Perceptions of nature-based solutions in the context of floods

Understanding the complexity of people and places at risk

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Univ.-Diss.

zur Erlangung des akademischen Grades
"doctor rerum naturalium"
(Dr. rer. nat.)
in der Wissenschaftsdisziplin "Naturrisikenforschung"

eingereicht an der
Mathematisch-Naturwissenschaftlichen Fakultät
Institut für Umweltwissenschaften und Geographie
der Universität Potsdam

Cumulative dissertation submitted for the degree of “doctor rerum naturalium” (Dr.rer.nat)

Submitted on: 10 June 2022
Defended on: 5 December 2022

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Published online on the
Publication Server of the University of Potsdam:
https://doi.org/10.25932/publishup-57952
https://nbn-resolving.org/urn:nbn:de:kobv:517-opus4-579524

Acknowledgments

I've had the luxury in last several years to look into a topic that truly fascinates me. I'm thankful for the opportunity I've been given, and I would like to express my gratitude for all the support my family, friends, and colleagues have given me while I've traveled this journey. First of all, I would like to thank my supervisor, Christian Kuhlicke who has guided this entire journey from the very beginning and provided endless encouragement and support. I am also grateful for the freedom to delve deeply into the subject matter. I am so grateful to another supervisor, Annegret Thieken, for giving me opportunities to meet colleagues in her working group and to exchange interesting thoughts. From my supervisors, I received not only professional advice, but also a lot of wisdom to tackle challenges in life. I'd like to add special thanks to Philip Bubeck, one of my co-authors of the paper, who provided me lots of insights in statistical analysis and helped me find the right direction. He has always been understanding and respectful of my decision.

I received great support from many colleagues at the department of urban and environmental sociology at UFZ. I was lucky enough to have great colleagues with whom I can exchange thoughts and have stimulating discussions, but also share happy and meaningful moments. I appreciate Mariana de Brito, my officemate, who always gladly reads my manuscript first and gives insightful comments to help better develop the manuscript—but also for spending a joyful Feierabend together. Another word of appreciation goes to Daniela Siedschlag, who really supported me in realizing a household survey. With her know-how, I was able to tackle all the details (in German) and logistics for the survey's practicalities. For the household survey, I cannot forget the important help from the student assistants, Zora, Ansgar, Simon, Sophie, and many more, who distributed and collected the questionnaires together despite heavy rainfall. I sincerely thank them for their support. Again, I thank Zora, who is with us again as a colleague and who helped me translate the summary of this dissertation into German. I thank Lisa, Anika, Tais, and Juliane, who gave constructive comments on the presentation and the slides for the defense, for lots of encouragement. I also would like to thank previous colleagues, Chloe Begg and Nona Schulte-Römer, who were great mentors.

At the UFZ campus, I met many wonderful people. It was a pleasure to be a member of the doctoral initiative Do-It. Participating in diverse activities and getting to know many new people within TB6 was fun. I would like to thank my only Korean friend at UFZ, Jungeun Lee. I am so proud of her and delighted that we have both made this journey. The previous statistician, Mick Wu, provided lots of great help on methodological matters, which I sincerely appreciate.

I'd like to thank the survey participants in Saxony-Anhalt, as well as the responsible people involved in the dikes relocation project, for providing detailed information prior to the survey. I hope that my research helps to better understand the communities. I also thank the experts in South Korea, who gladly accepted the interview invitation. I appreciate the time and effort they spent on this research.

The dissertation is financially supported by DAAD – German Academic Exchange Service and I have been hosted by Helmholtz Centre for Environmental Research – UFZ. I am truly grateful for the opportunities provided by the funding program, which allows me to fully focus on the research that I sought.

Finally, my deepest and greatest thanks go to my family for their unwavering support of my academic endeavors. My parents have always been people on whom I can rely. They raised me to know the importance of remembering to give back to society and those in need with the knowledge and accomplishments I have gained thus far. I still keep this in mind. My partner Dohyun has always been a great support; we had endless conversations with no limit to our imagination. Your love, commitment, and support have made this adventure possible.

Leipzig, January 2023

Sungju Han

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List of Acronyms and Abbreviation

APA	American Psychological Association
AVE	Average Variance Extracted
CFI	Comparative Fit Index
CR	Composite Reliability
EC	European Commission
FRM	Flood Risk Management
IPBES	Intergovernmental Platform for Biodiversity and Ecosystem Services
IUCN	International Union for Conservation of Nature
LID	Low Impact Development
NBS	Nature-Based Solutions
NCP	Nature's Contributions to People
NCS	Natural Climate Solutions
PADM	Protective Action Decision Model
PMT	Protection Motivation Theory
PRAM	Place-based Risk Appraisal Model
RMSEA	Root-Mean-Square Error of Approximation
SRMR	Standardized Root Mean Squared Residual
TLI	Tucker–Lewis Index

Abstract

Traditional ways of reducing flood risk have encountered limitations in a climate-changing and rapidly urbanizing world. For instance, there has been a demanding requirement for massive investment in order to maintain a consistent level of security as well as increased flood exposure of people and property due to a false sense of security arising from the flood protection infrastructure. Against this background, nature-based solutions (NBS) have gained popularity as a sustainable and alternative way of dealing with diverse societal challenges such as climate change and biodiversity loss. In particular, their ability to reduce flood risks while also offering ecological benefits has recently received global attention. Diverse co-benefits of NBS that favor both humans and nature are viewed as promising a wide endorsement of NBS. However, people's perceptions of NBS are not always positive. Local resistance to NBS projects as well as decision-makers' and practitioners' unwillingness to adopt NBS have been pointed out as a bottleneck to the successful realization and mainstreaming of NBS.

In this regard, there has been a growing necessity to investigate people's perceptions of NBS. Current research has lacked an integrative perspective of both attitudinal and contextual factors that guide perceptions of NBS; it not only lacks empirical evidence, but a few existing ones are rather conflicting without having underlying theories. This has led to the overarching research question of this dissertation, "What shapes people's perceptions of NBS in the context of flooding?"

The dissertation aims to answer the following sub-questions in the three papers that make up this dissertation:

1. What are the topics reflected in the previous literature influencing perceptions of NBS as a means to reduce hydro-meteorological risks? (Paper I)
2. What are the stimulating and hampering attitudinal and contextual factors for mainstreaming NBS for flood risk management? How are NBS conceptualized? (Paper II)

3. How are public attitudes toward the NBS projects shaped? How do risk-and place-related factors shape individual attitudes toward NBS? (Paper III)

This dissertation follows an integrative approach of considering "place" and "risk", as well as the surrounding context, by analyzing attitudinal (i.e., individual) and contextual (i.e., systemic) factors. "Place" is mainly concerned with affective elements (e.g., bond to locality and natural environment) whereas "risk" is related to cognitive elements (e.g., threat appraisal). The surrounding context provides systemic drivers and barriers with the possibility of interfering the influence of place and risk for perceptions of NBS. To empirically address the research questions, the current status of the knowledge about people's perceptions of NBS for flood risks was investigated by conducting a systematic review (Paper I). Based on these insights, a case study of South Korea was used to demonstrate key contextual and attitudinal factors for mainstreaming NBS through the lens of experts (Paper II). Lastly, by conducting a citizen survey, it investigated the relationship between the previously discussed concepts in Papers I and II using structural equation modeling, focusing on the core concepts, namely risk and place (Paper III).

As a result, Paper I identified the key topics relating to people's perceptions, including the perceived value of co-benefits, perceived effectiveness of risk reduction effectiveness, participation of stakeholders, socio-economic and place-specific conditions, environmental attitude, and uncertainty of NBS. Paper II confirmed Paper I's findings regarding attitudinal factors. In addition, several contextual hampering or stimulating factors were found to be similar to those of any emerging technologies (i.e., path dependence, lack of operational and systemic capacity). Among all, one of the distinctive features in NBS contexts, at least in the South Korean case, is the politicization of NBS, which can lead to polarization of ideas and undermine the decision-making process. Finally, Paper III provides a framework with the core topics (i.e., place and risk) that were considered critical in Paper I and Paper II. This place-based risk appraisal model (PRAM) connects people at risk and places where hazards (i.e., floods) and interventions (i.e., NBS) take place. The empirical analysis shows that, among the place-related variables, nature bonding was a positive predictor of the perceived risk-reduction effectiveness of NBS, and place identity was a negative predictor of supportive attitude. Among

the risk-related variables, threat appraisal had a negative effect on perceived risk reduction effectiveness and supportive attitude, while well-communicated information, trust in flood risk management, and perceived co-benefit were positive predictors.

This dissertation proves that the place and risk attributes of NBS shape people's perceptions of NBS. In order to optimize the NBS implementation, it is necessary to consider the meanings and values held in place before project implementation and how these attributes interact with individual and/or community risk profiles and other contextual factors. With the increasing necessity of using NBS to lower flood risks, these results make important suggestions for the future NBS project strategy and NBS governance.

Zusammenfassung

Herkömmliche Methoden zur Verminderung des Hochwasserrisikos stoßen in Zeiten des Klimawandels und der Urbanisierung an ihre Grenzen. So sind beispielsweise massive Investitionen erforderlich, um ein gleichbleibendes Sicherheitsniveau aufrechtzuerhalten, und das Hochwasserrisiko für Menschen und Eigentum steigt, weil die Hochwasserschutzinfrastruktur ein falsches Sicherheitsgefühl vermittelt. Vor diesem Hintergrund haben naturbasierte Lösungen (engl. Nature-Based Solutions, kurz: NBS) als nachhaltiger und alternativer Weg zur Bewältigung verschiedener gesellschaftlicher Herausforderungen wie Klimawandel und Verlust der biologischen Vielfalt an Popularität gewonnen. Insbesondere ihre Eigenschaft, das Hochwasserrisiko zu verringern und gleichzeitig ökologische Vorteile zu bieten, hat zuletzt weltweit Aufmerksamkeit erregt. Die vielfältigen Vorteile der NBS, die sowohl den Menschen als auch der Natur zugutekommen, sind vielversprechende Gründe für eine breite Befürwortung der NBS. Die Wahrnehmung der NBS durch die Bevölkerung ist jedoch nicht immer positiv. Lokaler Widerstand gegen NBS-Projekte sowie die mangelnde Bereitschaft von Entscheidungsträgern und Praktikern, NBS zu übernehmen, wurden als Hürden für die erfolgreiche Umsetzung und langfristige Etablierung von NBS identifiziert.

In diesem Zusammenhang hat sich die Notwendigkeit ergeben, die Wahrnehmung von NBS genauer zu untersuchen. In der aktuellen Forschung fehlt eine integrative Perspektive sowohl auf einstellungs- als auch auf kontextbezogene Faktoren, die die Wahrnehmung von NBS beeinflussen; es mangelt nicht nur an empirischen Belegen, sondern die wenigen vorhandenen Befunde sind eher widersprüchlich, ohne dass zugrunde liegende Theorien vorhanden sind. Daraus ergibt sich die übergeordnete Forschungsfrage dieser Dissertation: "Was beeinflusst die Wahrnehmung der Menschen von NBS im Kontext von Hochwasser?"

Die Dissertation intendiert, die folgenden Unterfragen in den drei Publikationen zu beantworten, die diese Dissertation bilden:

1. Welche Themen spiegeln sich in der bisherigen Literatur wider und beeinflussen die Wahrnehmung von NBS als Mittel zur Verringerung hydrometeorologischer Risiken? (Publikation I)
2. Was sind die fördernden und hemmenden Einstellungs- und Kontextfaktoren für das Mainstreaming von NBS für das Hochwasserrisikomanagement? Wie werden NBS von Experten konzeptualisiert? (Publikation II)
3. Wie wird die Einstellung der Öffentlichkeit zu NBS-Projekten geprägt? Wie beeinflussen risiko- und ortsbezogene Faktoren die individuelle Einstellung zu NBS? (Publikation III)

In dieser Dissertation wird ein integrativer Ansatz verfolgt, der Ort (Place) und Risiko (Risk) sowie den umgebenden Kontext berücksichtigt, indem einstellungsbezogene (d. h. individuelle) und kontextbezogene (d. h. systemische) Faktoren analysiert werden. "Ort" affektive Elemente betrifft (z. B. die Bindung an den Ort und die natürliche Umgebung), während "Risiko" bezieht sich auf kognitive Elemente (z. B. die Einschätzung der Bedrohung). Der umgebende Kontext bietet systemische Triebkräfte und Hindernisse, die den Einfluss von Ort und Risiko auf die Wahrnehmung der NBS beeinflussen können. Zur empirischen Beantwortung der Forschungsfragen wurde der aktuelle Stand der Forschung über die Wahrnehmung der NBS für Hochwasserrisiken durch eine systematische Literaturanalyse untersucht (Publikation I). Auf der Grundlage dieser Erkenntnisse wird eine Fallstudie aus Südkorea herangezogen, um die wichtigsten Kontext- und Einstellungsfaktoren für das Mainstreaming von NBS aus der Sicht von Experten aufzuzeigen (Publikation II). Schließlich wurde anhand einer Bürgerbefragung die Beziehung zwischen den zuvor in den Publikationen I und II erörterten Konzepten untersucht, mit Schwerpunkt auf den Kernkonzepten, nämlich Risiko und Ort. Die Analzse basiert auf einem Strukturgleichungsmodell (Publikation III).

In Publikation I wurden die wichtigsten Themen im Zusammenhang mit der Wahrnehmung der Menschen identifiziert, darunter der wahrgenommene Wert von Zusatznutzen, die wahrgenommene Wirksamkeit der Risikominderung, die Beteiligung von Interessengruppen, sozioökonomische und ortsspezifische Bedingungen, die Einstellung zur Umwelt und die Unsicherheit der NBS. Publikation II bestätigte die Ergebnisse von Publikation

I hinsichtlich der Einstellungsfaktoren (d.h. die Bereiche Ort und Risiko). Zusätzlich wurde festgestellt, dass mehrere hemmende und fördernde Kontextfaktoren denen aller neuen Technologien ähneln (d. h. Pfadabhängigkeit, fehlende operative und systemische Kapazitäten). Eines der besonderen Merkmale im Kontext der NBS, zumindest im Fall Südkoreas, ist die Politisierung der NBS, die möglicherweise zu einer Polarisierung der Ideen an sich führen und damit den Entscheidungsprozess untergraben kann. Schließlich bietet Publikation III einen Rahmen mit dem Fokus auf die Faktoren (d. h. Ort und Risiko), die in Papier I und Papier II als entscheidend angesehen wurden. Dieses ortsbezogene Risikobewertungsmodell (place-based risk appraisal model, PRAM) stellt eine Verbindung zwischen den gefährdeten Menschen und den Orten her, an denen Gefahren (z. B. Hochwasser) und Interventionen (z. B. NBS) stattfinden. Die empirische Analyse zeigt, dass bei den ortsbezogenen Konstrukten die Naturverbundenheit ein positiver Prädiktor für die wahrgenommene risikomindernde Wirksamkeit der NBS war und die Ortsidentität ein negativer Prädiktor für die unterstützende Einstellung. Bei den risikobezogenen Konstrukten wirkte sich die Einschätzung der Bedrohung negativ auf die wahrgenommene Wirksamkeit der Risikominderung und die unterstützende Einstellung aus, während gut kommunizierte Informationen, Vertrauen in das Hochwasserrisikomanagement und wahrgenommener Zusatznutzen positive Prädiktoren waren.

Diese Dissertation zeigt, dass die verschiedenen Ebenen der Orts-, Risiko- und Landschaftsattribute der NBS die Wahrnehmung der NBS durch die Menschen beeinflussen. Um die Umsetzung der NBS zu optimieren, müssen die vor der Projektumsetzung bestehenden Vorstellungen und Werte der dort lebenden Menschen berücksichtigt und analysiert werden, wie diese Attribute mit dem Risikokontext und anderen systemischen und kontextuellen Faktoren interagieren. Angesichts der zunehmenden Notwendigkeit, naturbasierte Methoden zur Verringerung von Hochwasserrisiken einzusetzen, liefern diese Ergebnisse wichtige Anregungen für die künftige NBS-Projektstrategie und NBS-Governance.

Chapter 1 General Introduction

1.1. Changes in Flood Risk Management

Flooding is a major hazard that causes significant losses to both people and property across the globe. In the last two decades (2000–2019), flooding has harmed over 1.6 billion individuals worldwide, accounting for the highest figure of 41% of all disaster types (CRED and UNDRR, 2020). Floods are becoming more frequent and intense as a result of continuous global climate change caused by climatic (Alfieri et al., 2015; Hirabayashi et al., 2013; Winsemius et al., 2016), and socioeconomic changes (Field et al., 2012; Thieken et al., 2016). Arnell and Gosling (2016) estimated that 450 million people will face a doubling in flood frequency in 2050.

Effective flood risk management (FRM) is critical to limiting future losses from floods while at the same time safeguarding people and their livelihoods. Until recently, most FRM relied on the "command and control" approach, which controls flood risks with conventional engineering measures (e.g., embankments, dams, dikes, levees, flood-control reservoirs, and channels) (Wolsink, 2006).

At the same time, the effectiveness of structured FRM and its consequences have been becoming increasingly questioned with the following limitations: First, structural measures have frequently reached their limit to keep pace with changing hydroclimatic risks, requiring massive investment and maintenance to ensure a rising frequency and magnitude of upcoming floods (Palmer et al., 2015). Maintaining a consistent degree of protection with an engineered approach is challenging to meet the pressing need to cope with the increasing frequency of extreme events (Heller & Zavaleta, 2009; Iacob et al., 2014). Second, the failure of the structural measures, such as a dike breach, could potentially cause a destructive impact due to the momentum of the flood wave (Haltas et al., 2016; Ogie et al., 2020) or it could amplify problems in downstream areas (Plate, 2002). Residual risks even after the implementation of structural measures are often neglected, causing a more vulnerable state (Di Baldassarre et al., 2018). Third, hard infrastructure creates the "levee effect," or "lulling

effect," which creates a false sense of safety; it produces a paradoxical situation in which the construction of a levee, or other hard infrastructure for flood risk management, encourages more investment in its catchment, resulting in increased risks and vulnerability (Burton & Cutter, 2008; Di Baldassarre et al., 2013; Tobin, 1995; White, 1994). In other words, structural protection measures have been connected to increased urbanization in flood-prone areas below the levee, resulting in more people and assets to be eventually exposed to less frequent but possibly catastrophic flooding.

Furthermore, a lack of consideration of the social and ecological systems of structured FRM was also raised as a problem. Structured FRM has a limited capacity to include complicated social variables such as different people's vulnerabilities and sensitivities to floods, as well as unequal capabilities to participate in risk agendas (O'Hare & White, 2018; Sanders & Grant, 2020). Furthermore, lateral disconnection of ecosystems (e.g., water, sediment, and aquatic species) has been criticized as a cause of habitat fragmentation and the subsequent loss of biodiversity (McKay et al., 2013; Seliger & Zeiringer, 2018). The connection between river channels and floodplains is important for planning and managing river basins (Hu et al., 2008; Van den Brink et al., 1996). However, structural measures for flood risk often ignore this connection.

These constraints necessitate a re-orientation of how we understand and manage risk to meet the changing central challenges of the Anthropocene (Field et al., 2012), including not only mitigating risks but also protecting biodiversity and ensuring human wellbeing (Bubeck et al., 2015; Seddon et al., 2020). One of the distinguishing features of the re-oriented approach in FRM is the reframing of natural systems to be utilized as resilient flood risk measures (Browder et al., 2019).

Such a utilitarian perspective for natural ecosystems is not a new contribution to ecosystem scholarship; rather, it has been proposed for several decades. The scientific notion of ecosystem services and their relevance to human wellbeing emerged in the late 1970s (De Groot, 1987; Ehrlich & Mooney, 1983; Westman, 1977), and gained prominence in the 1990s (Costanza & Daly, 1992; Dally & Power, 1997). For many Dutch scholars, particularly, such a shift was understood as a perspective that switched from mastery over nature to a more ecocentric stance on nature (e.g., De Groot, 1987; Van der Brugge et al., 2005; Wiering & Arts,

2006). Then, the Millennium Ecosystem Assessment (MEA, 2005) made important contributions to how ecosystem services were talked about in policy agendas, including how they could be used to help manage disasters.

With the increase of research on ecosystem services (Fisher et al., 2009), some researchers expressed concern that the utilitarian framing of ecological concerns may influence how humans view and react to the environment in ways that are ultimately detrimental to conservation efforts (McCauley, 2006; Robertson, 2004; Spash, 2008). Similarly, considerable disagreement in academia was shown about whether the values attributed to nature by humans can be conceptualized in an ecosystem services framework. Similarly, there has been much debate in academia regarding whether the values that humans place on nature can be defined in an ecosystem services paradigm. Following this, the more inclusive term "nature's contributions to people (NCP)" was advocated by the experts involved in the Intergovernmental Platform for Biodiversity and Ecosystem Services (IPBES), as "[a]ll the positive contributions or benefits, and occasionally negative contributions, losses or detriments, that people obtain from nature" (Díaz et al., 2018).

1.2. Nature-Based Solutions: Definitions and Interpretations

Against this backdrop, the discussion on Nature-Based Solutions (NBS) has gained relevance and has been highlighted as a sustainable, future-proof means to deal with diverse societal challenges, considering both natural and human systems in an attempt to reconnect them reciprocally. The term NBS was first adopted by the World Bank in 2008 (World Bank, 2008), and has since been widely accepted by international organizations such as the International Union for Conservation of Nature (IUCN) and the European Commission (EC). A few years later, NBS was included by the IUCN in its 2013–2016 Program (IUCN, 2012) and was established as a key study topic under the EU's Horizon 2020 research and innovation program in 2015 (European Commission, 2015), resulting in a surge of scientific activity (Maes & Jacobs, 2017). The definitions of NBS by the two organizations are illustrated in Table 1.1. The core ideas commonly expressed in the definitions first aim to promote sustainable development by addressing social concerns, and second, how that ambition should be realized using NBS along with their multiple benefits. While the IUCN's definition

emphasizes the importance of a well-managed or restored environment at the core of any NBS (Cohen-Shacham et al., 2016), the EC definition is slightly wider and lays more focus on deploying solutions that are not simply inspired and supported by nature, but include engineered hybrid solutions (Eggermont et al., 2015; Spalding et al., 2013).

Table 1.1 Definitions of nature-based solutions

	European Commission[1]	**International Union for Conservation of Nature**[2]
Definition	• "Nature-based solutions aim to help societies address a variety of environmental, social and economic challenges in sustainable ways. They are actions inspired by, supported by or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions" • "…[I]deally are energy and resource-efficient, and resilient to change, but to be successful they must be adapted to local conditions" • "…[H]arness the power and sophistication of nature to turn environmental, social and economic challenges into innovation opportunities"	• "Actions to protect, sustainably manage, and restore natural or modified ecosystems, that address societal challenges effectively and adaptively, simultaneously providing human wellbeing and biodiversity benefits" • "…[I]ntended to support the achievement of society's development goals and safeguard human wellbeing in ways that reflect cultural and societal values and enhance the resilience of ecosystems, their capacity for renewal and the provision of services" • "… [D]esigned to address major societal challenges, such as food security, climate change, water security, human health, disaster risk, social and economic development."

[1] 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'.

[2] Cohen-Shacham, E., Walters, G., Janzen, C., & Maginnis, S. (2016). Nature-based solutions to address global societal challenges. *IUCN: Gland, Switzerland, 97*, 2016-2036.

NBS, as defined in Table 1.1, are a collection of novel ideas and concepts from various disciplines that benefit both human and natural systems by sustaining and/or restoring hydrological processes, thereby addressing both the crises of climate change and biodiversity loss (Albert et al., 2017; Seddon et al., 2020; Zölch et al., 2017). NBS are often perceived as an opportunity to step back from a human-only orientation to consider the needs and priorities of non-human others with whom we co-exist and are intricately entangled in all environments (Maller, 2021).

However, despite the underlying reciprocal relationship between human and natural systems, beyond human-only interests, NBS have been used in many cases in more anthropocentric ways. For example, ecosystem services are often emphasized as a core notion of NBS, indicating how nature offers benefits to society (Eggermont et al., 2015; Pontee et al., 2016). In this sense, ecological principles are frequently incorporated into economic decision-making for NBS (Pauleit et al., 2017; Wamsler, 2015), highlighting the virtue of nature's numerous calculable benefits (Chausson et al., 2020; Kabisch et al., 2016). In cost analysis, the cost-effectiveness of NBS was also pointed out as a key feature (Kabisch et al., 2016; Osaka et al., 2021; Pauleit et al., 2017), often in comparison with the engineered alternatives (Collentine & Futter, 2018).

In particular, in FRM, the emerging approach has been sometimes contrasted with the conventional way and considered beyond the utilitarian perspective. For example, Nelson et al. (2020) explain the dichotomy of FRM outlook as, on the one hand, “hubris,” controlling, rigid, disconnected to nature, and deterministic perspective; on the other hand, “humility,” reconnected to nature, flexible, transparent, human-nature systems thinking, and uncertainty acknowledged perspective. The new perspective allows humans and nature to be acknowledged in a co-constitution (Asplen, 2008), and this perspective labeled “nature” develops into the position of problem-solver for the diverse societal challenges. Some criticized the dominant engineering approach to FRM as part of humans' mistaken attempts to control and tame nature (e.g., Latour, 2017; McPhee, 2011). In this regard, nature’s pure and pristine values are seen as one of the key characteristics around which NBS are founded (Osaka et al., 2021). Although categorizations of NBS include a spectrum of interventions from “less engineered” and more use of natural ecosystems to “more engineered” and the

creation of new ecosystems (Eggermont et al., 2015), the features of NBS were often regarded as a counterpart to traditional grey infrastructure measures (e.g., Gray et al., 2017; Onuma & Tsuge, 2018). Therefore, relating to such characteristics of NBS, anthropogenic interventions with the label of "nature" can be allegedly seen as more approving than those driven by unnatural and technology-based elements by "tampering with nature" (Sjöberg, 2000).

1.3. A Pluralistic Framing of Perceptions of Nature-Based Solutions

Despite the above-mentioned speculation that natural components in NBS would give a more positive connotation to people's perception, the projects using NBS are not always supported and encouraged by the local host communities (Bark et al., 2021; Ferreira et al., 2020; Puskás et al., 2021) as well as by the decision-makers and practitioners (Moosavi et al., 2021). Local FRM disputes can worsen flood impacts by delaying FRM implementation (Kuhlicke et al., 2016; Otto et al., 2018), making understanding public perceptions of NBS critical. At the same time, how decision-makers and practitioners perceive NBS is essential for creating a shared understanding of the concept and providing clarity, which can have a direct effect on the uptake and mainstreaming of NBS. In this regard, how NBS are socially framed in relation to the affected people is critical for their realization. The following points can be used to expand on the reasoning.

First, understanding public perception is essential as public involvement is at the center of the successful realization of NBS (Wamsler et al., 2020). The governance structure of NBS is distinguished from a traditional, top-down conversation (Pauleit et al., 2017), facilitating the use of local knowledge and resources through a participatory and decentralized process (Nesshover et al., 2017). Following the European Floods Directive (2007/60/EC), the role of the public has been reinforced, with a greater emphasis on societal flood risk management (Newig et al., 2014). The active participation of citizens was emphasized here with the realization that structural measures alone cannot provide complete protection. Therefore, exposed individuals are expected to take private countermeasures (Begg et al., 2018; Kuhlicke et al., 2020). In this light, public participation in NBS realization can be deemed as an individual initiative to achieve better flood risk management.

Second, implementing NBS is highly dependent on diverse actors and their interactions in social-ecological and technological contexts (Keeler et al., 2019). The extent to which NBS are realized and exercised is thus socially contextualized (Ernstson & Sörlin, 2013). Sometimes, these social contexts become barriers to implementing NBS; the fact that the number of implemented NBS is still low globally can be linked to these reasons. For instance, non-supportive governments (Kabisch et al., 2016; Sarabi et al., 2019), a lack of political commitment (Solheim et al., 2021), siloed thinking and practices (Frantzeskaki et al., 2019), and inefficient inter-sectoral communication (Wang et al., 2021) have slowed down the implementation of NBS. Understanding contextual factors that can socially construct people's perceptions of NBS, thus, is crucial to overcome such issues.

