



Barriers and Drivers for Mainstreaming Nature-Based Solutions for Flood Risks: The Case of South Korea

Sungju Han^{1,2} · Christian Kuhlicke^{1,2,3}

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Abstract Nature-based solutions (NBS) are seen as a promising adaptation measure that sustainably deals with diverse societal challenges, while simultaneously delivering multiple benefits. Nature-based solutions have been highlighted as a resilient and sustainable means of mitigating floods and other hazards globally. This study examined diverging conceptualizations of NBS, as well as the attitudinal (for example, emotions and beliefs) and contextual (for example, legal and political aspects) barriers and drivers of NBS for flood risks in South Korea. Semistructured interviews were conducted with 11 experts and focused on the topic of flood risk measures and NBS case studies. The analysis found 11 barriers and five drivers in the attitudinal domain, and 13 barriers and two drivers in the contextual domain. Most experts see direct monetary benefits as an important attitudinal factor for the public. Meanwhile, the cost-effectiveness of NBS and their capacity to cope with flood risks were deemed influential factors that could lead decision makers to opt for NBS. Among the contextual factors, insufficient systems to integrate NBS in practice and the ideologicalization of NBS policy were found to be peculiar barriers, which hinder consistent realization of initiatives and a long-term national plan for NBS. Understanding the barriers and

drivers related to the mainstreaming of NBS is critical if we are to make the most of such solutions for society and nature. It is also essential that we have a shared definition, expectation, and vision of NBS.

Keywords Climate change · Flood risk management · Nature-based solutions (NBS) · South Korea

1 Introduction

Globally, flooding has been one of the most devastating natural hazards, causing serious damage to people and surrounding environments (UNISDR 2015). The likelihood of such extreme events is expected to increase in coming years due to climate change (Hirabayashi et al. 2013) and extensive land-use changes in urban areas (Field et al. 2012; Thielen et al. 2016).

South Korea is no exception to this trend. In July and August 2020, a record-breaking rainfall event caused severe damage and fatalities in South Korea. It was the longest monsoon since records began in 1973, with torrential downpours affecting the central regions and Jeju. The nationwide floods and landslides took the lives of 42 people, over 5,100 households were forced to evacuate, and there was immense economic loss. Such extreme meteorological patterns are expected to increase in the East Asia region. This raises unsettling questions about how South Korea will cope with extreme flooding events that exceed the engineered capacity of current interventions (Shafique and Kim 2018).

In response to such extreme climate patterns, nature-based solutions (NBS) have come to the fore as novel and sustainable flood risk management (FRM) measures

✉ Sungju Han
sungju.han@ufz.de

¹ Department of Urban and Environmental Sociology, UFZ—Helmholtz Centre for Environmental Research, 04318 Leipzig, Germany

² Institute for Environmental Sciences and Geography, University of Potsdam, 14468 Potsdam-Golm, Germany

³ German Centre for Integrative Biodiversity Research (iDiv) Halle-Jena-Leipzig, 04103 Leipzig, Germany

(Wesenbeeck et al. 2017; Jongman 2018), although they do not yet play a major role in South Korea. The term NBS was first used by the World Bank in 2008 (MacKinnon et al. 2008), and the International Union for Conservation of Nature (IUCN) also adopted the term for its 2013–2016 program (Cohen-Shacham et al. 2016). The European Commission (EC) integrated the concept into its framework program for research and innovation—Horizon 2020—to support its ambition to make the European Union a forerunner in the realization of NBS (European Commission 2015). The IUCN and the EC define the concept of NBS differently. The IUCN defines NBS as “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. 2016, p. 2). In contrast, the EC defines nature-based solutions as a way to address societal challenges with solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience (European Commission 2015). Although the IUCN definition focuses on restoring the ecosystem that has been modified by human use, the EC definition puts a more explicit goal on dealing with societal challenges to co-benefits, with little emphasis on the ecosystem.

Despite such subtle differences, the term NBS is considered an umbrella term that encompasses other established concepts, such as green and blue infrastructure and ecosystem-based adaptation (Albert et al. 2017; Seddon et al. 2020). Agreeing on the inclusiveness of the term from the established definitions, this research used the term NBS from the design of the study as sustainable measures that aim to manage the diverse societal challenges effectively and simultaneously while delivering multiple benefits, but not incurring irreversible harm to nature hereafter. Here, we did not limit the balance of natural elements or engineering inputs on nature-based policy measures, but rather maintain a broad use of the term.

Contrary to conventional measures, which are often capital-intensive and can lead to biophysical degradation (Palmer et al. 2015), NBS can help to reduce flood risks effectively, while also contributing to nature conservation and sustainable natural resource management (Kabisch et al. 2016; Pauleit et al. 2017). An increasing number of studies have proven risk reduction effectiveness of NBS for floods in coastal areas (Narayan et al. 2016), river catchments (Daigneault et al. 2016), and urban areas (Zellner et al. 2016), as well as its cost-effectiveness compared to engineered alternatives (Collentine and Futter 2018). Likewise, some countries have initiated sustainable FRM frameworks that can be considered nature-based solutions,

such as “sponge cities” for flood control in China, and sustainable urban drainage systems in the UK.

Against this background, researchers have paid attention to the barriers and drivers behind the mainstreaming and successful implementation of NBS (O’Donnell et al. 2017; Wells et al. 2019). In previous research, barriers and drivers were identified by reviewing secondary literature (Sarabi et al. 2019), conducting surveys in the context of project implementation (Kabisch et al. 2016; Piacentini and Rossetto 2020), or interviewing practitioners (Matthews et al. 2015). People’s perception of the co-benefits was seen as a prominent driver of greater uptake (Raymond et al. 2017), while skepticism about the capacity of NBS to manage risks was interpreted as a barrier (Gray et al. 2017; Martinez-Juarez et al. 2019). Besides that, Chou (2016) pointed out that people’s existing knowledge about flood risks and the implemented measures can influence people’s acceptance of NBS. The barriers and drivers related to NBS are interdependent and context-dependent, which is why an understanding of the underlying reasons and causal factors impacting acceptance is essential for the mainstreaming of NBS (Eisenack et al. 2014).

Hence, our research aims, first, to summarize how NBS are conceptualized in South Korea and, second, to explore what hampers or promotes the perceptions and attitudes required for the mainstreaming of NBS. This is achieved by analyzing the attitudinal and contextual factors specific to South Korea by means of semistructured interviews with experts.

