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Article

Towards a Common Language for Mainstreaming Nature-Based Solutions Through Coastal Systems in the North Sea Region: The Manabas Coast Project

Geert J. M. van der Meulen [1,2,*], Jurre J. de Vries [1], Lisa van Well [3] and Frances A. Kannekens [4]

[1] DG Rijkswaterstaat, The Netherlands Ministry of Infrastructure and Water Management, 3526 LA Utrecht, The Netherlands; jurre.de.vries@rws.nl
[2] Department of Urbanism, Faculty of Architecture and the Built Environment, Delft University of Technology, 2628 BL Delft, The Netherlands
[3] Department of Natural Hazards and Geodata, Swedish Geotechnical Institute, SE-581 93 Linkoping, Sweden
[4] Asset Management Research Group, HZ University of Applied Sciences, 4331 NB Middelburg, The Netherlands
* Correspondence: geert.vander.meulen@rws.nl

Abstract: Nature-based solutions (NBSs) offer an opportunity to address environmental and societal challenges worldwide while simultaneously providing benefits for human well-being as well as biodiversity. Despite a growing demand and evidence base for NBSs in coastal systems, the scaling of their implementation and mainstreaming of their principles in policy and practice are constrained by multiple barriers, such as misinterpretations of concepts, effectiveness, or locked-in preferences or conventions of traditional solutions. To address these constraints, an international consortium of coastal authorities and experts in the North Sea Region collaborates to validate, document, and share learnings of NBSs to establish a framework for mainstreaming NBSs for flood and coastal erosion risk management around the North Sea. Co-creation processes of workshops, field visits, and expert knowledge sessions contributed to a theoretical framework and baseline assessments of exemplary sandy and muddy case study sites in the region, amongst others, iteratively providing and showcasing building blocks for the mainstreaming framework. This article takes stock halfway of the project's activities, learnings, and status of the called-for common language.

Keywords: co-creation; coastal systems; flood and coastal erosion risk management; mainstreaming; nature-based solutions; scaling

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1. Introduction

Unprecedented human-induced environmental and societal challenges exert pressures on coastal zones and result in increased vulnerability to flooding, erosion, and biodiversity loss [1]. The suitability of conventional 'grey' infrastructure for flood and coastal erosion risk management (FCERM) under these circumstances is receding as its cost for addressing the challenges rises [2], while its capacity to integrate biodiversity goals is limited [3]. Nature-based solutions (NBSs) are alternative approaches to address these challenges by taking inspiration from or being supported by nature and using or mimicking natural processes. By doing so, NBSs commonly provide co-benefits and multifunctionality which grey infrastructure lacks [4,5].

Despite the growing demand and implementation of NBSs worldwide, its scaling to large-scale implementation and mainstreaming to widespread integration and becoming the

norm are constrained by misconceptions and conventions posed by previous infrastructural paradigms, such as mono-functionality, measurability, distribution of responsibilities, and limited interdepartmental collaboration [6]. As coastal challenges do not recognize administrative borders, NBSs call for cross-departmental and international collaboration and aligned practice. Bearing this in mind, European Union (EU) policies are committed to NBSs [1]. However, at the same time, there is little consensus across EU countries on what concepts around NBSs and mainstreaming mean and how they can be implemented on the ground. Within the framework of the Interreg North Sea Region (NSR) (i.e., EU subsidy scheme for spatial and regional development), the project 'Building with Nature', therefore, developed a transnational evidence base for NBSs for FCERM between 2015 and 2021. 'Manabas Coast' (abbr., mainstreaming NBSs through coastal systems) is a follow-up in the same framework running from 2022 to 2027 to draw upon outcomes from Building with Nature and develop a framework for facilitating NBS mainstreaming in the NSR. To take stock halfway through, this article presents the Manabas Coast project (Section 2) and its underlying methods and processes (Section 3). The central project process and output are captured in a theoretical framework (Section 4) which co-creatively positions the concepts of NBSs, mainstreaming, and scaling in relation to each other for practice, to address the lack of consensus and call for a 'common language'. This article, moreover, sets out other results (Section 5), a discussion of future research (Section 6), and the project's intermediate conclusions (Section 7). Throughout these sections, as well as in ongoing Manabas Coast activities, the development of a common language as the first key step in the scaling and mainstreaming of NBSs can be recognized as the red thread and provides the focus of this article.

2. Manabas Coast

Regional and (inter)national coastal authorities, nature organizations, and knowledge institutes in the NSR form the consortium collaborating in Manabas Coast (Table 1). The project objective is to set the stage for the wide-scale application and implementation of NBSs along NSR coasts by developing a proven and accessible framework and principles based on case studies for mainstreaming to enable integrated policies and decision-making for FCERM which is contributing to biodiversity. Therefore, Manabas Coast is part of a growing amount and network of active programs for NBSs. As a common denominator, all these programs work on aspects of NBSs and identify similar needs and knowledge gaps around better understanding and awareness of the natural system, governance, funding, and capacity building. Despite such overlaps, these programs can be distinguished by their focus on alternative contexts (e.g., MERLIN on freshwater-related ecosystems (see [7]); ResiRiver on river systems (see [8]); SUPERB on forests (see [9]); WaterLANDS on wetlands (see [10]), alternative key approaches (e.g., REST-COAST (see [11]), SUPERB, and WaterLANDS on restoration), the absence of focus on the mainstreaming of NBSs (e.g., SUPERB and WaterLANDS (these do focus on scaling); REST-COAST), or more academic versus practice-oriented process. The latter two differences especially highlight the relevance of the process and objective described in this article to Manabas Coast. The network of programs mentioned generates valuable insights into the implementation of NBSs across diverse environmental contexts. Alongside the delivery of proof of the success of NBS implementation for FCERM, Manabas Coast distinguishes itself by seeking to effectively bridge science and practice and land best NBS practice in the responsible organizations and related policy- and decision-making processes. To do so and build upon the broad knowledge base, a projected key outcome of Manabas Coast is the delivery of strategies for NBS mainstreaming.

Table 1. Manabas Coast consortium partners and, if applicable, their case study sites.

Country	Consortium Member	Case Study	
		Sandy	**Muddy**
Belgium	Flemish Department of Mobility and Public Works	Living Lab Raversijde (dunes and coastal town)	
Denmark	Danish Coastal Authority	Lodbjerg-Nymindegab (estuary and dunes)	
	Danish Environmental Protection Agency		
	Municipalities of Copenhagen, Taarnby, Dragoer, and Hvidovre	Greater Copenhagen	
France	French Coastal Conservancy Agency	Authie Bay	Orne Estuary
			Lancieux Bay
Germany	Common Wadden Sea Secretariat		East Frisia Wadden Sea
	Lower Saxony Water Management, Coastal Protection, and Nature Conservation Agency		
	Schleswig-Holstein State Agency for Coastal Protection, National Park, and Marine Conservation		Halligen Islands
	World Wide Fund for Nature Germany		
The Netherlands	HZ University of Applied Sciences		
	Regional Water Authority of Hollands Noorderkwartier (HHNK)		Salt marches Wadden Sea
	ResilienServices (i.e., consultancy)		
	Rijkswaterstaat (i.e., executive agency Dutch Ministry of Infrastructure and Water Management) (lead partner)	Sand Motor (beach nourishment)	Westerschelde (estuary)
			Afsluitdijk (dam and causeway in muddy site)
	University of Twente		
Sweden	County Administrative Board of Skåne	Skåne coast	
	County Administrative Board of Västra Götaland		Salt marches in the 8+fjordar area
	Swedish Geotechnical Institute		

Manabas Coast partner organizations act as holders of knowledge and experience, co-creators, sounding boards, and, in some cases, case study owners (Table 1; Figure 1). (Refer to Appendix A which provides more information about the situation, habitats, dimensions, challenges, objectives, and stakeholders of the case studies.) The strength of the consortium, in fact, lies in the availability of diverse and exemplary on-the-ground case studies ('sandy' and 'muddy', depending on the general saturation of the soils) in a range of implementation phases and across the NSR, providing for broader insights, validation in different sociopolitical settings, and a higher pace when compared to focusing on individual countries or coastal sites. The aim is to learn from the hands-on experience of implementing NBSs on the ground to obtain better insights into what is needed for mainstreaming NBSs within physical environments as well as organizational procedures. However, in the initial years of the project, it became evident that, while the consortium shares the same goals, it did not always speak the same 'language' when it came to understanding what constituted NBSs and what mainstreaming meant within each regional context.

Figure 1. Manabas Coast case study sites.

3. Methods

Manabas Coast deploys a qualitative approach consistent with various methods. The project tasks include developing a framework that provides guidance for the scaling and mainstreaming of NBSs and formulating national strategy advice, identifying and evaluating enablers and actions for mainstreaming NBSs in different coastal settings (i.e., case studies) over time, and developing and promoting capacity-building tools to transfer gained insights into policy and practice.