In this context, it is critical to comprehend people's diverse views of NBS and the factors that shape them. However, research that empirically assesses or reviews people's perceptions of NBS for flood risk management is lacking. To the best of the author's knowledge, only a few review papers addressed shaping factors of perceptions of NBS. However, these are limited to only covering "public acceptance" toward NBS projects (Anderson & Renaud, 2021), preference over other options (Garcia et al., 2020; Mallette et al., 2021), implementation barriers (Raška et al., 2022) or limited scope of investigated terms (i.e., small-scale green infrastructure) (Venkataramanan et al., 2020). Empirical studies dedicated to such a purpose in the context of NBS for flood risk hardly exist except for a few studies on ecological restoration and nature conservation (e.g., Buchecker et al., 2016; Heldt et al., 2016; Kim & Petrolia, 2013). For instance, the perceived other benefits such as recreation and education opportunities (Kim & Petrolia, 2013), and aesthetic values (Buijs, 2009; Buijs et al., 2009; Junker & Buchecker, 2008) besides risk mitigation benefit have been shown to increase project optimism and endorsement. However, a few existing studies are somewhat speculative without an underlying theoretical framework (Han & Kuhlicke, 2019); Having a theoretical background is essential as it provides transparency in research design and data collection, and further enhances the possibility of generalization and reproducibility of the results (Kuhlicke et al., 2020).

Given this research gap in the present literature, the following provides a summary of key topics that are assumed to cause pluralistic framing of NBS in the flood risk context:

First, people in high-risk contexts are less likely to prefer the NBS option. Several studies have found that the physical presence of infrastructure creates a greater sense of security than natural ones (Gray et al., 2017; Martinez-Juarez et al., 2019) and that it is also viewed as a proactive governmental will to protect against hazards (Ardaya et al., 2017). The underlying reason that NBS are not preferred in high-risk contexts is, amongst others, their uncertainty of effectiveness or unknown effect (Raška et al., 2022). This can be partly ascribed to the complexity and variability inherent in nature particularly when interacting with other human-associated physical, ecological, and socioeconomic factors (Liao, 2014). Eventually, such variability could create and intensify potential fears about the dangers (Chou, 2016). Also, NBS, in many cases, aim at a more flexible long-term plan, often having a time lag to reap the benefits whereas engineered solutions are deployed with relative certainty regarding the type and timing of benefits (Seddon et al., 2020). In addition, the level of protection that NBS can offer is hard to predict (Iacob et al., 2014), as it depends on the intensity and frequency of threats, the resilience of the ecosystem, and the vulnerabilities of the socio-economic system.

Second, place-related elements are critical framing factors of NBS. Studies have found empirical evidence that the personal experiences associated with the place (Gray et al., 2017), including negative past experiences with competing priorities and interests (O'Donnell et al., 2017) are important contextual factors for NBS framing. Several other studies pointed out that the attachment to the place, which forms social bonding, can influence the public perceptions of the risk-mitigating measures or structural development implemented in the landscape (Davenport & Anderson, 2005; Verbrugge & van den Born, 2018; Verbrugge et al., 2019). However, the findings do not always lead to either positive or negative perceptions, but they are rather divergent and conflicting (Bonaiuto et al., 2002; Devine-Wright, 2009).

Third, institutional factors may play a role as a catalyst or an obstacle to positive framing and further mainstreaming of NBS. Studies have found several factors that may hinder decision-makers from opting for NBS over grey measures, for instance, silo mentality (Davies & Lafortezza, 2019; O'Donnell et al., 2018), lack of political will and sense of urgency (Trell & van Geet, 2019), unclear liability (Christine Wamsler et al., 2020), and the less perceived effectiveness of cost and function (Sarabi et al., 2019). These factors may influence decision-

makers to frame NBS as a mere nuisance or an unnecessary extra effort to pursue. In particular, as the management of NBS requires multi-sectoral leadership that cuts across local and national governments (Chausson et al., 2020; Kabisch et al., 2016; Nesshover et al., 2017), these factors may become a critical hindering context for a better endorsement of NBS among the decision-makers.

In summary, previous studies have identified several factors for grasping knowledge about perceptions of NBS. Yet, this knowledge is rather scattered across the disciplines (e.g., geography, ecology, landscape planning, hydrology, etc.), each of which employs distinct terminology (e.g., nature-based solutions, dike relocation and floodplain restoration, ecological restoration, etc.). In addition, each of the single studies is limited to either intrapersonal or contextual focus. Furthermore, the relationships between the constructs or to what extent the factors affect the perceptions are not rigorously investigated.

Against this backdrop, this dissertation seeks to address the chasm in understanding people's perceptions of NBS by attempting to aggregate scattered knowledge in the air and ultimately contributing to the development of a solid foundation for comprehending people's perceptions of NBS as a means of reducing risks. By doing so, it opens an avenue for unified language in the integrative comprehension of people's perceptions of NBS.

1.4. Research Questions and the Framework

The overarching objective of the dissertation is to investigate factors shaping perceptions toward NBS for flood risk management. The dissertation examines sub-questions under this key objective. The answers to these questions provide evidence to corroborate and enhance the current knowledge about the perception of NBS for flood risk management. The sub-questions are as follows:

1. What are the topics reflected in the previous literature influencing perceptions of NBS as a means to reduce hydro-meteorological risks? (Paper I)
2. What are the stimulating and hampering attitudinal and contextual factors for mainstreaming NBS for flood risk management? How are NBS conceptualized? (Paper II)

3. How are public attitudes toward the NBS projects shaped? How do risk-and place-related factors shape individual attitudes toward NBS? (Paper III)

The overall framework of this dissertation is based on two core concepts: place and risk. To fully grasp the socially contextualized framing of NBS, I argue that not only public perceptions of NBS are essential, but also the social contexts that hamper or stimulate perceptions of NBS need to be examined. In this regard, I argue that contextual factors that surround place and risk are influential to affect people's perceptions of NBS; it provides layers of meanings to individual affective and cognitive interaction to place and risk. Therefore, people's perceptions of NBS are shaped by both attitudinal and contextual factors, interactively changing and constantly evolving.

Therefore, this dissertation takes an integrative approach of considering "place" and "risk", as well as the surrounding context, by analyzing attitudinal and contextual factors (Figure 1.1). It considers how the dynamics of the factors eventually affect individual decision-making on their perceptions.

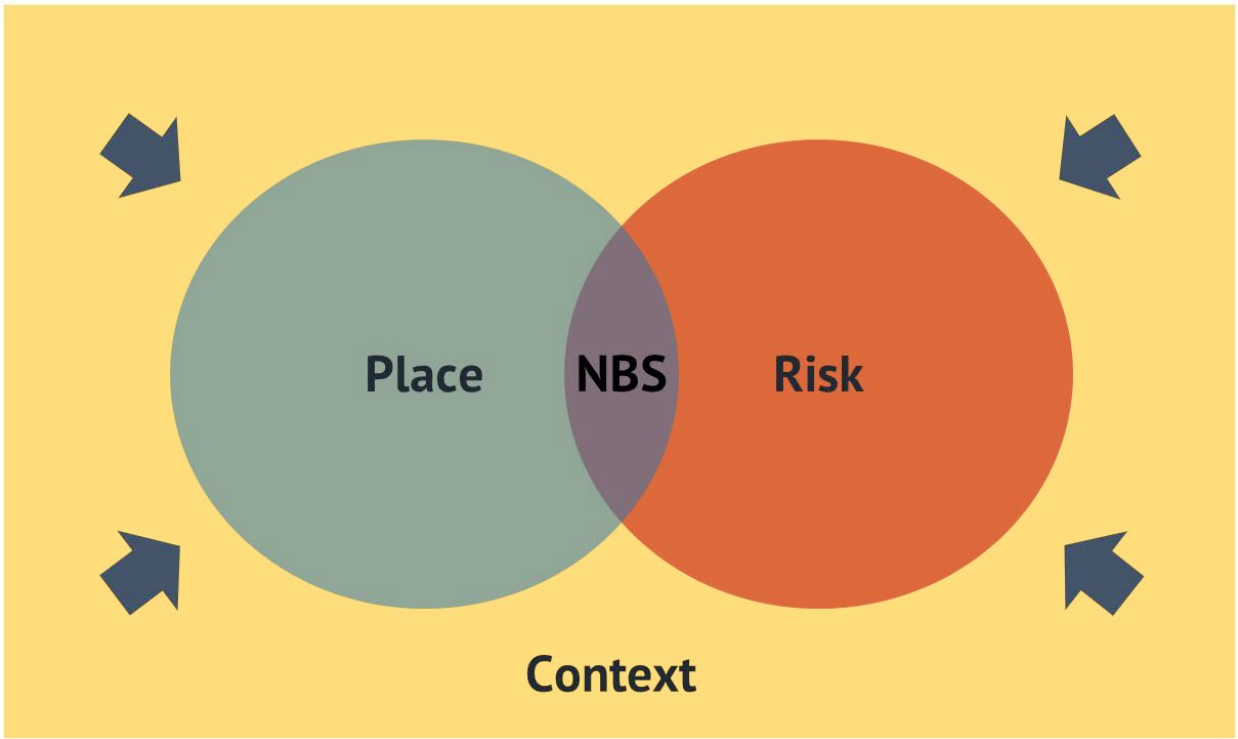

Figure 1.1 Schematic figure of "Place" and "Risk" surrounded by the "Context" to understand people's perceptions of NBS

Figure 1.2 illustrates how each paper contributes to responding to research questions: **Paper I** identifies the influencing factors for perceptions of NBS to reduce flood risks with a systematic review. By performing experts' interviews, **Paper II** aims at investigating both attitudinal and contextual factors that impact perceptions of NBS and how NBS are conceptualized. Lastly, **Paper III** focuses on the residents' attitudes toward the NBS projects by analyzing two main concepts: place-related factors and risk-related factors.

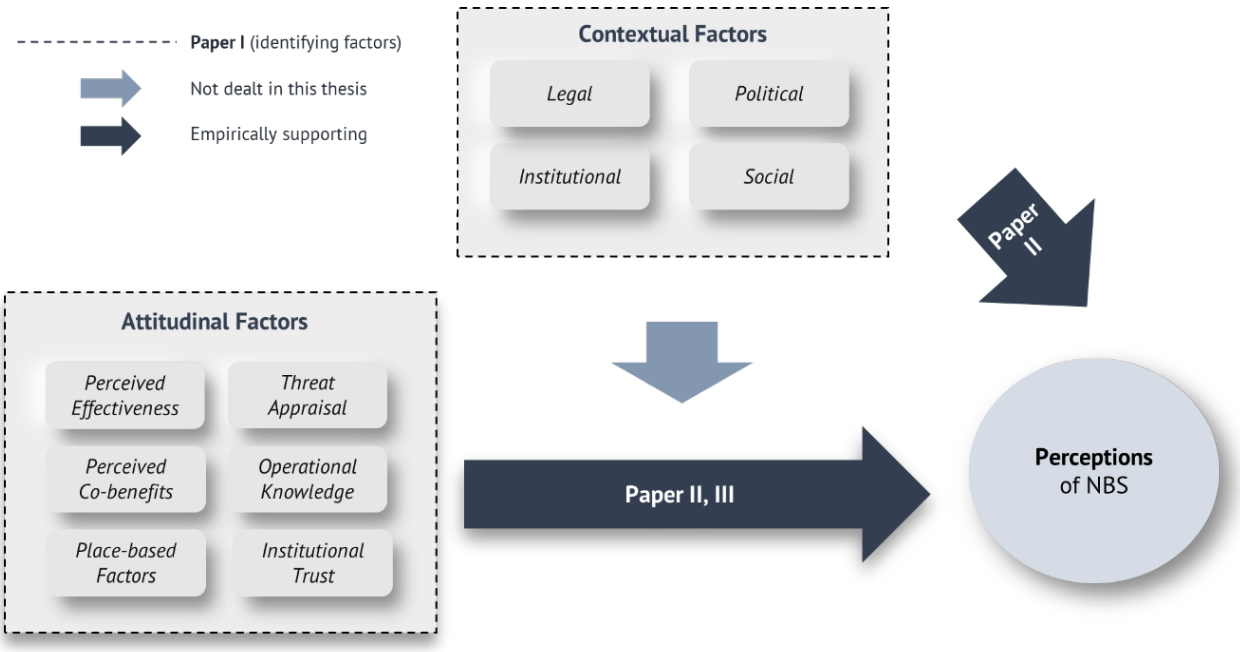

Figure 1.2 Paper contribution and the structure of the dissertation

1.5. Definitions

Before illustrating the details of the dissertation outline, the definitions of the key terms used in this dissertation are provided to clarify and eliminate vagueness.

Attitude

Attitude has various definitions by social psychologists. Vaughan and Hogg (2005, p. 150) stated that it is "a relatively enduring organization of beliefs, feelings, and behavioral tendencies toward socially significant objects, groups, events or symbols." Similarly, Eagly and Chaiken (1993, p. 1) saw it as "a psychological tendency" toward a specific entity, and further, Crano and Prislin (2006, p. 137) defined it as an evaluative integration. The common aspect across these definitions is that attitude is seen as a tendency toward specific objects

that show favor or disfavor. A tripartite model of attitude, which explains the components of attitude, insists on three components that consist of attitude: an affect (i.e., a feeling), cognition (i.e., a thought or belief), and behavior (i.e., an action) (Breckler, 1984; Rosenberg et al., 1960).

In consideration of the previous definitions, in this dissertation, I define attitude as "a person's inclined state of mind, initiated by a responding expression toward a person, place, object, or event."

Perception

Several definitions were also provided for perception. Heil (2011) defined that "perceiving is the picking up of information about the world made available to the perceiver by various sorts of physical stimulation." The American Psychological Association (APA) Dictionary of Psychology defined perception as "the process or result of becoming aware of objects, relationships, and events by means of the senses." Unlike the definition of attitude, perception is mainly concerned with external stimuli and perceptual receptors that may act as a barrier to perception, by selectively picking up or ignoring data. As a result, how a person perceives an object can alter depending on how much information individuals take in or ignore. This can lead to varied conceptualization and interpretation.

In light of these definitions, in this dissertation, I define perception as "a manner of regarding, comprehending, or interpreting objects, relationships, and events in an organized process in which individuals interpret their surroundings, derive subjective inference, and conclude it for certain actions."

In theory, there is a difference between two terms, perception and attitude. Perception, for example, might vary according to an individual's interpretation of how the environment (stimuli) is picked up (e.g., awareness of nature), resulting in varied personal conceptualization. Meanwhile, attitudes are used to describe the process of forming an opinion and are considered a precursor to conducting or linked to behavioral purpose. While cognitive inputs are thought to elicit perceptions, attitudes can be interpreted as a result of learning, mimicking others, and interactions with people and events. However, in practice, perceptions and attitudes are closely connected and interact with one another; people's

attitudes regarding individual NBS projects are influenced by their perceptions of the NBS. Therefore, I do not rigidly demarcate the decisive distinction between the two terms.

Nature-Based solutions (NBS)

Section 1.2 and Table 1.1 showed the definitions of NBS by IUCN and EC, which are widely used among researchers and practitioners. Embracing both definitions, this dissertation defines nature-based solutions as "a solution to diverse societal challenges that involve protection, restoration, or management of existing or previously-existing natural ecosystems by creating or modifying novel ecosystems with human interventions." In particular, this dissertation only deals with the type of NBS that aims at reducing flood risks (in Chapter 2, hydro-meteorological risks were investigated, but flood risks were included there).

1.6. Dissertation Outline

This dissertation consists of three peer-reviewed articles, which are presented in Chapters 2, 3, and 4. The writing style and punctuation of all chapters are now consistent. Some words used in Paper I are adjusted for consistency and clarity.

Paper I. Han, S., & Kuhlicke, C. (2019). Reducing Hydro-Meteorological Risk by Nature-Based Solutions: What Do We Know About People's Perceptions. *Water*, *11*(12), 2599.

Paper II. Han, S., & Kuhlicke, C. (2021). Barriers and Drivers for Mainstreaming Nature-Based Solutions for Flood Risks: The Case of South Korea. *International Journal of Disaster Risk Science*, *12*(5), 661-672.

Paper III. Han, S., Bubeck, P., Thieken, A., & Kuhlicke, C. (2023, forthcoming). A Place-based Risk Appraisal Model for Exploring Attitudes of Residents Toward Nature-Based Solutions. *Risk Analysis.*

Chapter 2 Reducing Hydro-Meteorological Risk by Nature-Based Solutions: What Do We Know About People's Perceptions

Abstract

Nature-based solutions (NBS) have recently received attention due to their potential ability to sustainably reduce hydro-meteorological risks, providing co-benefits for both ecosystems and affected people. Therefore, pioneering research has dedicated efforts to optimize the design of NBS, to evaluate their wider co-benefits and to understand promoting and/or hampering governance conditions for the uptake of NBS. In this article, we aim to complement this research by conducting a comprehensive literature review of factors shaping people's perceptions of NBS as a means to reduce hydro-meteorological risks. Based on 102 studies, we identified six topics shaping the current discussion in this field of research: (1) valuation of the co-benefits (including those related to ecosystems and society); (2) evaluation of risk reduction efficacy; (3) stakeholder participation; (4) socio-economic and place-specific conditions; (5) environmental attitude, and (6) uncertainty. Our analysis reveals that concerned empirical insights are diverse and even contradictory, they vary in the depth of the insights generated and are often not comparable for a lack of a sound theoretical-methodological grounding. We, therefore, propose a conceptual model outlining avenues for future research by indicating potential inter-linkages between constructs underlying perceptions of NBS to hydro-meteorological risks.

Keywords: disaster risk reduction; climate change adaptation; river restoration; green infrastructure; ecosystem services; acceptability; attitudes; co-benefits; preferences; participation

2.1. Introduction

An increase in natural hazards caused by meteorological and climate events such as floods, landslides, and hurricanes has been observed worldwide in recent decades (Wu et al., 2016). When these hazards are coupled with societal vulnerabilities (Watts & Bohle, 1993; Wisner et al., 2014), it creates a higher chance of disasters, which can cause not only serious economic loss but also loss of lives (Kundzewicz & Jania, 2007). Moreover, the likelihood of these hazards could become even higher in the future because of changes in precipitation and temperature patterns associated with ongoing global climate change (Hirabayashi et al., 2013; Milly et al., 2008). Next to climate change, alterations of land-use also play a decisive role in potentially increasing hydro-meteorological risk (Field et al., 2012; Hooijer et al., 2004; Thieken et al., 2016). Rural areas have been converted into urban landscapes, resulting in more deforested or drained areas vulnerable to erosion (Rogger et al., 2017; Seto et al., 2011) as well as an increased number of assets, infrastructure, and people exposed to hydro-meteorological hazards (Barredo, 2009; Beckers et al., 2013; Hall et al., 2006).

In response to this phenomenon, nature-based solutions (NBS) have recently received considerable attention (Accastello et al., 2019; Kabisch et al., 2016). They are positioned as an alternative to conventional technical solutions that have so far dominated the management of hydro-metrological risks (Bubeck et al., 2015). In contrast to traditional management measures, NBS are inspired by or copied from natural processes. NBS help to address multiple societal challenges and pursue more than one single objective (i.e., reduce hydro-meteorological risks); rather, they aim to generate multiple co-benefits for both ecosystems and humans (Fernandes & Guiomar, 2016; Mitsch & Jørgensen, 2003). Therefore, great efforts are currently being undertaken to establish pioneering projects that aim to design and implement NBS as well as systematically evaluate the wider co-benefits of NBS. Although some expected co-benefits are not tangible (Barthelemy & Armani, 2015) and need long-term observation strategies to evaluate them (Doswald et al., 2014), it is anticipated that the documentation of the wider effects of NBS will help stakeholders to better understand the potential positive impacts of NBS and eventually lead to increased uptake (Collentine & Futter, 2018). In addition to the evaluation of co-benefits, there is also an emerging debate

focusing on actors, institutions, and their interactions in order to identify governance conditions that support or hinder NBS (Albert et al., 2019; Nesshover et al., 2017; Raymond et al., 2017).

In this article, we aim to complement recent research that evaluates the co-benefits of NBS and the wider governance context. Although the importance of NBS and their effective implementation has been recognized (Brink et al., 2016; Kabisch et al., 2016; van Wesenbeeck et al., 2017), a comprehensive analysis of factors shaping perceptions of NBS as a means to reduce hydro-meteorological risks is still lacking. It is generally acknowledged that negative perceptions of NBS can be a decisive barrier to the uptake of NBS. Decision-makers might be uncertain with respect to the effects of NBS as well as with respect to procedural aspects related to their planning, implementation, and maintenance (Kabisch et al., 2016). Similarly, perceptions of NBS can be shaped by cognitive barriers, such as unawareness or fear, discouraging stakeholders from considering the realization of NBS (Dhakal & Chevalier, 2017). Moreover, the few existing studies that focus on NBS as a means to reduce hydro-meteorological risks highlight conflicting views. On the one hand, some studies imply that NBS are perceived positively as they not only help to reduce risks, but can also result in co-benefits (Gray et al., 2017; Loos & Rogers, 2016). On the other hand, studies suggest that exposed residents prefer technical solutions over NBS as the latter are perceived as less effective in reducing risks (Ardaya et al., 2017; Short et al., 2019).

In addition, we aim to advance the discussion on perceptions of hydro-meteorological risks. Within the social sciences, the term "risk perception" has a long tradition (Slovic, 1987). It refers to the process of collecting, selecting, and interpreting signals about uncertain impacts of events, activities, or technologies (Renn, 1992, 1998). In recent years, a behavioral turn has occurred in this field of research, focusing on perceptions of risks and factors shaping individual adaptive behavior (Wachinger et al., 2013). Relevant factors that have been identified include: experience of flood damage (Grothmann & Reusswig, 2006; Harvatt et al., 2011; Zaalberg et al., 2009), personal risk perception (Grothmann & Reusswig, 2006; Terpstra & Lindell, 2013), fear of flooding in the future (Harries, 2012; Terpstra, 2011), and coping appraisal (including self-efficacy and response/outcome efficacy) (Grothmann & Reusswig, 2006; Terpstra & Lindell, 2013). Some studies have also identified that individual adaptive

behavior is positively influenced by perceived social norms (Lo, 2013; Poussin et al., 2014), local connectedness (Kim & Kang, 2010) and perceived incentives for adaptive behavior (Poussin et al., 2014). What is lacking in this strand of research is how perceptions of measures to reduce future risks interact with both perceptions of risk as well as adaptive behavior. By means of this literature review, we aim to lay the basis for future research endeavors that tackle the above-mentioned relationships.

Against this background, this review paper aims to provide a systematic analysis of state-of-the-art research considering people's perceptions of NBS in the context of hydro-meteorological risks. By perceiving NBS as a means to reduce hydro-meteorological risks, we refer predominantly to how people perceive the co-benefits of NBS as well as the perceived efficacy of NBS to reduce risks.

The paper is structured as follows: Section 2.2 provides an overview of key terminology including NBS and relevant neighboring concepts, Section 2.3 lays out the methodology underlying the review process, Section 2.4 presents the main findings, Section 2.5 follows with a discussion, and Section 2.6 concludes with some overarching remarks.

2.2. Key Definitions and NBS as an Overarching Concept

In this section, we provide a short synoptic overview of NBS and their differences and similarities to related concepts, such as ecosystem-based adaptation/risk reduction or green infrastructure. Incorporating neighboring terms is relevant, not only because NBS is a relatively new concept but also because it is vaguely defined (Albert et al., 2017); this section also helps to further specify the definition of NBS underlying this literature review (see Section 2.3).

The scope of NBS, and how they differ from similar concepts, is a matter of ongoing debate (Nesshover et al., 2017; Pauleit et al., 2017). Nesshover et al. (2017), for instance, have identified six neighboring concepts: (1) ecological engineering/catchment systems engineering, (2) green/blue infrastructure, (3) ecosystem approach, (4) ecosystem-based adaptation/mitigation, (5) ecosystem service approach/framework, and (6) natural capital. Each of these concepts is based on different definitions (also for each of the terms), pursues

different objectives and can have potentially different relations to the NBS concept. In our view, there are two different viewpoints on NBS that can be identified: While some argue that NBS should be understood as an inclusive umbrella term that spans various neighboring concepts, others argue that NBS is a concept that is distinct from other established concepts. To further illustrate both views, a close look at two common definitions of NBS is helpful.

Since 2013, the European Commission (EC) has conceptualized NBS within the spectrum of ecosystem-based approaches "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." (Faivre et al., 2017). The International Union for Conversation of Nature (IUCN) provides a similar, but slightly different definition: NBS are understood as "actions to protect, sustainably manage and restore natural and modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits" (IUCN, 2016). Both definitions are directed toward addressing societal challenges (e.g., risk reduction) and highlight the decisive role of ecosystem processes that are framed as a means to provide multiple co-benefits to ecosystems and society. The IUCN definition, however, clearly features the relevance of protecting, sustainably managing, and ideally restoring ecosystems that have been modified by anthropogenic use. On the contrary, the EU definition is less strict with respect to the protection/restoration of ecosystems; it rather highlights how nature might support addressing societal challenges (Albert et al., 2019).

Applying both definitions to the subject of this literature review, differences in the means of reducing hydro-meteorological risks become apparent. Whereas conventional measures to reduce hydro-meteorological risks frame "nature" as an external entity that triggers hazards, both definitions highlight the importance of re-introducing nature as a solution to benefit both ecosystem and humans (Fernandes & Guiomar, 2018; Mitsch & Jørgensen, 2003). In this respect, both definitions focus on NBS to tackle the societal challenge of reducing risks by fostering resilience through consciously using the capacity of nature (Albert et al., 2019; Kronenberg et al., 2017; Short et al., 2019). However, these definitions propose different means to reduce risks. On the one hand, the EC definition implies that "ecosystem-based" solutions are not the sole way of reducing risks—NBS can also include engineered hybrid

solutions, meaning a mix of green and gray solutions (Eggermont et al., 2015; Spalding et al., 2013). The stance of the EC also clearly differs from that of the IUCN in terms of cost-effectiveness of the solution: the EC places the importance of cost-effectiveness at the same level as the multiple benefits in diverse systems and resilience that NBS can bring. On the other hand, the IUCN definition has a different emphasis: if NBS are utilized to reduce hydro-meteorological risks, they should also protect and restore affected ecosystems. In this regard, the IUCN definition has a clear focus on protecting or restoring ecosystems, such as river/ecological restoration and ecological engineering.

Likewise, various allegedly neighboring terms have shown some similarities and differences in comparison with the definitions provided by EC and IUCN. Table 2.1 illustrates some of the most relevant neighboring terms including ecosystem-based adaptation, river restoration/ecological engineering, and green infrastructure that are of relevance with respect to reducing hydro-meteorological risks. While the concept of ecosystem-based adaptation is quite similar to NBS, as it also points toward promoting multiple co-benefits apart from environmental benefits, its scope is more limited compared to that of NBS as it focuses primarily on reducing the consequences of climate change. Concepts related to river restoration/ecological engineering emphasize the relevance of re-naturalizing ecological elements so that riverine ecosystems develop the capacity to regenerate themselves. In that sense, they are close to the IUCN definition. However, publications for restoration have increased in past decades, not only focusing on classical ecological theories but also rendering "nature" as an objective for human use (Palmer et al., 2014), embracing utilitarian concerns that align more closely with the EC definition (Pauleit et al., 2017). In other words, restoration works should meet the needs of humans and, to do so, the delivery of the ecosystem should be maximized. Last, green infrastructure is a concept that originally emerged in urban contexts, whereas it meanwhile has also been adopted in rural contexts (European Commission, 2013). A major difference lies in the focus provided by the definition to solve a pressing societal problem. Whereas NBS emphasize a variety of actions to be taken, green infrastructure points toward solutions that can be provided by "infrastructure."