The remainder of the article is as follows: Case study and methods are laid out in Sect. 2; Sect. 3 presents the main findings from the expert interviews. To conclude, Sect. 4 summarizes and discusses the main findings and provides recommendations for the mainstreaming of NBS in South Korea.

2 Case Study and Methods

In this section, we elaborate the case of South Korea (Sect. 2.1) and the method (Sect. 2.2) that this research adopted.

2.1 Case Study

In the past, river management in South Korea primarily focused on achieving stability through command and control. The key objective was to supply water to farmers and to ensure consistent water levels in the river. With increasing demand for the reestablishment and recovery of nature, river management and its direction has gradually changed over time (Fig. 1).

In the 1970s, the government tried to control rivers by straightening, damming, and channeling. In the 1980s and

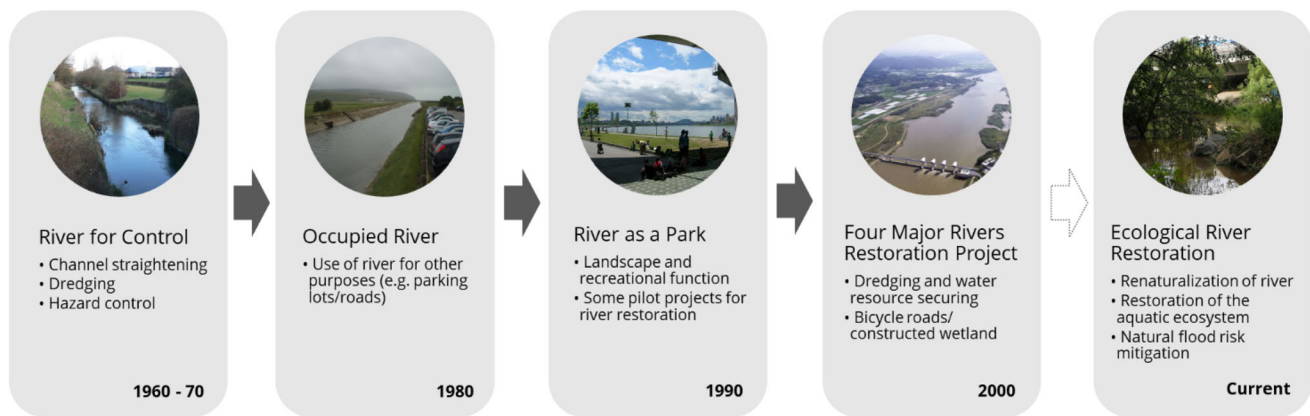


Fig. 1 Changes in river management in South Korea. *Source* Wikimedia Commons

1990s, there was an initial attempt to take river ecosystems into consideration during maintenance projects. The foci of these projects were limited to aesthetic attributes of the landscape, however, and pursued a rather utilitarian perspective (for example, the river as a park). Systematic ecological river restoration only appeared in the 2000s, first introduced by the *Yangjaecheon* stream restoration in Seoul. In the 2010s, the central government led the Four Major Rivers Restoration Project, a five-year national project that was implemented across the country as a part of the Green New Deal policy (Cha et al. 2011). The project consisted of large-scale dredging and the construction of reservoirs, weirs, and small dams, allegedly aiming to improve biodiversity and water quality. These changes to the river environment later became ecological disturbances such as eutrophication, which resulted in social controversy and conflicts about whether to call it natural restoration or destruction (Song and Lynch 2018). As a result, in 2018 South Korea's Ministry of Environment launched an investigation to evaluate the project's consequences and impacts on riverine ecosystems. A fierce discussion is ongoing about whether to dismantle or reopen the weir gates and pay more attention to the renaturalization and restoration of the rivers (Lah et al. 2015; Lee et al. 2019).

Despite a gradual change towards ecological river management, NBS approaches in FRM have so far not played an essential role in South Korea. Instead, responses to the unprecedented monsoon in the summer of 2020 were technical. For instance, the government proposed dam management using smart technology and artificial intelligence-generated flood forecasts and warnings but nothing significant was proposed that was related to NBS for FRM.

2.2 Methods

To explore what hampers and stimulates the uptake of NBS for flood risks, we conducted expert interviews in South Korea. This method of research helps to explore the views of the interviewees and how they frame specific problems and challenges (Pfadenhauer 2009).

The authors chose interviewees based on their expertise in flood risks and water management as indicated by their job descriptions and publications. Since the term NBS is not widely used in South Korea, water professionals with expertise and experience in low impact development (LID) and green infrastructure for flood risks, as well as ecological river restoration projects were identified. To identify additional water management experts, we employed a snowball method that involved searching interviewee referral lists. In total, 11 experts were interviewed; 10 interviewees were educated at the doctoral level, and one had a Master's degree with over 10 years of related research experience. The experts were from universities (coded AC), non-university research institutes (coded RE), government (coded GO), and civil society organizations (coded CS) (Table 1).

The face-to-face interviews were conducted between December 2019 and January 2020 in four cities (Seoul, Goyang, Busan, and Sejong), and each interview lasted around 60 to 200 minutes. The interview was semistructured with open-ended questions. All interviews were recorded with the written consent of the interviewees and then transcribed in Korean. The key topics covered by the questions were categorized into: (1) flood risks and their countermeasures in Korea (questions 4–8); (2) evaluation of NBS implementation in Korea (questions 9–15); and (3) procedural aspects in flood risk mitigation and NBS implementation in South Korea (questions 16–22). The data were then coded and thematically analyzed with the software MAXQDA. To better investigate the contexts and

Table 1 List of the experts interviewed about nature-based solutions (NBS) between December 2019 and January 2020

	Discipline				Total
	Planning	Engineering	Science	Policy	
University (AC)	AC1 AC3		AC2		3
Non-University Research Institute (RE)	RE3	RE1 RE2 RE4	RE5		5
Government (GO)		GO2		GO1	2
Civil Society (CS)				CS1	1
Total	3	4	2	2	11

to prevent linguistic confusion, the coding process for the text analysis was performed in the original language (Korean).

The coding scheme was guided by the following steps (also shown in Fig. 2). First, a broad range of potential themes was collected by reviewing existing literature. The themes were then narrowed down using the criterion of empirical evidence. The provisional parental codes developed through the previous steps were used to create a coding scheme structure; then a further inductive coding process was conducted to find emerging themes based on the interview transcript. New codes were added when additional nuance or related concepts were detected during the analysis, and provisional codes that did not appear were deleted. This process was implemented iteratively until the final coding scheme was developed and the analysis was completed.

