects from the viewpoints of multiple stakeholders, for example [29].

Collaborative monitoring approaches have also been encouraged by the literature. By using Internet of Things technology, the knowledge of local actors who interact daily with the urban ecosystem can be used to enrich the NBS monitoring systems [20]. Collaborative monitoring can provide valuable information for decision makers regarding how different groups recognize NBS functions, and can provide contextual information regarding the implementation and impact efficiency of the projects [13].

Experimenting with NBS has been mentioned as an effective strategy for implementing and evaluating solutions in a controlled environment. Artmann and Sartison [36] state that "residents doing urban gardening experience a sense of belonging". Experimentation provides an opportunity to identify optimal strategies for NBS development and to learn from mistakes without significant losses, and thus encourages appreciation for and acceptance of the solutions: "Experiments show a visible and tangible action that is accessible, invites discussions and can alter thinking and perceptions" [26]. For example, in the case of introducing perennial urban meadows in the UK, an experimentation strategy provided the maintenance staff and apprentices the opportunity to gain new skills [34]. Urban living labs (ULL) have been increasingly used, particularly in European countries, as an experimentation strategy for developing NBS. Experimentation provides opportunities for stakeholders from different levels to meet and interact, and as such facilitates innovation diffusion [15]. Experimentation strategies can thus turn a passive experience 'of nature' into an active experience 'with nature' [31].

Although the importance of bringing nature to urban areas is acknowledged, NBS should not be considered solely as an alternative to gray infrastructures in an 'either-or' sense. "Hybrid solutions that blend nature-based applications with engineered systems may provide the optimal impact considering environmental footprints, land requirements and cost expenditures" [43]. For instance, providing protection in face of extreme floods, or water cleaning functions in urban areas with high density cannot be accomplished solely through NBS implementation in most cases. Effective combination of NBS and gray infrastructure, or green-gray integration, can facilitate breaking the path dependency toward gray infrastructure in communities while retaining functional gray infrastructure [45]. Pontee et al. [23] provide detailed examples of hybrid solutions for improved coastal resilience. In some cases, using gray infrastructures with a relatively small physical footprint can be combined with implementing NBS in the remaining space [12]. For example, SUDs that combine green and gray solutions provide the opportunity to decrease flood risk and minimize the risk of pollution diffusion to downstream areas while providing several additional co-benefits [52].

In order to ensure solutions are fully implemented, they should be designed and located appropriately. For instance, Andersson et al. [48] emphasize that the size of a solution should be appropriate to the level of disturbance in case of extreme events, and Frantzeskaki [26] notes the importance of paying attention to the aesthetical aspects of NBS, critical for their successful uptake by the public. The other important issue is where NBS should be located. Andersson et al. [48] argue that "the insurance is achieved by the NBS providing a 'buffer' between the exposed area and the potential risk" and Hoyle et al. [34] recommend to locate perennial meadows in semi-rural parts of urban areas to provide optimal performance. It is important to consider NBS placement at a strategic level and plan for NBS from the landscape scale, in order to assess the interaction between NBS and urban setting and optimize the synergies and trade-offs between them [30]. Krauze and Wagner [37] emphasized the importance of looking at an urban area as an integrated system, by introducing the concept of a continuum of ecosystem services and focusing on NBS planning, to provide ecological corridors and transfer ecosystem services across different city zones. These considerations highlight the advantages of NBS planning as a component of urban development rather than as an 'added extra' arising from land use planning.

4. Strategic Planning for Nature-Based Solutions

4.1. Background

The results of our review, outlined in the previous section, provides an understanding of the state-of-the-art knowledge regarding the uptake of NBS. We discussed what NBS are, what their objectives are, which barriers arise in the development of NBS, and how to overcome these barriers. In addition, we identified the key actors in the NBS development process. Considering these different findings, we are going to propose a (preliminary) NBS strategic planning framework. In describing the various elements of this framework, we will also identify a number of areas where more research is needed.