Co-creation, expert knowledge sessions, and field visits are used throughout the project to iteratively develop, share, and validate project outputs. So far, these meetings have taken place in November 2022 in Amsterdam, The Netherlands, in March 2023 in Kijkduin, The Netherlands, in October 2023 in Saint Malo, France, in January 2024 in Stockholm, Sweden, and in March 2024 in Bruges, Belgium. As a foundation, both for this article as well as the Manabas Coast project, a theoretical framework is developed by means of a literature review of NBSs, mainstreaming, and scaling, with a focus on FCERM where possible. The literature review findings are being validated with consortium members during the workshop sessions targeted at gathering insights on how concepts are currently interpreted and used to be synthesized into working definitions for the project. Therefore, the theoretical framework functions not only as a foundation for the project work but should be regarded as a key process and output of the project in its capacity to develop a common language and perception of the concepts. The current status of the theoretical framework is presented in Section 4.

Case studies are used not only for building NBS evidence and identification of enablers but also for moving a step further to validate the effectiveness of enabling factors in influencing NBS development and contributing to mainstreaming by testing and challenging them in diverse FCERM practices across the NSR and at multiple governmental levels. Therefore, case study learnings facilitate consortium members in working on context-specific and impactful implementation strategies. For this purpose, case studies are subjected to a

baseline assessment following six enablers for NBSs, identified by EcoShape (i.e., a network of organizations working on the advancement of NBSs for water-related societal issues) [12]. To position and appropriate these six enablers in the project, they are grouped into three systems (i.e., natural, social, and governance), which provide a key initial structure for ongoing project activities and outcomes.

The assessment that follows is directed at facilitating cooperation and learning among case studies by visualizing the importance appointed to enablers and the identification of overlapping themes of interest for sharing and receiving knowledge. Therefore, the baseline assessment and theoretical framework mutually strengthen each other and produce a common language as a facilitator for the mainstreaming and scaling of NBSs. Ultimately, the set will provide input for a generic framework for mainstreaming NBSs that can be used for the development of the implementation of NBSs and maintenance strategies in the NSR, at the local, regional, and national levels. Section 5 presents the current set of results from the baseline assessment and a draft version of the framework.

4. Theoretical Framework

Numerous compatible high-level definitions of NBSs exist (e.g., [13–18]) including specifications per application in certain contexts (e.g., coastal, freshwater, rural, urban [18–20]). Yet, due to the context specificity and diversity of NBS applications [21,22] or hybrid applications with grey infrastructure [23], different interpretations, usage, and misconceptions of NBS notions across fields of practice, specialist disciplines, or contexts continue to persist [24], posing one of the major hindrances to NBS mainstreaming or even resulting in maladaptation [25]. The joint establishment of a theoretical framework is therefore crucial for Manabas Coast. This theoretical framework must not be confused with an introductory presentation of the key concepts. To secure it as a broadly supported project output, rather than an imposed foundational positioning of concepts, all following elements of the theoretical framework testify to a part of the process with the objective of developing a common language and are a product of the project co-created through workshop sessions in March 2024 in Bruges, Belgium, validating the literature review and encouraging discussion of the definitions and its synthesis in an infographic.

4.1. NBSs

Moving beyond the development of a definition and to thoroughly appropriate a definition for NBSs as a starting point for the common language, a review of 42 scientific articles [26] has identified the European Commission and International Union for Conservation of Nature and Natural Resources (IUCN) definitions of NBSs as being the most used: twelve and five times, respectively. The European Commission [13] coins NBSs as "*solutions that are [. . .] cost-effective, simultaneously provide environmental, social and economic benefits, and help build resilience, noting that such solutions need to involve locally adapted, resource-efficient, and systemic interventions, which result in bringing more and more diverse, nature and natural features and processes into cities, landscapes and seascapes. Hence, NBS must benefit biodiversity and support the delivery of a range of ecosystem services*". The IUCN [5], however, shifts the emphasis to ecosystems, human well-being, and biodiversity by defining NBSs as "*actions to protect, sustainably use, manage, and restore natural or modified ecosystems, which address societal challenges, effectively and adaptively, providing human well-being and biodiversity benefits*". Furthermore, the IUCN produced a Global Standard for NBSs with eight principles supporting the consistent design and verification of effective, sustainable, and adaptable NBSs. The IUCN Global Standard NBS principles include (1) societal challenges, (2) design at scale, (3) biodiversity net gain, (4) economic feasibility, (5) inclusive governance, (6) balance trade-offs, (7) adaptive management, and (8) sustainability and mainstreaming (Table 2).

This 'Standard' is the NBS framework which currently holds the greatest scope of application [27] yet is limited by its subjectivity and focus on the process of NBS establishment as opposed to NBS implementation and its results [28].

Table 2. NBS principles formulated by the International Union for Conservation of Nature and Natural Resources (IUCN) [5] and EcoShape [29].

Global Standard—IUCN	Integrated System-Based Asset Management—EcoShape
NBSs effectively address societal challenges	NBSs embrace and leverage upon the natural dynamics of the system, providing resilience, and adaptability towards future (climate-change-related) challenges
Design of NBSs is informed by scale	NBSs act at a landscape scale, including both the natural and socio-economic systems
NBSs result in a net gain to biodiversity and ecosystem integrity	NBSs integrate the management of multiple assets and functions within the landscape system context
NBSs are economically viable	
NBSs are based on inclusive, transparent, and empowering governance processes	
NBSs equitably balance trade-offs between the achievement of their primary goal(s) and the continued provision of multiple benefits	
NBSs are managed adaptively, based on evidence	
NBSs are sustainable and mainstreamed within an appropriate jurisdictional context	

To align and create ownership of the theoretical framework and rationale of NBSs within the consortium, the definitions and principles of NBSs were the subject of the co-creation workshops. Besides the Standard, during those workshops, partners were presented with a second pre-formulated set of NBS principles: the Integrated System-Based Asset Management (ISBAM) [29] concept by EcoShape. ISBAM enjoys increasing support from The Netherlands and the lead partner of Manabas Coast yet is not NBS-specific. The hypothesis behind ISBAM is that if the right boundary conditions (i.e., principles) are considered, NBSs will come out as a consequence of the process, instead of being an end goal in itself. ISBAM principles include the following: (1) leveraging system dynamics for resilience and adaptability for future challenges; (2) actions at the landscape scale and natural and socio-economic systems; and (3) integrated management of assets and functions (Table 2).

Besides ISBAM, EcoShape identifies six enablers for NBSs: (1) technology and (eco-, social, physical) system knowledge; (2) adaptive management, maintenance, and monitoring of NBSs to facilitate their dynamic character; (3) a multi-stakeholder approach throughout all phases of the NBS process; (4) capacity building among policy makers, industry, and local communities; (5) institutional embedding of NBSs; and (6) a sound business case for generating support and financing for NBSs [12]. During the co-creation workshop in Kijkduin, The Netherlands, in March 2023, these enablers have been grouped per system: enablers 1 and 2 as part of the natural system due to their focus on physical and natural processes; enablers 3 and 4 as part of the social system for their focus on integration into society and exchange of knowledge at local levels; and enablers 5 and 6 as part of the governance system as they highlight processes through which mainstreaming can be taken to higher levels and regulations and policy can be influenced. This grouping and

three-system perspective have been a key and foundational outcome of Manabas Coast and an initial step in clarifying the common language of enablers, which had previously been understood in converging manners by some project partners.

To appropriate the Global Standard and ISBAM principles (Table 2), partners were invited to (re)formulate their own. The drafted principles were analyzed to identify overlaps, synthesized accordingly, and categorized into the three systems derived from the EcoShape enablers: (a) natural, (b) social, and (c) governance (Table 3). The five resulting principles are an outcome of the Manabas Coast project and by its consortium considered to best reflect the needed NBS approach for FCERM in the NSR [30]. This appropriation does not entail that the Global Standard and ISBAM are disregarded. These sets of principles can co-exist and inform NBS interventions as such.

Table 3. NBS principles formulated by Manabas Coast partners and categorized into natural, social, and governance systems [30].

NBS Principles—Manabas Coast	System		
	Natural	**Social**	**Governance**
NBSs apply a holistic systems approach to address ecological, institutional, and societal challenges	x	x	x
NBSs embrace natural dynamics at different temporal and spatial scales	x		
NBSs combine multiple functions and provide benefits for people and nature for present and future generations	x	x	x
NBSs involve stakeholders throughout the entire project, ensuring transparency, commitment, and shared ownership		x	
NBSs support adaptivity in management, maintenance, and practice	x		x

4.2. Mainstreaming

A review of 23 scientific articles [26] on the subject highlighted that mainstreaming is embedded in theories on transition management for sustainable development [31] and is, as such, used across diverse fields of practice. In the context of NBSs or FCERM, mainstreaming refers to the process where a sustainable alternative approach disrupts the status quo to reconfigure itself as the new normal [32]. This means mainstreaming entails more than the end goal of becoming conventional but also both the development of knowledge and delivering proof for the specific innovation, as well as navigating the complexities of raising awareness, gaining acceptance, and integration into policy in a variety of unique contexts in which even the smallest contributions have an influence.