We analyzed how our interviewees reflected upon and conceptualized NBS and how they evaluated their multiple benefits. We also analyzed attitudinal factors that relate to individual emotions, beliefs, and behavior towards NBS. In this step, we also analyzed contextual factors from outside of the personal sphere, varying from institutional, legal,

social, and political aspects. We also focused on how both attitudinal and contextual factors affect individual perception towards NBS.

3 Results

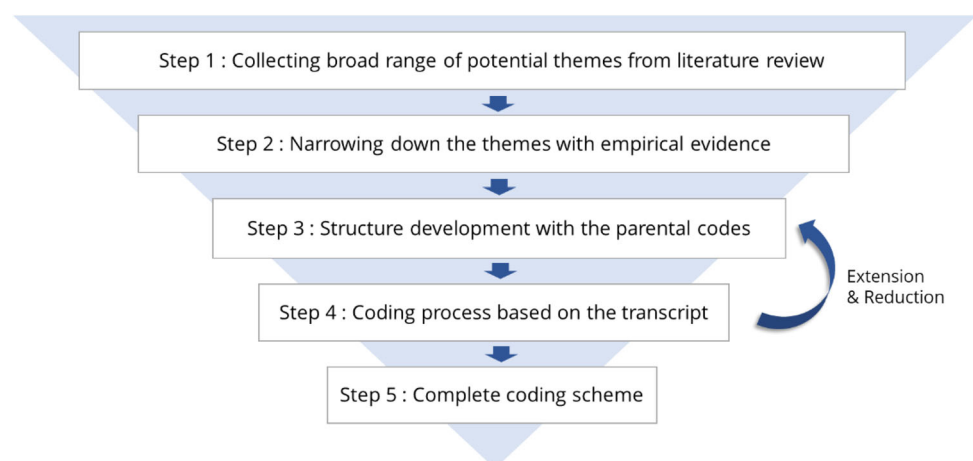
In this section, the analysis results are described. Conceptualization of nature-based solution is described in Sect. 3.1, and attitudinal and contextual factors are illustrated in Sects. 3.2 and 3.3.

3.1 Conceptualization of Nature-Based Solutions: Discordance and Conflicting Cases

The term NBS is not yet well established in South Korea. During the interviews, 10 out of the 11 experts preferred to use terms other than NBS, such as green infrastructure, low impact development (LID), or ecosystem-based approach.

Four experts perceived NBS as a new paradigm. They argued that the concept of NBS goes beyond established FRM concepts and engineering-based river restoration concepts. According to them, NBS are not just concerned

Fig. 2 Development of the coding scheme used for thematic analysis of data derived from nature-based solutions interviews



with the reestablishment or recovery of an ecosystem but rather aims to establish a harmonious socioecological system. In this regard, the four interviewees argued that the implicit aim of NBS is not complete control of the risks, but a kind of human adjustment to nature that entails living with the risk of floods. CS1 explained this point in the quote below and RE1 viewed it similarly:

In the past, artificial facilities such as embankments and dams were used to mitigate flood risks, therefore, we used the term “flood control,” or “flood prevention.” But now we realize it is impossible to control and prevent the flood completely. Therefore, we are now trying to adjust our lifestyles to the flood, get adapted, and survive with it by understanding nature. [...] It is advantageous in the long run and harmonious with nature.

In contrast, seven experts perceived NBS as a technological advancement that adds engineered techniques and materials to established measures. They argued that managing risks is not possible without technological advancement. In this regard, they highlighted the hybrid solution of technical and natural approaches, which they viewed as an innovation that maximizes risk mitigation efficacy. They also suggested that nature-based solutions do not always have to meet an expectation of renaturalization; instead, the seven interviewees emphasized the multiple benefits of NBS besides its capacity to manage risk. In this conceptualization, LID engineering and green technology elements in large-scale development projects are considered NBS.

The NBS cases drew conflicting opinions from the interviewees. For example, the well-known Cheonggyecheon river restoration was criticized by several experts (GO1 and CS1). They argued that it is a landscape work made into an urban park without considering ecological restoration elements. RE4 argued that the Eco-delta city project in Busan is an example of NBS in land development, while AC3 criticized it as a reckless development without a proper siting process. Considering this heterogeneity, we classified the conceptualization of experts into two groups (Table 2).

Overall, we did not find unanimous agreement on a NBS conceptualization. The interviewees conceptualized nature similarly as an input of ecological elements or principles to achieve a more sustainable and ecological ecosystem. However, the degree of nature or engineering input to the intervention and the perspectives on defining co-benefits, from anthropocentric to nature-centered, varied noticeably.

3.2 Attitudinal Factors

We found 16 attitudinal factors that impacted the mainstreaming of NBS, including 11 barriers and five drivers. These are summarized in Table 3 and further details are described in the following sections.

3.2.1 Perceived Capacity to Cope with Flood Risks

Nature-based solutions are perceived as insufficient for managing flood risk. Four interviewees argued that the effectiveness of NBS has not been well quantified due to a lack of practical implementation and scientific evaluation; NBS are not convincing enough for decision makers (AC2, AC3, RE1, and RE2). Also, three respondents believe that it is difficult for decision makers to opt for NBS due to the high uncertainty with regard to achieving desired benefits and effectively managing flood risks (AC2, CS1, and RE2). AC2 called NBS a “black box,” thereby aligning it with more natural elements and thus more ontological uncertainty. This attribute was exemplified by references to the time lag between the start and successful completion of NBS (AC2 and CS1), and the occurrence of unexpected events (RE2). Two interviewees mentioned that the spatial constraints facing the construction of a large and flexible NBS site as a drawback, particularly in the urban context (RE2 and RE3).

Nature-based solutions are sometimes perceived as auxiliary or decorative options. Five experts indicated that NBS can be effective in mitigating climate change in the long term and restoring ecological value with multiple co-benefits. But for dealing with immediate flood risks, technical flood barriers were seen to be more cost-efficient and effective (AC3, CS1, GO2, RE1, and RE3). The interviewees viewed the transition to NBS as a matter of choice and as something that will add value over the long term. AC3 cited the example of LID technology, such as permeable pavement, which would not work at all in an urban, localized, torrential downpour. According to GO2, the NBS are just “add-on” options for technical flood barriers when budgets allow. In this regard, RE3 emphasized the role of hybrid measures that combine grey and green measures.