The framework presented in this section is mainly relevant for cities that are planning to incorporate NBS and are looking for ways to decrease the risk of failure as much as possible. This framework includes three main steps (Figure 3), vision development, identification of appropriate solutions, and identification and prediction of barriers and enablers. It also provides general guidelines regarding how actors can interact in each step. The framework emphasizes the inclusion of multiple actors from different institutional levels, starting at the early stages of the planning process [8,13]. In addition, the iterative refinement of the plan regarding the barriers to and enablers of NBS uptake is another added value of this framework in comparison to conventional planning approaches. In the remainder of this section, we discuss each step separately.

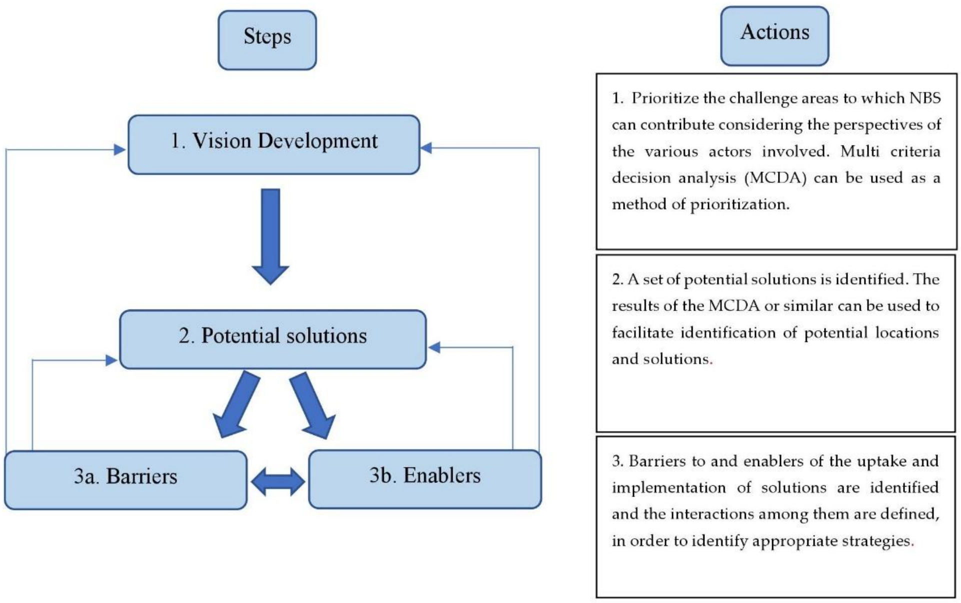

Figure 3. NBS strategic planning framework (i.e., the thick arrows represent the primary planning process and other arrows refer to feedback relations between various steps).

4.2. Vision Development

In the first step, the vision is developed in terms of the challenge areas and objectives for using NBS. In our literature review, we showed the high potential of NBS for addressing not only biophysical but also social challenges. Accordingly, NBS are able to address environmental, economic and social challenges simultaneously and give equal attention to these three aspects. Therefore, to realize the added values of NBS, one should not focus on a single challenge. For example, the municipality of Dresden cooperates with citizens, gardeners, and companies to develop a shared vision that not only covered ecological challenges but also focused on providing opportunities for learning and enhancing ecosystem stewardship [31]. Resources are often limited and each city has different needs; it may therefore be critical to prioritize the challenges to be addressed in the planning process [8,9].

Multi-criteria decision analysis (MCDA) can be used to prioritize identified challenge areas. Meerow and Newell [53] provide an example of MCDA use, whereby challenge areas were prioritized with a view to the implementation of green infrastructure in Detroit. Explicitly considering the perspectives of multiple stakeholders strongly supports development of a shared and publicly acceptable vision. However, inclusion of many different stakeholders can be highly challenging, as macro- and meso-level actors are likely to provide more strategic input while micro-level actors tend to adopt a more practical and project-based point of view. This is where transboundary actors play a key role based on their ability to speak the language of different groups and develop a shared understanding. For example, transboundary actors played an important role in co-creation actions in Stockholm by networking among local government and civil society and exploiting the synergies among different challenge areas [31].