The literature identifies disablers, knowledge frontiers, or barriers to overcome for mainstreaming NBSs. Frantzeskaki and McPhearson [33] call for advancements in terms strengthening of the global evidence base of the efficacy of NBSs, bridging disciplinary silos for scalable and improved design of NBSs, and ensuring coproduction of NBSs and global knowledge sharing; Han and Kuhlicke [34] discuss the attitudinal hindrance of underestimated FCERM capacity of NBSs and perceived low cost-effectiveness and the institutional hindrance of decentralization of FCERM, limited operational capacity to implement NBSs, and inadequate public participation for NBS implementation. As introduced before, EcoShape, on the other hand, identifies six NBS enablers [12] to facilitate its mainstreaming.

The multi-level perspective (MLP) on transitions (Figure 2) [35] is an established framework [36] providing a valuable overview of the scope of mainstreaming by conceptualizing complex transition processes as a result of the interplay between case study scales and socio-technical dimensions over time. The socio-technical landscape represents the

exogenous context of which dynamics are lowest (e.g., political ideology, demography, macro-economic patterns, values). The socio-technical 'regime' presents the dominant way in which societal needs are fulfilled. The regime is dynamically stable, yet mutable, should it experience pressure from developments of the socio-technical landscape, encouraging and creating windows of opportunity for niche innovation. Niche innovation is where experimentation happens, providing alternatives to underperforming elements of the regime, to potentially gain momentum and replace or align with those elements. Alternative representation and conceptualization of the MLP (Figure 3) [35] recognize that, in practice, multiple regimes and niches can coexist as there are societal subsystems, each with societal needs. Furthermore, it argues for in-between niche regimes which hold more power than stand-alone niches and provide a more viable and competitive functioning when compared to regimes [37]. Manabas Coast could be regarded at the level of the niche regime (Figure 3a), being a self-coordinating, collaborative, and international consortium with a degree of institutional power addressing the shortcomings of the regime and shifting values of the socio-technical landscape with multiple case study experiments in multiple contexts (Figure 3b).

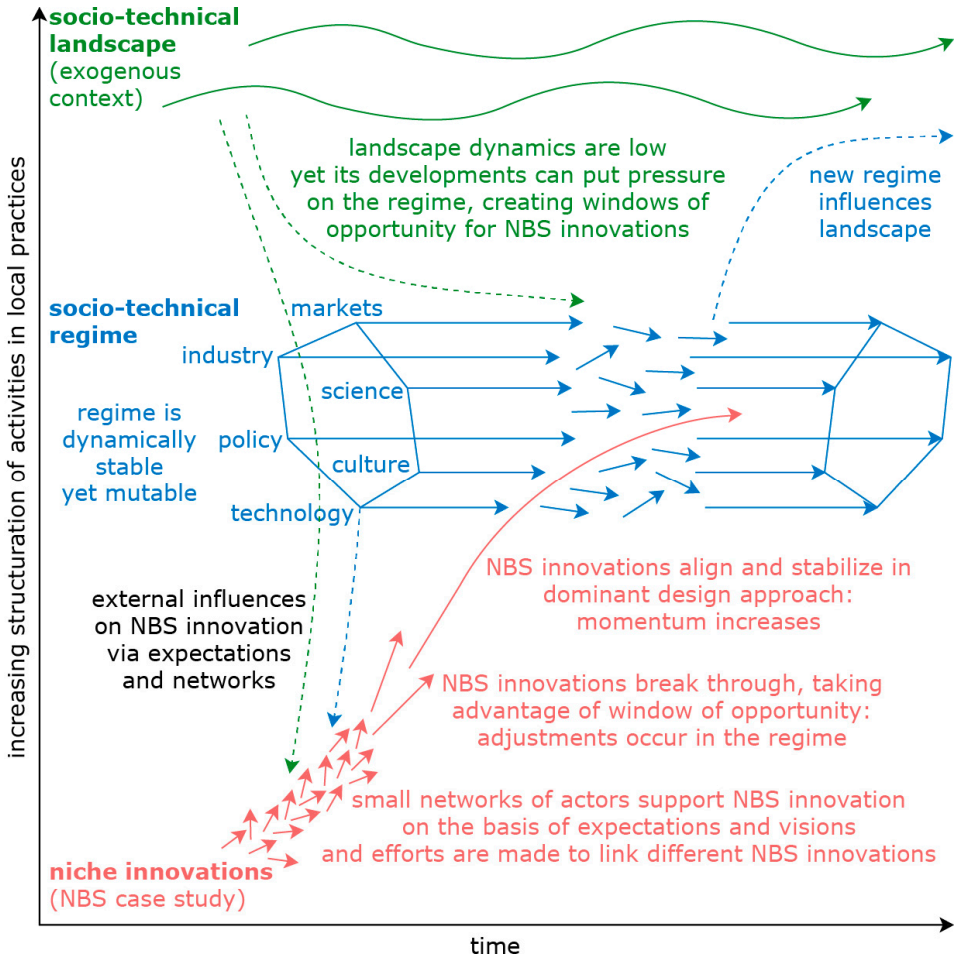

Figure 2. Multi-level perspective on transitions adapted from [35] (with permission from Elsevier, 2025) for NBSs.

For the ways niche innovations and niche regimes are positioned in mainstreaming processes (Figure 3c), the literature distinguishes horizontal and vertical mainstreaming. The former refers to the sharing of knowledge, integration of innovation, and collaboration and coordination across sectors or organizations. The latter refers to the integration of innovation through different levels of governance (i.e., from local and regional to na-

tional and international levels and from initiation to implementation) [38]. To appropriate mainstreaming theory in the project, in the co-creation workshops on the subject, both horizontal and vertical mainstreaming are considered imperative for NBSs, fostering both cross-sectoral collaboration and comprehensive solutions in the case studies, as well as policy alignment and coherence across levels of governance.

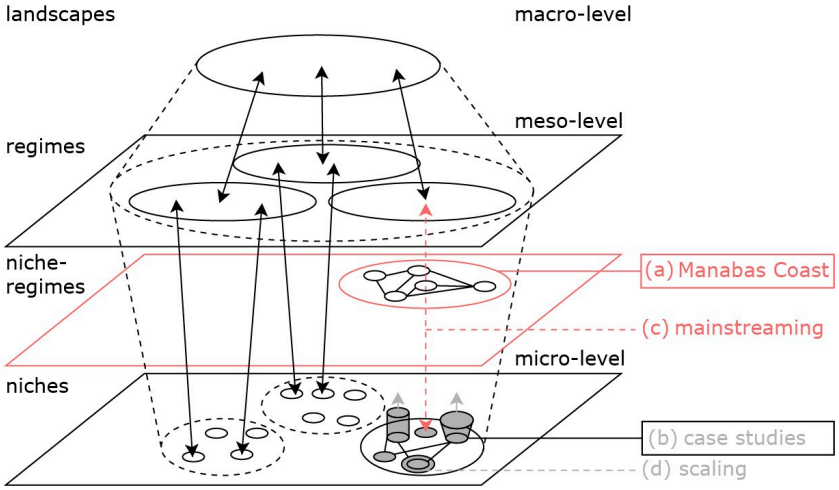

Figure 3. Alternative representation and conceptualization of the multi-level perspective adapted from [35] (with permission from Elsevier, 2025) to represent (**a**) Manabas Coast as a niche regime, (**b**) its case studies as niche experiments, and (**c**) the positioning of mainstreaming and (**d**) scaling.

4.3. Scaling

A review of ten scientific articles on scaling [26] highlighted a distinction between three types of scaling: up-, out-, and deep-scaling [39,40]. In this distinction, 'upscaling' refers to impacting policy at multiple levels and the efforts changing enabling conditions that would facilitate NBS implementation at larger scales or more locations. 'Scaling out' refers to impacting greater numbers by means of replication and potentially required adaptation of NBSs for application in additional or new contexts, as well as dissemination of NBS knowledge. 'Deep-scaling' refers to impacting culture and underlying problem domains, values, norms, et cetera, for example through participatory approaches, knowledge sharing, and communities of practice to locally and culturally embed NBSs.

Each typology of scaling plays a role in mainstreaming by relating (niche) case study experiments to the regime by strengthening their ability to challenge it (Figure 3d) [41], not in a single step, but with multiple smaller steps or changes, empowering transition. Therefore, scaling can occur without mainstreaming, yet mainstreaming cannot occur without scaling. To secure the appropriation and support of the theoretical framing of scaling in Manabas Coast, this interrelation of scaling and mainstreaming gave cause to align the two concepts in the co-creation workshops. The workshop recognized how types of scaling resonate with types of mainstreaming and the three systems in which NBSs operate. Upscaling connects with vertical mainstreaming and the governance system. The knowledge sharing and dissemination of out- and deep-scaling correspond with horizontal mainstreaming. In this, scaling out aligns with the natural system, and deep-scaling aligns with the social system. 'Physical scaling' has also been coined to encompass the spatial component of scaling out. Ultimately, 'economic scaling' was conceived to additionally represent a focus on advancements of cost-effectiveness, financial sustainability, economic viability, and the business case of NBSs in the long term, as deemed essential by project partners.