In relation to public perceptions, two experts suggested that technical barriers provide a greater feeling of security to the affected residents (RE3 and GO1). Specifically, a lack of physical appearance (RE3) and a high degree of naturalness (GO1) are seen as relevant barriers to public acceptance of NBS.

Table 2 Typology of the experts' conceptualization of nature-based solutions (NBS) for flood risks

Conceptualization	Arguments	Mentioned Cases
(1) NBS represent a recent paradigm shift away from traditional technical measures; NBS also have a different aim (argued by AC1, CS1, GO1, RE1)	<ul style="list-style-type: none"> • NBS goes beyond pure recovery of naturalness; it also considers social-ecological systems • NBS represent a transition from the “controlling” paradigm to the “living with hazards” paradigm 	<ul style="list-style-type: none"> • Restored reservoirs • Ecological parks with a flood mitigation purpose • River restoration with a human-nature relationship consideration, etc. • Set-back of levees and dikes
(2) NBS are an outcome of innovative advancements in engineering technology and materials (argued by AC2, AC3, GO2, RE2, RE3, RE4, RE5)	<ul style="list-style-type: none"> • NBS are just a way of using advanced methods and materials in a more environmentally friendly way • The hybrid approach represents the NBS • Technological advancement and the multiple benefits that come with it are considered essential 	<ul style="list-style-type: none"> • Small-size green infrastructure in urban areas (e.g., roof-top rain garden) • Permeable block paving • River restoration combining ecological techniques with more nature-mimicking techniques • Public (recreation) facilities with underground storage tanks, etc.

Table 3 Attitudinal barriers and drivers for mainstreaming nature-based solutions (NBS) in South Korea

Category	Barriers (B) and Drivers (D)	Number of Experts
Perceived coping capacity	(B) Insufficient quantification of risk management efficacy	4
	(B) Uncertainty regarding risk management efficacy and the achievability of desired benefits	3
	(B) Lack of physical appearance/structures	1
	(B) Time lag	2
	(B) Occurrence of unexpected events	1
	(B) Spatial constraint	2
	(B) Perception of nature-based solutions as an add-on option	5
Cost effectiveness	(B) Higher implementation cost than technical solutions	4
	(B) Higher maintenance cost and maintenance difficulties	3
	(D) Ageing of conventional infrastructures incurs higher maintenance cost	3
	(D) Comprehensive cost-benefit analysis with the values of nature-based solutions	3
Co-benefits/Self-interest	(D) Direct monetary benefit (for example, land or property price rise)	11
	(D) High aesthetic and recreational value	4
	(D) Use value of nature-based solutions: user convenience, proximity to the sites	2
	(B) Influence on residents' livelihood by dismantling old infrastructure	2
	(B) “Untouched nature” aspect of nature-based solutions	2

3.2.2 Perceived Cost-Effectiveness

The interviewees had conflicting views on the implementation and maintenance of NBS. Four individuals perceived general NBS implementation costs as higher than the cost of conventional measures (AC3, RE2, RE3, and RE4). They attributed these higher implementation costs to patent rights for innovative technologies and more expensive materials (RE2) or the immense compensation costs

involved in land acquisition for large-scale NBS projects (AC3, RE3, and RE4). Regarding maintenance and monitoring, three interviewees perceived many difficulties associated with maintenance due to a lack of understanding among the public and practitioners (AC3, RE2, and RE4). For example, AC3 mentioned the “urban rain garden” that uses vegetation for stormwater management and stated that long-term maintenance of such systems is hindered by a lack of knowledge about sustaining vegetation. Also,

Table 4 Contextual barriers and drivers for mainstreaming of nature-based solutions (NBS) in South Korea

Category	Barriers (B) and Drivers (D)	Number of Experts
Institutional	(B) Lack of operational capacity among engineering companies and practitioners	4
	(B) Industrial inertia set in conventional flood risk management	3
	(D) Incentives for marketability and business environment	3
	(B) Incentives used for “greenwashing” or indulgent development projects	3
	(B) Siloed thinking and psychological path dependence	5
Legal	(B) Intrinsic value of nature not recognized in flood risk management	3
	(B) Insufficient legal basis for land acquisition, compensation, and incentives	4
	(B) Unclear liability between the local governments or within the organizations	5
Political	(B) Populism in nature-based solutions politics	3
	(B) Ideologicalization of nature-based solutions policy	3
Social	(B) Insufficient practices of public participation at the local government level	4
	(B) Strong coalitions and stakeholder groups	4
	(B) Lack of public understanding of nature-based solutions operations	4
	(B) Discrepancies in nature-based solutions knowledge	1
	(D) Role of intermediaries and facilitators	1

unspecified and vague responsibilities for maintenance and monitoring were mentioned as a barrier (AC3). Meanwhile, three interviewees pointed out that the aging of conventional infrastructures could incur higher maintenance costs (AC3, CS1, and RE5). In contrast, a government official refuted this, saying that the maintenance costs for dams and weirs are just an ongoing expense, which would apply to any infrastructure, and do not burden the government (GO2).

Three interviewees argued that a more comprehensive cost-benefit analysis that considers the long-term value of NBS (AC3 and RE4) and multiple co-benefits including ecological value (RE2) ought to be applied to compare the alternative options. This view acknowledged the broader discourse about the cost-effectiveness of NBS.

3.2.3 Perceived Co-Benefits and Self-Interest

All interviewees believed that direct monetary benefits (for example, rises in land or property prices) are the most influential factor in people’s acceptance of NBS. Four interviewees described a type of NBS with a particular aesthetic and recreational value as an “urban garden” or “playground” (CS1, GO1, GO2, and RE4). Two interviewees pointed out that NBS that affect the livelihoods of residents, for instance, through the dismantling of old infrastructures or alterations to the landscape, would lower public acceptance (RE2 and RE3). People were especially unlikely to support the implementation of a new measure if

it hampered their income-generating activities (for example, altered landscape after the removal of a dam).

Two interviewees stated that the perceived use-value of NBS varies by individual and results in different degrees of acceptability (AC2 and RE4). Here, user convenience and proximity to the NBS sites were seen as important factors that influence how individuals perceive the benefits. In this regard, individual willingness to pay for NBS would differ (AC2) depending on individual characteristics and resulting differences in perceived marginal benefits. Also, CS1 and RE1 recognized that untouched nature is not always preferred by everyone.