4.3. Identification of Potential Solutions

The second step for cities is to find out how they can reach their vision. Cities should identify potential solutions that can contribute to the challenges selected. Our review suggests that NBS should be recognized as combination of elements and strategies, including all three types of NBS, as addressing challenges usually needs a cascade of NBS [41]. For example, in the case of Lambhill Stables in Glasgow, constructed wetland, urban agriculture, and bioremediation pond elements form an integrated solution to restore the minefield and provide areas for environmental education [26]. The results of the MCDA applied in the previous step can be used to prioritize protentional solutions based upon the documented performance of various types of NBS, although knowledge gaps remain concerning the performance and impact of various NBS implemented at different scales and across a range of environments. As observed earlier, the current literature largely focuses on NBS type 3, characterized by a high level of intervention (see Table 3). Additional research is required to fully characterize the performance and impact of all types of NBS, but particularly those with a lower level of intervention (i.e., Type 1 and 2). The choice of NBS is closely connected with the target location(s), and knowing the answer to the question of "where" can help each city find potential solutions. Here, the NBS literature does not currently provide a single standardized technique or tool for identifying the optimal location for NBS. Green infrastructure planning methods can also be relevant for identifying optimal NBS locations within a given urban area [53–55], although the additional sociocultural, socioeconomic and institutional/governance dimensions associated with NBS compared with green infrastructure are not fully considered by these extant techniques.

Bringing the perspectives of multiple stakeholders together is critical in this step. Macro- and meso-level actors can enrich this step by their broader view of the longer-term and large scale benefits arising from NBS, while micro-level actors can enrich the process with their local 'grassroots' knowledge about shorter-term needs and preferences [56]. It is the role of transboundary actors to ensure alignment between objectives across temporal scales, supporting design of shorter-term actions to foster achievement of longer-term goals. The importance of transboundary actors is further discussed by Andersson et al. [56], Olsson et al. [57] and Borgström et al. [58].

4.4. Identification and Prediction of Barriers

Step 3a in Figure 3 explores and predicts the barriers for the uptake and implementation of NBS. In the review, we identified six major barriers. Four of these are socio-institutional barriers and one barrier was both socio-institutional and biophysical, which is consistent with previous studies [8,59,60]. The most frequently observed barrier was uncertainty regarding the implementation process and the benefits arising from NBS, followed by inadequate financial resources, land and time availability, path dependency in decision making, institutional fragmentation, and inadequate regulations.

Every city will face a unique set of barriers, which highlights the importance of including multiple actors in all stages of the planning process. Meso-level actors are likely to be more familiar with the political and institutional barriers that may occur, while micro-level actors are more familiar with project-specific barriers. Transboundary actors can help by identifying the connections and interactions among different barriers, as well as strategies to overcome them. Methods like interpretive structural modeling (ISM) have been used to model barriers and identify the interactions among them in complex situations [61,62] and can thus also be relevant in the context of NBS. Past experiences in the same city or other cities can help to identify and predict potential barriers [8]. The process of barrier identification may result in changes to the initial vision and/or preferences for particular solutions, illustrating the iterative nature of the NBS planning process (see Figure 3). Future research on NBS should further explore the process of barrier identification to formalize a standard methodology aimed at the development of a best practices approach to overcome commonly identified barriers.

4.5. Identification and Prediction of Enablers

Step 3b illustrates the identification and prediction of enablers of NBS. Previously, we identified nine enablers for successful uptake and implementation of NBS. Five are socio-institutional enablers, two are hybrid in nature, and the remaining two are biophysical enablers; previous studies found similar results [59,60]. Developing partnerships between stakeholders appears to be the most frequently observed enabler, followed by effective monitoring, knowledge sharing, financial instruments, plans and legislations, education and training, combining with gray infrastructures, open innovation and experimentation, and appropriate planning and design. As in step 3a barrier identification, the presence of multiple actors can enrich the identification of enablers. Meso-level actors can readily map institutional and organizational enablers, while micro-level actors are better positioned to identify project- and design-related enablers. Transboundary actors drawing upon a multi-dimensional perspective are key to the identification of new, or innovative potential enablers and important in the definition of the most appropriate actions.