4.4. Synthesis Infographic

The March 2024 co-creation workshops in Bruges, Belgium, explored how the concepts of NBSs, mainstreaming, and upscaling are interpreted in the daily professional practice of Manabas Coast partners and were targeted at understanding commonalities in perspective or if interpretations vary based on the case study or country of origin. They called attention to the difficulty of making the connection between theory and practice and making the theoretical framework available to a broader audience as a common language. Different cultural and professional backgrounds lead to different interpretations of principles and definitions. This may result in differing or absent applications of the concepts in practice. The workshop exercises highlighted capacity building, shared learning, and the creation of ownership as a key focus and called for keeping it simple.

To bridge gaps between cultures, professions, and languages, one activity, therefore, asked participants to visualize the relevant NBS concepts and their interrelations and illustrate ideas of scaling or mainstreaming. This ultimately led to the creation of an infographic (Figure 4). The infographic has been developed based on workshops, to visually synthesize the theoretical framing of NBSs, mainstreaming, and scaling across the natural, social, and governance systems and make the practical implications of the included information more tangible and appropriable for all project partners (Figure 4). The mainstreaming and scaling of NBSs in the natural system entail shifting from compartmentalized views of nature and the natural system to system knowledge and understanding of dynamics and historical changes. In the social system, this shift entails the advancement of public perception and participation. Mainstreaming and scaling NBSs in the governance system require a shift from monodisciplinary to multidisciplinary approaches in which NBSs are integrated into policies throughout spatial and temporal scales. Ultimately, the three systems are interrelated, and the three shifts mutually influence each other. Advancements or constraints in one system can amplify or hinder progress in another. Therefore, note that the lines in the infographic are not represented as constant but experience pulls and pushes. NBSs are a means to achieve the set objectives of the systems, such as creating a resilient coast or halting biodiversity loss.

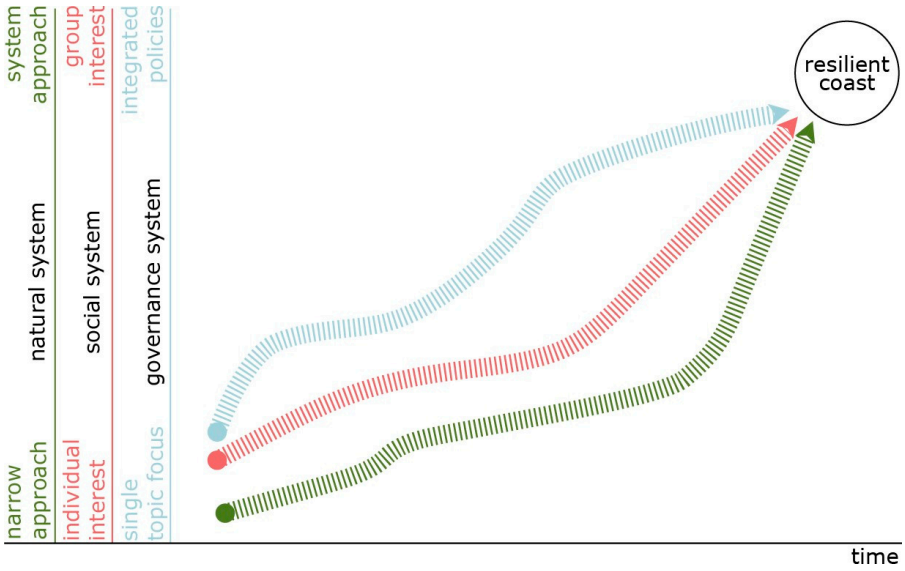

Figure 4. Visual synthesis infographic of mainstreaming and scaling of NBSs across natural, social, and governance systems.

5. Results

5.1. Baseline Assessment

To advance the connection between the developing theoretical framework and the practical reality of the case studies, the establishment and execution of the baseline assessment have been key. This assessment was initiated and established at the co-creation workshops in October 2023 in Saint Malo, France, and analyzed in a workshop in Stockholm, Sweden, in January 2024. To facilitate cooperation between the case study sites, the assessment was targeted at mapping with whom experience and knowledge on NBSs and their mainstreaming is held, and where or by whom it is desired. To do so, the assessment is made up of a case study description and uses the six EcoShape enablers [12] to rank the importance of enablers and inquire into the position of mainstreaming per case study. By means of a survey, the positioning of mainstreaming within organizations and case studies was collected and analyzed. Ultimately, the baseline assessment forms the basis from which to evaluate progress on further activities. A second intermediate assessment will be developed and conducted in the summer of 2025 to gauge the progress of case studies with respect to their contributions to mainstreaming.

For the enabler ranking, muddy and sandy case studies were asked to rank the importance of each enabler on a scale from one (unimportant) to ten (most important), of which the results can be seen in Table 4. It shows high rankings for all enablers, with the business case for NBSs ranking lowest. It should be noted that the assessment reflects the subjective case study contexts in which finance for NBS implementation of mainstreaming may have been secured, making a business case less essential in these cases. Comparing the sandy and muddy cases indicates technology and system knowledge are more important to muddy cases and capacity building is more important to sandy cases. To be able to review, explain, and act upon these commonalities or contrasts, in Stockholm, the rankings have also been visualized per case study (Table 5). This overview provides a quick overview of enabler importance and expertise per case study and facilitates the desired knowledge sharing or collaboration. Across the vertical columns, case studies with the highest rankings can support cases with lower rankings. Therefore, Table 5 is referred to as the enabler expertise 'heatmap' of Manabas Coast. Also note that different case studies are in different development stages, which can also explain some of the differences (see Appendix A).

Table 4. EcoShape enabler [12] importance ranking for muddy and sandy cases.

	System					
	Natural		**Social**		**Governance**	
	Technology and (eco-, social, physical) system knowledge	Adaptive management, maintenance, and monitoring of NBSs	Multi-stakeholder approach throughout all phases of the NBS process	Capacity building among policy makers, industry, and local communities	Institutional embedding of NBSs	Sound business case for generating support and financing for NBSs
Muddy cases	8.3	7.4	8.5	7.9	8.6	5.6
Sandy cases	7.4	7.4	8.6	8.6	8.3	5.9

The outcomes of the enabler ranking facilitate identifying key themes around which knowledge development and sharing are considered important or desired. In Bruges, Belgium, in March 2024, a non-exhaustive list of questions was made around which small workgroups were formed and knowledge dissemination was stimulated. These 'How-to . . .?' questions are listed in Table 6. Furthermore, several key themes were identified: (1) NBSs in sandy areas; (2) NBSs in muddy areas; (3) NBS monitoring; and (4) NBSs in

Natura 2000 areas (i.e., designation for areas part of the European network of protected nature reserves as assigned by the EU). The questions most aligned with these key themes are addressed first and used to form expert work groups to develop knowledge and explore how the international and multidisciplinary inquiry and sharing of lessons learned may evolve and contribute to mainstreaming NBSs in the NSR.

Table 5. EcoShape enabler [12] importance ranking per case study to facilitate knowledge sharing and collaboration. Referred to as the 'heatmap' of enabler expertise visualizing the spectrum from higher (green) to lower (red) rankings.

		System					
		Natural		**Social**		**Governance**	
		Technology and (eco-, social, physical) system knowledge	Adaptive management, maintenance, and monitoring of NBSs	Multi-stakeholder approach throughout all phases of the NBS process	Capacity building among policy makers, industry, and local communities	Institutional embedding of NBSs	Sound business case for generating support and financing for NBSs
FR	Lancieux, Orne, Authie	6	7	10	9	10	4
BE	Raversijde	9	7	10	7	7	7
NL	Westerschelde	10	8	8	8	9	9
NL	Sand Motor	5	8	7	6	9	5
NL	HHNK	8	10	10	10	8	4
NL	Afsluitdijk	8	8	8	8	8	10
NL	Saltmarshes Wadden Sea	8	6	7	7	8	3
DE	East Frisia	9	8	8	4	8	3
DE	Halligen	10	10	8	7	8	5
DK	Lodbjerg-Nymindegab	10	10	5	10	10	8
DK	Greater Copenhagen	9	6	9	10	4	5
SE	Skåne Coast	5	6	9	9	10	5
SE	8+Fjordar	9	8	10	10	9	10

Table 6. Longlist of '*How-to . . .?*' questions per system. Shortlisted initial questions to address are underlined.