In the light of the previous discussion and being aware of similarities, differences, and the underlying vagueness in NBS concepts (Albert et al., 2017; IUCN, 2016; Nesshover et al., 2017), we are not pursuing a narrow definition of NBS (Pauleit et al., 2017). Rather, our analysis is inclusive of various neighboring terms (see Section 2.3). In line with the definition provided by the EC, the solutions should be clearly directed toward a societal challenge (in this case disaster risk reduction and climate change adaptation), the means to achieve this objective should be inspired and supported by ecosystems and they should provide wider co-benefits for society and/or ecosystems.

Table 2.1 Interlinkages of the related concepts of NBS in hydro-meteorological contexts

	Ecosystem-based approach	**Restoration technology/engineering approach**		**Infrastructure-related approach**
Concept (main) Other concepts	**-Ecosystem-based Adaptation** -Ecosystem Services -Ecosystem Disaster Risk Reduction	**-River Restoration** -Ecological Restoration -Ecosystem-service Restoration	**-Ecological Engineering** -Hybrid Engineering	**-Green Infrastructure** -Blue-Green Infrastructure -Natural Infrastructure
Definition	"use biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change." (Diversity, 2009)	"re-establishment of natural physical processes (e.g., variation of flow and sediment movement), features (e.g., sediment sizes and river shape) and physical habitats of a river system (including submerged, bank and floodplain areas). ... it promotes the idea of encouraging natural processes to create characteristic, self-sustaining, dynamic physical habitat that induces biological recovery and restores the benefits humans rely on." (Addy et al., 2016)	"the design of sustainable ecosystems that integrate human society with its natural environment for the benefit of both" (Mitsch & Jørgensen, 1989) "actions using and/or acting for nature" (Rey et al., 2015) "...can stand alone, but can also be incorporated into hybrid engineering solutions, where ecosystems are utilized alongside engineered defenses." (Spalding et al., 2013)	"an interconnected network of natural areas and other open spaces that conserves natural ecosystem values and functions, sustains clean air and water, and provides a wide array of benefits to people and wildlife." (Benedict & McMahon, 2012) "...is a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services. It incorporates green spaces (or blue if aquatic ecosystems are concerned) and other physical features in terrestrial (including coastal) and marine areas. On land, green infrastructure is present in rural and urban settings." (European Commission, 2013)
Focus	Benefits that humans derive from biodiversity and ecosystem services, focus on tackling with climate change (Nesshover et al., 2017)	Ecosystem self-design and self-organization (Fath, 2018)		Connectivity, multifunctionality and smart conservation (European Environment Agency, 2011)

2.3. Methods

We conducted a systematic literature review using the Web of Science database by following the PRISMA guidelines. Web of Science provides an advanced research query tool that guarantees effective and proper coverage (Bramer et al., 2017). We used a structured query with keywords from three categories to extract the literature from the aforementioned database. This included NBS and relevant neighboring terms, different hydro-meteorological hazards as well as key themes we considered as relevant for a better understanding of how people perceive NBS. We based our search in the Web of Science on the Topic Search, which includes title, abstract, author keywords, and Keywords Plus (assigned by Web of Science). Table 2.2 summarizes the searched terms and an overview of how we conducted the search.

The search elicited 1834 entries. All entries were scanned by having a closer look at the title, abstract, and keywords in order to exclude entries of no relevance for the aim of this study. We only considered papers that included at least one search term within each of three categories (i.e., neighboring terms, hydro-meteorological hazards, and key themes). Articles that did not focus on the reduction of hydro-meteorological risks, such as forest fire, landslide, volcanic risk, etc. were eliminated. After this screening process, 110 papers were left for full-text assessment for its eligibility. These 110 papers were fully read in order to identify papers that have no direct relation to the topic of this paper. Through this process, eight papers were excluded again, resulting in a final database of 102 papers.

Table 2.2 Keywords for the literature survey

NBS and related concepts	Hydro-meteorological hazards	Key themes
Nature-Based Solution	Pluvial Risk/Hazard	Perception
Ecosystem-based solution/management /adaptation/mitigation /approach/framework	Coastal Risk/Hazard	Awareness
	Meteorological Risk/Hazard	Resilience
	Hydrological Risk/Hazard	Participation
	Flood Risk/Hazard	Stakeholder Involvement
Ecological engineering	Climate Change Risk/Hazard	Governance
Catchment System Engineering	Disaster Risk/Hazard	Vulnerability
Ecological Restoration	Natural Risk/Hazard	Trust
Green Infrastructure	Environmental Risk/Hazard	Planning
Natural Infrastructure		Policy
Eco-hydrological solution/management /adaptation/mitigation /engineering		Acceptance
		Cognition
		Preference
Adaptation service		
Natural Capital		
River Restoration		

Search Terms		
"Nature based solution*" OR ("Eco*system*" NEAR (solution OR management OR adaptation OR mitigation OR Approach OR Framework)) OR "Ecolog* Engineer*" OR "Catchment System Engineer*" OR "Ecolog* Restor*" OR "Green Infrastructur*" OR "Natur* Infrastructur*" OR ("Eco*hydro*" NEAR (solution OR management OR adaptation OR mitigation OR engineer)) OR "Adapt*service*" OR "Natural Capital" OR "River Restoration"	AND (pluv* OR coast* OR *meteo* OR hydro* OR flood* OR climate Change OR disaster OR natural OR environmental) AND (risk OR hazard)	AND (perce*) OR (aware*) OR (resilien*) OR (participat*) OR (stakeholder involv*) OR (governance) OR (vulnerab*) OR (trust) OR (planning) OR (policy) OR (accept*) OR (*cognit*) OR (prefer*)

With this database, we drew an overview which includes: the types of conceptual terms underlying the studies (e.g., NBS, green infrastructure, restoration, etc.); countries where the study was conducted (if the study has more than one site, all sites mentioned were counted); year of publication; type of analysis followed in each of the papers (e.g., review study, original empirical research), and key topics underlying the studies in order to better understand the

factors shaping the perceptions of NBS as a means to reduce hydro-meteorological risks (see Section 2.4 for the results). During this step, it became apparent that the majority of papers (N = 71) were too generic and lacked methodological rigorousness in order to generate robust evidence on factors shaping perceptions of NBS as a means to reduce hydro-meteorological risks. In this regard, we decided to identify the papers that were based on a robust methodology and which presented empirical evidence in order to pursue an in-depth analysis. As a result, we chose 31 field studies for the in-depth analysis. The flow chart that shows the whole analytical reviewing process can be found in Figure 2.1.

The authors acknowledged the inherent limitations of the methodology. The online research of the peer-reviewed papers using keywords does not provide an exhaustive survey, lacking other essential documents such as gray literature or project reports. However, with the concise and detailed keywords, the authors tried to include the relevant articles as much as possible. To minimize such errors, the result was also double-checked by both authors to raise the credibility of the analysis. By doing so, this review provided readers insight into the scholarly work on the perceptions of NBS with a social science perspective.

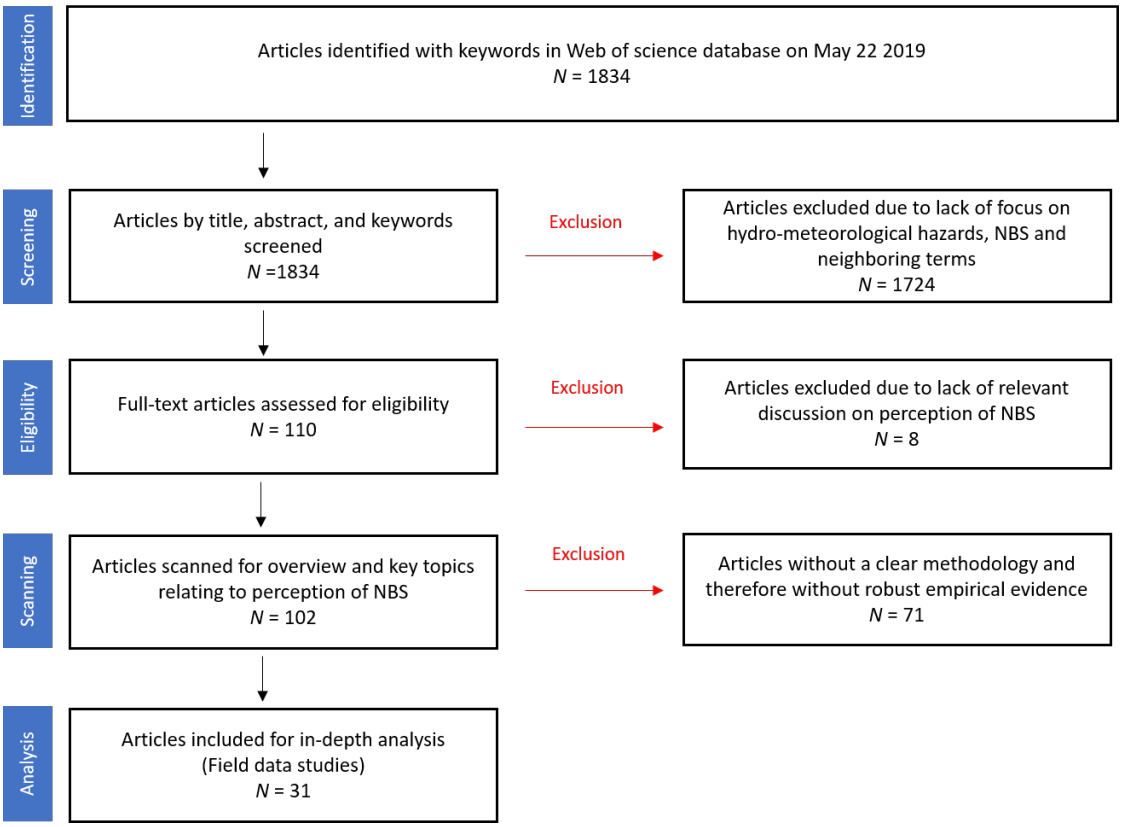

Figure 2.1 Flow chart of the underlying review process

2.4. Result

In this section, we present the findings of the review as follows. First, the background information of 102 relevant articles is outlined, such as publication trends, usage of conceptual terms, and geographical location of papers. Second, we identify the core topics that construct perceptions of NBS in hydro-meteorological contexts. Last, the result of in-depth analysis investigating the evidence of the aforementioned topics in 31 field data studies is presented by each topic.

2.4.1. Overview of the relevant articles

All 102 papers were published between January 2000 and May 2019. Although papers focusing on "ecosystem-based" and "green infrastructure" were already being published in the 1980s and early 1990s (Long et al., 2015; Mell, 2017), they did not focus on the hazards and key topics relevant for this review. As Figure 2.2 indicates, the number of publications has increased over time. Not only has the absolute number of selected publications increased, but also the normalized value of numbers of the selected papers shows an increase in more recent years compared to the normalized value of papers with the topic of flood risk in general. The keywords for the general flood research included the topics we outlined in the "hydro-meteorological hazard" column in Table 2.2. The escalation of normalized values in the selected publications indicates that the increase in the number of selected papers did not correlate with an overall increase in general flood risk research, but rather seemed to be related to a greater focus on NBS and neighboring concepts.

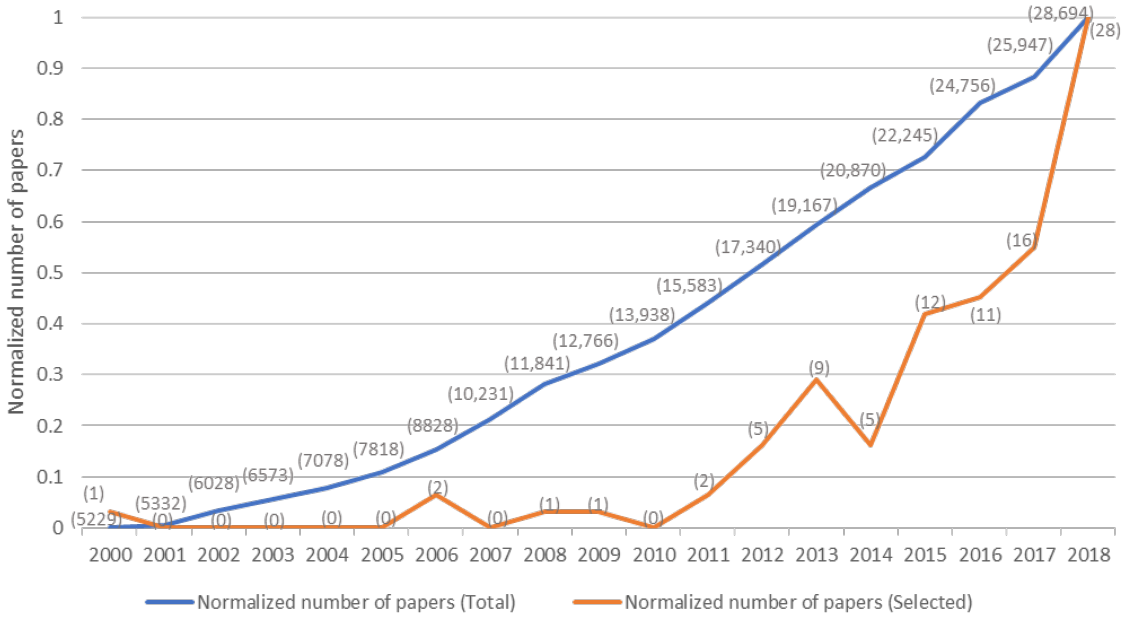

Figure 2.2 Normalized number of articles comparing the selected papers (n=102) with all flood-related publications between 2000 and 2018 in Web of Science (see Table 2.2; hazard context)

In the next step, we classified whether the papers focused on NBS or neighboring concepts (Table 2.3). The broad concepts that represent the sum of sub-concepts are stated in bold. The term "ecosystem-based" was most widely used in the papers we selected (n = 31, 30%), followed by "green infrastructure" (n = 24, 24%) and "restoration" (n = 21, 21%). NBS was used in 14 papers (14%), and noticeably all of them were published after 2016 reflecting the recent history of the term. Three papers used the term "natural infrastructure" or "nature-based infrastructure." Besides, nine papers labeled as "Etc." adopted specific contextual terms such as hybrid engineering, multi-functional urban watercourses, de-culverting, etc.

Table 2.3 The list of full concepts in broad conceptual categories

Concepts	Number of papers	Percent
Ecosystem-based	31	30%
Eco-Disaster Risk Reduction	4	4%
Ecosystem Approach	1	1%
Ecosystem Services	4	4%
Ecosystem-based Adaptation	13	13%
Ecosystem-based Approach	1	1%
Ecosystem-based DRR	2	2%
Ecosystem-based Management	5	5%
Ecosystem-based Solution	1	1%
Green Infrastructure	24	23%
Blue-Green Infrastructure	3	3%
Green Infrastructure	20	20%
Urban Green Infrastructure	1	1%
Restoration	21	21%
Ecological Restoration	2	2%
Ecosystem Restoration	1	1%
Ecosystem Services Restoration	1	1%
Restoration	2	2%
River Restoration	14	14%
Stream Restoration	1	1%
Nature-based solution	14	30%
Etc.	9	9%
Conservation	1	1%
Flood Control Infrastructure	1	1%
Hybrid Engineering	2	2%
Integrated Catchment Management	1	1%
Multi-functional Urban Watercourses	1	1%
Planned Retreat	1	1%
River Corridor Management	1	1%
River Engineering, de-culverting	1	1%
Natural Infrastructure	3	3%
Natural and Nature-based Infrastructure	1	1%
Natural Infrastructure	1	1%
Nature-based Infrastructure	1	1%
Total	102	100%

Our analysis revealed that the term “restoration” was gradually substituted by other emerging terms such as NBS, “ecosystem-based” and “green infrastructure” (Figure 2.3).

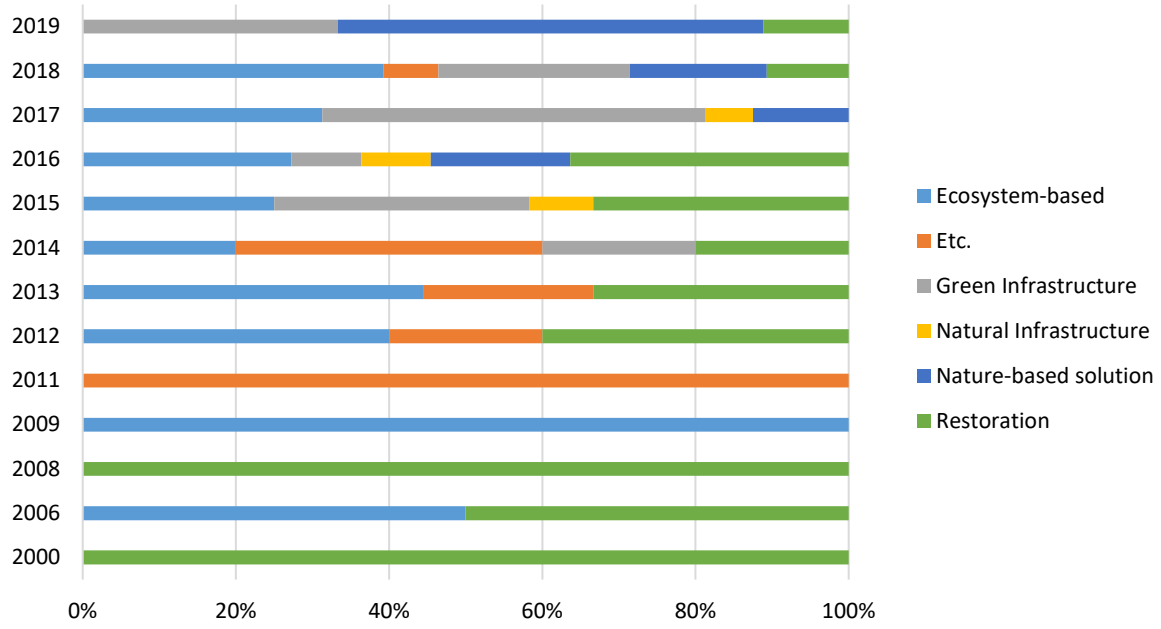

Figure 2.3 Use of the dominant terms in each paper by publication year

With 34 papers, most studies were conducted in the European context (32%), followed by 19 papers in North America (18%) and 13 in Asia constituting 12% (Table 2.4).

Table 2.4 Number of papers by continent

Continent	# of papers	Percent
Europe	34	32%
North America	19	18%
Asia	13	12%
Africa	4	4%
South America	4	4%
Oceania	3	3%
Global	28	27%
Total	105*	100%

* When the research was conducted at more than one site, all sites were counted. Therefore, the total number of papers does not conform to the total number of reviewed papers (N=102).

Within the sample of this study, studies pursuing an "ecosystem-based" approach were most frequent in Asia. The terms "NBS" and "green infrastructure" were most commonly applied in Europe and, in North America (particularly in the US) the term "restoration" was used most often. Interestingly, "green infrastructure" was used relatively evenly among all three continents (Figure 2.4).

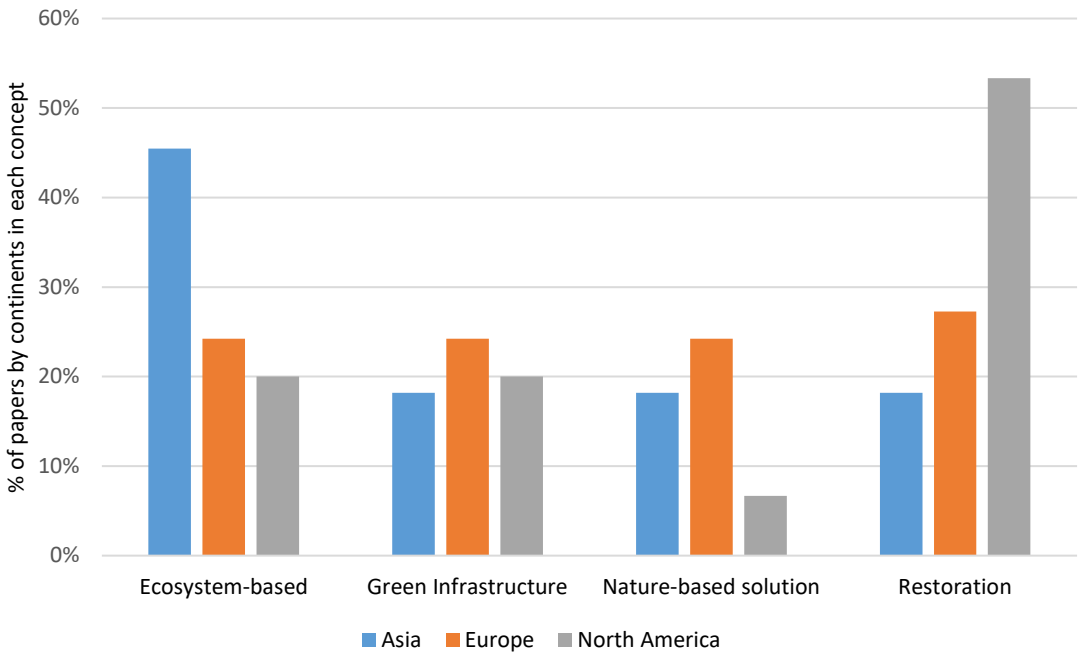

Figure 2.4 Use of the terms by three major continents

2.4.2. Core topics

There are six core topics with respect to perceptions of NBS as a means to reduce hydro-meteorological risks we could identify by scanning 102 relevant papers: (1) valuation of co-benefits (including the valuation of benefits related to ecosystems and society); (2) evaluation of risk reduction efficacy; (3) stakeholder participation; (4) socio-economic and place[c]-specific conditions; (5) environmental attitude, and (6) uncertainty. Table 2.5 provides an overview of the key features that are dealt with in the single topics.

[c] The originally published paper used the term "location." To keep consistency, it is changed to 'place' in this dissertation.

Table 2.5 Core topics for perceptions of NBS

Topics	Key references
[1] Valuation of co-benefits	
• Valuation of benefits for ecosystem	• Cousins (2018); Drake et al. (2013); Gray et al. (2017); Hammersley et al. (2018); Jones and Somper (2014)
• Valuation of societal or other benefits	• Barthelemy and Armani (2015); Brouwer et al. (2016); Duan et al. (2018); Gray et al. (2017); Gumiero et al. (2013); Loos and Rogers (2016); Matthews et al. (2015); Tunstall et al. (2000)
[2] Evaluation of risk reduction efficacy	
• Relevance of the physical presence and visibility of measures	• Barthelemy and Armani (2015); Gray et al. (2017); Gumiero et al. (2013); Loos and Rogers (2016); Matthews et al. (2017); Matthews et al. (2015); Mazzorana et al. (2018); Sutton-Grier et al. (2015)
• Expectation toward the successful realization of NBS	• Chou (2012); Gray et al. (2017); Tunstall et al. (2000)
[3] Stakeholder participation	
• Role of communication between stakeholders	• Biggs et al. (2011); Brink and Wamsler (2018); Denjean et al. (2017); Jones et al. (2012); Loos and Rogers (2016); Tunstall et al. (2000)
• Role of trust between stakeholders	• Dalimunthe (2018); Metcalf et al. (2015); Reynaud et al. (2017)
• Role of trust in institutions	• Verbrugge and van den Born (2018)
[4] Socio-economic and place-specific conditions	
• Individual economic conditions	• Ambrey et al. (2017); Brouwer et al. (2016)
• Educational level	• Chin et al. (2008); Duan et al. (2018); O'Donnell et al. (2017); Short et al. (2019)
• Place-specific conditions	• De Groot (2012); Gray et al. (2017); Laura et al. (2016); Nalau et al. (2018); Thorne et al. (2018)
• Environmental justice and equity	• Ambrey et al. (2017); Dalimunthe (2018)
[5] Environmental Attitude	
• Stewardship of nature	• De Groot (2012); Duan et al. (2018); Thorne et al. (2018)
[6] Uncertainty	
• Time lag for observing benefits	• Doswald et al. (2014); McVittie et al. (2018); Meyer (2013); Spalding et al. (2013); Sutton-Grier et al. (2015)
• Lack of data and knowledge	• Buhl-Mortensen et al. (2017); Carter et al. (2017); Dalimunthe (2018); Gray et al. (2017); Nalau et al. (2018); Spalding et al. (2013); Thorne et al. (2018); Triyanti and Chu (2018)
• Uncertain conditions upon human-nature interactions	• Doswald et al. (2014); Liao (2014)

2.4.3. In-depth analysis based on empirical evidence for core topics

The in-depth analysis was based on six key topics derived from the scanning process of the 31 field data studies. The investigation process allowed us to grasp what kind of empirical evidences are presented with respect to the six key topics.

The analysis first revealed that 21 out of 31 papers (68%) did not show any explicit theories. Three papers used utility theory, along with contingent valuation and choice modeling as a methodology to scrutinize people's preferences. Another three papers were based on grounded theory, which is rather a methodological for gathering and analyzing data based inductive reasoning. In addition, we found that the following theories were utilized by one paper each: the theory of sustainability transition, the theory of adaptive co-management, human ecology and interdisciplinary theories of governance, socio-ecological systems, infrastructure studies, and multilevel politics. Last, we identified some papers that, while not explicitly engaged with a theory, showed a slight inclination toward certain theories such as protection motivation theory and environmental justice. In the following subsections, we analyzed how empirical studies illustrate and operationalize six key topics and the underlying relationships between the constructs.

2.4.3.1. Valuation of Co-benefits

One of the most prominent topics in the reviewed literature, represented in 15 papers, addresses how people value and perceive the co-benefits of NBS and related concepts. The assessment, evaluation and demonstration of the wider benefits of NBS is currently a prominent topic in research on NBS and emphasizes the funding of Horizon 2020 calls (European Commission, 2015). Compared to conventional, technical, and/or engineering-based solutions, NBS are expected to deliver wider benefits, including various "ecosystem services" they provide to society (Reynaud et al., 2017). Therefore, studies have explored how people value ecosystem services and how this influences their perceptions of NBS. All reviewed studies are based on surveys, interviews and workshops. The following methods were adopted: content analysis (Chou, 2013; Gray et al., 2017), statistical analysis (Duan et al., 2018; Wong-Parodi & Klima, 2017), contingent valuation as a form of willingness to pay

(Reynaud et al., 2017), and multi-criteria decision analysis (MCDA) paired with multi-attribute utility theory and choice experiment (Drake et al., 2013).

Studies focusing on the individual valuation of co-benefits focused predominantly on aesthetical (Barthelemy & Armani, 2015; Chou, 2013; Loos & Rogers, 2016; Ruiz-Villanueva et al., 2018; Verbrugge & van den Born, 2018) and recreational aspects (Chou, 2016; Gray et al., 2017; Tunstall et al., 2000; Verbrugge & van den Born, 2018). Both co-benefits seem to have a positive influence on people's perception of NBS, although in some studies aesthetical aspects were found to be perceived as of lower relevance compared to other co-benefits (Loos & Rogers, 2016; Ruiz-Villanueva et al., 2018).

Other studies explored attitudes toward NBS compared to more established technical-engineering based measures to reduce risks. Findings indicate that people support NBS and that they prefer NBS if they also positively value wider social and natural co-benefits, such as aesthetical, recreational, economic, and nature-related aspects (Loos & Rogers, 2016; Martinez-Juarez et al., 2019; Wong-Parodi & Klima, 2017).

Studies have also explored how interaction with NBS shapes individual perceptions of NBS. People who directly interact with NBS report higher awareness of both the potential positive effects of NBS and of risks compared to people with lower degrees of interaction, such as tourists (Duan et al., 2018), users compared to non-users (Brouwer et al., 2016), or NBS sites that are less accessible (Tunstall et al., 2000).

2.4.3.2. Evaluation of Risk Reduction Efficacy

The perceived efficacy of NBS is another prominent topic in the literature we reviewed (n = 9). As NBS are often replacing or complementing more established technical, engineering-based risk reduction measures, many studies take a comparative perspective by, at least implicitly, comparing the efficacy of established measures with NBS.