The ISM method has been frequently used to model the drivers and enablers in complex situations [63,64]. Iteration of previous steps to refine outcomes can also be important at this stage. For example, if an enabler is characterized by high cost or can only be realized in the long term, this may affect how actors prioritize the challenges and solutions. In Section 3, we provided several examples of how a specific enabler may alleviate a particular barrier. However, the body of knowledge explicitly addressing interactions among barriers and enablers is limited at present. The compilation of extant knowledge regarding interactions among barriers and enablers, including specific examples as case studies, could underpin practical guidelines about effectively overcoming barriers to NBS uptake and implementation.

5. Concluding Remarks

NBS are increasingly recognized as a promising means to address a number of societal challenges arising from climate change and urbanization, with multiple social, environmental and economic co-benefits. The present review shows that NBS have the potential to transform the concept of “urban nature” from a real or perceived barrier to sustainable and inclusive socioeconomic development to a necessary element of development planning and implementation. To date, the NBS literature has focused largely on NBS requiring relatively higher levels of intervention (i.e., type 3 NBS). Types of NBS characterized by a relatively greater management component compared with restoration or creation components have received lesser attention in the scientific literature. Further investigation of all types of NBS, including not only the co-creation but also the co-implementation and co-governance aspects, is necessary in order to derive a comprehensive understanding of NBS performance, impact and cross-sectoral benefits in both the short- and long-term. In particular, the contribution of NBS to social-ecological resilience requires additional examination as a function of NBS type across a broad range of sociocultural, socioeconomic and environmental contexts.

Systematic co-planning and co-management of NBS is necessary to fully exploit the potential value of NBS in any context. Herein, we identified the primary barriers to and enablers of the uptake and implementation of NBS. Based on the review results, we proposed a strategic planning framework for NBS that minimize the risk of failure and reduce the level of uncertainty associated with NBS adoption. This framework also advocates the participation of multiple actors in the early stages of the planning process to maximize the capture of relevant barriers and enablers.

Limitations of the present review include focus on publications using the keyword "nature-based solution(s)", whilst related literature discussing similar approaches such as "green infrastructure" or "ecosystem-based adaptation" may also be relevant and potentially enrich the results of this study. Despite its acknowledged limitations, the results obtained in the present study highlight several knowledge gaps related to NBS. Foremost, additional research is needed regarding the barriers, opportunities and co-benefits associated with different types of NBS as well as the synergies and trade-offs among them. In-depth analysis of barriers and enablers in each documented case of NBS uptake is required to build a reference based to identify and predict barriers to and enablers of NBS uptake and implementation. Finally, future work should study the interactions among specific barriers and enablers, as well as the influences they have on, and how they are in turn influenced by, various actors at the macro-, meso-, micro- and transboundary levels. This analysis could support the derivation of user-specific guidelines regarding the means by which a particular enabler may alleviate or overcome a given barrier, further promoting the widespread uptake and implementation of NBS.

Supplementary Materials: The following are available online at http://www.mdpi.com/2079-9276/8/3/121/s1.

Author Contributions: S.E.S. conducted the review and wrote the first version of the manuscript, and Q.H., A.G.L.R., B.d.V. and L.W. provided feedback on earlier versions of the manuscript and edited it.

Funding: This research has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No. 730052.