	System		
	Natural	**Social**	**Governance**
How to . . .?	How to monitor a NBS?	How to develop a common vision?	How to implement NBS in Natura 2000 areas?
	How to implement a sand nourishment project?	How to make an implementation strategy?	How to roll out a top-down project?
	How to implement a salt marsh project?	How to communicate in an innovative and active way?	How can you implement NBS at a municipality level?
	How to optimize for added ecological value?	How to change mindsets and public perceptions?	How to influence decision-making in NBS favor?
	How to deal with uncertainty? (Risk Management Plan)	How to bridge the gap between institutions and communities?	How to start bottom-up projects?
	How to bring across the benefits of NBS more adequately?	How to appreciate the historical and cultural context of NBS?	How to combine different functions in limited space?
	How to balance short- and long-term benefits?	How to enable NBS capacity building?	How to get money for basic research?
	How to implement a managed realignment project?	How to make the trade-off between different benefits and interests?	

In the baseline assessment, mainstreaming within organizations was inquired into by means of the questions 'How committed is your organization to mainstreaming NBS within and after the Manabas Coast project timespan?' and 'How do current institutional arrangements within your organization already facilitate mainstreaming of NBS?'. In the responses, commitment could be disclosed in the integration of NBSs into FCERM and climate change adaptation. Uncertainty about climate change scenarios and the ecological impacts and spatial requirements of NBSs is overcome by a commitment to sustainable solutions. The navigation of the challenges and facilitation of NBS mainstreaming is supported by the involvement of both higher-level national and regional authorities as well as local parties. The Swedish partners showcase that institutional arrangements leverage collaboration with major national agencies responsible for climate adaptation and environmental management, and in Germany, national authorities play crucial roles in integrating NBSs into management plans. Whereas in Flanders, local governments and coastal communities collaborate to actively promote NBSs by advocating for the creation and co-use of dunes and beaches. The Wadden Sea necessitated intergovernmental institutional arrangements and cross-sectoral cooperation in which multiple national and regional bodies collaborate on NBS projects for FCERM crossing borders yet highlights the need for strong legal frameworks to support these initiatives. Strategic policy frameworks that explicitly include NBSs ensure that these solutions are part of broader climate adaptation and FCERM, like in The Netherlands where a dynamic coastal preservation policy from the 1990s demonstrates a commitment to operationalizing natural processes for FCERM. Academic partnerships ensure NBS projects benefit from and integrate findings from cutting-edge research, and a willingness to actively incorporate lessons learned from NBS projects into operational practices and national policy decisions concerning FCERM could be distinguished from the survey.

To survey mainstreaming within case studies, the questions included the following: 'What do you experience as the main barriers to mainstreaming NBS in your case study?', 'What types of capacity building would your case study need in order to facilitate mainstreaming of NBS?', 'What is essential in the mindset or way of working of parties (e.g., policy makers, managers, professionals, general audience) to promote mainstreaming of NBS?', and 'Do stakeholders need more information on mainstreaming?'. Additional key insights from the responses include the importance of more and better practical demonstrations of successful NBS examples as a proof of concept to promote and inspire NBS implementation with accessible, plain-language guidance (e.g., on goals, financing, permits, contracts, design) for broader understanding and acceptance of NBSs, for example, by means of comprehensive handbooks or staff training. A desired shift from reactive implementation, in response to legislation, to proactive integration of FCERM and ecologic and socio-economic goals calls for the advancement of system knowledge (e.g., coastal morphodynamics and associated biodiversity and regulations) and NBS awareness and support. For such advancements, intensive and ongoing stakeholder engagement, collaboration, and knowledge sharing are considered crucial. Improved data monitoring, analysis, and dissemination and their policy integration and support for decision-making are regarded as essential for the long-term sustainability of NBSs. Non-fragmented legislation ought to facilitate long-term and larger-scale plans and projects as opposed to short-term and small-scale solutions. Furthermore, budget sufficiency, funding mechanisms, and cost-effectiveness are paramount. These insights and needs correspond with the 'How-to . . .?' question list and are investigated further in the Manabas Coast project.

5.2. Framework

The results and spin-off activities of the baseline assessment cater to the Manabas Coast mainstreaming framework. To elaborate on and connect knowledge and ongoing learnings from the case studies to handles for the mainstreaming of NBSs for FCERM throughout spatial scales (i.e., regional to NSR scales) a framework has been under development since the co-creation workshops in Saint Malo, France, in October 2023. The Manabas Coast mainstreaming framework (Figure 5) intends to provide (1) the essence and basic information for NBSs and mainstreaming (green spheres: narrative and NBS basics), (2) an evidence base from case study experience and tools for progress (red spheres: guidance and tools and pilot experience), (3) inspiration for other locations to engage in NBSs and its mainstreaming (yellow spheres: narrative and pilot experience), and (4) strategies for this purpose (blue spheres: strategies and guidance). All project activities feed the spheres of the framework with information and develop as the project progresses. For example, the theoretical framework (Section 4) is currently collected under NBS basics; baseline assessment learnings (Section 5.1), enablers (Sections 4.2 and 4.3), and working across the natural, social, and governance systems (Sections 4 and 5.1) are collected under guidance; the infographic (Section 4.4) is placed under strategies; and knowledge from the 'How-to . . .?' questions (Section 5.1) is collected under pilot experience. The structure of the framework is based on the literature and theoretical frameworks such as ISBAM [29] and the EcoShape enablers [12] as well as several Manabas Coast co-creation workshops. The structure of the framework may still change and be accompanied by recommendations for using the framework but already provides a platform for uniting knowledge contributions and strengthening the diverse knowledge base. Furthermore, it enables iterative development and improvement of the framework and co-creation within the Manabas Coast project.

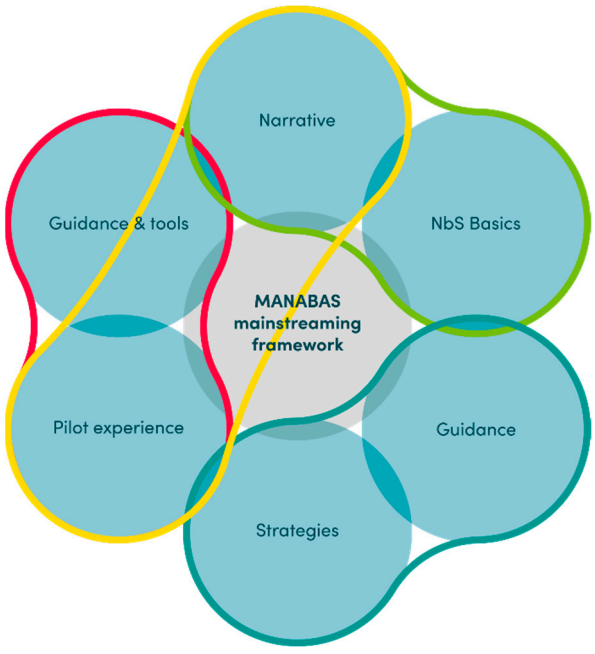

Figure 5. Manabas Coast mainstreaming framework.

6. Discussion

The baseline assessment has made evident how the center of gravity of mainstreaming NBSs for Manabas Coast mostly lies with the provision of evidence for NBSs, by showcasing NBSs in practice and actively sharing lessons learned. Mainstreaming NBSs for FCERM in the NSR entails navigating a very broad and diverse field of practice, differing per

country as well as per specific location along the North Sea coast. At all these locations, mainstreaming is, in fact, a process well underway, yet always unique and distinctive. Case studies providing evidence are in different project stages, ranging from explorations prior to implementation to monitoring after realization. The NBSs in the project differ from small-scale and low-tech interventions or experiments to some of the world's largest-scale infrastructure (i.e., Sand Motor), which influences the role case studies can play within mainstreaming NBSs in local or international policy and FCERM practice. To mainstream NBSs, it is essential to enable the successful implementation of NBSs across these diverse natural and socio-economic settings.

Despite the strong existing theoretical frameworks and set of NBS evidence, ongoing efforts to establish a common language struggle to succeed in representing the diversity of case studies in relation to their local conditions of NBS acceptance, policies, processes, et cetera. On the one hand, this results in a continuous desire for more evidence and a call for more long-term monitoring of aspects of FCERM as well as biodiversity and ecosystem services which is responded to by the growing network of NBS programs. Among the partners and case studies of Manabas Coast, there is a clear collaborative effort to involve local and regional authorities and stakeholders to navigate issues of the uncertainty of implementation and overcome limitations of system knowledge and societal acceptance. Communication for awareness of a wide audience is important, yet at times, it is a neglected aspect enabling mainstreaming.

On the other hand, the challenge lies in overcoming the seemingly infinite hunger for more evidence and changing the existing narrative about the implementation of NBSs. Insights from already existing successful NBS projects, practices, and programs (e.g., [7–11]) should now land in integrated national and international policies, decision-making, and FCERM practice. The theoretical framework indicates that all activities within Manabas Coast—however minor or major—are contributing acts of mainstreaming. Insights gained outside of Manabas Coast also contribute. By means of positioning these activities in the mainstreaming framework (Figure 5) and iteratively structuring and developing a platform for lessons and handles for mainstreaming as such, the project aims to disseminate and amplify the outreach of its learnings. The framework benefits from future attention in Manabas Coast to be directed at specifying guidance and strategies. On the one hand, guidance for different stages of NBS implementation processes (e.g., initiative, financing, construction, monitoring) secures long-term and ongoing applicability. On the other hand, strategies for NBS mainstreaming in regions or organizations are targeted at embedding NBS practice in policies or objectives and connecting to relevant associated local developments around FCERM. Furthermore, there is a potential to instrumentalize the demand-based coupling of ecosystem services and co-benefits for NBSs. The diversity of partners and case studies calls for an inventory of the capacity, roles, and agency of project partners and stakeholders in the NSR to mainstream NBSs (see [42,43]), as well as the specification of the mainstreaming end goals per organization or site which may significantly differ and require different strategies and guidelines to be included in the mainstreaming framework.