NBS and related approaches are often perceived by people as being less effective than traditional protection schemes. This pattern was found in the management of coastal hazards (Gray et al., 2017) and urban flooding (e.g., removal of culverts) (Chou, 2012, 2013, 2016; Martinez-Juarez et al., 2019). We can only speculate about the reasons for this pattern: Some authors suggest that the immediate physical presence and visibility of technical measures are

interpreted by individuals as a demonstration of progress and problem-solving attitudes by responsible governmental bodies (Ardaya et al., 2017), and may also contribute to an increased feeling of protection (Gray et al., 2017; Martinez-Juarez et al., 2019). Other studies point to the underlying threat appraisal. People who perceive a high threat of future typhoons and monsoon events also report higher trust in technical solutions than in NBS (Chou, 2012). Similarly, the ambivalent role of pioneering projects is touched upon: if preceding NBS projects were not well planned and implemented and turned out to be ineffective, this can undermine people's trust in their effectiveness (Chou, 2012).

We found one study stating that respondents of a survey reported that flood risk was reduced and that this reduction was attributable to the successful realization of NBS (Tunstall et al., 2000). Another study suggested that the framing of NBS as a means to enhance the safety of a place could positively influence the perceived efficacy of NBS (Verbrugge & van den Born, 2018). At the same time, one study showed that lower levels of perceived efficacy of NBS do not affect the support of people. Wong-Parodi and Klima (2017) found out that people support and prefer green infrastructure over gray, even though they think that current engineer-based infrastructure secures them more effectively.

2.4.3.3. Stakeholder Participation

Stakeholder participation has received attention as one of the essential elements in risk management processes and NBS implementation. It is crucial to respect the right of stakeholders, including those affected by NBS for hydro-meteorological risk reduction purpose, to be involved in decision-making processes and to facilitate effective solutions for societal problems (van Ham & Klimmek, 2017).

The willingness of stakeholders to take part in the realization of NBS can be explained in multiple ways, including from a supportive attitude toward NBS, or from strong resistance to the realization of NBS.

Although participation was touched upon in 12 of the empirical studies we reviewed, it was not usually their main focus. Nevertheless, we found several cases that prove that participation can stimulate people to be aware of ongoing local problems and needs (Ardaya et al., 2017; Martinez-Juarez et al., 2019). This can result in improved stakeholder

coordination to realize projects (Pinto et al., 2018). In addition, participation can embrace the diversity of the affected community in the design and planning process, promoting local buy-in of solutions (Loos & Rogers, 2016). In this regard, effective communication among stakeholders is considered key to innovation and dynamism in NBS projects (Ardaya et al., 2017; Tunstall et al., 2000), which can be a driving force to sustainable project implementation (Barthelemy & Armani, 2015).

A few other studies insist that trust influences stakeholder participation and involvement. Trust between stakeholders facilitates the exchange of information and strengthens relationships (Ardaya et al., 2017). By doing so, it enhances stakeholders' acceptance of vulnerability to project implementation (Dalimunthe, 2018; Metcalf et al., 2015) and can ease conflicts of interest between actors (Reynaud et al., 2017). In addition, participation can also increase ownership among local communities of the realization of NBS projects (Dalimunthe, 2018). Furthermore, trust in responsible organizations and institutions (as exemplified in the Room for River Program in the Netherlands and people's trust in Dutch safety standards) brings more support for new solutions (Dalimunthe, 2018). When involved communities have a strong attachment to a proposed project site, extra care for the building of trust is needed (Verbrugge & van den Born, 2018).

Lastly, the studies also found that wider stakeholder participation can contribute to mainstreaming NBS while fulfilling the project's ecological aim (Wamsler, 2015). In order to foster more participation and satisfaction of stakeholders, the implementation scheme, including the purpose and technique of the project, should be described to them in advance of its implementation (Sheng et al., 2019). Likewise, a realistic implementation scheme, including information about long-term benefits or time lags in a project's successful delivery, should be shared between stakeholders to prevent frustration (Tunstall et al., 2000).

2.4.3.4. Socio-Economic and Place-Specific Conditions

Numerous other papers (n = 10) have reported socio-economic and place-specific conditions related to people's perceptions of NBS. However, the reviewed papers provided inconsistent findings; they showed heterogeneous results that are largely shaped by the respective context.

In contrast with a study that indicated that different socio-economic conditions do not affect perceptions of green measures (Ambrey et al., 2017), other papers show evidence for such a correlation. For example, Sheng et al. (2019) found that household income and the amount of government subsidy received for owned pasture area correlated with the positive support of a restoration project. However, Brouwer et al. (2016) found that this correlation is not universal but only occurs for lower-income households depending on the respective national context. Furthermore, educational level seems to have a clear positive effect on perceptions of NBS (Duan et al., 2018; O'Donnell et al., 2018). This observation can be linked with the finding that a lack of knowledge/understanding of NBS affects people's supportive attitudes (Chin et al., 2008; Gray et al., 2017; O'Donnell et al., 2017).

Other studies found that a preference for NBS can be place-specific (Gray et al., 2017; Wong-Parodi & Klima, 2017). On the one hand, the place associated with the personal experiences of a hazard influences perceptions of NBS (Gray et al., 2017). This is particularly true for negative experiences, which may impede NBS support (O'Donnell et al., 2018). On the other hand, socio-cultural aspects seem to influence the preference of the local communities with respect to NBS. In detail, it can differ depending on how much people are attached to the project place (Verbrugge & van den Born, 2018) and the local history regarding mitigation measures (Gray et al., 2017).

2.4.3.5. Environmental Attitude

A few studies (n = 2) have found evidence that the environmental attitude of stakeholders shapes their attitude toward NBS. For instance, people who reported higher degrees of stewardship to nature or, otherwise stated, those who put a higher value on feeling responsible for the conservation of nature, preferred NBS over more conventional flood management approaches (De Groot, 2012). Another study interpreted a preference for NBS as evidence of altruistic behavior: though individuals did not receive any personal benefit, they still preferred NBS for the sake of "the level of environmental quality provided" and "the act of giving" (Drake et al., 2013).

2.4.3.6. Uncertainty

A considerable number of papers, which we scanned previously for the core topics, mentioned uncertainty in NBS implementation. This was attributed to lack of long-term data and the complexity inherent in nature (i.e., "surprise," given by the variability of nature as a baseline) and human-nature interactions, which depend on physical, ecological, and socio-economic conditions (see Table 2.5). However, these arguments are backed up by merely two empirical studies. First, uncertain aspects of project implementation are seen to play a role in raising local concerns about safety. It relates to the individual perception of risk efficacy of NBS, and the idea that unstable features of nature threaten local people (Chou, 2016). Second, a survey-based study revealed that a lack of knowledge and understanding was a barrier to gaining support from local authorities and public (O'Donnell et al., 2017).

2.5. Discussion

This review has thematically focused on documenting state-of-the-art factors that shape perceptions of NBS by means of reducing hydro-meteorological risks. Departing from a rather broad understanding of NBS that is grounded in the definitions of NBS provided by the EC and IUCN, we also included neighboring terms in this review to ensure broad thematic coverage.

Based on 102 studies, we identified six topics shaping the current discussion in this field of research. The empirical insights concerning these topics are not only diverse but also sometimes even contradictory, and they also vary in the depth of the insights generated. Most pronounced are studies focusing on affected people's perceptions of the co-benefits and efficacy of NBS.

Concerning perceptions of co-benefits, the results are relatively consistent: Studies suggest that if co-benefits are valued positively, NBS are also perceived positively, particularly if people have direct access to NBS and interact with these solutions relatively often. However, the studies we reviewed focused only on co-benefits related to recreational and aesthetical aspects of NBS – other aspects such as health, wellbeing, cultural values, and economic development have not yet been considered.

As for the perceived efficacy of NBS, findings are rather mixed. While NBS are often perceived as less effective than more established and technical risk reduction measures, we know very little about the underlying reasons for this tendency. Next to the immediate physical presence of technical measures, the relation between perceived efficacy of NBS and threat appraisal seems relevant: if threat appraisal is high, trust in NBS seems to be lower. However, few available studies explore this connection more thoroughly. Some studies indicate that trust in NBS efficacy can increase over time if exposed residents realize that NBS can reduce the risk of hydro-meteorological events.

Regarding socio-economic and place-specific conditions, findings are also mixed: While some studies suggest no correlation between socio-economic statuses of households and their perception of NBS, other studies highlight a correlation. We assume that contextual factors play a decisive role here. This is at least suggested by the cross-country studies conducted by Brouwer et al. (2016), which imply that different spatial, socio-economic-demographic, cultural, and institutional settings may correlate with a different perception of NBS.

Very few studies have focused on how people's environmental attitudes shape their perceptions of NBS. It was shown that people who report higher degrees of stewardship to nature prefer NBS over more conventional flood management approaches (De Groot, 2012; Drake et al., 2013).

The role of uncertainty is also seldom explored. High uncertainty concerning the realization of NBS projects may undermine people's feelings of safety, furthermore, a lack of knowledge about the effects of NBS may also be a barrier for the support for NBS.

Finally, findings on stakeholder participation are rather limited. We found that participation can stimulate people's awareness of ongoing local problems and needs, and can, therefore, result in improved stakeholder coordination to realize projects. Stakeholder perceptions of NBS also seem to be positively influenced when effectively informed about the realization of NBS. Studies also found that wider stakeholder participation can contribute to the mainstreaming of NBS and can help fulfill the wider ecological objectives of NBS projects.

The field of research in this review is still emerging. Among the papers we reviewed, very few focus explicitly on NBS to reduce hydro-meteorological risks and how they are perceived.

The majority focuses on other topics, though they do touch upon the core topics of this paper. The studies we identified as most relevant for this paper (i.e., defined by an explicated methodology aiming at generating evidence) also underline that this research field is still developing. Most of the papers did not explicate their underlying theories. This hampers the comparability of empirical insights. For instance, in other related fields of research (e.g., what motivates individual adaptive behavior) where at least basic theoretical aspects are shared (e.g., protection motivation theory), a comparison of empirical studies has become possible eventually by allowing the conduction of statistically grounded meta-analyses (Bamberg et al., 2017). However, this is barely possible in for the reviewed studies, most of which collect empirical data and insights without grounding them in a theoretical framework.

As an implication of the previously identified gap, there are hardly any studies that systematically frame the inter-linkages between the different constructs we previously outlined. Based on the review, however, it is possible to outline some basal inter-linkages that require further exploration in future studies (see Figure 2.5). We also believe that this generic model has the potential to be applied in other hazard contexts such as a landslide and earthquake, which can be investigated more in-depth in future studies.

More specifically, we expect that interacting constructs, particularly the valuation of efficacy and co-benefits of NBS, could influence people's perception of NBS. We also consider it likely that other variables might moderate these interactions. First, people's threat appraisal could moderate the impact of evaluation of risk reduction efficacy on perceptions of NBS. If people feel threatened by the consequences of hydro-meteorological risks, they may have lower levels of trust in the effectiveness of NBS to reduce risk. This lack of trust could outweigh positive attitudes toward the co-benefits of NBS, and result in negative attitudes toward NBS. However, it is likely that people's threat appraisal not only relates to primary hydro-meteorological risks but also to potential secondary risks related to NBS. People may believe that the replacement of technical measures with NBS will increase hydro-meteorological risk for their property (Jørgensen & Renöfält, 2013), or that NBS may cause new risks such as invasive organic species or rising groundwater levels (Eggermont et al., 2015). Second, we also expect that people's environmental attitudes and the likelihood of their direct use of, or interaction with, NBS could moderate their perception of co-benefits. If

people have a strong pro-environmental attitude, this might positively reinforce the impact of their valuation of the NBS co-benefits. Perceived NBS co-benefits also might then outweigh concern about the efficacy of NBS, resulting in more positive attitudes toward NBS. Likewise, if affected people are more likely to benefit from or interact with NBS due to spatial proximity, etc., this might positively moderate the valuation of co-benefits. However, at this stage, we can only speculate about these construct interactions.

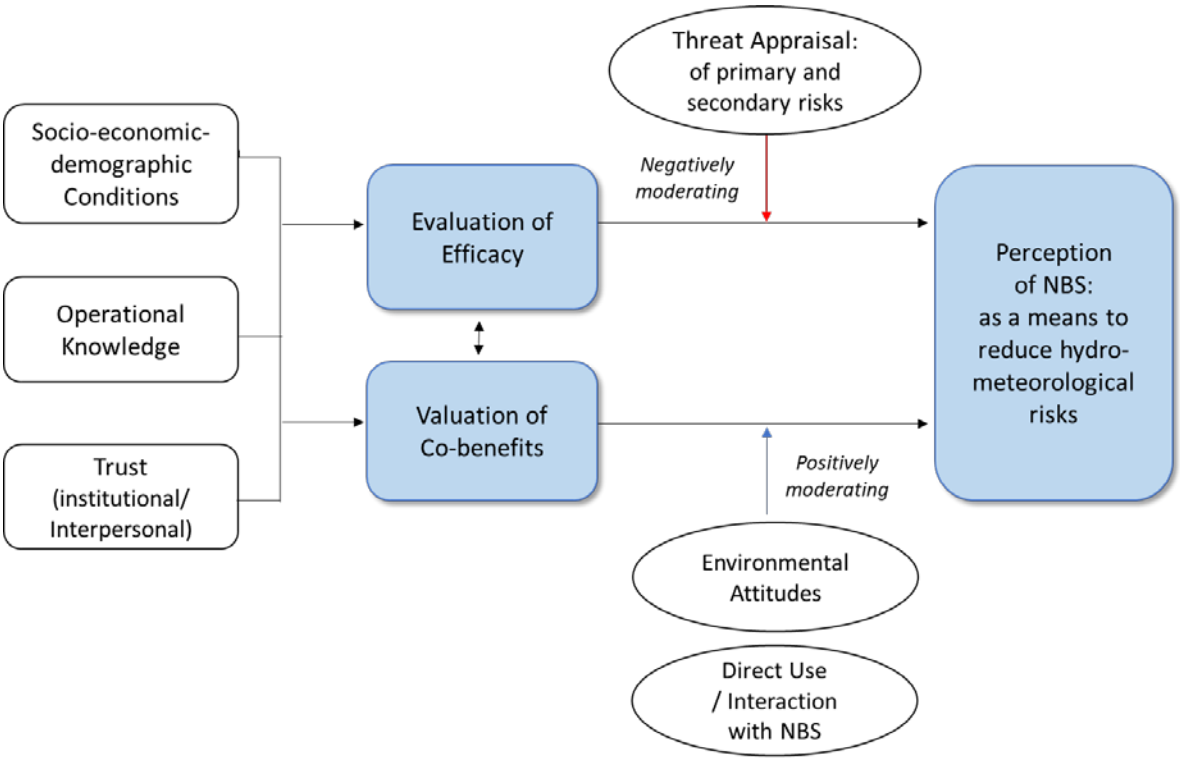

Figure 2.5 A generic model for the potential interplay of key constructs underlying perceptions of NBS as a means to reduce hydro-meteorological risks

Furthermore, we assume that an individual's valuation of NBS co-benefits and efficacy might be influenced by their socio-economic-demographic conditions and NBS knowledge (for instance, knowledge about the effects of NBS and realistic implementation scheme), possibly obtained from prior experiences or other informational sources. Based on our literature review, we could only conjecture about the role of people's socio-economic-demographic situation and point toward contextual factors. In addition, it is assumed that both intrapersonal (i.e., between stakeholders) and institutional (i.e., in responsible organizations and institutions) trust shape the valuation of NBS co-benefits and efficacy. We also surmise that participation may play a role in stimulating these factors and, ultimately, positively influence the valuation of efficacy and co-benefits.

While we believe that a more structured and theoretically grounded approach to the assessment of people's perception of NBS is necessary, we also consider that greater attention needs to be paid to what counts as NBS. In this study, we reviewed a considerable number of publications that focused on different concepts, such as ecosystem-based adaptation, restoration, and green infrastructure. As the concept of NBS implies, at least in its more inclusive definition, all "solutions" are comparable as long as they are directed toward addressing societal challenges, provide co-benefits and are inspired or supported by ecosystems. Focusing on how people perceive NBS, however, it is debatable that a small-scale hybrid NBS, implemented in an urban context, is comparable to a large-scale river restoration project at the catchment scale, the latter of which not only influences people's livelihoods but also profoundly transforms an entire landscape. In addition, environmental attitudes were distinctively scrutinized in publications focusing on restoration, while the perceived co-benefit was explored more systematically in literature dealing with NBS and green infrastructure literature. Such differences, both for NBS and thematic emphases, need to be accounted for more carefully in future research.

We, therefore, propose that future research should reflect these different NBS by using a more conscious sampling strategy, at least for the quantitative standardized surveys—this would contribute a better understanding of how different NBS perceptions are shaped. The typology proposed by Eggermont et al. (2015) can offer some instructive insights on how to operationalize such a sampling procedure. They argue that NBS approaches can be broadly classified into three types along a gradient of the level and intensity of engineering applied. Type 1 NBS approaches involve no or minimal intervention in ecosystems, type 2 measures are aimed at establishing sustainable and multifunctional ecosystems, and type 3 NBS approaches imply a profound transformation of ecosystems possibly even resulting in new ecosystems. Based on our review, we assume that these fundamental differences in NBS setup would have a great impact on people's attitudes toward them. Therefore, such differences should be reflected in the selection of case studies for empirical research.

2.6. Conclusions

We believe that more social science research, based on rigorous methodologies and grounded in social science theories, is needed to complement the currently dominant approach that focuses on the quantitative evaluation of NBS co-benefits. As this review has indicated, our knowledge about perceptions of NBS as a means to reduce hydro-meteorological risks is still hampered by profound gaps in knowledge. With this article, we have outlined some avenues for future research.

Our results show that the current knowledge of concepts surrounding perceptions of NBS is not always consistent. While perceived co-benefits show a relatively strong positive impact on the people's perceptions of NBS, other factors such as perceived efficacy of NBS and individual socio-economic-demographic conditions show conflicting results. We concluded that the scale of each NBS project (e.g., large-scale river restoration compared with small scale installation of green infrastructure) and the level of engineering used can contribute to the discrepancies in perceptions of NBS shown in the empirical studies. Therefore, we propose that future empirical studies regarding perceptions of NBS should conduct a careful sampling of different NBS and be cognizant of comparing NBS projects. We also found that some essential variables, such as environmental attitudes and uncertainty, have been overlooked in the empirical research. Finally, our model for the potential interplay of key constructs underlying perceptions of NBS shows the possible relationships between constructs and emphasizes the need for a theoretical framework. Such frameworks encompass fragmented knowledge and generate meaningful insights to help raise people's supportive attitudes toward NBS.

Chapter 3 Barriers and Drivers for Mainstreaming Nature-Based Solutions for Flood Risks: The Case of South Korea

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

3.1. 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; Thieken 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 (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 Section 3.2; Section 3.3 presents the main findings from the expert interviews. To conclude, Section 3.4 summarizes and discusses the main findings and provides recommendations for the mainstreaming of NBS in South Korea.

3.2. Case Study and Methods

In this section, we elaborate the case of South Korea (Section 3.2.1) and the method (Section 3.2.2) that this research adopted.

3.2.1. 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 (Figure 3.1).

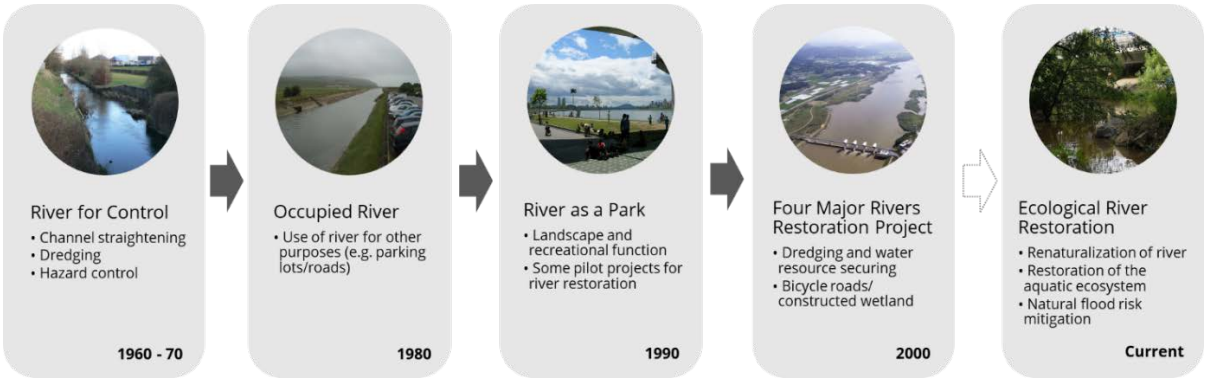

Figure 3.1 Changes in river management in South Korea (Image Source: Wikimedia Commons)

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

3.2.2. 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 3.1).

Table 3.1 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

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 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 Figure 3.2). 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.

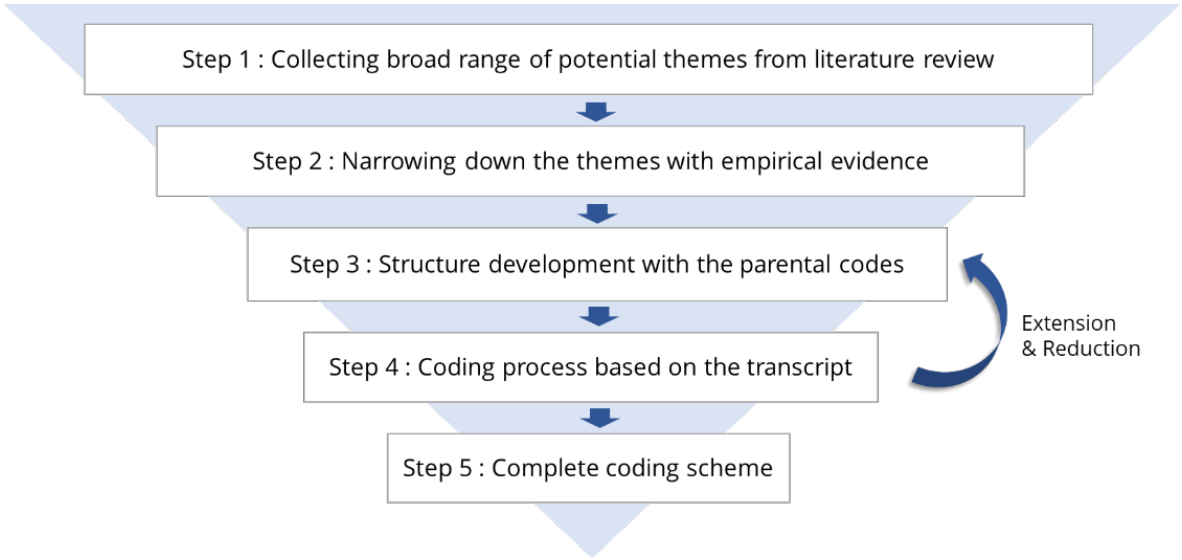

Figure 3.2 Development of the coding scheme used for thematic analysis of data derived from nature-based solutions interviews

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 toward 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 toward NBS.

3.3. Results

In this section, the analysis results are described. Conceptualization of nature-based solution is described in Section 3.3.1, and attitudinal and contextual factors are illustrated in Section 3.3.2 and 3.3.3.

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 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 3.2).

Table 3.2 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).	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.	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).	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.	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.

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.

3.3.2. Attitudinal factors

We found 16 attitudinal factors that impacted the mainstreaming of NBS, including 11 barriers and five drivers. These are summarized in Figure 3.3 and further details are described in the following sections.

Table 3.3 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

3.3.2.1. 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.

3.3.2.2. 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, 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.

3.3.2.3. 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.

3.3.3. Contextual factors

We found13 barriers and 2 drivers to the mainstreaming of NBS; we categorized these factors as institutional, legal, political, or social (Figure 3.4). The details are illustrated in the next section.

Table 3.4 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

3.3.3.1. 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,[4] 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.

3.3.3.2. 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

[4] AC1 addressed both the pros and cons of incentives.

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).

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.

3.3.3.3. 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.*

3.3.3.4. 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.

3.4. 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 toward 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.

3.5. 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 toward 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.

Chapter 4 A Place-based Risk Appraisal Model for Exploring Residents' Attitudes Toward Nature-based Solutions to Flood Risks

Abstract

Nature-based solutions (NBS) have gained popularity as a sustainable and effective way of dealing with increasing flood risks. One of the key factors that often hinders the successful implementation of NBS is residents' opposition to their implementation. In this paper, we argue that the place where a hazard exists should be considered as a critical contextual factor alongside flood risk appraisals and perceptions of NBS themselves. We have developed a theoretical framework – the 'Place-based Risk Appraisal Model (PRAM)' – that draws on constructs inspired by theories of place and risk perception. A citizen survey (n=304) was conducted in five municipalities in Saxony-Anhalt, Germany where dike relocation and floodplain restoration projects have been conducted along the Elbe River. Structural equation modeling was adopted to test the PRAM. Attitudes toward the projects were assessed in terms of 'perceived risk-reduction effectiveness' and 'supportive attitude'. With regard to risk-related constructs, well-communicated information, and perceived co-benefits were consistently positive factors for both perceived risk-reduction effectiveness and supportive attitude. Trust in local flood risk management was a positive and threat appraisal a negative predictor of perceived risk-reduction effectiveness affecting 'supportive attitude' only through 'perceived risk-reduction effectiveness'. Regarding place attachment constructs, place identity was a negative predictor of a supportive attitude. The study emphasizes that risk appraisal, pluralities of place contexts to each individual, and their relations are key for determining attitudes toward NBS. Understanding these influencing factors and their interrelationships enables us to provide theory- and evidence-based recommendations for the effective realization of NBS.

Keywords: Dike relocation; flood risk management; place attachment; risk perception; structural equation modeling

4.1. Introduction

Recent evidence has revealed a rise in the frequency and intensity of flood risks globally (Alfieri et al., 2015; Hirabayashi et al., 2013; Winsemius et al., 2016). Flooding has injured nearly 1.6 billion people globally in the previous two decades (2000-2019), accounting for 41% of all disaster types (CRED and UNDRR, 2020). In July 2021, More than 150 people lost their lives as a result of the severe floods in Western Germany. Although flood defense is still dominant as a technical or structural approach to prevent losses, an integrative perspective in flood risk management (FRM) that considers both natural and human systems has recently appeared on the scene (Bubeck et al., 2017). This perspective constitutes a response to the international call for Nature-Based Solutions (NBS) as sustainable, future-proof means to manage flood risks (Browder et al., 2019; European Commission, 2015; IUCN, 2016). While the goals of NBS span a wide range of societal concerns, this study focuses on NBS aimed at reducing flood risks. The salient characteristic of NBS as a means to manage flood risk is that they preserve the ecosystem's multi-functionality and contribute to nature conservation while also having the potential to reduce flood risks effectively (Kabisch et al., 2016; Pauleit et al., 2017). The effectiveness of reducing flood risks of NBS was shown in a number of studies (e.g. S. Ferreira et al., 2020; Vermaat et al., 2016; Vojinovic et al., 2021). Kousky and Walls (2014) estimated the benefits and costs of levee setbacks in the Middle Mississippi River and concluded that setbacks would decrease expected annual damages by 55 percent in urban areas. In this regard, a shift in the way rivers themselves are framed goes hand in hand with the focus on NBS. In the past, rivers were regarded primarily as objects entailing hazards that needed to be better controlled by technical means such as flood defense systems. In the meantime, the meanings of rivers and floodplains have changed as they have come to also be considered as an area in which diverse co-benefits (including ecological, aesthetic, and recreational benefits) can be achieved while simultaneously reducing the risk of flooding (Albert et al., 2021). As a result, the renaturalization of rivers and floodplains has come much more to the fore in a new FRM paradigm.

Along with this shift, greater emphasis has been placed on local participation in FRM. As in other European countries, a change from flood defense strategies to broader-based flood risk management has occurred in Germany since the European Floods Directive

(2007/60/EC) came into force. The European Floods Directive thus became a basis for including participatory planning practices, regardless of EU member states' differing adopting strategies (Newig et al., 2014). Debates about public participation in FRM tend to focus mainly on the need (or otherwise) for more intense, broader, and earlier participation in various controversies seeking distributive justice and procedural equity. At the same time, public participation per se, or whether it really promptly copes with the facing challenges in flood risk plans, has also been questioned in the narratives constructed, particularly after the severe flood events of 2013 in Germany (Otto et al., 2018). Kuhlicke et al. (2016), among others, has documented the narratives that have arisen around highly politicized public participation in flood risk management in Germany. Similarly, others report that in some projects involving NBS, conflicts of interest and disagreements have frequently caused bottlenecks in project implementation (Bark et al., 2021; Ferreira et al., 2020; Puskás et al., 2021). Therefore, undertaking the public participation process in consideration of diverse public perspectives, which may trigger conflicts, should be taken into account in order to successfully implement NBS (Wamsler et al., 2020).