Acknowledgments: We would like to thank Elke den Ouden and Rianne Valkenburg for comments and feedback on previous versions of this paper. We are grateful for UNaLab partners and especially to Tom Hawxwell and Sophie Mok who shared their ideas and perspectives with us during the development of this paper.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. White, P.; Pelling, M.; Sen, K.; Seddon, D.; Russell, S.; Few, R. *Disaster Risk Reduction: A Development Concern. A Scoping Study on Links between Disaster Risk Reduction, Poverty and Development*; Report to UK Department for International Development (DFID): London, UK, 2004.
2. European Environmental Agency. *Climate Change, Impacts and Vulnerability in Europe 2012: An Indicator-Based Report*; European Environmental Agency: Copenhagen, Denmark, 2012.
3. McDonald, R.I.; Marcotullio, P.J.; Güneralp, B. Urbanization and Global Trends in Biodiversity and Ecosystem Services. In *Urbanization, Biodiversity and Ecosystem Services: Challenges and Opportunities*; Springer: Dordrecht, The Netherlands, 2013; pp. 31–52.
4. Haase, D.; Larondelle, N.; Andersson, E.; Artmann, M.; Borgström, S.; Breuste, J.; Gomez-Baggethun, E.; Gren, Å.; Hamstead, Z.; Hansen, R.; et al. A Quantitative Review of Urban Ecosystem Service Assessments: Concepts, Models, and Implementation. *Ambio* **2014**, *43*, 413–433. [CrossRef] [PubMed]

5. United Nations. *World Urbanization Prospects, The 2011 Revision*; United Nations Department of Economic and Social Affairs: New York, NY, USA, 2012.
6. United Nations. *World Urbanization Prospects: The 2014 Revision (Highlights)*; United Nations Department of Economic and Social Affairs: New York, NY, USA, 2014; Volume 32.
7. European Commission. *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*; European Commission: Brussels, Belgium, 2015.
8. Kabisch, N.; Stadler, J.; Korn, H.; Bonn, A.; Frantzeskaki, N.; Pauleit, S.; Naumann, S.; Davis, M.; Artmann, M.; Haase, D.; et al. Nature-based solutions to climate change mitigation and adaptation in urban areas. *Ecol. Soc.* **2016**, *21*. [CrossRef]
9. Eggermont, H.; Balian, E.; Azevedo, J.M.N.; Beumer, V.; Brodin, T.; Claudet, J.; Fady, B.; Grube, M.; Keune, H.; Lamarque, P.; et al. Nature-based solutions: new influence for environmental management and research in Europe. *GAIA Ecol. Perspect. Sci. Soc.* **2015**, *24*, 243–248. [CrossRef]
10. Yang, K.; Meho, L.I. Citation Analysis: A Comparison of Google Scholar, Scopus, and Web of Science. *Proc. Am. Soc. Inf. Sci. Technol.* **2007**, *43*, 1–15. [CrossRef]
11. Cohen-Shacham, E.; Walters, G.; Janzen, C.; Maginnis, S. *Nature-Based Solutions to Address Global Societal Challenges*; IUCN: Gland, Switzerland, 2016.