7. Conclusions

The Manabas Coast project is directed at facilitating the mainstreaming of NBSs for FCERM in the NSR, including biodiversity goals. Halfway through the span of the project, this article takes stock of the conducted activities and learnings. Manabas Coast holds a strong theoretical framework, facilitating appropriation of conceptualizations of NBSs, mainstreaming, and scaling by the involved organizations and for the diversity of case studies. Co-defined principles for NBSs include the application of a holistic system approach to address ecological, institutional, and societal challenges; embracing natural

dynamics on different temporal and spatial scales; combining multiple functions and provision of benefits for people and nature for present and future generations; involving stakeholders throughout the project, ensuring transparency, commitment, and shared ownership; and supporting adaptivity in management, maintenance, and practice. These principles operate within or across the natural, social, and governance systems (Table 3) which have been derived from the six EcoShape enablers [12]. Mainstreaming for Manabas Coast entails the process of promoting the NBS alternative to FCERM in order for it to become the norm. Manabas Coast already engages in mainstreaming by its international collaboration on bridging the current dominant socio-technical practice of FCERM to NBS niche innovation in multiple case study experiments across the NSR, thereby being living labs of ongoing NBS mainstreaming.

A baseline assessment of the Manabas Coast case studies facilitates the improvement of the theoretical framework and its connection to the experience and evidence base in practice and identifies themes for the co-creation and sharing of knowledge in smaller expert groups (i.e., about NBSs in sandy areas (sand nourishments), NBSs in muddy areas (salt marsh), NBS monitoring, NBSs in Natura 2000 areas, and ecology). In fact, the focus of mainstreaming NBSs in the project mostly lies in practical demonstration through diverse successful examples. Key takeaways from the baseline assessment highlight the variety of case studies, being in different stages ranging from exploration and design to implementation and monitoring, different scales ranging from small and low-tech to system-wide and mega-scale sand nourishment, different roles within mainstreaming, and different mainstreaming demands. Mainstreaming NBSs for FCERM in the NSR will therefore not be 'one-size-fits-all'. Despite the solid theoretical framework and evidence base as current Manabas Coast project outputs, its permeation into the common language is likely to be decelerated by the rich variety of project partners and case studies and associated natural, social, and governance climates, as well as the differing languages and vocabularies on the subject. This calls for more long-term evidence in practice through monitoring how NBSs work and the values they provide in the coming project period. The FCERM capacity of NBSs is better known than biodiversity and ecological functions and contributions to sustainability and resilience. Efforts on the collaboration or involvement of authorities and stakeholders contribute to overcoming issues regarding implementation and societal acceptance. Mainstreaming NBSs along the coast of the NSR is a continuous and long process, where goals differ per organization and might also evolve over time. This also raises the question of when exactly is mainstreaming achieved if societal needs change.

To connect the growing practical evidence base about NBSs to broader learning-by-doing mainstreaming activities, the Manabas Coast framework provides a simple and flexible format for collecting and structuring learnings to use for the ongoing elaboration of the common language and formulating guidelines and strategies. Throughout the entire project span, this framework will iteratively be filled and built to ultimately provide practical handles for mainstreaming diverse NBSs for FCERM in the variety of coastal systems of the NSR.

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Appendix A

Table A1. Manabas Coast case studies (bold) and their situations, habitats, sizes, challenges, objectives, and stakeholders.

Case Study	**Living Lab Raversijde, Belgium**
contact	Flanders Hydraulics Research, Ministry of Mobility and Public Works, XPERTA
situation	Raversijde is a typical Belgian coastal town with an important touristic sector and recreational importance as well as ecological values (e.g., in the dune areas). The coast from Nieuwpoort to Wenduine suffers from erosion, which is expected to increase due to climate change.
habitat	Coastal sand dunes; sandy shoreline; urban area
size	2.6 × 4.5 km test area including 750 m dune-for-dike setup
challenge	The main challenge is to engage partners in monitoring, performing tests in the field, and innovating at Raversijde to improve the understanding of the soft coastal defenses.
mainstreaming and results	New monitoring programs by research groups will contribute to increased system knowledge, which is applicable to similar projects elsewhere. The in situ behavior of beaches, dunes, and the shore face will be monitored, while knowledge is shared with stakeholders.
stakeholders	Flemish region, municipality of Oostende, federal state, research institutes, local citizens
case study	**Lodbjerg-Nymindegab, Denmark: Thyborøn inlet and Hvide Sande coast**
contact	Danish Coastal Authority (DCA)
situation	At the Thyborøn inlet, the estuary and surrounding dunes have eroded significantly over the last few decades, leading to a changed biodiversity and steepening of the coastal profile. Climate change is expected to increase coastal erosion, threatening flooding of the surrounding land and cities. At the Hvide Sande coast, it is necessary to adapt coastal management to ensure tourism and socio-economic development of the area in the future.
habitat	Coastal sand dunes; estuary; sandy shoreline
size	±100 km coast
challenge	At the Thyborøn inlet, natural biodiversity is impacted by present coastal protection, which includes more than 100-year-old groins. At the Hvide Sande coast, there is a lack of knowledge on the natural dynamics of the coastal morphology and biology and their relation with sand nourishments around the Hvide Sande harbor. This knowledge gap inhibits the application of NBSs in the coastal area surrounding the harbor.

Table A1. *Cont.*

case study	**Lodbjerg-Nymindegab, Denmark: Thyborøn inlet and Hvide Sande coast**
mainstreaming and results	Ensuring sustainable socio-economic development (e.g., ecotourism), restoring nature in the long term by enhancing knowledge and creating maintenance plans for upscaling sand nourishments, while improving flood protection (extending/restoring groins) at the Thyborøn inlet. Improving scientific basis on the coastal dynamics regarding morphology and biology. Different coastal protection management options based on the BwN principle will be assessed, how these could be optimized regarding safety, and their impact on morphology and biology at the Hvide Sande coast.
stakeholders	Knowledge institutes, municipalities, NGOs, private sector
case study	**Greater Copenhagen, Denmark: Dragør coast**
contact	Danish Coastal Authority (DCA)
situation	Due to the partial protection of dikes along the Dragør coast, salt marshes are not able to develop sufficiently to match sea-level rise. The salt marshes are part of a Natura 2000 area and are threatened by climate change.
habitat	Sandy shoreline; urban area; wetland
size	$\pm$10 km coast
challenge	The understanding of the effect of traditional coastal protection on nature areas is very limited, which inhibits the implementation of sustainable coastal protection schemes.
mainstreaming and results	The goal is to improve (knowledge on) Natura 2000 areas, while decreasing the risk of flooding. Courses will be given to municipalities, authorities, and citizens to build support for new measures and mainstream NBSs.
stakeholders	State, municipality, citizens, agencies, and NGOs
case study	**Authie Bay, France**
contact	Conservatoire du Littoral, délégation Manche Mer du Nord
situation	Accelerated sea-level rise and other climate change effects are threatening dyke systems, dunes, coastal wetlands, and current land use (agriculture, hunting, recreation).
habitat	Coastal sand dunes; salt marshes; sandy shoreline
size	$\pm$16 km^2 bay area
challenge	Combining different approaches in a territorial perspective with a dedicated cross-bay governance (combining different administrational areas); changing perspective from coastal defense to an integrated approach.
mainstreaming and results	Integrate NBSs, dyke planning, and land use through developing steering committees, scientific and participative monitoring, giving workshops, developing a business case, and institutional embedding through PAPI.
stakeholders	Municipalities, knowledge institutes, local stakeholders (farmers, hunters, tourism), NGOs
case study	**Orne Estuary, France**
contact	Conservatoire du Littoral
situation	The Orne estuary is heavily canalized and lacks flood retention areas. During high tide, the water level already reaches the dike crests and sometimes overflows during storm events.
habitat	Estuary; sandy shoreline; tidal marshes; urban area
size	$\pm$8 km^2 estuary