The reasons behind such conflicts and resistance include (but are not limited to) underestimating the potential of NBS (Gray et al., 2017) coupled with uncertainty around their effectiveness (Thorne et al., 2018; Wolf et al., 2021). An underlying explanation has been identified as a lack of long-term data to convince stakeholders, and unpredictability in nature as a baseline that interacts with physical, ecological, and socioeconomic aspects (Han & Kuhlicke, 2019). Furthermore, disputes over land acquisition from private landowners for the implementation of NBS projects can be a source of contention (Van Straalen et al., 2018). For example, when a project requires a change in land use and, particularly, when stakeholder interests are involved, citizens' participation in decision-making may prevent conflicts (Begg et al., 2018; Wamsler et al., 2020). How individual attitudes toward NBS projects are constructed and which factors affect public perceptions are, therefore, key issues in achieving successful outcomes.

So far, a small number of review papers have explored the factors shaping public perceptions and attitudes toward projects involving NBS (Anderson & Renaud, 2021; Garcia et al., 2020; Han & Kuhlicke, 2019; Mallette et al., 2021; Venkataramanan et al., 2020). In their

review of 102 papers, for example, Han and Kuhlicke (2019) identified six topics as being the most influential factors shaping attitudes toward NBS for flood risks, including, among others, the perceived co-benefits and risk reduction efficacy of NBS.

By way of summary, the current literature indicates that several factors are essential in shaping individuals' attitudes toward projects involving NBS:

First, risk perceptions were identified as a critical factor affecting people's attitudes toward NBS. The major underlying reason is that local people often perceive natural flood risk management measures as less effective than structural measures (e.g. Chou, 2012; Chou, 2013; Martinez-Juarez et al., 2019). Some studies pointed out that the immediate physical presence of structural measures gives the people affected a stronger sense of safety (Gray et al., 2017; Martinez-Juarez et al., 2019) and can be perceived as an expression of the (local) government's commitment to guarantee that safety (Ardaya et al., 2017). Other studies have shown that policymakers as well as practitioners also tend to underestimate the efficacy of NBS. For example, policymakers and practitioners have more reliance on technical measures than nature-based solutions compared to the people in academia from their interviews (Han & Kuhlicke, 2021; Wolf et al., 2021). In cases where flood risks were considered to be high or where a locality has experienced severe flooding in the past, technical measures were preferred by the policymakers (Brillinger et al., 2020). Furthermore, the reintroduction of natural elements might sometimes be interpreted as rather a trigger for increased flood risk (Gapinski et al., 2021).

Second, heterogeneous preferences and concerns of stakeholders need to be considered prior to project design and implementation. It is important to ensure greater effectiveness and less resistance during implementation (Alves et al., 2019). People's perceptions of the co-benefits of NBS, including the provision of ecosystem services, vary (Cinderby & Bagwell, 2018; Giordano et al., 2020; Hagedoorn et al., 2021; Spahr et al., 2021). How people perceive these co-benefits depends also on whether they consider themselves as beneficiaries (Jacobs et al., 2016; Sanon et al., 2012; Small et al., 2017). Sometimes co-benefits of NBS are offset by uncertainty or negative externalities from NBS. When perceived risks and negative externalities are greater than the perceived present value of NBS the project may generate conflicts (Howe et al., 2014; Jacobs et al., 2016; Small et al., 2017). For example, when

stakeholders place a high value on agricultural productivity, there is a greater likelihood of conflict over retention and wetland restorations between different stakeholder groups, which may result in lost farm income (Collentine & Futter, 2018; Giordano et al., 2020).

Third, place attachment is key to understanding people's attitudes toward measures aimed at reducing local flood risks. An increase in extreme weather events and subsequent significant environmental impacts cause changes in where people live. The changes involve not only climatic ones but also human modifications to the place for risk reduction (Devine-Wright & Quinn, 2020). Such local dynamics along with the changes brings alterations in people's attitudes and perception, interwoven with emotional attachment to the place (ibid).

One of the shortcomings of existing studies on public perceptions and attitudes toward NBS is that only a few empirical studies grounded in an explicit theoretical framework have been conducted so far (e.g. Heldt et al., 2016). Theory-driven research is essential, as it makes the research reproducible and generalizable, allowing researchers to build up a body of knowledge on a particular subject (Kuhlicke et al., 2020).

In light of these introductory comments, we present a case study on dike relocation and floodplain restoration in Saxony-Anhalt, Germany, which reflects a paradigm shift from structural flood defenses to NBS in flood risk management. Floodplain restoration on the River Elbe has been ongoing since the beginning of the 1990s. The German federal state of Saxony-Anhalt provided funding for Elbe floodplain restoration initiatives and performed a feasibility study on 32 dike relocation projects (Puhlmann & Jährling, 2003). The first pilot study in Rosslau Oberluch was completed by the year 2005. The subsequent large-scale natural floodplain project in Lödderitzer Forst was implemented in 2006, as part of a nature conservation project (Monstadt, 2008). Another project that opened the traditional dike (Vasenwall) and relocated the dike to the motorway was implemented near the town of Vockerode starting in 2010 and completed in 2018. These three projects from a total of 15 dike relocation projects carried out along the Elbe River are to protect and renaturalize the floodplain forests from the river Mulde to the mouth of the river Saale with diverse animal and plant species that are typically found in floodplains. It is expected that reconnecting former floodplains directly to parts of the river often affected by flooding will facilitate the enactment of floodplain dynamics, including habitat dynamics and other functions of

floodplains such as retention, sedimentation, hydrodynamics, and so on (Scholten et al., 2005).

To advance our understanding of the factors that drive stakeholders' attitudes toward NBS, this paper analyzes how different kinds of risk appraisal and place-based factors influence people's attitudes toward NBS. We, therefore, propose a theoretical framework, referred to as a Place-based Risk Appraisal Model and described in greater detail in Section 2, which allows us to analyze how risk perception and place attachment affect people's attitudes toward dike relocation. Structural equation modeling (SEM) was utilized to test the hypotheses based on theoretical underpinnings (Fan et al., 2016).

This article continues in section 2 with a review of relevant theories and suggests a theoretical framework that links risk and place-related attributes to attitudes toward NBS. Section 3 describes the data collection and methodology. The results are presented in section 4, followed by a discussion in section 5. Finally, Section 6 concludes with suggestions for future study.

4.2. Theoretical Framework

Based on the assumption that attitudes toward NBS are shaped not just by individual psychological processes (and thus individual risk appraisal) but also by the specific place where NBS are realized and implemented, we based our framework on both place-oriented theories and risk perception-related theories.

4.2.1. Place attachment focusing on place identity and nature bonding

Place attachment entails an emotional bond between people and their environment (Low & Altman, 1992; Manzo, 2005). It is a powerful predictor of attitude toward place-related changes, while attitudes can be both positive and negative (Bonaiuto et al., 2002; Devine-Wright, 2009). It can play a role as a motivation for long-term stewardship (Chapin & Knapp, 2015, p. 38) and action supporting conservation initiatives, or pro-environmental behaviors (Larson et al., 2015; Marr & Howley, 2019). In addition, place attachment can work as a catalyst for residents to acknowledge changes to the place in question (Chapin et al., 2012).

In this sense, place attachment can be helpful in better understanding preferences for place-based changes by providing cues for patterned attitudes and behaviors (Stedman, 2016). Conversely, place attachment can also often be an obstacle to transformative change when stakeholders perceive the change as disruptive (Adger et al., 2013; Marshall et al., 2012; Marshall & Stokes, 2014).

Place attachment can be operationalized differently depending on the context. In a given context, it is operationalized using the place identity construct (White et al., 2008). Place identity refers to the symbolic meanings people ascribe to a specific place (Kyle et al., 2005) and it has been found to correlate significantly positively with pro-environmental behavior (Scannell & Gifford, 2010a; Vaske & Kobrin, 2001) as well as place-protective action (Devine-Wright & Howes, 2010).

Another dimension of place attachment studies emphasizes the relevance of people's ties to the natural world, referred to as nature bonding. Nature bonding portrays people's interactions with the environment as vital to their sense of self (Clayton, 2003). Terms such as environmental identity, emotional affinity to nature, and closeness to nature have all been used to define nature bonding (Raymond et al., 2010). Several studies have demonstrated that people who have high nature bonding believe more in the effectiveness of natural risk-reduction measures (D'Souza et al., 2021; De Groot, 2012; Ferreira et al., 2020).

We argue that using a place attachment theory is appropriate for understanding place-related contextual attributes in people's attitudes toward NBS, particularly if the implementation of NBS is associated with profound physical changes to a place. It is crucial, therefore, to understand how people perceive a place and the changes it is undergoing and to unravel how they assign value and/or meaning to this change. In light of this, this study focuses on the two key constructs in place attachment: place identity and nature bonding.

4.2.2. Theories of risk appraisal

Studies on risk perception refer to people's subjective judgments about the probability and severity of hazards, including the process of gathering, selecting, and analyzing signals concerning the unpredictable consequences of events, activities, or technologies (Renn, 1995; Slovic, 2000, 2016; Wachinger et al., 2013). Risk perception can vary between individuals

based on the information they have obtained, different levels of uncertainty, and other contextual interests (Slovic, 2000). In order to analyze risk adaptive attitudes, two prominent frameworks have been used in previous research - Protection Motivation Theory (PMT) and the Protective Action Decision Model (PADM).

PMT, which was initially developed to describe health-related behavior (Rogers, 1975, 1983), has become prominent in flood risk management studies (e.g. Bubeck et al., 2013; Bubeck et al., 2018; Grothmann & Reusswig, 2006; Terpstra & Lindell, 2013). PMT captures the individual decision-making process as a response to risk by focusing on threat and coping appraisals (Maddux & Rogers, 1983; Rogers, 1975, 1983). Threat appraisal can also be rephrased as risk perception, meaning a person's acknowledgment of risks, including perceived probability and perceived severity (Grothmann & Reusswig, 2006). Coping appraisal captures the evaluation of possible responses to avoid or avert the perceived risk and is composed of perceived response costs, response efficacy, and self-efficacy.

Complementing PMT, the PADM explains human responses to environmental hazards using a multistage model that involves a pre-decisional, perception, and protective action decision-making process (Lindell & Perry, 1992, 2012; Terpstra & Lindell, 2013). An important attribute of the PADM is that it emphasizes the perceived attributes of hazard adjustment as being important for understanding the perceived attributes of the hazard itself. According to the pathbreaking work of Lindell and Perry (2012), hazard adjustment has usually been demonstrated as a form of individual adaptive behavior that focuses on the modification of human behavior, but it also includes long-term hazard adjustment that enables people to live in a place. In addition, the scope of response efficacy in the PADM is broader than that of PMT, including not only the efficacy of protecting people and property but also its utility for other purposes (Lindell & Perry, 2012).

Although the focus of this study is on public protection and not on individual adaptive behaviors, we argue that some of the constructs underlying both PMT and the PADM are highly relevant in understanding people's attitudes toward NBS. One reason for this is that people's attitudes toward NBS can be seen as a result of the multi-dimensional individual-societal decision process in assessing risks. Second, we argue that the individual adaptive behavior primarily captured in PMT and PADM can be also reflected in a person's attitude

or behavior toward a long-term public adaptive measure. Therefore, theories explaining individual adaptive behavior toward risk are also related to our research.

4.2.3. Operationalization and hypotheses

Attitudes are defined as dispositions toward a specific issue (Ajzen, 2005). So far, studies with a focus on NBS for flood risk reduction have dealt with attitudinal and behavioral acceptance (Anderson et al., 2021), perceived utility and co-benefits (Kim & Petrolia, 2013; Venkataramanan et al., 2020), as well as the effectiveness of the measures (Santoro et al., 2019).

In this study, we understand 'supportive attitude' toward NBS as an overarching variable for the degree of acceptance of a project. In addition, the perceived risk-reduction effectiveness of NBS is considered in the attitude as key among the diverse benefits NBS can bring. Therefore, we measure attitudes as a result of a) supportive attitude toward a specific project involving NBS and b) the perceived risk-reduction effectiveness of such a project.

Six hypotheses were formulated, inspired by the place attachment and risk appraisal theories (PMT and PADM). These hypotheses are summarized in the proposed 'Place-based Risk Appraisal Model' or 'PRAM' (Figure 4.1) presented here. Within this framework, our study seeks to answer two core research questions.

1. How do various risk appraisal factors influence individuals' attitudes (i.e. supportive attitude and perceived risk reduction effectiveness) toward NBS?
2. How do various place-based factors influence individuals' attitudes toward NBS?

First, risk perception is an essential determinant for decision making relating to hazard adjustment (Lindell & Perry, 2012; Rogers, 1983). In previous empirical studies, a higher threat appraisal leads to a lower perceived risk reduction effectiveness of NBS and a preference for technical measures (e.g. Chou, 2013; Gray et al., 2017; Martinez-Juarez et al., 2019). Against this backdrop, we postulate the following hypothesis:

Hypothesis 1: Threat appraisal has a negative effect on the perceived risk-reduction effectiveness of (H1a) and a supportive attitude toward (H1b) NBS.

Second, when it comes to resource-related attributes, the perceived benefits of NBS for other purposes was previously assumed to be as influential in people's attitudes. Some empirical studies supported the idea of positive perceptions toward NBS when these demonstrate multiple benefits in addition to risk reduction (e.g. Kim & Petrolia, 2013; Raymond et al., 2017). These observations lead us to the following hypothesis:

Hypothesis 2: Perceived co-benefits have a positive effect on the perceived risk-reduction effectiveness of (H2a) and a supportive attitude toward (H2b) NBS.

Third, stakeholder perceptions include people's perceptions of the relevant authorities' expertise, trustworthiness, and responsibility to provide protection (Arlikatti et al., 2007; Siegrist & Gutscher, 2006). More specifically, the perceived trustworthiness of the information acquired from authorities and experts could significantly increase the effectiveness of risk communication (Slovic, 2000). Therefore, transparent and efficient communication of procedural information about a project is important in order to encourage a supportive attitude. Furthermore, the more information people receive, the more they may support and perceive the greater effectiveness of NBS. In this sense, positive attitudes toward NBS as a hazard adjustment measure can be motivated by effectively communicated information as well as by people's trust in local flood risk management. From this we derive the following hypothesis:

Hypothesis 3: Well-communicated information on NBS has a positive effect on the perceived risk-reduction effectiveness of (H3a) and a supportive attitude toward (H3b) NBS.

Hypothesis 4: Trust in local FRM has a positive effect on the perceived risk-reduction effectiveness of (H4a) and a supportive attitude toward (H4b) NBS.

Fourth, we interpret the realization of a large-scale NBS as a disruptive change to a place, particularly if local residents have a strong place identity. Considering that we focus on large-scale NBS, we assume that there is a greater chance that people will perceive such transformative changes rather negatively (Adger et al., 2013; Marshall et al., 2012; Marshall & Stokes, 2014). On this basis we propose the following hypothesis:

Hypothesis 5: Place identity does not affect the perceived risk-reduction effectiveness of NBS (H5a), but it does have a negative effect on a supportive attitude (H5b) toward them.

Finally, we focus on the relevance of stakeholders' ties to the natural world in the place attachment studies. Considering previous research on nature bonding which argues that it is linked with the perceived effectiveness of risk reduction of NBS (De Groot, 2012), we propose the following hypothesis:

Hypothesis 6: Nature bonding has a positive effect on the perceived risk-reduction effectiveness of (H6a) and a supportive attitude toward (H6b) NBS.

A summary of the above hypotheses is shown in Figure 4.1.

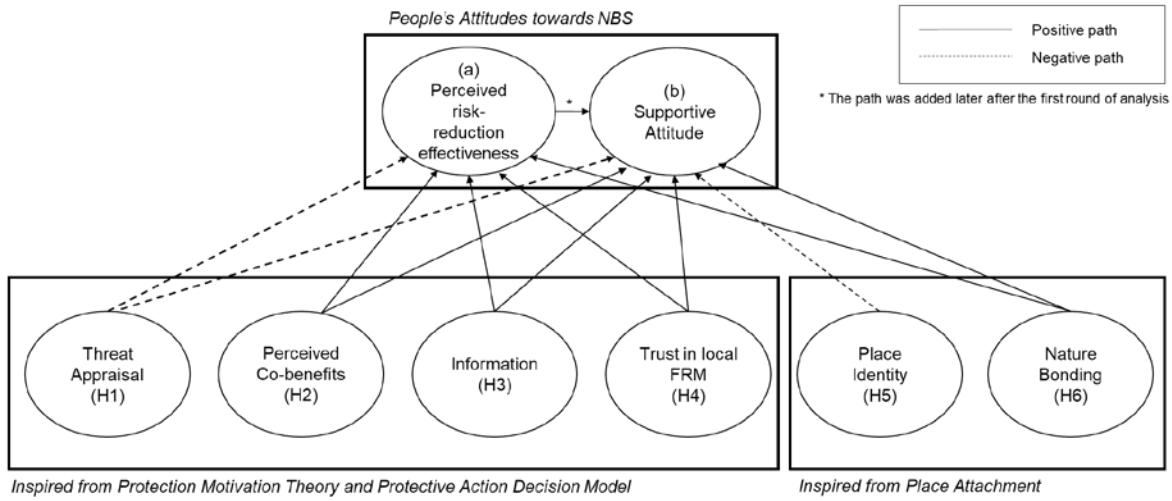

Figure 4.1 Hypotheses and constructs in the PRAM framework

4.3. Methods

In the following sub-sections we provide information on our case study areas, data collection, and analytical method. We also describe how we applied structural equation modeling (SEM) to analyze the relationship between the constructs in the framework.

4.3.1. Case study and data collection

This study uses the data collected in five towns, namely, Lödderitz, Kühren, Aken, Rosslau, and Vockerode near Dessau-Rosslau in Saxony-Anhalt, where the dike relocation projects described in the introduction section were implemented (Figure 4.2 and Figure 4.3). The towns were severely hit by the flood in Saxony in 2002 and 2013. The dike relocation was chosen to reduce flood risks after the disastrous events. The survey data was collected in July

2021. About three times as many flyers containing survey information as the planned distribution of the questionnaire were distributed in flood-prone areas in each town according to the 100-year and 50-year flood hazard map. For instance, in Rosslau, we only surveyed the three horizontal alleys near the river, i.e., higher-risk areas. In total, 650 questionnaires were distributed, a week after putting information flyers into local citizens' postboxes. The survey campaigners visited the household door-to-door and asked about their willingness to participate. If there was no one responding, we passed to the next household. The questionnaires could be returned in a dedicated return envelope free of postage, or to the survey campaigner during their visit a week later. 304 questionnaires were answered; the response rate was very high, ranged from 41.5% to 56% in each location. Table 4.1 provides socio-demographic variables to obtain a better overview of the data. Overall, the sample represents the population characteristics of age and gender, but the education level in our sample is slightly higher than the average in the state of Saxony-Anhalt. The sample population is aged on average 60.1. Slightly more males than females answered the questionnaire. More than half of them possessed a middle school diploma (POS 10th grade) and 41.4% answered that they possessed university/technical college entrance quantification or other college degrees. Table 4.2 shows the characteristics of the towns surveyed. The whole questionnaire is attached in Appendix B.

Table 4.1 Socio-demographic variables in five towns (pooled result)

Variables	Sample Size	Average or Percentage
Age	290	60.1 years
Gender	294	
... Female		41.8%
... Male		57.1%
... Diverse		1%
Number of household members	291	2.3
Education	280	
... Elementary school diploma (8th/9th grade)		6.8%
... Middle school diploma (10th grade)		51.8%
... University/Technical college entrance qualification		40%
... Other college degrees		1.4%

Figure 4.2 Study area and the federal state of Saxony-Anhalt in the map of Germany

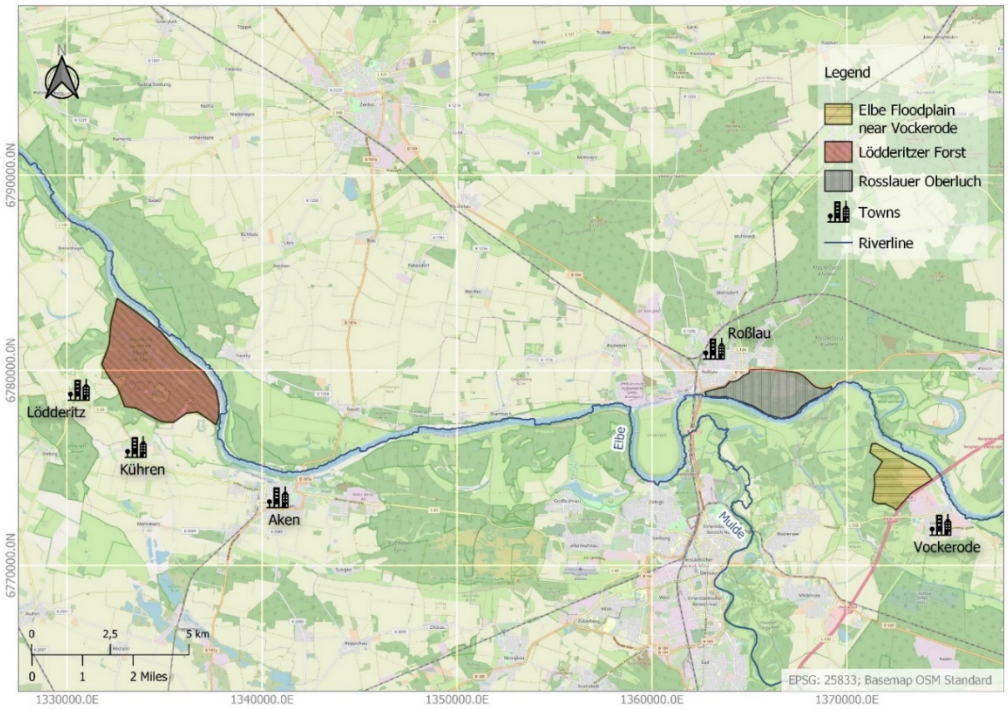

Figure 4.3 Map of the sites surveyed

Table 4.2 Characteristics of the towns surveyed, and response statistics

Town	Lödderitz	Kühren	Aken	Rosslau	Vockerode
Geographical context	A section of the town of Barby Approx. 3.8km from the Elbe	A district of town Aken Approx. 3km from the Elbe	A town in the district of Anhalt-Bitterfeld in Saxony-Anhalt Located on the left bank of the river Elbe. Approx. 700m from the Elbe	A district of the town of Dessau-Roßlau Located on the right bank of the Elbe Approx. 1km from the Elbe	A district of the city Oranienbaum-Wörlitz Approx. 800m from the Elbe
Estimated population	230	612	7,363	11,958	1,694
Project (Construction year)	Mittlere Elbe – Large-scale nature conservation project (2006 – 2018)			Dike relocation and floodplain restoration of Rosslauer Oberluch (1996 – 2005)	Life+Nature 'Elbauen bei Vockerode' (2010 – 2018)
Type of project	Dike relocation and floodplain restoration				
Number of responses/ Total distributed questionnaires (Rate)	25/50 (50%)	28/50 (56%)	65/150 (43%)	83/200 (41.5%)	103/200 (51.5%)
Total number of responses (Rate)	304 (46.7%)				

4.3.2. Variables

In the questionnaire, the various variables used in the PRAM framework were specified as latent variables. Latent variables enable us to connect theory and data by measuring them at the construct level. The variables used in the survey were all measured on continuous 7-point Likert scales. The detailed scales are set out in Table 4.3.

Table 4.3 Latent construct and manifest variables used in the survey

Construct	Item	Scale	Mean (SD)	Est. [a]	Alpha [b]	AVE [c]	CR [d]
Dependent variables/Endogenous variables							
Perceived risk-reduction effectiveness (Source: Authors)	Because of the dike relocation, *Town* is better protected against floods.	Do not agree at all (1) – Agree completely (7)	4.59 (1.82)	-	-	-	-
Supportive attitude (Source: Authors)	I support the dike relocation.	Do not agree at all (1) – Agree completely (7)	4.21 (2.07)	-	-	-	-
Independent variables/Exogenous variables							
Threat appraisal (Source: Authors)	How likely do you think it is that a severe flood will occur in your home within the next 5 years?	Very unlikely (1) – Very likely (7)	3.10 (1.87)	1.68	0.81	0.60	0.81
	How big do you expect the damage to your home to be in such an event?	No damage (1) – Very large damage (7)	3.69 (2.18)	1.63			
	The thought of future flooding in *Town* makes me …	Not afraid (1) – Very much afraid (7)	4.00 (1.92)	1.24			
Perceived co-benefits (Based on: Verbrugge et al., 2019)	*NBS Site* is a good place to experience nature.	Do not agree at all (1) – Agree completely (7)	5.65 (1.45)	1.16	0.85	0.59	0.85
	NBS Site is an ecologically valuable space.	Do not agree at all (1) – Agree completely (7)	5.78 (1.41)	1.00			
	NBS Site is a place for rest and relaxation.	Do not agree at all (1) – Agree completely (7)	5.89 (1.33)	1.15			
	NBS Site is an attractive landscape element.	Do not agree at all (1) – Agree completely (7)	5.32 (1.72)	1.17			
Well-communicated Information on NBS (Source: Authors)	I feel well informed about the dike relocation project.	Not informed at all (1) – Very much informed (7)	3.34 (2.01)	-	-	-	-
Trust in local FRM	Public flood protection gives me a sense of safety.	Do not agree at all (1) – Agree completely (7)	4.44 (1.80)	1.72	0.94	0.89	0.94

(Based on: Babcicky & Seebauer, 2021)	I trust that there is good public flood protection in my community.	Do not agree at all (1) – Agree completely (7)	4.54 (1.81)	1.65			
Place identity (Based on: Williams & Miller, 2020)	*Town* means a lot to me.	Do not agree at all (1) – Agree completely (7)	5.49 (1.65)	1.57	0.93	0.83	0.94
	I am very connected to *Town*.	Do not agree at all (1) – Agree completely (7)	5.40 (1.68)	1.62			
	I have many fond memories of *Town*.	Do not agree at all (1) – Agree completely (7)	5.57 (1.62)	1.27			
Nature bonding (Based on: Verbrugge et al., 2019)	The natural environment is important to me.	Do not agree at all (1) – Agree completely (7)	6.273 (1.16)	1.01	0.91	0.78	0.91
	When I spend time in the natural environment, I feel at peace with myself.	Do not agree at all (1) – Agree completely (7)	5.89 (1.35)	1.14			
	I am very attached to the natural environment.	Do not agree at all (1) – Agree completely (7)	5.97 (1.31)	1.23			

[a] Est.= estimates
[b] Alpha = Cronbach's alpha,
[c] AVE = average variance extracted,
[d] CR = composite reliability

Table 4.4 illustrates site-specific and NBS project-related variables in the towns. Most of the survey participants have lived in the town on average for more than 40 years and own their property. Almost 90% of the residents have visited the NBS sites at least once. 36.4% of the respondents said that they visited the NBS sites several times a year, while 13.6% rarely visited the sites. The distance traveled to the NBS sites varies by town; people in Aken need more time to visit the sites (average 55.6 min) than the residents of the other towns. Approximately a quarter of people in Kühren and Lödderitz received compensation for land acquisition due to the project. People's attitudes toward the NBS project were either mixed (45%) or supportive (41%).