3.3 Contextual Factors

We found 13 barriers and 2 drivers to the mainstreaming of NBS; we categorized these factors as institutional, legal, political, or social (Table 4). The details are illustrated in the next section.

3.3.1 Institutional Aspects: Operational Capacity and Path Dependence

Four interviewees regarded the insufficient operational capacity of local governments and practitioners as a key barrier for NBS uptake (CS1, RE2, RE3, and RE4). Three members of this group also mentioned that lack of technical expertise among local practitioners was reflected in pilot projects that did not consider NBS as an option at the proposal stage (CS1, RE2, and RE4). Two interviewees

pointed out that the FRM structure, in which the central government has long played a pivotal role also causes reduced organizational capability at the local government level owing to lack of experience and knowledge (RE3 and RE4). A recently changed law mandates the transfer of responsibility for the management of the provincial rivers from the central government to the corresponding local governments, but interviewees expressed concern about local governments' lack of technical capacity to carry out these new responsibilities and therefore implement NBS.

At the practitioner level (that is, industries that implement NBS), three interviewees saw industrial inertia as a barrier to the mainstreaming of NBS (AC1, CS1, and GO1). They argued that the established industries in conventional FRM and underlying interests have set the current system in stone, discouraging practitioners to move on to the new scheme. Transitioning to NBS requires practitioners to give up familiar knowledge or language and, potentially, their existing sources of income. In this regard, three interviewees argued in favor of providing practitioners with incentives to invigorate the business environment and marketability of NBS (AC1,¹ CS1, and RE5). Three interviewees thought that incentives can be used for indulgent urban development projects or greenwashing—as if having an NBS element in the project design is a panacea for any environmental harm caused by the project (AC1, AC3, and GO1).

At the decision-maker level, five interviewees regarded psychological path dependence—the concept that decisions are dependent on previous experience and customary practices—as a barrier (AC3, CS1, GO1, RE3, and RE4). They pointed out that, particularly when perceived flood risk is high, decision makers are likely to seek “good old” technical measures to secure the area.

3.3.2 *Legal Aspects: Lack of Conceptualization of Nature-Based Solutions and Unclear Liability*

Some interviewees perceived that the elements that support NBS implementation have not been fully translated into current law. Three interviewees indicated that the intrinsic value of nature is not well recognized in the current FRM system (GO1, RE2, and RE4). GO1 highlighted the observation that the river laws that overarch FRM have conceptualized the river as an object of use or an object to control in order to facilitate human life. Therefore these laws focus merely on the river's instrumental value. Another four interviewees considered there to be an insufficient legal basis for land acquisition, compensation, and incentives during the NBS implementation process (AC1, AC3, GO1, and RE2).

¹ AC1 addressed both the pros and cons of incentives.

Around half of the interviewees thought that unclear liability between the local governments or within organizational structures exists in the current legal system (AC1, AC3, GO2, RE4, and RE5). They maintained that pluralities in liability in the current laws cause inter-governmental and organizational conflicts of interest and inhibit trans-sectoral cooperation. GO2 was skeptical about the complete transfer of FRM authority from the central government to local governments; this ambiguity aggravates the conflicts of interest between the local governments and removes the central government as an arbitrator.

3.3.3 *Political Aspects: Populism and Ideologicalization of Ecological Policy*

Three experts argued that nature-based solutions are often adopted for populist reasons (AC1, GO1, and RE2). In such cases, the aesthetic attributes of the landscape (for example, urban gardens) are more emphasized than the restorative aspects for the ecosystem. At the same time, the fact that more instrumental NBS are implemented in urban areas with larger populations suggests inequity between urban and rural areas. GO1 pointed out that even though some housing land development projects were sold as NBS, they have not restored nature properly. In most cases, the projects with more aesthetical selling points have received greater residential approval and developers' interest than projects that focus exclusively on ecological restoration, revealing the dilemma of public acceptance and ecosystem restoration.

Three experts argued that NBS and overall restoration policies often represent a particular political ideology, pointing out that the change of the ruling party in 2017 has generated the political will to push ahead with policies related to NBS (CS1, GO1, and RE2). They perceive the policies related to NBS as having become a political football; people have polarized opinions regardless of their environmental attitudes or values, and those opinions are strongly informed by political ideology. CS1 illustrated this point as follows.

They don't object to river restoration. They hate it because the current government is pushing for it. [...] It is important not to make it political, particularly for renaturalization.

3.3.4 *Social Aspects: Inadequate Public Participation and Knowledge Discrepancy*

Although all the experts appreciated public participation in FRM and the process of NBS realization, some pointed out that practices of public participation have not yet been properly operationalized at the local government level

(AC2, CS1, RE1, and RE3). They perceived that local governments lack FRM experience and attributed this to the long history of the central government's role in FRM. RE3, for instance, argued that public involvement in NBS implementation should be encouraged at earlier stages of development, such as during the design process.

Two government officials (GO1 and GO2) stated that strong coalitions or stakeholder groups impede the effective implementation of NBS. They criticized these stakeholders for forming coalitions that seek to promote their own business development and serve fragmented interests, defying public interest. Questioning the representativeness of stakeholder groups in the participation process for NBS implementation, they argued that the power dynamics of the stakeholders should be more carefully considered in NBS implementation.

Four interviewees found that a lack of public understanding of NBS operations is a hindrance to smooth consultation between residents and the project team. It makes it more difficult to gain residents' support and convince them of the effectiveness of NBS for risk management (AC1, RE2, RE4, and RE5). RE2 pointed out that such a discrepancy in NBS knowledge exists between academics and planners. In this regard, AC1 advocated for the role of intermediaries or facilitators who can translate different languages and close the knowledge gap. RE2 also stated that such a discrepancy can happen during the communication between practitioners from different disciplines when they stick to their own siloed language.

4 Summary and Discussion

The interviewed experts framed and conceptualized NBS very differently. The majority of experts (seven out of 11) conceptualized NBS as having instrumental value that helps to achieve a variety of co-benefits, such as aesthetic and recreational values with technological advancement. Fewer experts conceptualized NBS with respect to their intrinsic value, that is, the promotion of socioecological considerations in flood risk management. The implemented projects mentioned during the interviews ranged from small-scale urban green infrastructures primarily designed to produce co-benefits for residents by applying diverse technological elements, to the large-scale river and floodplain restorations that strongly support the recovery of ecosystems and their functions.