Table A1. *Cont.*

case study	**Orne Estuary, France**
challenge	The risk of flooding of surrounding agricultural and urban areas will increase in the coming decades due to climate change. Due to the variety of activities and interests around the Orne estuary, there is a challenge in considering the estuary as a whole and working towards a common objective.
mainstreaming and results	Co-creation of NBSs with local stakeholders, implementing monitoring protocols and executing them, and translating results in regional and national coastal adaptation strategies for mainstreaming purposes.
stakeholders	Residents, farmers, industry, regional and state agencies, knowledge institutes
case study	**Lancieux Bay, France**
contact	Conservatoire du Littoral
situation	The dikes around Lancieux Bay are in poor condition, and overflow occasionally during storm surges. The dunes along the Roche Morin beach are exposed to erosion, and surrounding agricultural land is at risk of flooding and saltwater intrusion.
habitat	Grassland; rocky shoreline; salt marshes
size	$\pm$8 km^2 bay area
challenge	There are a lot of different interests and activities present in the area, which comprises two municipalities. The challenge is to prepare the territory for dealing with the presence of salt water, and there is a governance challenge as it covers two municipalities.
mainstreaming and results	The long-term territorial development perspective is based on relocating existing economic issues, including agricultural ones; reorganizing accessibility to the area; adapting buildings to flooding risks; and valorizing the landscape potential, especially through ecotourism. This case will serve as a learning case on how to upscale NBSs in a challenging governance context, by adopting a multi-stakeholder approach and building a solid business case in ecotourism.
stakeholders	Farmers, residents, local business/industry, knowledge institutes, NGOs, municipalities
case study	**East Frisia Wadden Sea, Germany: Ecosystem-based protection of marshland coasts in East Frisia**
contact	Lower Saxony Water Management, Coastal Protection and Nature Conservation Agency
situation	Forelands along the Friesian coast are an important legal, nature-based element of the coastal protection system and include very important biotopes such as salt marshes.
habitat	Salt marshes
size	$\pm$120 km coast
challenge	Protection systems (e.g., groins) should be optimized to avoid further loss of area, due to accelerated sea-level rise and increased erosion risk. The maintenance of forelands should be adapted to climate change to limit erosion and ensure the preservation and functionality of the salt marshes.
mainstreaming and results	Co-design of novel integrated foreland management plans, and development of nature-based protection and management measures in order to integrate coastal protection and nature conservation demands.
stakeholders	State and regional agencies, local dike boards, NGOs, landowners

Table A1. *Cont.*

case study	**Halligen Islands, Germany: Ecosystem-based protection of the Halligen under stronger sea-level rise (ECOHAL)**
contact	LKN.SH together with WWF Germany
situation	The Halligen are small marsh islands that have been strongly reduced in size in the last few centuries due to cliff erosion.
habitat	Marsh islands; seasonally flooded land
size	Three islands with ± 6–11 km circumference
challenge	Stone revetments have been placed to prevent further shoreline retreat, but they reduce sediment accumulation and salt intrusion on the salt marshes. Accumulation of sediment on the salt marshes is necessary to balance sea-level rise, and regular salt intrusion is crucial to avoid deterioration of the salt marshes.
mainstreaming and results	Multi-stakeholder approaches will be used to develop a set of locally accepted solutions. The preferred solutions will be modeled to test the full-scale application. This knowledge will actively contribute to the development of NBSs elsewhere.
stakeholders	Local residents, WWF, state and regional agencies
case study	**Salt marshes, Wadden Sea, The Netherlands**
contact	Rijkswaterstaat
situation	Salt marshes are an important part of the Wadden Sea. Salt marshes are more and more recognized as a nature-based solution for reducing flood risk. Many initiatives are undertaken to employ salt marshes for flood risk management, and they often do not align with priorities set for nature conservation.
habitat	Salt marshes
size	±170 km coast
challenge	There are many stand-alone projects, but these lack an overarching vision or approach. The challenge is how to deal with the different services provided by salt marshes and develop a collective approach that helps individual initiatives.
mainstreaming and results	The aim of this pilot is to define a set of collective working principles to use salt marshes as NBSs. Working principles will be translated into tools and instruments that will be used in other projects in The Netherlands and abroad. This project will enable collaborative and integrated assessment of salt marshes as NBSs, reasoning from a systems perspective.
stakeholders	PAGW, Rijkswaterstaat, water boards, nature organizations, and provinces
case study	**Sand Motor, The Netherlands**
contact	Rijkswaterstaat
situation	Larger nourishments are expected to be used in the Sand Motor to minimize flood risk in the coastal areas when the sea level rises.
habitat	Coastal sand dunes; mega sand nourishment; sand bars; sandy shoreline
size	±128 ha peninsula
challenge	There is still a lot of uncertainty regarding the potential of the Sand Motor as a sustainable coastal management tool in the long term, especially regarding accelerated sea-level rise, coastal erosion, and socio-economic challenges.

Table A1. *Cont.*

case study	**Sand Motor, The Netherlands**
mainstreaming and results	Use the Sand Motor as a living laboratory and solve blind spots which are vital for the further application of sand nourishments in The Netherlands and abroad. This project will enhance system knowledge and actively share this with monitoring optimization projects along the Dutch coast. In this way, the Sand Motor can contribute to the broader application of sand nourishments in different morphological contexts and thus promote mainstreaming.
stakeholders	PAGW, Rijkswaterstaat, water boards, provinces, knowledge institutes and universities
case study	**Westerschelde, The Netherlands: Hedwige-Prosper Coastal Landscape Transition**
contact	HZ University of Applied Sciences
situation	In the Western-Scheldt estuary, room is sought to alleviate increasing coastal squeeze through the implementation of different NBSs landward and seaward of existing flood defenses. Some projects have been implemented (e.g., Hedwige-Prosper polder), and more will be needed in the future.
habitat	Estuary; seasonally flooded land
size	±4500 ha estuary
challenge	How can we learn from this design for future maintenance and design elsewhere? How does the morphological template affect ecological functioning? How does society perceive the project, and does that change over time?
mainstreaming and results	The aim is to use different NBS strategies in the area to develop a long-term strategy to upscale NBSs at the estuary scale. By offering Living Labs and Winter Schools and performing surveys among local residents, the aim is to contribute to capacity building and a multi-stakeholder approach.
stakeholders	Universities, Polder2Cs, water boards, provinces/municipalities, Flanders Hydraulics, STOWA
case study	**Skåne Coast, Sweden: Strandängar söder om Malmö, Falsterbonäset**
contact	Länsstyrelsen Skåne (County Administrative Board of Skåne, CAB)
situation	Plans for the maintenance of the protected nature areas and spatial planning by municipalities along the Skåne coast have not included the effects of climate change.
habitat	Coastal sand dunes; lagoons; sand bars; sandy shoreline; seagrass
size	±60 km coast
challenge	Improving coordination between municipalities and CAB to protect infrastructure and nature, while designing and implementing NBSs to maintain the protected nature areas.
mainstreaming and results	Climate change will be included in existing maintenance plans of nature areas, and in municipality plans. Different measures will be implemented and evaluated to enhance system knowledge, while guidelines on how to embed NBSs in policymaking will be composed.
stakeholders	Local farmers, municipalities of Malmö and Vellinge, national agencies, NGOs
case study	**Salt marches in the 8+fjordar area, Sweden**
contact	Länsstyrelsen Västra Götaland (County Administrative Board of Vastra Gotaland)
situation	Nature-based solutions (NBSs) within the 'living-shoreline' concept will be implemented (e.g., break walls consisting of wood material) to reduce flood risk and erosion and to restore salt marshes.

Table A1. *Cont.*

case study	**Salt marches in the 8+fjordar area, Sweden**
habitat	Islands; rocky shoreline; salt marshes
size	Four sites of ±15–60 km^2 salt meadow area
challenge	The area of salt meadows (N2000-habitat 1330 'Atlantic salt meadows') is decreasing due to intensified wave exposure and stronger flooding.
mainstreaming and results	The goal is to maintain and restore habitats and biodiversity in designated Natura 2000 areas, while co-creating NBSs with local entrepreneurs and landowners. This will be achieved through enhancing system knowledge (creating guidelines on NBSs for other municipalities), testing and optimizing monitoring techniques, and capacity building (providing trainings and creating story maps).
stakeholders	Municipalities, several national agencies, community and landowner associations