Table 4.4 Site-specific and NBS project-related variables

Variables	Aken	Kühren	Lödderitz	Rosslau	Vockerode	Total
Duration of residence (years) / Mean (SD)	48.3 (20.2)	40.9 (24.2)	42.2 (17.6)	45.0 (20.6)	40.6 (19.6)	43.5 (20.4)
Home ownership	96.8%	92.9%	92%	85%	85.1%	88.9%
Visit experience to NBS site	88.5%	92.6%	96%	79%	92.9%	88.4%
Distance to NBS site (av. min) / Mean (SD)	55.6 (37.6)	17.5 (8.5)	15.8 (11.3)	25.4 (17.2)	18.5 (18.5)	27 (26.3)
Duration of visits (av. min) / Mean (SD)	68.6 (43.7)	82.9 (40.9)	81.5 (69.2)	68.6 (50.7)	62.6 (44.8)	69 (48.8)
Frequency of visits						
... Every day	0%	3.8%	12.5%	0%	5.4%	3.5%
... Several times a week	3.7%	7.7%	25%	0%	25%	12.8%
... Once a week	3.7%	11.5%	8.3%	0%	9.8%	6.2%
... Several times a month	13%	15.4%	12.5%	8.10%	22.8%	15.5%
... Once a month	3.7%	3.8%	0%	12.9%	2.2%	5%
... Several times a year	37%	42.3%	20.8%	48.4%	30.4%	36.4%
... Once a year	14.8%	3.8%	4.2%	11.3%	1.1%	7%
... Rare	24.1%	11.5%	16.7%	19.4%	3.3%	13.6%
Compensation	0%	28.6%	24%	0%	5.3%	6.9%
Attitude toward NBS project						
... Indifferent	1.8%	11.5%	4%	18.2%	6.5%	9%
... Mixed feelings	50%	42.3%	64%	29.9%	49.5%	44.8%
... Rejection	7.1%	3.8%	12%	0%	6.5%	5.1%
... Supportive	41.1%	42.3%	20%	51.9%	37.6%	41.2%

4.3.3. Data pre-processing and analysis

Structural Equation Modelling (SEM) was conducted to test the hypotheses. SEM is a comprehensive statistical method that shows relationships between latent variables and their indicators (Hoyle, 1995). It tests the patterns of directional and non-directional relationships between the manifest (or observed) variables and unobserved latent variables (MacCallum & Austin, 2000). As SEM is a method based on covariance, having a sufficient sample size is important. Some studies noted that sample size needs to be decided dependent on the number of parameters, while the ratio of sample size and the number of parameters should be at least 5 to 1 (Bentler & Chou, 1987) or even 10 to 1 (Schreiber et al., 2006). Although there is no consistent rule of thumb for sample size in SEM, having a larger sample size is essential when

the model is complex and the assumption of normality is violated. Without imputation, the full sample size of 304 observations is reduced to 260 observations with 53 parameters.

Overall, our data contains 2 to 12% of missing values per variable of interest, missing at random. We used multiple imputations to make the best use of the data by including variables in the imputation model. Multiple imputation has been considered to improve the power of predictions and is more effective than listwise deletion (Collins et al., 2001; Raaijmakers, 1999). To reflect the contextual heterogeneity of towns and to increase statistical power, we adopted two-level imputation in this study. Ignoring the clusters and imputing the data by a single-level imputation method was not recommended unless the case has less than 5% of missing values, and the intra-class correlation is less than 0.1 (Grund et al., 2018). For this reason, the package 'miceadds' in R software (version 4.1.2) was used to include the contextual effects, meaning that an aggregated variable at a cluster level is included as a further covariate (Robitzsch et al., 2017). As a result, a full sample size of 304 households was gained as pooled data from three imputed data sets.

To check the reliability of the latent construct, we ran a confirmatory factor analysis model. Cronbach's alpha (alpha), composite reliability (CR), average variance extracted (AVE), and the correlation between latent constructs were checked (see Table 4.3). Cronbach's alpha and CR measure internal consistency, i.e. they measure how closely a set of variables is related as a construct. The Cronbach's alpha and CR of each construct are above 0.8, showing a good level of internal consistency. AVE, a measure of the amount of variance that is captured by a construct in relation to the amount of variance due to measurement error, is captured to assess discriminant validity. It can be seen from Table 4.5 that AVE is greater than the squared correlation coefficient with latent variables, meaning that it has sufficient discriminant validity for the SEM analysis.

Table 4.5 Squared correlation coefficients of latent variables and AVE

	Threat Appraisal	Perceived Co-benefits	Trust	Place Identity	Nature Bonding	AVE
Threat Appraisal	1.00	0.00	0.19	0.02	0.01	0.60
Perceived Co-benefits	0.00	1.00	0.06	0.10	0.20	0.59
Trust	0.19	0.06	1.00	0.00	0.03	0.89
Place Identity	0.02	0.10	0.00	1.00	0.10	0.83
Nature Bonding	0.01	0.20	0.03	0.10	1.00	0.78

For structural regression analysis, the packages 'semTools' and 'lavaan' in R were run with imputed pooled data using maximum likelihood estimation. The originally planned model considered only the residual covariance between the two endogenous variables (perceived-reduction effectiveness and supportive attitude). However, the residual covariance between these variables was significant, which indicates that these two variables could be causally related. To tackle this, we decided to establish a causal link between the two variables. Therefore, risk reduction effectiveness is considered one of the dimensions that explain people's supportive attitude towards nature-based solutions.

Next, fit indices show the ability of a model to reproduce the data using a variance-covariance matrix. A good-fitting model is required before the model can be properly interpreted. This study employs four model fit indices: the comparative fit index (CFI), the Tucker–Lewis index (TLI), the root-mean-square error of approximation (RMSEA), and the sample standardized root mean squared residual (SRMR) (Table 4.6). The threshold value of CFI and TLI for a well-fitting model is 0.95 (Hu & Bentler, 1999) or even 0.90 (Marsh & Hocevar, 1985). RMSEA is considered to be good below 0.06, and SRMR below 0.08 (Browne & Cudeck, 1992; Hu & Bentler, 1999). All four indices are within the scope of the well-fitting model (Goodness of fit: X2 = 133.252 (110 d.f.), p =0.07, CFI = 0.992, TLI = 0.989, RMSEA = 0.026, SRMR = 0.038).

4.4. Results

In this section, we discuss the regression and covariance coefficients that show the strength of relationships among variables for the research hypotheses.

The results mostly support our hypotheses from the PRAM framework except for H6 about the nature bonding construct (Figure 4.4, Table 4.6, and Table 4.7). Figure 4.4 illustrates the structural equation model with standardized regression and covariance coefficients. Table 4.6 illustrates the standardized regression coefficient of each hypothesis (H1-H6) with the p-value marked with stars (*).

First of all, for the regression part, perceived risk-reduction effectiveness explains 30% of the variance, and the supportive attitude explains 31% of the variance. The regression of risk-reduction effectiveness on supportive attitude was additionally measured, and it was positively significant ($\beta = 0.20$, $p < 0.001$). It showed an indirect effect of the perceived risk-reduction effectiveness on the supportive attitude of the independent constructs (exogenous variables).

For the four risk-appraisal constructs, all the hypotheses are well supported for the perceived risk-reduction effectiveness, but the hypotheses of threat appraisal and trust in local FRM construct were not supported for the supportive attitude toward NBS. In detail, threat appraisal acts as a negative predictor for perceived risk-reduction effectiveness with the standardized coefficient of -0.16 ($p < 0.05$) (H1a), however, the regression of threat appraisal on supportive attitude was not significant (H1b). This means that if a person has a high threat appraisal, it is more likely that they will perceive lower risk-reduction effectiveness of NBS, however, it does not necessarily lead to a lower degree of support toward NBS. The regression of perceived co-benefit of NBS (H2a/b) was also positively significant for both NBS attitudinal variables.

It was slightly more powerful for the supportive attitude ($\beta = 0.18$, $p < 0.01$) than perceived risk-reduction effectiveness ($\beta = 0.14$, $p < 0.05$). The information variable (H3a/b), which shows how well a person is informed about the NBS project, was strongly significant with a regression coefficient of 0.23 and 0.32 for each attitudinal variable respectively ($p < 0.001$). The perceived level of information of each individual seems influential with regard

to positive attitudes toward NBS. Trust in local FRM (H4a) shows a strong regression coefficient for perceived risk-reduction effectiveness ($\beta = 0.28$, $p < 0.001$), while for supportive attitude it was not significant (H1b). In other words, people's trust in local FRM influences their belief in the efficacy of NBS, but this would lead to a supportive attitude only indirectly through perceived risk-reduction effectiveness.

Regarding the place-based constructs, the results are mixed. The regression of place identity on risk-reduction effectiveness (H5a) was not significant, while it showed a negative regression coefficient for the supportive attitude (H5b) ($\beta = -0.11$, $p < 0.05$). The regression path of nature bonding was not significant at all for both perceived risk-reduction effectiveness and the supportive attitude (H6a/b). This explains that people do not show support for the project if they feel more attached to the place at a group or community level. It showed no explanatory power in terms of how supportive people are of NBS and how much they perceive NBS as safe.

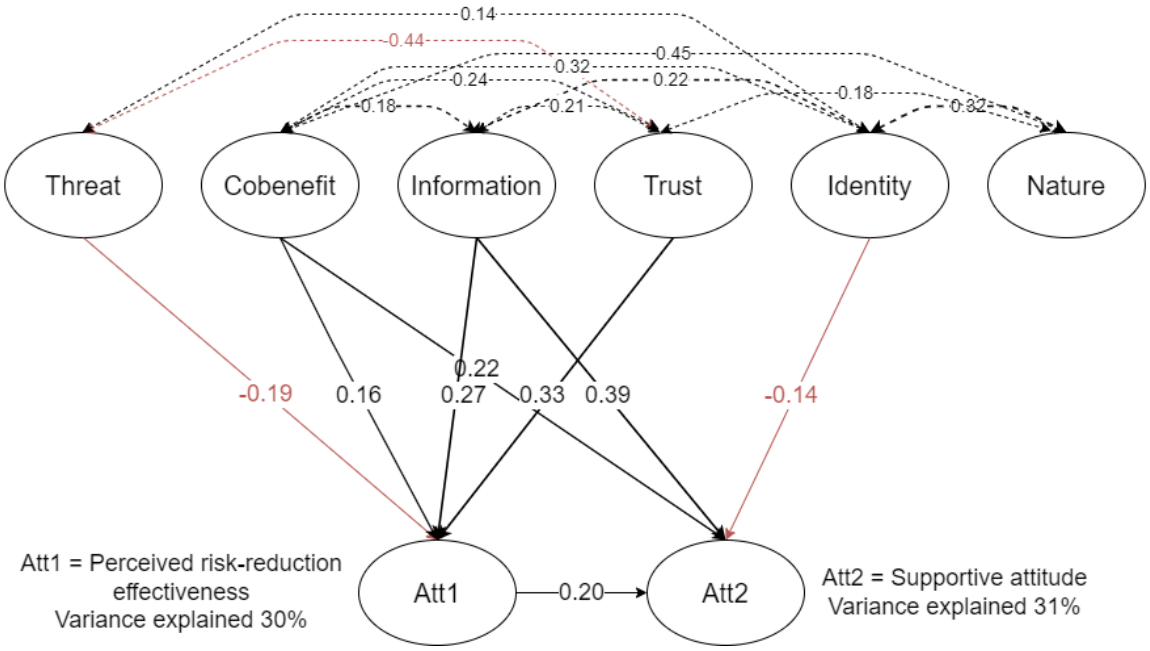

Figure 4.4 Structural equation model with the standardized regression (non-dotted arrow) and covariance coefficients (dotted arrow)

Note: Only structural parts with significant paths are illustrated. Goodness of fit: X2 = 133.252 (110 d.f.), p =0.07, CFI = 0.99, TLI = 0.99, RMSEA = 0.026, SRMR = 0.038).

Table 4.6 shows standardized covariance coefficients with the p-value denoted by stars (*). There was no strong correlation such that the coefficients are greater than 0.5. Taking only the significant correlation into account, first, it demonstrates that trust in local FRM is positively but weakly correlated with perceived co-benefits. Well-communicated information is negatively weakly correlated with threat appraisal, while it is positively weakly correlated

with both perceived co-benefit and trust in FRM. Nature bonding is moderately positively correlated with perceived co-benefits and weakly positively with trust in FRM. Lastly, place identity is correlated with most of the other latent variables; it is moderately correlated with perceived co-benefits and nature bonding and weakly positively correlated with threat appraisal and well-communicated information.

Table 4.6 Regression part in structural equation model

Regression part		Coefficient Estimate (Std. Err)	Standardized Estimate	P(>|t|) Significance
Att1 (Perceived risk reduction effectiveness)				
~	Threat appraisal (H1a)	-0.19 (0.08)	-0.16	0.02*
~	Perceived Co-benefits (H2a)	0.16 (0.08)	0.14	0.04*
~	Well-communicated information (H3a)	0.27 (0.07)	0.23	0.00***
~	Trust in local FRM (H4a)	0.33 (0.08)	0.28	0.00***
~	Place identity (H5a)	-0.09 (0.07)	-0.08	0.18
~	Nature bonding (H6a)	0.13 (0.08)	0.11	0.10
Att 2 (Supportive attitude)				
~	Threat appraisal (H1b)	-0.10 (0.08)	-0.09	0.19
~	Perceived Co-benefits (H2b)	0.22 (0.08)	0.18	0.01**
~	Well-communicated information (H3b)	0.39 (0.07)	0.32	0.00***
~	Trust in local FRM (H4b)	0.06 (0.08)	0.05	0.48
~	Place identity (H5b)	-0.14 (0.07)	-0.11	0.05*
~	Nature bonding (H6b)	0.04 (0.08)	0.03	0.64
~	Att1 (Perceived risk reduction effectiveness)	0.20 (0.06)	0.20	0.00***

Note: If a p-value is less than 0.05, it is flagged with one star (*). If a p-value is less than 0.01, it is marked with 2 stars (**). If a p-value is less than 0.001, it is flagged with three stars (***). Goodness of fit: X2 = 201.576 (145 d.f.), p =0.001, CFI = 0.98, TLI = 0.98, RMSEA = 0.04, SRMR = 0.04.

Table 4.7 Correlation between the constructs (standardized covariance coefficients)

	Threat	Co-benefit	Information	Trust	Identity	Nature
Threat	1.00					
Co-benefit	-0.03	1.00				
Information	-0.12	0.18**	1.00			
Trust	-0.44**	0.24**	0.21**	1.00		
Identity	0.14*	0.32**	0.22**	0.03	1.00	
Nature	0.12	0.45**	0.12	0.18**	0.32**	1.00

Note: * p<.05, ** p<.01, standardized paths coefficients and correlations.

4.5. Discussion

The PRAM framework is novel, as there have been no such studies previously that deal in an integrated way with the link between place attachment and risk appraisal in the context of NBS and floods or natural hazards. It establishes the link between place and risk, which goes beyond the traditional understanding of attitudes that are fragmented and does not fully consider the multidimensional aspects of attitude. Another novel aspect of this framework is that it provides ample evidence for each risk and place theory while also being benefited from standing on the solid foundations of each theory. The empirical findings of this study largely support the newly developed framework, while the relevance of nature bonding to a supportive attitude and perceived risk-reduction effectiveness toward NBS was not confirmed.

4.5.1. Local perceptions of 'natural' elements in NBS and the trade-offs

The results show that nature bonding is not a positive significant factor for both attitudinal variables of NBS, rejecting the hypotheses of H6a/b. Our hypotheses were designed to consider the previous studies using other related concepts with nature bonding, such as 'environmental attitude' (De Groot, 2012), 'self-transcendence value' (D'Souza et al., 2021), and 'stewardship' (Ferreira et al., 2020), and empirical findings that people with higher levels of environmental awareness prefer 'natural' measures over structural measures (Anderson et al., 2022). It has been commonly said that anthropogenic interventions that make more use of natural ecosystems enjoy greater approval compared to those driven by artificial and technology-based elements (Sjöberg, 2000). Such findings corroborate the positive connotation of 'nature' provided in the NBS as an effective human intervention for dealing with risks. However, our analysis does not support nature bonding as a precursor of either supportive attitude or perceived risk reduction effectiveness.

So far, the eco-centric perspective, including beliefs expressing concern for the environment and positive consideration of the intrinsic value of nature, has been perceived as a powerful predictor for individual behavior directed toward supporting restoration activities (Connelly et al., 2002; House & Fordham, 1997; Schaich, 2009). One of the plausible

reasons for this discrepancy may be whether or not the measures implemented in our case study were perceived as 'restorative' or 'natural' activities by the local people concerned. Nature's pure and pristine values are seen as one of the key characteristics around which NBS are founded (Osaka et al., 2021), thus, the features of NBS were often regarded as a counterpart to traditional grey infrastructure measures (e.g. Gray et al., 2017; Onuma & Tsuge, 2018). However, a spectrum of NBS covers less engineered and closer to non-man-made/wild but also more engineered and hybrid measures (Eggermont et al., 2015). Likewise, a study by De Groot and De Groot (2009) showed a clear preference for options involving less human interference among diverse NBS options and a traditional structural option. In other words, when local stakeholders do not perceive the measure to be sufficiently 'natural', there is a greater likelihood that the option will not be endorsed.

On the contrary, some have argued that 'naturalness' actually hinders individuals' perceived risk-reduction effectiveness of NBS and therefore support for NBS. We could also question how nature bonding would influence people's attitudes in the case of more hybrid NBS, i.e. involving more technical elements. In this regard, the 'naturalness' of NBS becomes an obstacle to be dealt with, encouraging an integration of 'green' and 'gray' as a promising way forward (Anderson et al., 2022; Browder et al., 2019).

However, the discussion so far does not deliver a straightforward answer to the question of whether (perceived) naturalness brings more support for NBS. Rather, another element that has to be considered is the trade-offs (cost and co-benefit) people are exposed to alongside the primary objective of the project (i.e. reducing flood risks). In this case, individual appraisals of cost and benefit could affect the extent to which people support or do not support the project. On the one hand, the perceived co-benefits were positively significant for both perceived risk-reduction effectiveness and supportive attitudes, as stated in H2a and H2b. In line with this outcome, several restoration studies corroborated this argument that the perceived other utilities such as recreation and education opportunities (Kim & Petrolia, 2013), and aesthetic values (Buijs, 2009; Buijs et al., 2009; Junker & Buchecker, 2008) besides risk mitigation benefit bring more positivity and endorsement to the project. On the other hand, the appraisal also needs to consider the diverse costs that the individual is being asked to bear. For example, issues of user convenience/inconvenience, such as road alterations that

may be implemented as part of a project, may prove to be a hurdle to gaining more support for NBS. Thus, we can speculate that the power of nature bonding to generate more support for NBS may be offset by people's cost-benefit appraisal.

4.5.2. Importance of communication in presenting NBS as an option for risk reduction

Our results regarding threat appraisal show that it affects the perceived risk-reduction effectiveness negatively as stated in H1a. H1b that threat appraisal affects supportive attitude was only supported through the mediation of perceived risk-reduction effectiveness. It means that people who have higher threat appraisal would have a higher possibility of not endorsing NBS as an ensuring measure against floods, and this indirectly affects the supportive attitude of NBS. The hypothesis confirms that the primary goal of safeguarding people and property from hazards should be understood as a non-negotiable criterion. It also confirms findings from previous empirical studies demonstrating that, for example, high perceived likelihood and severity of hazards were linked with more trust in technical solutions (Buchecker et al., 2016; Chou, 2012; D'Souza et al., 2021) and also with lower trust in the approach of dealing with hazards in a natural way (Kim & Petrolia, 2013). Uncertainty around the effectiveness of NBS was also considered by policymakers to be an obstacle to the implementation of NBS (Wolf et al., 2021). This poses a distinct challenge for risk management in many locations, in which a purely technical approach such as dams, dykes, and retention basins, is no longer appurtenant to meet the demand for climate resilience (Browder et al., 2019).

In this context, establishing effective communication and providing high-quality information for residents is critical to change attitudes and behavioral change (Seebauer & Babcicky, 2018). On the one hand, risk communication should include the fact that technical flood defense infrastructure can also fail, and that residual risks can be very high (Di Baldassarre et al., 2018). On the other hand, information and knowledge about NBS should be communicated effectively to the stakeholders concerned. The significance of well-communicated information for both perceived risk-reduction effectiveness and supportive attitude, as shown in H3a and H3b, demonstrates the importance of conveying information clearly during the NBS process. Sharing knowledge about how NBS work to achieve specific

purposes is particularly important in NBS projects as a way of improving people's assessments of the measures implemented (Chou, 2016). In addition, high uncertainty about the efficacy of NBS on the basis of a lack of technical components (Ardaya et al., 2017), and its non-market value (Czembrowski et al., 2016; Mukherjee et al., 2014) justify the need for effective communication with residents. With effective communication regarding the project, it becomes possible to facilitate more participatory decision-making (Roca & Villares, 2012) and thus to enable a shared vision to be developed that delivers benefits for all (Schmidt et al., 2014).

4.5.3. Role of trust when large-scale NBS are perceived as a disruptive change

Place identity was significant for negatively influencing supportive attitude, as stated in H5b and previous studies (Marshall et al., 2012). However, it was not significant for perceived risk-reduction effectiveness. This result suggests that dike relocation was considered as a rather critical disruptive change to the integrity of a place and not primarily as a solution suited to reduce flood risks. The psychological distress due to such environmental change can be comparable with the concept of 'solastalgia' coined in the seminal work of Albrecht (2005) (see also Albrecht et al., 2007). The concept received significant attention in the environmental change literature (e.g. natural hazards) but was not discussed well in the context of NBS or other restoration activities. This may also be attributed to the conflicting decision-making levels involved, powerful interest groups, and the landscape consequences of such interventions (Bonaiuto et al., 2002). From this finding, we can argue that a high degree of place identity can be a significant obstacle to consider when seeking to implement NBS. Considering heterogeneous civil groups within a community, the challenge is how to persuade individuals to recognize NBS as a positive transformative measure for their community. In this regard, values and meanings associated with a place need to be shared in order to generate agreement around collaborative action in favor of transformation (Chapin et al., 2012). Quinn et al. (2019), for example, argued that the meanings attached to a place impact people's preferences for local flood risk management. When a policy-oriented understanding of a place differs from that of local people, it may lead to additional opposition

and disagreements over its significance. Therefore, the explicit purpose and process of NBS should be communicated to local residents as constituting a sustainable transformation in the place where they are emotionally attached and spend their lives.

In this context, the role of trust becomes essential. Trust in local FRM was strongly significant in perceived risk reduction effectiveness (H4a), and affected supportive attitude indirectly (H4b) through the perceived risk-reduction effectiveness. In other words, underlying trust in overall local flood risk management policy can be linked to support for non-conventional types of flood risk management. It aligns with the finding of Spaccatini et al. (2022) that distrust in science affects people's attitudes towards adaptive measures, including dislike and aversion. Trust in responsible governmental bodies helps to provide more familiarity with the project, and also offers an opportunity to share the values of NBS with citizens (Gordon et al., 2014; Verbrugge & van den Born, 2018). Therefore, a large-scale NBS project that involves major landscape changes may necessitate additional actions to gain residents' trust in the institutions involved and to persuade them to accept the changes, for the sake of effective and beneficial improvements in FRM. Following the 2013 floods in Germany, it was demonstrated that previously implemented participation processes, such as public hearings, were not always an appropriate method, as they could exacerbate disputes and distrusts rather than allow for consensus (Kuhlicke et al., 2016; Renn, 2015). Further research is needed in order to have "intense, broader, earlier and continuous participation"; following other examples of already-ended controversies (e.g. renewable energy projects) can inspire the locally-fitted strategy (Otto et al., 2018), to boost the trust.

4.5.4. Limitations

Some limitations are acknowledged by the authors. First, although our study is novel and we believe our research contributes to advancing this line of research, there are still additional factors that could be taken into account in order to fully understand the unexplained dimension of the NBS's supportive attitude, such as cost-benefit appraisal or assigned meanings in places. Second, the construct of nature bonding does not focus on the place we investigated, but rather it points to the general natural environment (Martin et al., 2020; Scannell & Gifford, 2010a). Although previous research points out that emotional bonding

to the general natural environment is important for their behavioral reaction, we bear in mind that it may not show the specific attachment of residents to the place. A more in-depth examination of place attachment needs to be further expanded.

4.6. Conclusions

In this paper, we have explored the factors shaping people's attitudes toward NBS using a framework inspired by theories of place and risk. We have shown that the elements that make NBS more 'natural' do not guarantee either support or resistance and that there is no significant relationship between nature bonding and a supportive attitude toward NBS. Individual appraisal, as well as trade-offs, need to be considered understanding attitudes toward NBS. Our analysis also suggested that high-threat appraisal could become a hindrance to gaining greater public support for NBS. This suggests the need for transparent and effective communication of the information needed by the public. The analysis also revealed the challenge arising from the fact that NBS are frequently perceived as a major disruptive change to a place from the perspective of local residents, making the role of trust more critical. We, therefore, recommend that stakeholders' attitudes need to be understood in relation to heterogeneous place contexts and each individual's risk appraisal. Often place-related attributes are neglected while the costs and benefits of NBS and their effectiveness in mitigating risk are emphasized. While we provide empirical evidence in favor of the newly developed PRAM, future research should investigate whether these findings can also be transferred to other geographical contexts and in relation to different environmental change processes. For example, blue-green infrastructure projects, other types of ecosystem-based adaptation measures, or even deep geothermal or offshore wind power projects whose aim is to cope with other environmental conditions and which, at the same time, bring changes to a place can be considered within the PRAM framework.

Chapter 5 Synthesis and General Conclusion

The preceding chapters analyzed people's perceptions and attitudes regarding nature-based solutions (NBS) projects. This chapter evaluates the major achievements of the dissertation by providing a synthesis of the research findings and answering the overarching research question:

What shapes people's perceptions of NBS in the context of flooding?

Chapter 5 is structured with six sub-sections; Section 5.1 summarizes the data collection and research methods and key findings, Section 5.2 outlines the explored influencing factors for perceptions of nature-based solutions; Section 5.3 explains the Place-based Risk Appraisal Model (PRAM), extending the discussion to the specifics of place and risk contexts; Section 5.4 deals with the policy recommendations and insights gained from the research; Section 5.5 states the limitations of this dissertation and recommendations of possible topics and outlook for future research; and finally, Section 5.6 provides the concluding remarks.

5.1. Summary of the Papers

5.1.1. Data collection and research methods

The following methods were applied for data collection and analysis in this dissertation.

Paper I. Desk research (Systematic review)

A systematic review is a guideline-driven comprehensive review that allows the systematic analysis of state-of-the-art research. After setting key questions, a set of keyword strings was used to identify relevant primary research data, followed by a critical evaluation of the data. The approach should be reproducible, therefore, transparent. In total, 1,834 papers were identified from the keyword string, and after the screening process, 102 papers were analyzed to identify major topics that affect people's perceptions of NBS. Among them, 31 empirical papers were further investigated to provide ample evidence for the defined key topics.

Paper II. A Semi-structured survey (Expert interview)

Expert interview was used as a means to understand shaping social practices in a field of action, by drawing attention to the implicit aspects of expert knowledge, such as perceptions (Döringer, 2021); Social scientists have advocated a broader conception of expert knowledge beyond technical data and facts (Bogner & Menz, 2009; Meuser & Nagel, 2009). By doing so, it develops an inductive theory based on empirical data, with the aim of disclosing interpretative knowledge (Bogner & Menz, 2009; Bogner et al., 2018).

Against this backdrop, in-depth experts' interviews were performed on the topic of (1) flood risks and their countermeasures in Korea; (2) evaluation of NBS implementation in Korea; and (3) procedural aspects in flood risk mitigation and NBS implementation in South Korea. With the written consent of the interviewees, all interviews were coded and thematically analyzed using the software MaxQDA. The coding was iteratively processed to develop a final reduced coding scheme.

Paper III. A structured survey (Questionnaire)

A citizen survey using questionnaires was conducted to collect quantitative data regarding the residents' perceptions of the local NBS projects. The questionnaires were distributed in five towns in Saxony-Anhalt, Germany, where dike relocation projects were implemented. In total, 650 questionnaires were distributed and 304 questionnaires are collected with a response rate of 46.7%. The questionnaires entail questions about flood risk perception, adaptive behavior, individual attitude toward NBS projects, general environmental attitude, sense of place, socio-demographic conditions, etc. The survey data was entered and labeled in the SPSS software. Later, the statistical analysis (e.g., structural equation modeling) was performed in the software R.