Such heterogeneity of conceptualization is not particular to South Korea. By definition, the NBS concept is understood variously. The European Commission definition employs the broader objective of using nature-inspired measures to cope with diverse social and economic challenges, while the International Union for Conservation of

Nature emphasizes that the conservation and protection of ecosystems should be prerequisites for the implementation of NBS measures (Albert et al. 2019; Han and Kuhlicke 2019). A recent empirical study in Australia by Moosavi et al. (2021) also showed diverging and inconsistent perceptions of NBS between water professionals despite a common commitment to the imperative to protect ecosystems and improve biodiversity.

Interviewees agreed that the term NBS is commonly defined in a broader and more flexible way than other neighboring terms, such as green infrastructure or ecosystem-based approach. The fact that there was no agreement or discussion about the conceptualization of NBS and its application at a national level, however, can itself be understood as a barrier to mainstreaming NBS in the long term. Particularly, the experts predominantly conceptualized NBS in terms of technological advancements, thereby revealing that most interviewees did not prioritize NBS' ecological values. Flood risk management planning in South Korea reflects a predominantly technocratic conceptualization by emphasizing the adoption of innovative technologies for monitoring and forecasting, whereas the intrinsic value of nature in FRM is still not considered relevant. Moosavi et al. (2021) also pinpointed the importance of the intrinsic value of nature underlying the concept of NBS, which is often ignored in the anthropocentric perspective on NBS. A more widely shared and agreed upon conceptualization, including more specific criterion as to what extent "natural" interventions can be considered as part of NBS, needs to be developed among researchers, professionals, and government.

Our research confirmed that some attitudinal factors already identified in previous research in different cultural settings are also present in South Korea. First, the cost-effectiveness of NBS was identified as a barrier due to the high compensation costs of land acquisition, particularly for large-scale projects, as well as the high cost of maintenance and implementation. Similarly, Dushkova and Haase (2020) warn against "overselling nature" without thinking of financial limitations, which can result in mediocre maintenance practices. Despite fear of the higher cost of NBS, established technical measures are also becoming expensive and are considered a future budgetary challenge (K-Water 2019). In this regard, a better evaluation of the co-benefits of NBS approach is essential; this would account for future value in addition to the economic and biophysical value of NBS.

Second, the underestimated capacity of NBS to reduce flood risks and uncertainty around NBS' effectiveness is in line with the results noted in previous literature. We found that these views frame NBS as merely an auxiliary choice rather than a primary solution that decision makers might select to mitigate immediate risks. Empirically, Brillinger

et al. (2020) demonstrated that the preference of the German federal states for NBS to mitigate flood risks depends on their perceived level of risks in a German context; the states with low flood risks have a higher NBS uptake than the states with higher risks. More research is required on public attitudes towards NBS and the perceived ability of NBS to manage flood risks effectively; we have found no such research so far within an NBS framework.

Third, all interviewed experts noticed that utility-related factors, which relate to direct monetary benefits including subsidies, compensation, or expected increases in land prices, are the most critical driver for gaining public acceptability of NBS. Previous research, in different cultural backgrounds, has counted perceived co-benefits as critical drivers of NBS mainstreaming, particularly in relation to the aesthetic (Barthelemy and Armani 2015) and recreational benefits of NBS (Gray et al. 2017).

This drive that promotes NBS with co-benefits comes with a caveat, particularly in South Korea. On the one hand, our result showed that the benefits can be accompanied by moral hazards or “greenwashing”: Those carrying out NBS projects may take advantage of incentives without actually considering site-specific ecological conditions. Seddon et al. (2021) defined this as a dilemma of NBS, and suggested more stringent criteria such as the Oxford Principles for Net Zero Aligned Carbon Offsetting and IUCN global standards for NBS. On the other hand, it raises increasing concerns about the unintended side-effects of upgrading exposed neighborhoods, which eventually leads to eco-gentrification processes due to focusing on the co-benefits aspect of NBS (Millington 2015; Haase 2017). This connects to our interview result regarding strong stakeholder groups who only pursue monetary interests, and therefore perceive NBS as a lucrative opportunity. Kwon et al. (2017) proved that the urban park, in the case of the Gyeongui Line Forest Park in South Korea, actually caused gentrification, which was analyzed by setting housing property prices as a proxy variable. In this regard, South Korea’s speculative urbanization should be carefully acknowledged when planning NBS.

For contextual factors, not only did the findings identify the prevalent topics, but also some specific factors that need to be read with particular background settings were analyzed. First, unclear accountability in the current FRM system was identified as a factor that leads to conflict of interest within organizations and inhibits the coproduction process. We found the underlying ground in the dichotomized responsibility in FRM between the Ministry of Environment (MOE) and the Ministry of Land, Infrastructure and Transport (MOLIT) to be conflicting and counterproductive. While the MOE establishes countermeasures on river discharge and flood forecasting, the MOLIT establishes maintenance plans for river facilities

including flood protection measures, river maintenance, and restoration. Such divided responsibilities make it difficult to reduce flood risk more proactively, as the management bodies in which cooperation work is inevitable, are separated. The systematic and ecological integration of NBS elements into FRM is not possible under such a divided system. Coherent flood risk and water resource management should be prioritized as it is a key government approach to tackling climate change (Gain et al. 2013).

Second, capacity building of local governments is crucial. We noted that the decentralization of FRM was a contentious issue throughout all our interviews—interviewees were concerned about whether local governments have the capacity to carry out FRM. Considering that 98.5% of the damage caused by fluvial flooding was concentrated around the provincial rivers managed by local governments, such power transfer is inevitable. For more effective management, capacity building of local governments should be encouraged to support this transition with more responsibilities and expertise and skills. Maskrey et al. (2020) suggested enhancing learning action alliances between institutional actors to tackle with challenges. Particularly for NBS cases, building efficient knowledge-transfer mechanisms (Xing et al. 2017) such as with an online data pool to provide an NBS catalog (Schröter et al. 2020) was suggested.

Lastly, the ideologicalization of NBS policy needs to be circumvented because it impedes the realization of innovative new initiatives and a long-term national plan for sustainability. Politicization of ecological policy in Korea polarizes opinions and hinders the achievement of goals that safeguard nature and society through the implementation of NBS. So far, although ecological issues often represent a certain political ideology in some cultures (Watkin Lui et al. 2016; Buletti Mitchell and Ejderyan 2021), the topic is rarely discussed in the context of NBS governance. With the encouragement for future research, above all, all parties need to agree on exercising a united political will to avoid irreversible environmental damage and prioritize ecological goal of NBS that can serve long-term value.