12. 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]
13. Nesshöver, C.; Assmuth, T.; Irvine, K.N.; Rusch, G.M.; Waylen, K.A.; Delbaere, B.; Haase, D.; Jones-Walters, L.; Keune, H.; Kovacs, E.; et al. The science, policy and practice of nature-based solutions: An interdisciplinary perspective. *Sci. Total Environ.* **2017**, *579*, 1215–1227. [CrossRef] [PubMed]
14. Maes, J.; Jacobs, S. Nature-Based Solutions for Europe's Sustainable Development. *Conserv. Lett.* **2017**, *10*, 121–124. [CrossRef]
15. Van der Jagt, A.P.N.; Szaraz, L.R.; Delshammar, T.; Cvejić, R.; Santos, A.; Goodness, J.; Buijs, A. Cultivating nature-based solutions: The governance of communal urban gardens in the European Union. *Environ. Res.* **2017**, *159*, 264–275. [CrossRef] [PubMed]
16. Short, C.; Clarke, L.; Carnelli, F.; Uttley, C.; Smith, B. Capturing the multiple benefits associated with nature-based solutions: Lessons from a natural flood management project in the Cotswolds, UK. *L. Degrad. Dev.* **2019**, *30*, 241–252. [CrossRef]
17. Kronenberg, J.; Bergier, T.; Maliszewska, K. The Challenge of Innovation Diffusion: Nature-Based Solutions in Poland. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 291–305. ISBN 978-3-319-56091-5.
18. Thorslund, J.; Jarsjo, J.; Jaramillo, F.; Jawitz, J.W.; Manzoni, S.; Basu, N.B.; Chalov, S.R.; Cohen, M.J.; Creed, I.F.; Goldenberg, R.; et al. Wetlands as large-scale nature-based solutions: Status and challenges for research, engineering and management. *Ecol. Eng.* **2017**, *108*, 489–497. [CrossRef]
19. Bridgewater, P. Whose nature? What solutions? Linking Ecohydrology to Nature-based solutions. *Ecohydrol. Hydrobiol.* **2018**, *18*, 311–316. [CrossRef]
20. Chen, W.; He, B.; Nover, D.; Lu, H.; Liu, J.; Sun, W.; Chen, W. Farm ponds in southern China: Challenges and solutions for conserving a neglected wetland ecosystem. *Sci. Total Environ.* **2019**, *659*, 1322–1334. [CrossRef] [PubMed]
21. Pauleit, S.; Zölch, T.; Hansen, R.; Randrup, T.B.; Konijnendijk van den Bosch, C. *Nature-Based Solutions and Climate Change—Four Shades of Green*; Springer International Publishing: Cham, Switzerland, 2017; pp. 29–49.
22. Santoro, S.; Pluchinotta, I.; Pagano, A.; Pengal, P.; Cokan, B.; Giordano, R. Assessing stakeholders' risk perception to promote Nature Based Solutions as flood protection strategies: The case of the Glinščica river (Slovenia). *Sci. Total Environ.* **2019**, *655*, 188–201. [CrossRef] [PubMed]
23. Pontee, N.; Narayan, S.; Beck, M.W.; Hosking, A.H. Nature-based solutions: Lessons from around the world. *Proc. Inst. Civ. Eng. Marit. Eng.* **2016**, *169*, 29–36. [CrossRef]