5.1.2. Key messages

The objective of **Paper I** was to provide a state-of-the-art overview of key factors for perceptions of and attitudes toward NBS for hydro-meteorological risks. Based on 102 studies, the paper identified six topics shaping people's perceptions of NBS as a means to reduce hydro-

meteorological risks: (1) valuation of the co-benefits (including those related to ecosystems and society); (2) evaluation of risk reduction efficacy; (3) stakeholder participation; (4) socio-economic and place-specific conditions; (5) environmental attitude, and (6) uncertainty. The paper concludes with a generic model that shows the potential relationship between the above-mentioned topics (constructs). Here, it assumes two major constructs, evaluation of efficacy and valuation of co-benefits of NBS, with the consideration of moderating effect of threat appraisal, environmental attitudes, and interaction with NBS. Lastly, it suggests a more structured and theoretically grounded approach to generalize the findings and share insights for NBS projects' implementation.

Paper II aims to examine conceptualizations of the term NBS among experts as well as attitudinal and contextual barriers and drivers of NBS as a means to reduce flood risks in South Korea. This paper benefited from understanding complicated challenges spanning sectors and recognizing real-world practices and existing limits by using an expert-based method. As a result, the study found that expert conceptualizations of NBS differed. The views were contrasted with "a pathway beyond pure recovery" and "methodological advancement." For the barriers and drivers, 11 barriers and five drivers in the attitudinal domain, and 13 barriers and two drivers in the contextual domain were found to be relevant in the South Korean context. The details of barriers and drivers can be found in Chapter 3. The cost-effectiveness of NBS and their ability to cope with flood threats were mentioned the most as influencing factors in the attitudinal domain. Among the contextual variables, insufficient systems to integrate NBS in practice and ideologicalization of NBS policy were identified as barriers that impede consistent implementation of initiatives and a long-term national plan for NBS.

The aim of **Paper III** was to provide ample empirical evidence of the impact of risk- and place-related constructs on residents' attitudes toward local NBS projects. In order to do so, a theoretical framework that combines "place" and "risk"-related factors was developed. A citizen survey data from five municipalities in Saxony-Anhalt, Germany where dike relocation and floodplain restoration projects along the Elbe River was analyzed. Regarding place-related constructs, "nature bonding" was shown to be a positive predictor of perceived risk-reduction efficacy, but "place identity" was found to be a negative predictor of a supportive attitude.

Concerning risk-related constructs, well-communicated knowledge, trust, and perceived co-benefits positively, while threat appraisal negatively affected both supportive attitude and perceived risk-reduction efficacy. It was found that risk appraisal, pluralities of place contexts to each individual, and their relations are key for determining attitudes toward NBS.

The summary of research questions, methods, and key messages is displayed in Table 5.1.

Table 5.1 Summary of the dissertation

Paper	Research questions	Method	Research summary	Chapter
I. Han and Kuhlicke (2019)	What are the topics reflected in the previous literature influencing perceptions of NBS as a means to reduce hydro-meteorological risks?	Systematic literature review (PRISMA guideline)	Based on 102 studies, the paper identified six topics shaping people's perceptions of NBS as a means to reduce hydro-meteorological risks. Evaluation of efficacy and valuation of co-benefits of NBS were analyzed as major influencing factors, along with the assumed moderating effect of threat appraisal, environmental attitudes, and interaction with NBS.	Ch 2.
II. Han and Kuhlicke (2021)	What are the stimulating and hampering factors for mainstreaming NBS for flood risk management in South Korea? How are NBS conceptualized?	Expert interview; thematic coding	The paper found 11 barriers and five drivers in the attitudinal domain, and 13 barriers and two drivers in the contextual domain. The cost-effectiveness and efficacy of flood risk management were perceived as major attitudinal factors that influence perceptions of NBS. Regarding contextual factors, insufficient systems to integrate NBS in practice and ideologicalization of NBS policy were identified as barriers.	Ch 3.
III. Han et al. (2023)	How are public attitudes toward the NBS projects shaped? How do risk-and place-related factors shape individual attitudes toward NBS?	Questionnaire; multiple imputation; structural equation modeling	For the place-related constructs, nature bonding was shown to be a positive predictor of perceived risk-reduction efficacy, but place identity was found to be a negative predictor of a supportive attitude. For the risk-related constructs, well-communicated knowledge, trust, and perceived co-benefits were found to be positive predictors for attitude, however, threat appraisal was a negative predictor.	Ch 4.

5.2. Synthesis: Factors Shaping Perceptions of Nature-Based Solutions

The importance of exploring perceptions of nature-based solutions has recognized by not only academia but also practitioners (Andersson et al., 2017; Eggermont et al., 2015; Nesshover et al., 2017). Understanding people's perceptions of NBS is essential to achieving communication among stakeholders (Gray et al., 2017), as well as generating support and reducing tensions (Dalimunthe, 2018; Holstead et al., 2017; Mallette et al., 2021; Metcalf et al., 2015). This led to the first research question, "What are the topics reflected in the previous literature influencing perceptions of NBS as a means to reduce hydro-meteorological risks?" The first research question attempts to grasp the previously existing knowledge about people's perceptions of NBS. In Chapter 2, the key topics related to people's perceptions of NBS by means of reducing hydro-meteorological risks were identified by reviewing 102 papers. As a result, six-core topics were drawn and 31 papers with empirical evidence were used to provide supporting arguments. These topics include: (1) the value of the co-benefits (including those related to ecosystems and society); (2) the evaluation of the effectiveness of risk reduction; (3) the participation of stakeholders; (4) the socioeconomic and place-specific conditions; (5) the attitude toward the environment; and (6) uncertainty. With these topics, the authors suggested a generic model for the potential interplay of key constructs underlying perceptions of NBS (see Chapter 2, Figure 2.5).

Building on these findings, Chapter 3 posed the second research question, which was an extension of the first research question, "What are the stimulating and hampering attitudinal and contextual factors for mainstreaming NBS for flood risk management?" and "How are NBS conceptualized?" Expert interviews were used to investigate the research questions in the case of South Korea, as they are an effective method for gaining information and exploring specific problems and challenges (Pfadenhauer, 2009).

First, the study discovered that expert conceptualizations of NBS varied. The first group of four people considered NBS a "paradigm shift," or "pathway beyond pure recovery," while the second group of seven people considered NBS an outcome of "innovative advancement in technology," viewing it as a methodological advancement. The prevalence of technocratic conceptualization among experts, in particular, shows the risk of neglecting the ecological

significance of NBS and reciprocal interaction between human and natural systems beyond the human-only interests. Such conflicting perspectives emphasized the importance of shared agreement on a conceptualization of NBS, for example, to what extent "natural" and "technical" interventions should be considered as NBS. Second, concerning the attitudinal barriers and drivers of mainstreaming of NBS, the most-mentioned ones corresponded to the findings of Chapter 2, such as perceived co-benefits, perceived risk-reduction effectiveness, place-related conditions, etc.

To summarize, Table 5.2 illustrates major attitudinal factors identified in Chapters 2 and 3 in the context of floods. In addition, this table shows how the factors can be divided into risk and place concepts.

Table 5.2 Key topics for perceptions of nature-based solutions in the context of floods identified in Paper I and II

Topics	Sub-topics	Path	Paper
Risk	Risk-reduction effectiveness of the measures	+	Paper I · II
	Perceived utilities and benefits of the measures	+	Paper I · II
	Knowledge of NBS and local flood risk management	+	Paper I · II
	Uncertainty arising with the implementation of the measure	-	Paper I · II
	Threat appraisal against hazards	-	Paper I
	Trust in responsible institutions	+	Paper I
	Effective communication	+	Paper I
	Socio-economic conditions	+/-	Paper I
	Cost-effectiveness of the measures	+	Paper II
Place	Nature bonding or environmental attitude	+	Paper I · II
	Perceived changes to the landscape	-	Paper I
	Local history regarding mitigating measures	+/-	Paper I
	Environmental stewardship	+	Paper I
	Wilderness or "untouched nature" aspect	+	Paper I

In addition to the attitudinal factors, the contextual factors that shape attitudinal factors were examined to broaden the discussion; these consist of institutional, legal, political, and social barriers and drivers of NBS mainstreaming. They either help or hinder NBS performance as well as their implementation in practice. On the one hand, the most mentioned contextual factors are consistent with hampering or stimulating factors for any similar emerging technologies. For example, the path dependence of industries and decision-makers, a lack of operational capability, insufficient system basis, and ambiguous legal

liability can be seen as a major hurdle for other emerging technologies. Political aspects, on the other hand, were demonstrated to be peculiar to NBS contexts when compared to other emerging technology contexts, at least for the South Korean case. It was stated that the politicization of NBS polarizes opinion and potentially leads to fierce disputes. Large coalitions and interest groups advocating NIMBYism against/for NBS projects are also attributable to populism in the politics of NBS.

Finally, the analysis of the factors shaping perceptions of NBS in Chapters 2 and 3 prompted an empirical analysis of residents' attitudes to the local NBS projects in Chapter 4. It answered the third research question of "How are public attitudes toward the NBS projects shaped?" and "How do risk-and place-related factors shape the individual attitudes toward NBS?" The starting point of this study is two core concepts: place and risk, which were shown to be crucial for people's perceptions in Chapters 2 and 3. Inspired by theories of place (i.e., sense of place) and risk (i.e., protection motivation theory and protective action decision model), Chapter 4 built the hypotheses using the constructs drawn from the theories to analyze the attitudes of the residents at risk. Understanding the interconnectedness between people, risk, and the place—where interventions and hazards occur—becomes critical for NBS implementation. Such interconnectedness is not viewed as static; rather, their meanings and relationships evolve dynamically in response to time and changing circumstances (Fox et al., 2016). In this sense, Chapter 4 further empirically probed the sphere of place with two sense of place theory constructs, namely place identity and nature bonding. The empirical analysis undertaken in Chapter 4 showed that nature bonding was a positive predictor of perceived risk-reduction effectiveness for the place-related constructs, whereas place identity was a negative predictor of supportive attitude. For the constructs from risk theories, threat appraisal negatively affected perceived risk reduction effectiveness and supportive attitude, whereas, well-communicated information, trust in flood risk management, and perceived co-benefit were positive predictors. The results provided ample empirical evidence for the constructed model of at-risk residents' perceptions of NBS.

In sum, this dissertation has shown that people's perceptions of NBS consist of multiple layers of determinants that cannot be explained by a single or few indicators. It implies that any means cannot become a panacea that fits everyone's needs for the planned or already

realized NBS projects. The factors need to be carefully investigated in consideration of the heterogeneous contexts of each individual and community. Finally, Figure 5.1 provides a synthesis of the aforementioned contextual (or, systemic) as well as attitudinal (or, individual) factors using the schematic figure of place and risk used in Chapter 1. The perceptions of NBS are formed and shaped by diverse cognitive and affective changes due to risk-and place-related factors, while the context adds more layers of the meanings.

In detail, "place" focuses on the transaction between people and place, with aspects such as place attachment, place meanings, and place dynamics (i.e., changes over time). "Risk" encompasses threat and coping appraisal, communication, trust, and uncertain aspects of both NBS and hazards. Finally, the surrounding context provides systemic elements such as power relations, institutions, interests, social relations, and political ideology, with the possibility of an interfering influence of place and risk for perceptions of NBS. Figure 5.1 illustrates that the shaping process of perceptions of NBS is interactively linked with all these dimensions.

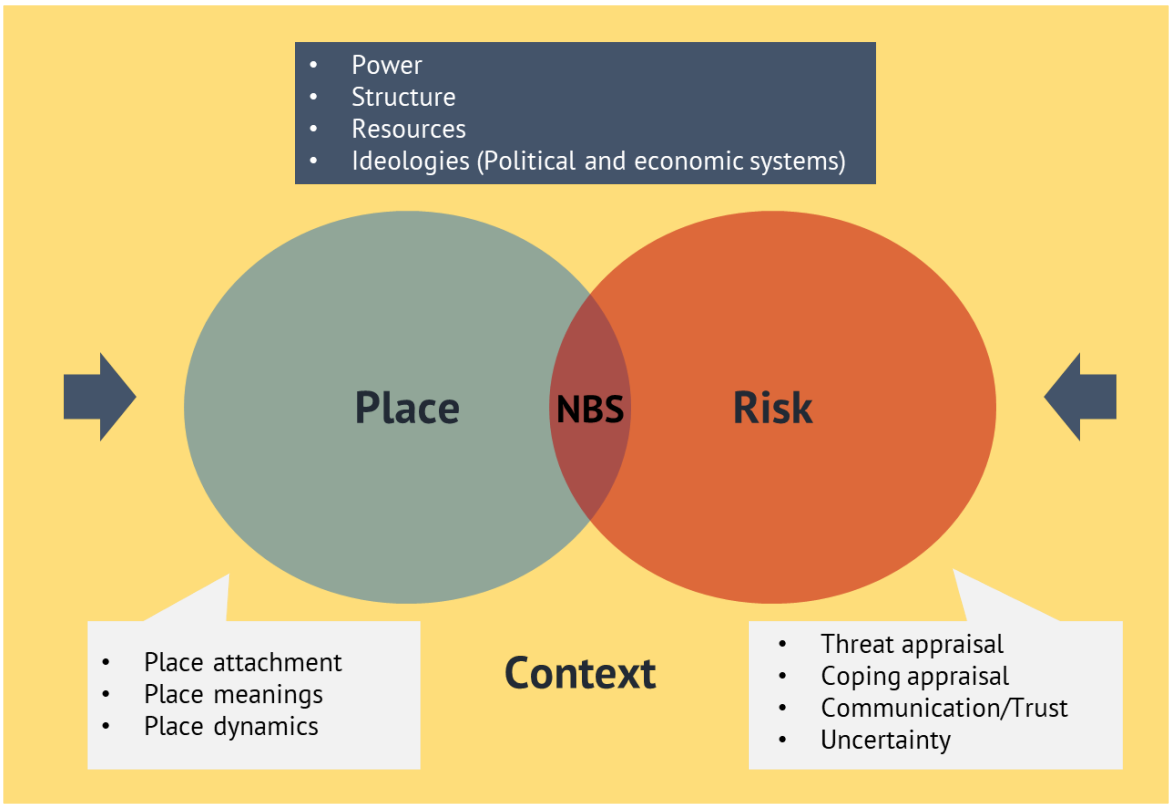

Figure 5.1 Place-Risk framework for perceptions of NBS

5.3. Place-based Risk Appraisal Model for Public Attitudes Toward NBS

This section particularly elaborates on the "place" and "risk" spheres for understanding perceptions of residents at risk of NBS. The emphasis on place and risk was discovered to be critical in the first two studies described in Chapters 2 and 3. It starts from the initial underlying setting of the dissertation: places and people at risk. Changes in the environment (e.g., flooding), as well as the adoption of adaptive measures (e.g., NBS) to the place, then become stimulators for changing people's attitudes; the changes anchored in people's lives, with diverse natural and social components interwoven as one fabric, affect how people shape their attitudes toward the local NBS projects. Also, they become a reason for a pluralistic framing of the NBS of each individual. On this backdrop, the Place-based Risk Appraisal Model, or PRAM, in Chapter 4 established the link between place and risk, which goes beyond the traditional understanding of attitudes that are fragmented and does not fully consider the multidimensional aspects of attitudes. Therefore, in this section, I would like to further open up a discussion regarding how this framework can be used and developed.

With regard to place-related factors, residents' attachment to the natural environment, as well as to the community to which they belong, is key to the mental process of perceiving changes that occur in the place. Starting from the premise that place is not a static entity, the relationship and interaction between place and a person, or "person-place transactions" that invariably include contexts of natural environmental risks, are thus positioned to produce cultural processes of shaping perceptions (Bonaiuto et al., 2016). Such a perspective sees the place as a container for human activity that is mutually connected (Cresswell, 2010). Therefore, neighborhoods (local areas) are places infused with meaning and made up of physical and social aspects that form interactions.

In this regard, I suggest considering the meanings attached to a place in the PRAM for future studies. These meanings may include an individual appraisal of values attributed to the place based on a subjective appreciation and assessment of adjustment measures that alter the place. Quinn et al. (2019), for example, argued that the meanings attached to a place impact people's preferences for local flood risk management. Furthermore, when assigned place meanings differ between policy-oriented understanding and that of local people, it may lead to additional opposition and disagreements over its significance.

With regard to risk-related factors, most importantly, threat appraisal and coping appraisal were found to be significant predictors that affect perceptions of NBS. These two variables are inspired by the protection motivation theory and the protective action decision model (see more in Chapter 4). On the one hand, threat appraisal (i.e., risk perception) refers to an intuitive judgment of the risk, based on people's heuristics. Early research on risk perception has been based on a psychometric paradigm of risk that primarily focused on the cognitive processing of the subject (e.g., Slovic, 1987). Coping appraisal, on the other hand, offers background information for making decisions about their attitudes, taking into account things like the amount of information they get and how much they trust the government. Contrary to the previous dominant research on risk perception, Paper III attempts to reflect the place-based affective element; it incorporates constructs of sense of place including place identity and nature bonding.

So far, only a few studies have found the linkage between a sense of place and risk perception in the context of environmental risk (e.g., Bonaiuto et al., 2016; Dandy et al., 2019; Jamali & Nejat, 2016). Still, there is a large gap in empirical research examining their impact and interconnectedness. Not only is the number of studies investigated limited, but also the evidence is constrained to the context of evacuation plans against immediate risks such as volcanic eruptions (e.g., Ruiz & Hernández, 2014), or displacement based on the livability of a place due to environmental changes (e.g., Adams, 2016).

In the previous research where the linkage between place and risk was found, emotional attachment to the place, on the one hand, was interpreted as an optimistic bias for risk perception; that is, the affective bond to place provides more feelings of safety and inhibits coping behaviors. In other words, place attachment functions as a barrier to more active coping behavior against the perceived risk (e.g., Armaş, 2006; De Dominicis et al., 2015). On the other hand, some identified that place attachment assisted communities in better preparing for the risk (e.g., Daryanto & Song, 2021; Swapan & Sadeque, 2021). As a plausible reason for the conflicting results, the risk contexts that people face were found to be relevant. For example, Bernardo (2013) found that place attachment makes people more aware of risks with high likelihood but less severe (perceived) effects, such as pollution or global warming, while it makes people less aware of risks with low likelihood but potentially disastrous effects,

such as earthquakes. It further opens up a discussion on the effect of optimistic bias in risk perception when people attempt to decrease their cognitive dissonance due to environmental changes by lowering their risk perception (ibid).

By the same token, the role of perceived co-benefits of NBS for more local endorsement can be interpreted likewise. The affected people may need to emphasize any other benefits from NBS to offset the distress gained through the process of change. In this regard, benefit appraisal can be considered within the PRAM framework, in addition to the factors used for traditional risk perception theories, such as threat and coping appraisal. It concerns how people evaluate multiple benefits apart from risk-reduction effectiveness or other disadvantages, including elements of uncertainty associated with the implementation of NBS.

Lastly, I argue that threat appraisal and coping appraisal can be extended to cover sensitivity to changes (or levels of acceptance), showing the extent to which individuals can embrace or accept changes or risks (Buchecker et al., 2013; Jansen, 2020). In an environmentally changing world, how much people are willing to accept changes tells how they will counteract the changes; this can result in inactive or active actions.

5.4. Policy Recommendations

This section highlights two main policy recommendations derived from this dissertation. Improving people's perceptions of nature-based solutions helps the effective realization of NBS and provides an opportunity to enhance citizen participation. The following sections include recommendations on a better understanding of individual "place" and "risk" contexts, as well as building secure supporting systems for mainstreaming NBS.

5.4.1. Plurality of "place" and "risk" profiles of individuals

This dissertation contends that a one-size-fits-all policy does not ensure optimal adaptation of NBS policy for every scenario. Hence, this dissertation recommends considering the relationality of meanings and perceptions when initiating an NBS project and related policies.

First, before the implementation of NBS, multiple place meanings and identities must be considered in the planning stage. This is particularly critical when carrying out a large-scale

project that involves spatial alterations in the place. The accrued meanings by the residents of the place are so diverse that the changes to the place can be regarded differently. When individuals have a strong attachment to a place, they may regard local NBS efforts as disrupting change, as addressed in Chapter 5. In the meantime, high attachment to place can encourage a more inclusive and effective governance model in NBS projects. Therefore, it is desirable to use this as an opportunity to enhance project realization.

Second, the heterogeneous risk perception of an individual can provide different interpretations for the adaptive measures that use more "natural" elements (i.e., NBS). A handful of studies, including Chapter 4 of this dissertation, have proven that people with higher risk contexts would not prefer more natural elements in flood adaptive measures; they perceive NBS as not sufficient to provide enough security against floods. Also in Chapter 1, the discussion in academia about "naturalness" was provided to give an outlook on people's perceptions of NBS concerning its naturalness. People's underestimation of natural flood risk management measures in higher risk contexts may elicit significant opposition, regardless of their actual effectiveness in risk reduction. Therefore, it is necessary to understand the underlying mechanism for naturalness and risk perception in order to minimize the risk of a conflict. At the same time, the decision-makers should also keep in mind that the knowledge of NBS projects, including their processes and operations, needs to be fully grasped by the affected group to avoid any miscommunication and incorrect information. In this sense, it is critical to survey and comprehend the status quo of the residents' perception beforehand.

In sum, I argue for the importance of conducting a survey to assess risk-and place-related factors before, during, and after project implementation. Although the influencing factors are not entirely restricted to risk and place, such a survey can give an overview of the affected people and can speculate on whether naturalness will boost or diminish local support.

5.4.2. Dealing with system discrepancy

I contend that resolving a system discrepancy that supports enhanced perceptions and implementation of NBS is critical. In Chapter 3, a system discrepancy in pursuing NBS in the South Korean context was discussed. On the one hand, the discrepancy means that the systems for operating NBS do not meet its expectations for supporting optimal

operationalization. The most argued contextual barriers to NBS realization are related to the appropriate system to facilitate the transition toward NBS in FRM (in Chapter 3, but argued also in Sarabi et al., 2020; Solheim et al., 2021). For example, it is seen that inadequate financial resources, legal basis, and unclear liabilities inhibit better uptake of the NBS policy in flood risk management. Therefore, enhancing the systems that support the successful implementation of NBS is an important aspect of making them function and mainstreaming them.

To deal with such a discrepancy, more political support also needs to be premised. I argue for a more consistent NBS policy along with sufficient supporting resources. The diverse benefits of NBS would need more time to be realized than the structural measures. Therefore, short-term actions based on the political cycle or electoral mandate will not be sufficient to realize the NBS' long-term benefits. In addition, in Chapter 3, the politicization of NBS was considered one of the biggest hindrances to NBS realization in South Korea, as the polarized opinions hamper the long-term plan of NBS. In a highly politicized context, up-scaling of NBS cannot be achieved, but rather, the likelihood of eco-gentrification can be increased.

5.5. Limitations of the Study and Recommendations for Future Research

Above all, I acknowledge that methodological limitations exist in this dissertation, particularly related to the sampling method and size. First of all, for Paper I (Chapter 2), I admit that the study did not include some of the essential documents, such as gray literature or project reports. However, the authors were able to include the relevant articles as much as possible thanks to concise and detailed keywords. Likewise, the sample size of Paper II (Chapter 3) for interviews was relatively small; the 11 participants could be too few to ensure capture of all aspects and fields. To deal with it, despite the small sample size, the authors tried to interview experts from diverse disciplines and fields to obtain broad perspectives. The survey for Paper III (Chapter 4) also had a relatively small sample size of 304. To deal with this, a multiple imputation method was used to make the best use of the data and improve the prediction of the model.

Next, I would like to highlight three future directions that expand on the dissertation's theoretical and methodological contributions and fill out the conceptual limitations of this

dissertation. The first possible direction is to expand the use of the Place-based Risk Appraisal Model (PRAM) in various environmental change situations. The second potential path is to examine the place and risk profiles of residents at risk. Third, the third direction is to compare the types of NBS and how they influence the factors affecting people's perceptions of NBS.

First, I suggest that the PRAM provides a general framework not only for dike relocation projects to deal with the flood risk but also for a variety of other environmental change-induced cases. By integrating the findings in Chapter 4 and the extended discussion from Section 5.2, the PRAM provides an opportunity to broaden its reach. For example, blue-green infrastructure projects, other types of ecosystem-based adaptation measures, or even deep geothermal or offshore wind power projects whose aim is to cope with other environmental conditions and which, at the same time, bring changes to a place, can be considered within the PRAM framework. Furthermore, the differences between urban and rural environments as well as how different factors interact in different environments can be compared; lower place attachment could be expected and the scale of NBS could be smaller in the urban environment. Therefore, the urban and rural environments can expect a different interplay between the factors.

Future studies can further investigate the linkage between a sense of place and risk perception, providing empirical evidence for an extended model. The current state of knowledge only gives us a partial picture of how these two constructs influence our cognitive and behavioral levels. It is possible to determine how these elements influence behavioral aspects like adaptive and coping behavior. Chapter 4 showed one of the initial attempts to investigate the impact of place and risk-related factors on people's attitudes toward NBS. Similarly, a few studies provided initial insights into how the sense of place can be related to adaptive behavior in the context of emergency communication or imminent risks such as an earthquake or volcanic eruption (e.g., Qing et al., 2022; Ruiz & Hernández, 2014; Stancu et al., 2020; Xu et al., 2020). However, empirical evidence has been lacking in this strand of research until recently. In Section 5.2, some possible constructs that can be investigated in the extended PRAM were discussed. Future studies are recommended to pursue ample empirical evidence based on the PRAM.

Second, this dissertation recommends examining residents' profiles of place and risk. First of all, place meanings assigned by individuals should be included in the PRAM. In Chapter 4, I analyzed place identity and nature bonding that affect public attitudes toward NBS, but the place meanings assigned by the residents have not been investigated. Furthermore, the types of risks that are much more perceived in a neighborhood than globally can show differences. For example, the likelihood or severity of flood risk in the town can be perceived more at a neighborhood level, whereas climate change risk is perceived at a global level. One possible hypothesis is that risk perceived at a neighborhood level is more interconnected with a sense of place than globally perceived risk. To summarize, I propose using place meanings and types of risk in addition to other place and risk variables that I previously used in PRAM, as well as clustering residents' place and risk profiles. This allows researchers to examine how these profiles alter the interplay between the factors.

Third, I propose that the type of NBS, particularly the level of natural and technological components in the NBS, be examined further. To what extent people trust the effectiveness of NBS can be affected by the level of natural and technological elements in NBS. Therefore, the type of NBS is closely related to the impact of risk perception on perceptions of NBS. Likewise, certain urban and technological NBS projects that may have more eco-gentrification concerns would exhibit different interplays between the constructs compared to more restorative NBS in rural contexts. Therefore, future research should outline the impacts of different types of NBS on people's perceptions.

5.6. Concluding Remarks

The importance of NBS has received more attention due to changing climate patterns as well as the demands of society. Understanding people's perceptions of nature-based solutions is imperative for garnering the most of the multiple benefits that NBS can bring. This dissertation collected an overview of the major factors influencing perceptions of NBS and proved their relevance by conducting a systematic review, expert interviews, and citizen surveys. Throughout the process, it is confirmed that despite the diverse benefits that the NBS project can bring to the locality, the project can be acknowledged as a disruptive change to the place, which evokes objections or resistance to the project, particularly when the residents'

place attachment is high. Also, the risk context, such as the perceived likelihood and severity of the hazards, was found to be influential in the individual process of forming their perceptions/attitudes. Furthermore, systemic contexts, which include social, institutional, legal, and political aspects, act as an intervenor or stimulator for people's perceptions, ultimately enabling or discouraging the mainstreaming of NBS practices. The dissertation confirms that numerous layers of place and risk attributes of NBS surrounded by contextual factors make differences in people's perceptions of NBS. Therefore, in addition to the NBS effectiveness that has been investigated at the core so far, the degree to which people are willing to accept changes in place based on the meanings and values they had prior to the project implementation and how these interact with one's risk appraisal and other systemic factors should be carefully considered in order to optimize the NBS realization. Admitting room for development in this kind of research, I suggest that the research framework suggested in this dissertation can be easily transferred to other NBS cases and to other hazard contexts. Also, in the context of growing interest in a more natural way of reducing flood risks, these conclusions are important guidance for the future NBS project strategy and NBS governance that consider people and places at risk.