5 Conclusion

In this article, we revealed the current NBS-related knowledge and experience held by practitioners, researchers, and government officials, and displayed how these experts see barriers and drivers to the mainstreaming of NBS in South Korea. These findings are not just limited to a South Korean context—they can also contribute towards current research primarily focused on other cultural and institutional contexts. The study suggests that

clearer conceptualizations of NBS are essential at a national level to ensure the long-term sustainability of FRM and a common understanding of NBS between the professionals. Some of our findings, such as the perceived co-benefits of NBS, confirm previously researched barriers and drivers of NBS. But these findings also are understood properly within the unique context of South Korea. We discovered the cultural and institutional specificity of barriers and drivers. For instance, the ideologicalization of NBS policy has not been a serious topic in other cultural contexts, but the experts interviewed for this study criticized this gap as an obstacle. Additionally, the centralized FRM structure described here is unique to the South Korea setting. Such contextual reflections confirm that future research into NBS needs to be built upon a cultural and contextual understanding. This may influence the future upscaling of NBS projects by encouraging a careful consideration of site-based and contextual factors to ensure an optimal design and implementation strategy.

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References

- Albert, C., B. Schröter, D. Haase, M. Brillinger, J. Henze, S. Herrmann, S. Gottwald, and P. Guerrero et al. 2019. Addressing societal challenges through nature-based solutions: How can landscape planning and governance research contribute?. *Landscape and Urban Planning* 182: 12–21.
- Albert, C., J.H. Spangenberg, and B. Schröter. 2017. Nature-based solutions: Criteria. *Nature* 543(7645): 315.
- Barthelemy, C., and G. Armani. 2015. A comparison of social processes at three sites of the French Rhone River subjected to ecological restoration. *Freshwater Biology* 60(6): 1208–1220.
- Brillinger, M., A. Dehnhardt, R. Schwarze, and C. Albert. 2020. Exploring the uptake of nature-based measures in flood risk management: Evidence from German federal states. *Environmental Science & Policy* 110: 14–23.
- Bulletti Mitchell, N., and O. Ejderyan. 2021. When experts feel threatened: Strategies of depoliticisation in participatory river restoration projects. *Area* 53(1): 151–160.
- Cha, Y.J., M.-P. Shim, and S.K. Kim. 2011. The four major rivers restoration project. Paper presented at the UN-Water international conference, 3–5 October 2011, Zaragoza.
- Chou, R.-J. 2016. Achieving successful river restoration in dense urban areas: Lessons from Taiwan. *Sustainability* 8(11): Article 1159.
- Cohen-Shacham, E., G. Walters, C. Janzen, and S. Maginnis. 2016. *Nature-based solutions to address global societal challenges*. Gland, Switzerland: IUCN.
- Collentine, D., and M.N. Futter. 2018. Realising the potential of natural water retention measures in catchment flood management: Trade-offs and matching interests. *Journal of Flood Risk Management* 11(1): 76–84.
- Daigneault, A., P. Brown, and D. Gawith. 2016. Dredging versus hedging: Comparing hard infrastructure to ecosystem-based adaptation to flooding. *Ecological Economics* 122: 25–35.
- Dushkova, D., and D. Haase. 2020. Not simply green: Nature-based solutions as a concept and practical approach for sustainability studies and planning agendas in cities. *Land* 9(1): Article 19.
- Eisenack, K., S.C. Moser, E. Hoffmann, R.J.T. Klein, C. Oberlack, A. Pechan, M. Rotter, and C.J.A.M. Termeer. 2014. Explaining and overcoming barriers to climate change adaptation. *Nature Climate Change* 4(10): 867–872.
- European Commission. 2015. 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”. Luxembourg: Publications Office of the European Union.
- Field, C.B., V. Barros, T.F. Stocker, and Q. Dahe. 2012. *Managing the risks of extreme events and disasters to advance climate change adaptation*. Special report of the Intergovernmental Panel on Climate Change. Cambridge, UK: Cambridge University Press.
- Gain, A.K., J.J. Rouillard, and D. Benson. 2013. Can integrated water resources management increase adaptive capacity to climate change adaptation? A critical review. *Journal of Water Resource and Protection* 5(4A): 11–20.
- Gray, J.D.E., K. O'Neill, and Z.Y. Qiu. 2017. Coastal residents' perceptions of the function of and relationship between engineered and natural infrastructure for coastal hazard mitigation. *Ocean & Coastal Management* 146: 144–156.
- Haase, A. 2017. The contribution of nature-based solutions to socially inclusive urban development—Some reflections from a social-environmental perspective. In *Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice*, ed. N. Kabisch, H. Korn, J. Stadler, and A. Bonn. Cham: Springer International Publishing.
- Han, S., and C. Kuhlicke. 2019. Reducing hydro-meteorological risk by nature-based solutions: What do we know about people's perceptions? *Water* 11(12): Article 2599.
- Hirabayashi, Y., R. Mahendran, S. Koirala, L. Konoshima, D. Yamazaki, S. Watanabe, H. Kim, and S. Kanae. 2013. Global flood risk under climate change. *Nature Climate Change* 3(9): 816–823.
- Jongman, B. 2018. Effective adaptation to rising flood risk. *Nature Communications* 9(1): Article 1986.
- K-Water (Korea Water Resources Corporation). 2019. *A preliminary study on development of guidance for estimating dam's OM&R cost*. Deajeon, Korea: Korea Water Resources Corporation (in Korean).
- Kabisch, N., N. Frantzeskaki, S. Pauleit, S. Naumann, M. Davis, M. Artmann, D. Haase, S. Knapp, et al. 2016. Nature-based solutions to climate change mitigation and adaptation in urban