24. Van Ham, C.; Klimmek, H. Partnerships for Nature-Based Solutions in Urban Areas—Showcasing Successful Examples. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 275–289. ISBN 978-3-319-56091-5.
25. Arkema, K.K.; Griffin, R.; Maldonado, S.; Silver, J.; Suckale, J.; Guerry, A.D. Linking social, ecological, and physical science to advance natural and nature-based protection for coastal communities. *Ann. N. Y. Acad. Sci.* **2017**, *1399*, 5–26. [CrossRef] [PubMed]
26. Frantzeskaki, N. Seven lessons for planning nature-based solutions in cities. *Environ. Sci. Policy* **2019**, *93*, 101–111. [CrossRef]
27. 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]
28. Xing, Y.; Jones, P.; Donnison, I. Characterisation of Nature-Based Solutions for the Built Environment. *Sustainability* **2017**, *9*, 149. [CrossRef]
29. 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]
30. Emilsson, T.; Ode Sang, Å. Impacts of Climate Change on Urban Areas and Nature-Based Solutions for Adaptation. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 15–27. ISBN 978-3-319-56091-5.
31. Frantzeskaki, N.; Borgström, S.; Gorissen, L.; Egermann, M.; Ehnert, F. Nature-Based Solutions Accelerating Urban Sustainability Transitions in Cities: Lessons from Dresden, Genk and Stockholm Cities. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 65–88. ISBN 978-3-319-56091-5.
32. Droste, N.; Schröter-Schlaack, C.; Hansjürgens, B.; Zimmermann, H. Implementing Nature-Based Solutions in Urban Areas: Financing and Governance Aspects. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 307–321. ISBN 978-3-319-56091-5.
33. Faivre, N.; Fritz, M.; Freitas, T.; de Boissezon, B.; Vandewoestijne, S. Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. *Environ. Res.* **2017**, *159*, 509–518. [CrossRef]
34. Hoyle, H.; Jorgensen, A.; Warren, P.; Dunnett, N.; Evans, K. "Not in their front yard" The opportunities and challenges of introducing perennial urban meadows: A local authority stakeholder perspective. *Urban For. Urban Green.* **2017**, *25*, 139–149. [CrossRef]
35. Gulsrud, N.M.; Hertzog, K.; Shears, I. Innovative urban forestry governance in Melbourne?: Investigating "green placemaking" as a nature-based solution. *Environ. Res.* **2018**, *161*, 158–167. [CrossRef]
36. Artmann, M.; Sartison, K. The Role of Urban Agriculture as a Nature-Based Solution: A Review for Developing a Systemic Assessment Framework. *Sustainability* **2018**, *10*, 1937. [CrossRef]
37. Krauze, K.; Wagner, I. From classical water-ecosystem theories to nature-based solutions — Contextualizing nature-based solutions for sustainable city. *Sci. Total Environ.* **2019**, *655*, 697–706. [CrossRef] [PubMed]
38. Engström, R.; Howells, M.; Mörtberg, U.; Destouni, G. Multi-functionality of nature-based and other urban sustainability solutions: New York City study. *L. Degrad. Dev.* **2018**, *29*, 3653–3662. [CrossRef]
39. Blau, L.M.; Luz, F.; Panagopoulos, T. Urban River Recovery Inspired by Nature-Based Solutions and Biophilic Design in Albufeira, Portugal. *Land* **2018**, *7*, 141. [CrossRef]
40. Denjean, B.; Altamirano, M.A.; Graveline, N.; Giordano, R.; van der Keur, P.; Moncoulon, D.; Weinberg, J.; Máñez Costa, M.; Kozinc, Z.; Mulligan, M.; et al. Natural Assurance Scheme: A level playing field framework for Green-Grey infrastructure development. *Environ. Res.* **2017**, *159*, 24–38. [CrossRef]
41. Keesstra, S.; Nunes, J.; Novara, A.; Finger, D.; Avelar, D.; Kalantari, Z.; Cerdà, A. The superior effect of nature based solutions in land management for enhancing ecosystem services. *Sci. Total Environ.* **2018**, *610–611*, 997–1009. [CrossRef]