References

1. Burgos, N.; Rizzi, D.; Davis, M. *Bridging Continents. Exploring the State of-Play of Nature-Based Solutions in the EU and LAC: Building a Foundation for Collaboration*; European Commission, Directorate-General for Research and Innovation, Publications Office of the European Union: Luxembourg, 2024.
2. Tol, R.S.J. The Economic Impacts of Climate Change. *Rev. Environ. Econ. Policy* **2018**, *12*, 4–25. [CrossRef]
3. Firth, L.B.; Airoldi, L.; Bulleri, F.; Challinor, S.; Chee, S.Y.; Evans, A.J.; Hanley, M.E.; Knights, A.M.; O'Shaughnessy, K.; Thompson, R.C.; et al. Greening of grey infrastructure should not be used as a Trojan horse to facilitate coastal development. *J. Appl. Ecol.* **2020**, *57*, 1762–1768. [CrossRef]
4. Bridges, T.S.; King, J.K.; Simm, J.D.; Beck, M.W.; Collins, G.; Lodder, Q.J.; Mohan, R.K. *International Guidelines on Natural and Nature-Based Features for Flood Risk Management*; U.S. Army Engineer Research and Development Center: Vicksburg, MS, USA, 2021. [CrossRef]
5. IUCN (International Union for Conservation of Nature and Natural Resources). *Global Standard for Nature-Based Solutions. A User-Friendly Framework for the Verification, Design and Scaling Up of NbS*; IUCN: Gland, Switzerland, 2020.
6. Bark, R.H.; Martin-Ortega, J.; Waylen, K.A. Stakeholder's views on natural flood management: Implications for the nature-based solutions paradigm shift? *Environ. Sci. Policy* **2021**, *115*, 91–98. [CrossRef]
7. MERLIN Project. Mainstreaming Ecological Restoration of Freshwater-Related Ecosystems in a Landscape Context: INnovation, Upscaling and Transformation. Available online: https://project-merlin.eu (accessed on 6 February 2025).
8. ResiRiver. Creating Resilient River Systems by Mainstreaming and Upscaling NbS. Available online: https://resiriver.nweurope.eu (accessed on 6 February 2025).
9. SUPERB. Upscaling Forest Restauration. Available online: https://forest-restoration.eu (accessed on 6 February 2025).
10. WaterLANDS. Water-Based Solutions for Carbon Storage, People and Wilderness. Available online: https://waterlands.eu (accessed on 6 February 2025).
11. REST-COAST. Large Scale RESToration of COASTal Ecosystems Through Rivers to Sea Connectivity. Available online: https://rest-coast.eu (accessed on 6 February 2025).
12. Van Eekelen, E.; Bouw, M. *Building with Nature. Creating, Implementing, and Upscaling Nature-Based Solutions*; nai010 Publishers: Rotterdam, The Netherlands, 2020.
13. European Commission (Directorate-General for Environment). *Science for Environment Policy: The Solution Is in Nature*; Publications Office of the European Union: Luxembourg, 2021.
14. IUCN. *Ensuring Effective Nature-Based Solutions*; IUCN: Gland, Switzerland, 2020.
15. IUCN; MNR (Ministry of Natural Resources, People's Republic of China). *Towards Nature-Based Solutions at Scale: 10 Case Studies from China*; MNR: Beijing, China, 2023.
16. UNEP (United Nations Environment Programme). *The Economics of Nature-Based Solutions: Current Status and Future Priorities*; UNEP: Nairobi, Kenya, 2020.
17. White House (Council on Environmental Quality, Office of Science and Technology Policy, Domestic Climate Policy Office). *Opportunities for Accelerating Nature-Based Solutions: A Roadmap for Climate Progress, Thriving Nature, Equity, and Prosperity. Report to the National Climate Task Force*; White House: Washington, DC, USA, 2022.

18. World Bank. *The Nature-Based Solutions Opportunity Scan: Leveraging Earth Observation Data to Identify Investment Opportunities in NBS for Climate Resilience in Cities and Coasts Across the World*; World Bank: Washington, DC, USA, 2024.
19. UNEPFI (United Nations Environment Programme Finance Initiative). Nature-Based Solutions. Available online: https://www.unepfi.org/nature/nature/nature-based-solutions/ (accessed on 30 July 2024).
20. World Bank. *A Catalogue of Nature-Based Solutions for Urban Resilience*; World Bank: Washington, DC, USA, 2021.
21. Albert, C.; Brillinger, M.; Guerrero, P.; Gottwald, S.; Henze, J.; Schmidt, S.; Ott, E.; Schroter, B. Planning nature-based solutions: Principles, steps, and insights. *Ambio* **2021**, *50*, 1446–1461. [CrossRef]
22. Sowinska-Swierkosz, B.; Garcia, J. What are Nature-based solutions (NBS)? Setting core ideas for concept clarification. *Nat.-Based Solut.* **2022**, *2*, 100009. [CrossRef]
23. Suedel, B.C.; Naylor, L.A.; Meckley, T.; Cairns, C.; Bernier, J.; Morgereth, E.; Mears, W.; Piercy, C.D.; Ter Hofstede, R. Enhancing Structural Measures for Environmental, Social, and Engineering Benefits. In *International Guidelines on Natural and Nature-Based Features for Flood Risk Management*; Bridges, T.S., King, J.K., Simm, J.D., Beck, M.W., Collins, G., Lodder, Q.J., Mohan, R.K., Eds.; U.S. Army Engineer Research and Development Center: Vicksburg, MS, USA, 2021; pp. 730–800.
24. Waylen, K.A.; Wilkinson, M.E.; Blackstock, K.L.; Bourke, M. Nature-based solutions and restoration are intertwined but not identical: Highlighting implications for societies and ecosystems. *Nat.-Based Solut.* **2024**, *5*, 100116. [CrossRef]
25. Guerrero, P.; Haase, D.; Albert, C. Locating Spatial Opportunities for Nature-Based Solutions. *Water* **2018**, *10*, 1869. [CrossRef]
26. Kannekens, F.A. *Literature Review to the Concepts of Nature-Based Solutions, Mainstreaming and Scaling*; Rijkswaterstaat: Utrecht, The Netherlands, 2025.
27. Berg, M.; Spray, C.J.; Blom, A.; Slinger, J.H.; Stancanelli, L.M.; Snoek, Y.; Schielen, R.M.J. Assessing the IUCN global standard as a framework for nature-based solutions in river flood management applications. *Sci. Total Environ.* **2024**, *950*, 175269. [CrossRef]
28. Berg, M.; Spray, C.J.; Blom, A.; Slinger, J.H.; Stancanelli, L.M.; Snoek, Y.; Schielen, R.M.J. Assessing the IUCN global standard for nature-based solutions in riverine flood risk mitigation. *Environ. Dev.* **2024**, *51*, 101025. [CrossRef]
29. Sittoni, L.; Wilson, S.; De Vries, J.J. *Integrated System-Based Asset Management 2: A Methodology for Sustainable Nature-Based Water Management*; EcoShape: Amersfoort, The Netherlands, 2022.
30. Pluis, S. *NbS Principles for MANABAS Coast: Part of the MANABAS Coast Mainstreaming Framework*; Rijkswaterstaat: Utrecht, The Netherlands, 2024.
31. Loorbach, D. Transition Management for Sustainable Development: A Prescriptive, Complexity-Based Governance Framework. *Governance* **2010**, *23*, 161–183. [CrossRef]
32. Xie, L.; Bulkeley, H.; Tozer, L. Mainstreaming sustainable innovation: Unlocking the potential of nature-based solutions for climate change and biodiversity. *Environ. Sci. Policy* **2022**, *132*, 119–130. [CrossRef]
33. Frantzeskaki, N.; McPhearson, T. Mainstream Nature-Based Solutions for Urban Climate Resilience. *BioScience* **2022**, *72*, 113–115. [CrossRef]
34. Han, S.; Kuhlicke, C. Barriers and Drivers for Mainstreaming Nature-Based Solutions for Flood Risks. *Int. J. Disaster Risk Sci.* **2021**, *12*, 661–672. [CrossRef]
35. Geels, F.W. Technological transitions as evolutionary reconfiguration processes: A multi-level perspective and a case-study. *Res. Policy* **2002**, *31*, 1257–1274. [CrossRef]
36. Runhaar, H.A.C.; Fünfschilling, L.; Van den Pol-Van Dasselaar, A.; Moors, E.H.M.; Temmink, R.; Hekkert, M. Endogenous regime change. *Environ. Innov. Soc. Transit.* **2020**, *36*, 137–150. [CrossRef]
37. De Haan, J.; Rotmans, J. Patterns in transitions: Understanding complex chains of change. *Technol. Forecast. Soc. Change* **2011**, *78*, 90–102. [CrossRef]
38. Rauken, T.; Mydske, P.K.; Winsvold, M. Mainstreaming climate change adaptation at the local level. *Local Environ.* **2015**, *20*, 408–423. [CrossRef]
39. Moore, M.L.; Riddell, D.; Vocisano, D. Scaling Out, Scaling Up, Scaling Deep. *J. Corp. Citizsh.* **2015**, *58*, 67–84. [CrossRef]
40. Salafsky, N.; Suresh, V.; Bierbaum, R.; Clarke, E.; Smith, M.S.; Whaley, C.; Margoluis, R. *Taking Nature-Based Solutions Programs to Scale*; Foundation of Success: Bethesda, MD, USA, 2021.
41. Van den Bosch, S.; Rotmans, J. *Deepening, Broadening and Scaling Up. A Framework for Steering Transition Experiments*; Knowledge Centre for Sustainable System Innovations and Transitions: Delft, The Netherlands, 2008.
42. Adams, C.; Frantzeskaki, N.; Moglia, M. Mainstreaming nature-based solutions in cities: A systematic literature review and a proposal for facilitating urban transitions. *Land Use Policy* **2023**, *130*, 106661. [CrossRef]
43. Adams, C.; Frantzeskaki, N.; Moglia, M. Actors mainstreaming nature-based solutions in cities: A case study of Melbourne's change agents and pathways for urban sustainability transformations. *Environ. Sci. Policy* **2024**, *155*, 103723. [CrossRef]