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Appendix

List of Appendices:

Appendix A. Interview Guide Used for Paper II

English Version

Opening questions

1. Can you please tell me your job title and your position? Which responsibilities do you have in your job?
2. What is your original academic/business background?
3. How many years have you already been working in your current field?

Floods and the measures for flood risk reduction in Korea

4. What were the most serious flood events in recent years? Could you please illustrate more?
5. Do you think that the frequency or severity of flood events changed over the last years and will change in the future? What are the underlying reasons?
6. What kinds of measures have been implemented dominantly to reduce the flood risk in Korea?
7. Do you think these measures are effective?
8. What kinds of barriers/drawbacks of these measures have been acknowledged?

Evaluation of nature-based solutions (NBS) in Korea

9. Are you aware of any NBS measures implemented in Korea, if yes, which?
10. Could you please introduce the types of NBS which are implemented particularly for flood risk reduction in Korea? Could you name and introduce any projects?
11. What kinds of benefits have you encountered in the project? / What do you think the benefits of NBS are?
12. What kinds of barriers/drawbacks have you encountered in the project? / What do you think the barriers/drawbacks of NBS are?
13. What do you think, would support are broader uptake/stronger implementation of NBS in Korea. What are the supporting factors?
14. Do you think more technology development is needed for the realization of NBS? (optional)
15. Do you think more restoration is needed for the realization of NBS? (optional)

Public Participation in flood risk management in Korea

16. Who has the primary responsibility for implementing flood risk management in South Korea?
17. What role does each entity (e.g., central government, local government, individuals, etc.) play in flood mitigation measures?
18. Is there an institutional/legal framework that promotes the participation of individuals (residents) in preparing countermeasures to reduce flood risk in Korea?
19. What advantages/disadvantages do you think resident participation brings in the process of establishing flood risk reduction measures?
20. Can you give an example of citizen participation in flood risk management? What achievements or resistance were there? What is the reason?
21. Can you give an example of citizen participation in the implementation of nature-based solutions? What achievements or resistance were there? What is the reason?
22. Do you think social capital (bond with relevant public officials/trust in the relevant government office, etc.) has an impact on the resident participation process?

Ending question

23. Is there anything else that you want to add?

Korean Version

배경질문

1. 먼저 소개를 부탁드리겠습니다. 소속하신 기관과 직책을 말씀해주시겠습니까? 자세하게는 현재는 어떠한 업무(연구)를 하고 계십니까?
2. 혹시 이전에는 어떤 업무/연구를 하셨습니까?
3. 현재 이 분야에서 일을 하신지는 얼마나 되셨습니까?

한국 홍수사례 및 위험저감방안

4. 최근 몇 년동안 한국에서 일어난 가장 심각했던 홍수는 언제, 어디에서 일어났는지 설명해주실 수 있습니까?
5. 홍수의 빈도나 심각성이 지난 몇 년간 증가했습니까? 이러한 경향성이 미래에도 지속 될 것이라고 생각하십니까?
6. 우리나라에서는 홍수위험을 저감하기 위해 지금까지 어떠한 대책을 취하고 있습니까?
7. 언급하신 대책이 홍수위험을 저감하는데 효과적이라고 생각하십니까?
8. 이러한 대책이 가지고 있는 단점/방해물은 어떤것이 있습니까?

자연기반솔루션에 대한 평가

9. 한국에서 수행되고 있는 자연기반해법에 대해 알고계십니까? 혹시 관련된 프로젝트에 대해서 설명해주실 수 있습니까?
10. 그 중에서 특별히 홍수저감을 위한 자연기반해법에 대해 알고계십니까?
11. 자연기반해법이 가지고 있는 장점은 어떠한 것이 있습니까? (또는) 자연기반해법이 가지고 있는 장점은 어떠한 것이 있습니까?
12. 자연기반해법 프로젝트를 참여하면서 어떠한 단점을 경험하셨습니까? (또는) 자연기반해법이 가지고있는 단점은 어떠한 것이 있습니까?
13. 자연기반해법이 성공적으로 수행되고, 보다 효과적으로 활용되기 위해서는 어떠한 요소가 더 필요하다고 생각하십니까?
14. (선택) 자연기반해법의 성공적인 수행을 위해 기술발전이 더 필요하다고 생각하십니까?
15. (선택) 자연기반해법의 성공적인 수행을 위해 자연복원이 더 필요하다고 생각하십니까?

홍수위험저감을 위한 주민참여

16. 홍수저감방안을 실행하는 가장 주된 책임이 있는 주체는 무엇입니까?
17. 각각의 주체는 홍수저감방안 대책을 위해 어떠한 역할을 하고 있습니까?
18. 우리나라에서 이러한 홍수위험저감을 위한 대책마련에 개개인(주민)의 참여를 촉진시키는 제도적/법적프레임워크가 존재합니까?
19. 홍수위험저감방안을 수립하는 과정에서 주민참여는 어떠한 장점/단점을 가지고 온다고 생각하십니까?
20. 홍수위험저감을 위한 주민참여의 예를 들어주실 수 있습니까? 어떠한 성과 또는 어떠한 저항이 있었습니까? 이유는 무엇입니까?
21. 자연기반해법을 실행하는 과정에서 주민참여의 예를 들어주실 수 있습니까? 어떠한 성과 또는 어떠한 저항이 있었습니까? 이유는 무엇입니까?
22. 주민참여 과정에서 사회적 자본(관련 공무원과의 유대감/해당 관청에 대한 신뢰 등)이 영향을 끼친다고 생각하십니까?

마무리 질문

23. 이 외에 추가하고 싶으신 내용이 있으십니까?

Appendix B. Questionnaire Used for Paper III (Town: Aken)

Als Einstieg in den Fragebogen bitten wir Sie, Ihren persönlichen Teilnahmecode anzulegen. Dieser Teilnahmecode ist aus folgenden Grund wichtig: Sie haben zu jedem späteren Zeitpunkt die Möglichkeit, Ihre Angaben im Fragebogen zu widerrufen.

1. Bitte tragen Sie folgende Buchstaben bzw. Zahl in der vorgegebenen Reihenfolge in das nebenstehende Feld ein:

1. … den ersten Buchstaben Ihres Geburtsortes (z.B. **A**ken),
2. … den dritten Buchstaben Ihres Vornamens (z.B. An**T**on),
3. … die letzte Ziffer Ihres Geburtsjahres (z.B. 197**1**) sowie
4. … den ersten Buchstaben des Vornamens Ihrer Mutter (z.B. **I**nge).

1.	2.	3.	4.

Zu Beginn möchten wir Ihnen einige Fragen zu Ihrer persönlichen Erfahrung mit Überschwemmungsereignissen stellen.

2. Wie häufig waren Sie in der Vergangenheit bereits persönlich von einer Überschwemmung (z.B. Flusshochwasser oder Starkregen) betroffen?

☐ Noch nie → Bitte weiter mit Frage 6

☐ Einmal ☐ Zweimal ☐ Dreimal oder mehr

3. Wann genau war das letzte Überschwemmungsereignis?

Monat: …….. Jahr: ……..

4. Wie schwerwiegend war diese Erfahrung für Sie (z.B. wegen Evakuierung, gesundheitlichen Folgen, finanziellen Schäden oder Personenschäden)?

Überhaupt nicht schwerwiegend ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr schwerwiegend

5. Wie machtlos haben Sie sich bei dieser Überschwemmung gefühlt?

Überhaupt nicht machtlos ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr machtlos

Nun haben wir einige Fragen zu Ihrer Einschätzung zukünftiger Überschwemmungsereignisse beziehungsweise der dadurch verursachten Schäden.

6. Für wie wahrscheinlich halten Sie das Auftreten einer schweren Überschwemmung innerhalb der <u>nächsten 5 Jahre in Ihrer Wohnung</u>?

Sehr unwahrscheinlich ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr wahrscheinlich

7. Für wie groß erwarten Sie die <u>Schäden an Ihrer Wohnung</u> bei solch einem Ereignis?

Keine Schäden ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr große Schäden

8. Für wie wahrscheinlich halten Sie das Auftreten einer schweren Überschwemmung innerhalb der <u>nächsten 5 Jahre in Aken</u>?

Sehr unwahrscheinlich ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr wahrscheinlich

9. Für wie groß erwarten Sie die <u>Schäden in Aken</u> im Fall eines solchen Ereignisses?

Keine Schäden ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr große Schäden

10. Als nächstes bitten wir Sie, uns den folgenden Satz zu ergänzen: Der Gedanke an eine zukünftige Überschwemmung in Aken macht mir ...

... keine Angst ☐ ☐ ☐ ☐ ☐ ☐ ☐ ... sehr große Angst

11. Wenn ich über zukünftige Überschwemmungsereignisse nachdenke, fühle ich mich hilflos.

Stimme gar nicht zu ☐ ☐ ☐ ☐ ☐ ☐ ☐ Stimme vollkommen zu

Um Schäden durch Überschwemmungen vorzubeugen, kann man unterschiedliche private Vorsorgemaßnahmen treffen. Wir haben nachfolgend nun einige Fragen zu diesem Thema.

12. Wie <u>wirksam</u> halten Sie die aufgelisteten Vorsorgemaßnahmen, um Überschwemmungsschäden zu verringern?

	Gar nicht wirksam						Sehr wirksam
Sichere Aufbewahrung von persönlichen Wertgegenständen und Dokumenten	☐	☐	☐	☐	☐	☐	☐
Abschluss einer Elementarschadens-versicherung	☐	☐	☐	☐	☐	☐	☐
Bauliche Vorsorgemaßnahmen am Wohngebäude	☐	☐	☐	☐	☐	☐	☐
Umzug in ein Gebiet ohne Überschwemmungsrisiko	☐	☐	☐	☐	☐	☐	☐
Andere Maßnahme: ……..	☐	☐	☐	☐	☐	☐	☐

13. Wir bitten Sie jetzt anzugeben, ob Sie eine der genannten Maßnahmen in den <u>nächsten 6 Monaten beabsichtigen</u> umzusetzen bzw. <u>bereits umgesetzt</u> haben.

	Keine Absicht						Starke Absicht	Bereits umgesetzt
Sichere Aufbewahrung von persönlichen Wertgegenständen und Dokumenten	☐	☐	☐	☐	☐	☐	☐	☐
Abschluss einer Elementarschadens-versicherung	☐	☐	☐	☐	☐	☐	☐	☐
Bauliche Vorsorgemaßnahmen am Wohngebäude	☐	☐	☐	☐	☐	☐	☐	☐
Umzug in ein Gebiet ohne Überschwemmungsrisiko	☐	☐	☐	☐	☐	☐	☐	☐
Andere Maßnahme: ……..	☐	☐	☐	☐	☐	☐	☐	☐

14. Abschließend bitten wir Sie anzugeben, für wie groß Sie Ihren <u>persönlichen Aufwand</u> einschätzen, um die folgenden Maßnahmen umzusetzen beziehungsweise wie groß Ihr persönlicher Aufwand war, als Sie die Maßnahmen bereits umsetzten.

	Sehr geringer Aufwand						Sehr großer Aufwand
Sichere Aufbewahrung von persönlichen Wertgegenständen und Dokumenten	☐	☐	☐	☐	☐	☐	☐
Abschluss einer Elementarschadens-versicherung	☐	☐	☐	☐	☐	☐	☐
Bauliche Vorsorgemaßnahmen am Wohngebäude	☐	☐	☐	☐	☐	☐	☐
Umzug in ein Gebiet ohne Überschwemmungsrisiko	☐	☐	☐	☐	☐	☐	☐
Andere Maßnahme: ……	☐	☐	☐	☐	☐	☐	☐

Im Folgenden interessiert uns, wie sehr Sie dem Hochwasserschutz in Aken vertrauen.

15. Bitte geben Sie an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Ich kann mich vollständig auf den öffentlichen Hochwasserschutz in meiner Gemeinde verlassen.	☐	☐	☐	☐	☐	☐	☐
Der öffentliche Hochwasserschutz gibt mir ein Gefühl der Sicherheit.	☐	☐	☐	☐	☐	☐	☐
Ich vertraue darauf, dass es in meiner Gemeinde einen guten öffentlichen Hochwasserschutz gibt.	☐	☐	☐	☐	☐	☐	☐
Ich fühle mich gut über den aktuellen Hochwasserschutz in Aken informiert.	☐	☐	☐	☐	☐	☐	☐
Ich weiß, welche Vorsorgemaßnahmen ich in meiner Wohnung gesetzlich umsetzen darf, um mich vor Überschwemmungen zu schützen.	☐	☐	☐	☐	☐	☐	☐

Als nächstes interessiert uns, wie gerne Sie Ihre Zeit in der Natur verbringen und welche Verbindunge Sie zur Natur haben.

16. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Bitte geben Sie an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Die natürliche Umwelt ist wichtig für mich.	☐	☐	☐	☐	☐	☐	☐
Wenn ich Zeit in der natürlichen Umwelt verbringe, fühle ich mich mit mir selbst im Reinen.	☐	☐	☐	☐	☐	☐	☐
Ich hänge sehr an der natürlichen Umwelt.	☐	☐	☐	☐	☐	☐	☐
Ich wäre sehr traurig, wenn es zum Verlust von Pflanzen und Tieren in der natürlichen Umwelt kommen würde.	☐	☐	☐	☐	☐	☐	☐
Umweltfreundlich zu handeln ist ein wichtiger Teil von mir.	☐	☐	☐	☐	☐	☐	☐
Ich bin jemand, der sich stark um Umweltprobleme kümmert.	☐	☐	☐	☐	☐	☐	☐
Wenn ich nicht in der Lage wäre, umweltfreundlich zu handeln, würde mir das sehr viel ausmachen.	☐	☐	☐	☐	☐	☐	☐

Als nächstes interessiert uns, wie sehr Sie mit der Gemeinschaft und der Natur verbunden sind und wie Sie die Vorteile vom Lödderitzer Forst bewerten und wie Sie Ihre Zeit dort verbringen.

17. Wie viele Jahre leben Sie schon in Aken?

..... Jahre

18. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Bitte geben Sie an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Aken bedeutet mir sehr viel.	☐	☐	☐	☐	☐	☐	☐
Ich bin sehr mit Aken verbunden.	☐	☐	☐	☐	☐	☐	☐
Ich habe viele schöne Erinnerungen an Aken.	☐	☐	☐	☐	☐	☐	☐
Aken ist für mich etwas ganz Besonderes.	☐	☐	☐	☐	☐	☐	☐
Ich identifiziere mich stark mit Aken.	☐	☐	☐	☐	☐	☐	☐
Aken ist ein Teil von mir.	☐	☐	☐	☐	☐	☐	☐

19. Waren Sie schon einmal im Lödderitzer Forst?

☐ Ja ☐ Nein → Bitte weiter mit **Frage 26**

20. Durchschnittliche Wegzeit für Personen zu Fuß zum Lödderitzer Forst.

..... Min

21. Wie oft besuchen Sie den Lödderitzer Forst pro Jahr?

☐ Täglich
☐ Mehrmals pro Woche
☐ Einmal pro Woche
☐ Mehrmals im Monat
☐ Einmal im Monat
☐ Mehrmals im Jahr
☐ Einmal im Jahr
☐ Seltener

22. Wie lange bleiben Sie normalerweise dort (im Durchschnitt)?

..... Min

23. Es ist für mich einfach, den Lödderitzer Forst zu erreichen.

Stimme gar nicht zu	☐	☐	☐	☐	☐	☐	☐	Stimme vollkommen zu

24. Haben Sie das Projekt zur Deichrückverlegung im Bereich Lödderitzer Forst von Anfang an verfolgt?

☐ Ja ☐ Nein → Bitte weiter mit **Frage 26**

25. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Bitte geben Sie an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Der Lödderitzer Forst zieht mich jetzt mehr an als vor der Deichrückverlegung.	☐	☐	☐	☐	☐	☐	☐
Ich besuche den Lödderitzer Forst jetzt öfter als vor der Deichrückverlegung.	☐	☐	☐	☐	☐	☐	☐
Der Lödderitzer Forst entspricht jetzt mehr meinem Flussideal als vor der Deichrückverlegung	☐	☐	☐	☐	☐	☐	☐
Der Lödderitzer Forst lädt nun mehr zum Verweilen ein als vor der Deichrückverlegung.	☐	☐	☐	☐	☐	☐	☐
Der ökologische Wert des Lödderitzer Forsts hat sich erhöht in Folge der Deichrückverlegung.	☐	☐	☐	☐	☐	☐	☐
Seit der Deichrückverlegung trägt der Lödderitzer Forst zu einer höheren Lebensqualität bei.	☐	☐	☐	☐	☐	☐	☐

26. Die folgenden Aussagen beziehen sich wieder auf den Lödderitzer Forst. Können Sie für jede der folgenden Bedeutungen angeben, wie sehr Sie zustimmen.

„Der Lödderitzer Forst ist ein …“

	Stimme gar nicht zu						Stimme vollkommen zu
Naherholungsgebiet im Freien	☐	☐	☐	☐	☐	☐	☐
Ort des Naturerlebnisses	☐	☐	☐	☐	☐	☐	☐
Quelle der Gefahr	☐	☐	☐	☐	☐	☐	☐
Raum für wirtschaftliche Ausbeutung	☐	☐	☐	☐	☐	☐	☐
Ökologisch wertvoller Raum	☐	☐	☐	☐	☐	☐	☐
Ort der Ruhe und Entspannung	☐	☐	☐	☐	☐	☐	☐
Teil des Zuhauses	☐	☐	☐	☐	☐	☐	☐
Entwässerungsfunktion	☐	☐	☐	☐	☐	☐	☐
Teil meines Wohnraums	☐	☐	☐	☐	☐	☐	☐
Errungenschaft der Technik	☐	☐	☐	☐	☐	☐	☐
Erinnerungen an die Kindheit	☐	☐	☐	☐	☐	☐	☐
Attraktives Landschaftselement	☐	☐	☐	☐	☐	☐	☐

Bitte geben Sie andere Vorteile an, die Sie Ihrer Meinung nach von der Deichrückverlegung haben, falls vorhanden.

……

……

……

27. Haben Sie irgendeine Art von Entschädigung für den staatlichen Landerwerb für die Deichrückverlegung im Lödderitzer Forst erhalten?

☐ Ja ☐ Nein

28. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Bitte geben Sie an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Die Deichrückverlegung im Lödderitzer Forst hat dazu geführt, dass meine Immobilie oder mein Grundstück finanziell höher bewertet wurde.	☐	☐	☐	☐	☐	☐	☐
Durch die Deichrückverlegung im Lödderitzer Forst gewann die Stadt an Attraktivität.	☐	☐	☐	☐	☐	☐	☐
Der Lödderitzer Forst trägt dazu bei, das Einkommen meiner Familie zu erhöhen (z.B. wegen mehr Besuchern).	☐	☐	☐	☐	☐	☐	☐

29. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Bitte geben Sie an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Wegen der Deichrückverlegung ist Aken besser vor Hochwasser geschützt.	☐	☐	☐	☐	☐	☐	☐
Aken ist nun gefährdeter, da der Deich näher an den Stadtteil verlegt wurde.	☐	☐	☐	☐	☐	☐	☐
Ich brauche mehr Beweise dafür, dass die Deichrückverlegung einen positiven Effekt auf Hochwasser hat.	☐	☐	☐	☐	☐	☐	☐
Angesichts der Nutzen, ist die Deichrückverlegung zu teuer.	☐	☐	☐	☐	☐	☐	☐
Ich unterstütze die Deichrückverlegung.	☐	☐	☐	☐	☐	☐	☐
Ich fühle mich gut über das Deichrückverlegungsprojekt informiert.	☐	☐	☐	☐	☐	☐	☐

30. Wie ist Ihre Einstellung zum Deichrückverlegung Projekt?

- ☐ Ablehnung
- ☐ Gemischte Gefühle
- ☐ Gleichgültig
- ☐ Unterstützend

Nun wechseln wir das Thema. Im Folgenden möchten wir gern von Ihnen erfahren, welche Einstellungen Sie zu Problemen haben und wie sehr Sie Ihrem Hochwasserschutz vertrauen.

31. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Geben Sie bitte an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

	Stimme gar nicht zu						Stimme vollkommen zu
Schwierigkeiten sehe ich gelassen entgegen, weil ich meinen Fähigkeiten immer vertrauen kann.	☐	☐	☐	☐	☐	☐	☐
Für jedes Problem kann ich eine Lösung finden.	☐	☐	☐	☐	☐	☐	☐
Ich traue mir zu, meine Wohnung durch die Umsetzung von Vorsorgemaßnahmen vor Überschwemmungen schützen zu können.	☐	☐	☐	☐	☐	☐	☐
Ich selbst kann Vorkehrungen gegen Überschwemmungsschäden treffen.	☐	☐	☐	☐	☐	☐	☐
Ich kann mich gut auf zukünftige Überschwemmungen vorbereiten.	☐	☐	☐	☐	☐	☐	☐

32. Sind Sie im Allgemeinen ein risikobereiter Mensch oder versuchen Sie, Risiken zu vermeiden?

Gar nicht risikobereit ☐ ☐ ☐ ☐ ☐ ☐ ☐ Sehr risikobereit

Aus gegebenem Anlass möchten wir Sie auch fragen, wie sich die Corona-Pandemie auf Ihr Leben ausgewirkt hat.

33. Wir nennen Ihnen jetzt eine Reihe von Aussagen. Geben Sie bitte an, ob Sie den Aussagen eher zustimmen oder eher nicht zustimmen.

Seit dem Ausbruch der Covid-19-Pandemie,

	Stimme gar nicht zu						Stimme vollkommen zu
... beeinträchtigt mich die soziale Isolation sehr.	☐	☐	☐	☐	☐	☐	☐
... habe ich bemerkt, dass sich die Menschen in meiner Gemeinde zunehmend gegenseitig unterstützen.	☐	☐	☐	☐	☐	☐	☐
... habe ich gemerkt, dass Grünflächen und die Natur immer wichtiger werden.	☐	☐	☐	☐	☐	☐	☐
... ist mir die Notwendigkeit von Grünflächen und Natur bewusster geworden.	☐	☐	☐	☐	☐	☐	☐
... habe ich mehr Zeit in der Natur verbracht.	☐	☐	☐	☐	☐	☐	☐
... verbringe ich mehr Zeit in den Auen im Lödderitzer Forst.	☐	☐	☐	☐	☐	☐	☐

Vielen Dank, dass Sie den Fragebogen bis hierhin ausgefüllt haben. Abschließend haben wir noch ein paar Fragen zu Ihrer Person und zu Ihrem Haushalt. Diese Angaben dienen ausschließlich dazu, die Befragten in statistische Gruppen einzuteilen. Daher bitten wir Sie, auch diese Fragen noch vollständig zu beantworten.

34. Wie alt sind Sie? ..... Jahre

35. Sind Sie …?

☐ … männlich ☐ … weiblich ☐ … divers

36. Hat Ihre berufliche Tätigkeit mit Gefahren oder Schäden durch Katastrophen zu tun (z.B. Feuerwehr, THW, Versicherung o.ä.)?

☐ Nein

☐ Ja, und zwar bin ich in folgendem Bereich tätig:

……

37. Üben Sie nebenberuflich oder ehrenamtlich Tätigkeiten aus, die mit Gefahren oder Schäden durch Katastrophen zu tun haben?

☐ Nein

☐ Ja, und zwar folgende Tätigkeit:

……

38. Die Wohnung/das Haus in der ich/in dem ich lebe ist …

☐ Gemietet

☐ Eigentum/Teileigentum

☐ Anderes, nämlich:

……

39. In was für einem Haustyp wohnen Sie und wann wurde das Haus gebaut?

	(ca.) Baujahr
☐ Freistehendes Einfamilienhaus	.....
☐ Doppelhaushälfte	.....
☐ Reihenhaus	.....
☐ Mehrfamilienhaus/Wohnblock	.....
☐ Anderer Typ, nämlich: ……..	.....

40. In welchem Geschoss wohnen Sie? (mehrere Antworten sind möglich)

☐ Souterrain

☐ Erdgeschoss

☐ 1. Obergeschoss

☐ 2. Obergeschoss

☐ 3. Obergeschoss

☐ 4. Obergeschoss

☐ 5. Obergeschoss

☐ 6. Obergeschoss und höher

41. Liegen von Ihnen genutzte Räume im Keller?

☐ Ja

☐ Nein

42. Wie viele Personen, <u>Sie eingeschlossen</u>, leben in Ihrem Haushalt?

..... Personen

☐ Ich lebe allein. → <u>Bitte weiter mit Frage 56</u>

43. Mit wem leben Sie in Ihrem Haushalt? Bitte geben Sie nur eine Antwort.

- ☐ Mit Kind/ern (allein erziehend)
- ☐ Mit Partner/in, aber ohne Kind/er
- ☐ Mit Partner/in und Kind/ern
- ☐ Mit anderen Menschen in einer Wohngemeinschaft
- ☐ Mit meinen Eltern
- ☐ Mit meinen erwachsenen Kindern
- ☐ Mit anderen Personen, nämlich:

  ……

44. Wie viele Kinder leben in Ihrem Haushalt?

..... Kind/Kinder unter 18 Jahre ..... Kind/Kinder 18 Jahre und älter

45. Leben in Ihrem Haushalt auch behinderte bzw. dauerhaft kranke Personen?

- ☐ Ja → **Wenn ja, wie viele?** ..... Personen
- ☐ Nein

46. Was ist Ihr Familienstand?

- ☐ Ledig
- ☐ Zusammenlebend
- ☐ Verheiratet
- ☐ Anderes, nämlich:

  ……

47. Was ist Ihr höchster schulischer Ausbildungsabschluss?

- ☐ Hauptschul-/Volksschulabschluss, POS 8./9. Klasse
- ☐ Mittlere Reife/Realschulabschluss, POS 10. Klasse
- ☐ Hochschul-/Fachhochschulreife
- ☐ Ohne Abschluss/vor 8. Klasse abgegangen
- ☐ Anderer Schulabschluss, nämlich:

  ……

48. Was ist Ihr höchster beruflicher Ausbildungsabschluss?

- ☐ Anlernzeit, Volontariat, Teilfacharbeiter
- ☐ Abgeschlossene Lehrausbildung, Berufsfachschule
- ☐ Meister-/Technikerabschluss, Fachschule
- ☐ Fachhochschulabschluss
- ☐ Hochschul-/Universitätsabschluss
- ☐ Ohne beruflichen Ausbildungsabschluss
- ☐ Noch in der Ausbildung (Ausbildung, Studium)
- ☐ Anderer Berufsabschluss, nämlich:

  ……

49. Was ist Ihr derzeitiger Erwerbsstatus?

- ☐ Vollzeiterwerbstätig (mind. 35 h)
- ☐ Teilzeit- oder stundenweise erwerbstätig
- ☐ Arbeitslos/auf Arbeitssuche
- ☐ In Fortbildung oder Umschulung
- ☐ Bundesfreiwilligendienst
- ☐ In Ausbildung (Ausbildung, Studium)
- ☐ Hausfrau/Hausmann
- ☐ Im Mutterschutz/in der Elternzeit
- ☐ In Rente
- ☐ Aus anderen Gründen nicht erwerbstätig

50. Wie hoch schätzen Sie das Nettoeinkommen ein, das Ihr Haushalt monatlich zur Verfügung hat? Denken Sie dabei an das Nettoeinkommen aller Haushaltsmitglieder, Kindergeld, Renten, Arbeitslosengeld, etc.

- ☐ Bis 499 €
- ☐ 500 – 899 €
- ☐ 900 – 1.299 €
- ☐ 1.300 – 1.499 €
- ☐ 1.500 – 1.699 €
- ☐ 1.700 – 1.999 €
- ☐ 2.000 – 2.599 €
- ☐ 2.600 – 3.199 €
- ☐ 3.200 € und mehr
- ☐ Keine Angabe