42. Wendling, L.A.; Huovila, A.; zu Castell-Rüdenhausen, M.; Hukkalainen, M.; Airaksinen, M. Benchmarking Nature-Based Solution and Smart City Assessment Schemes Against the Sustainable Development Goal Indicator Framework. *Front. Environ. Sci.* **2018**, *6*. [CrossRef]
43. Santiago Fink, H. Human-Nature for Climate Action: Nature-Based Solutions for Urban Sustainability. *Sustainability* **2016**, *8*, 254. [CrossRef]
44. 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] [PubMed]
45. Davies, C.; Lafortezza, R. Transitional path to the adoption of nature-based solutions. *Land Use Policy* **2019**, *80*, 406–409. [CrossRef]
46. Langemeyer, J.; Camps-Calvet, M.; Calvet-Mir, L.; Barthel, S.; Gómez-Baggethun, E. Stewardship of urban ecosystem services: Understanding the value(s) of urban gardens in Barcelona. *Landsc. Urban Plan.* **2018**, *170*, 79–89. [CrossRef]
47. Turkelboom, F.; Leone, M.; Jacobs, S.; Kelemen, E.; García-Llorente, M.; Baró, F.; Termansen, M.; Barton, D.N.; Berry, P.; Stange, E.; et al. When we cannot have it all: Ecosystem services trade-offs in the context of spatial planning. *Ecosyst. Serv.* **2018**, *29*, 566–578. [CrossRef]
48. Andersson, E.; Borgström, S.; McPhearson, T. Double Insurance in Dealing with Extremes: Ecological and Social Factors for Making Nature-Based Solutions Last. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 51–64. ISBN 978-3-319-56091-5.
49. Camps-Calvet, M.; Langemeyer, J.; Calvet-Mir, L.; Gómez-Baggethun, E. Ecosystem services provided by urban gardens in Barcelona, Spain: Insights for policy and planning. *Environ. Sci. Policy* **2016**, *62*, 14–23. [CrossRef]
50. Wamsler, C. Mainstreaming ecosystem-based adaptation: Transformation toward sustainability in urban governance and planning. *Ecol. Soc.* **2015**, *20*. [CrossRef]
51. Vujcic, M.; Tomicevic-Dubljevic, J.; Grbic, M.; Lecic-Tosevski, D.; Vukovic, O.; Toskovic, O. Nature based solution for improving mental health and well-being in urban areas. *Environ. Res.* **2017**, *158*, 385–392. [CrossRef] [PubMed]
52. Davis, M.; Naumann, S. Making the Case for Sustainable Urban Drainage Systems as a Nature-Based Solution to Urban Flooding. In *Nature-Based Solutions to Climate Change Adaptation in Urban Areas: Linkages between Science, Policy and Practice*; Kabisch, N., Korn, H., Stadler, J., Bonn, A., Eds.; Springer International Publishing: Cham, Switzerland, 2017; pp. 123–137. ISBN 978-3-319-56091-5.
53. Meerow, S.; Newell, J.P. Spatial planning for multifunctional green infrastructure: Growing resilience in Detroit. *Landsc. Urban Plan.* **2017**, *159*, 62–75. [CrossRef]
54. Kremer, P.; Hamstead, Z.A. The value of urban ecosystem services in New York City: A spatially explicit multicriteria analysis of landscape scale valuation scenarios. *Environ. Sci. Policy* **2016**, *62*, 57–68. [CrossRef]
55. Norton, B.A.; Coutts, A.M.; Livesley, S.J.; Harris, R.J.; Hunter, A.M.; Williams, N.S.G. Planning for cooler cities: A framework to prioritise green infrastructure to mitigate high temperatures in urban landscapes. *Landsc. Urban Plan.* **2015**, *134*, 127–138. [CrossRef]
56. Andersson, E.; Barthel, S.; Borgström, S.; Colding, J.; Elmqvist, T.; Folke, C.; Gren, Å. Reconnecting Cities to the Biosphere: Stewardship of Green Infrastructure and Urban Ecosystem Services. *Ambio* **2014**, *43*, 445–453. [CrossRef] [PubMed]
57. Olsson, P.; Folke, C.; Galaz, V.; Hahn, T.; Schultz, L. Enhancing the fit through adaptive co-management: Creating and maintaining bridging functions for matching scales in the Kristianstads Vattenrike Biosphere. *Ecol. Soc.* **2007**, *12*. [CrossRef]
58. Borgström, S.; Elmqvist, T.; Angelstam, P.; Alfsen-Norodom, C. Scale mismatches in management of urban landscapes. *Ecol. Soc.* **2006**, *11*. [CrossRef]
59. O'Donnell, E.C.; Lamond, J.E.; Thorne, C.R. Recognising barriers to implementation of Blue-Green Infrastructure: a Newcastle case study. *Urban Water J.* **2017**, *14*, 964–971. [CrossRef]
60. Ahn, Y.H.; Pearce, A.R.; Wang, Y.; Wang, G. Drivers and barriers of sustainable design and construction: The perception of green building experience. *Int. J. Sustain. Build. Technol. Urban Dev.* **2013**, *4*, 35–45. [CrossRef]
61. Singh, M.D.; Kant, R. Knowledge management barriers: An interpretive structural modeling approach. *Int. J. Manag. Sci. Eng. Manag.* **2008**, *3*, 141–150. [CrossRef]

62. Winz, I.; Trowsdale, S.; Brierley, G. Understanding barrier interactions to support the implementation of sustainable urban water management. *Urban Water J.* **2014**, *11*, 497–505. [CrossRef]
63. Nishat Faisal, M. Sustainable supply chains: A study of interaction among the enablers. *Bus. Process Manag. J.* **2010**, *16*, 508–529. [CrossRef]
64. Rehman, M.A.A.; Shrivastava, R. An innovative approach to evaluate green supply chain mamagement (GSCM) drivers by using interpretive structural modeling (ISM). *Int. J. Innov. Technol. Manag.* **2011**, *8*, 315–336. [CrossRef]