- areas: Perspectives on indicators, knowledge gaps, barriers, and opportunities for action. *Ecology and Society* 21(2): Article 39.
- Kwon, Y., S. Joo, S. Han, and C. Park. 2017. Mapping the distribution pattern of gentrification near urban parks in the case of Gyeongui Line Forest Park, Seoul, Korea. *Sustainability* 9(2): Article 231.
- Lah, T., Y. Park, and Y.J. Cho. 2015. The four major rivers restoration project of South Korea: An assessment of its process, program, and political dimensions. *The Journal of Environment & Development* 24(4): 375–394.
- Lee, S., J. Kim, B. Choi, G. Kim, and J. Lee. 2019. Harmful algal blooms and liver diseases: Focusing on the areas near the four major rivers in South Korea. *Journal of Environmental Science and Health, Part C* 37(4): 356–370.
- MacKinnon, K., C. Sobrevila, and V. Hickey. 2008. *Biodiversity, climate change, and adaptation: Nature-based solutions from the World Bank portfolio*. Washington, DC: The World Bank.
- Martinez-Juarez, P., A. Chiabai, C. Suarez, and S. Quiroga. 2019. Insights on urban and periurban adaptation strategies based on stakeholders' perceptions on hard and soft responses to climate change. *Sustainability* 11(3): Article 647.
- Maskrey, S., T. Vilcan, E. O'Donnell, and J. Lamond. 2020. Using Learning and Action Alliances to build capacity for local flood risk management. *Environmental Science & Policy* 107: 198–205.
- Matthews, T., A.Y. Lo, and J.A. Byrne. 2015. Reconceptualizing green infrastructure for climate change adaptation: Barriers to adoption and drivers for uptake by spatial planners. *Landscape and Urban Planning* 138: 155–163.
- Millington, N. 2015. From urban scar to “park in the sky”: Terrain vague, urban design, and the remaking of New York City's High Line Park. *Environment and Planning A* 47(11): 2324–2338.
- Moosavi, S., G.R. Browne, and J. Bush. 2021. Perceptions of nature-based solutions for urban water challenges: Insights from Australian researchers and practitioners. *Urban Forestry & Urban Greening* 57: Article 126937.
- Narayan, S., M.W. Beck, B.G. Reguero, I.J. Losada, B. van Wesenbeeck, N. Pontee, J.N. Sanchirico, and J.C. Ingram et al. 2016. The effectiveness, costs and coastal protection benefits of natural and nature-based defences. *PLoS One* 11(5): e0154735.
- O'Donnell, E.C., J.E. Lamond, and C.R. Thorne. 2017. Recognising barriers to implementation of blue-green infrastructure: A Newcastle case study. *Urban Water Journal* 14(9): 964–971.
- Palmer, M.A., J. Liu, J.H. Matthews, M. Mumba, and P. D'Odorico. 2015. Manage water in a green way. *Science* 349(6248): 584–585.
- Pauleit, S., T. Zölch, R. Hansen, T.B. Randrup, and C. Konijnendijk van den Bosch. 2017. Nature-based solutions and climate change—Four shades of green. In *Nature-based solutions to climate change adaptation in urban areas: Linkages between science, policy and practice*, ed. N. Kabisch, H. Korn, J. Stadler, and A. Bonn, 29–49. Cham: Springer International Publishing.
- Pfadenhauer, M. 2009. At eye level: The expert interview—a talk between expert and quasi-expert. In *Interviewing experts*, ed. A. Bogner, B. Littig, and W. Menz, 81–97. Amsterdam: Springer.
- Piacentini, S.M., and R. Rossetto. 2020. Attitude and actual behaviour towards water-related green infrastructures and sustainable drainage systems in four North-Western Mediterranean Regions of Italy and France. *Water* 12(5): Article 1474.
- Raymond, C.M., N. Frantzeskaki, N. Kabisch, P. Berry, M. Breil, M.R. Nita, D. Geneletti, and C. Calfapietra. 2017. A framework for assessing and implementing the co-benefits of nature-based solutions in urban areas. *Environmental Science & Policy* 77: 15–24.
- Sarabi, S.E., Q. Han, A.G.L. Romme, B. de Vries, and L. Wendling. 2019. Key enablers of and barriers to the uptake and implementation of nature-based solutions in urban settings: A review. *Resources* 8(3): Article 121.
- Schröter, B., A. Zingraff-Hamed, E. Ott, J. Huang, F. Hüesker, C. Nicolas, and N.J.S. Schröder. 2020. The knowledge transfer potential of online data pools on nature-based solutions. *Science of The Total Environment* 762: Article 143074.
- Seddon, N., A. Chausson, P. Berry, C.A.J. Girardin, A. Smith, and B. Turner. 2020. Understanding the value and limits of nature-based solutions to climate change and other global challenges. *Philosophical Transactions of Royal Society B: Biological Sciences* 375(1794): Article 20190120.
- Seddon, N., A. Smith, P. Smith, I. Key, A. Chausson, C. Girardin, J. House, S. Srivastava, and B. Turner. 2021. Getting the message right on nature-based solutions to climate change. *Global Change Biology* 27(8): 1518–1546.
- Shafique, M., and R. Kim. 2018. Recent progress in low-impact development in South Korea: Water-management policies, challenges and opportunities. *Water* 10(4): Article 435.
- Song, H., and M.J. Lynch. 2018. Restoration of nature or special interests? A political economy analysis of the four major rivers restoration project in South Korea. *Critical Criminology* 26(2): 251–270.
- Thieken, A.H., H. Cammerer, C. Dobler, J. Lammel, and F. Schöberl. 2016. Estimating changes in flood risks and benefits of non-structural adaptation strategies—A case study from Tyrol, Austria. *Mitigation and Adaptation Strategies for Global Change* 21(3): 343–376.
- UNISDR (United Nations International Strategy for Disaster Reduction). 2015. *Sendai framework for disaster risk reduction 2015–2030*. Geneva: UNISDR.
- Watkin Lui, F., M. Kiatkoski Kim, A. Delisle, N. Stoeckl, and H. Marsh. 2016. Setting the table: Indigenous engagement on environmental issues in a politicized context. *Society & Natural Resources* 29(11): 1263–1279.
- Wells, J., J.C. Labadz, A. Smith, and M.M. Islam. 2019. Barriers to the uptake and implementation of natural flood management: A social-ecological analysis. *Journal of Flood Risk Management* 13(S1): e12561.
- van Wesenbeeck, B.K., and S. Ijff, B. Jongman, S. Balog, S. Kaupa, L. Bosche, G.-M. Lange, N. Holm-Nielsen, et al. 2017. *Implementing nature based flood protection: Principles and implementation guidance*. Washington, DC: World Bank Group.
- Xing, Y., P. Jones, and I. Donnison. 2017. Characterisation of nature-based solutions for the built environment. *Sustainability* 9(1): Article 149.
- Zellner, M., D. Massey, E. Minor, and M. Gonzalez-Meler. 2016. Exploring the effects of green infrastructure placement on neighborhood-level flooding via spatially explicit simulations. *Computers, Environment and Urban Systems* 59: 116–128.