Interreg North Sea

Co-funded by the European Union

MANABAS COAST

How to Ecology in MANABAS

Evaluation of pilot experiences for upscaling & mainstreaming approaches

MANABAS COAST
NATURE-BASED SOLUTIONS

Credits cover
Common redshank in the 8+fjordar pilot in Sweden. Picture by Erik Landgren.

This two-pager summarizes the pilot experiences from MANABAS COAST in overcoming the barriers to upscaling and mainstreaming Nature-based Solutions (NbS) in coastal regions. These barriers exist in three systems: social, natural and governance. The results of the NbS pilots (WP2) have been reflected upon in “How to” group meetings. From this reflection, several key points of best practices have emerged for other coastal stakeholders to upscale or mainstream NbS. It also provides input for the regional, national and/or international upscaling and mainstreaming strategies of NbS, linked to our project partners’ pilot areas. This paper evaluates the results of the WP2 “How to Ecology” group. The How to Ecology 2-pager consists of this document, the Summary Framework How to Ecology (appendix 1) and the How to Ecology checklist (appendix 2).

The replaced sea pea and sea fennel growing on the new revetment of the Afsluitdijk in the Netherlands.

Picture by Sophie Lauwaars.

In coastal protection strategies, NbS are more and more becoming common practice globally (Seddon et al., 2020). In the Netherlands, there is increasing interest in NbS. The large Dutch program NL2120 (Netherlands 2120), which was recently drawn up, aims for the implementation and export of NbS (budget 110 M EUR). It combines a national knowledge program on NbS with the experience gained from local projects in different landscape types (https://www.Nationaalgroeifonds.nl/, n.d.).
When implementing NbS, conserving biodiversity is not only an objective but also a prerequisite, as it is a crucial component of functioning ecosystems, which are essential in delivering ecosystem services.

It is widely recognized that merely being inspired by nature is not sufficient to classify an action as an NbS. This can be seen in the definitions of NbS that have been adopted by various institutions. The European Commission stresses that any NbS must be supported by nature, and both the United Nations Environmental Assembly and the International Union for Conservation of Nature (IUCN) emphasize the need for NbS to provide the benefits that biodiversity offers (EC, 2015; IUCN, 2020; UNEA 2022). As such, innovative interventions must not only draw inspiration from nature, but also involve functioning ecosystems to resolve societal and ecological problems effectively. In addition to meeting the criteria for being considered an NbS, enhancing the biodiversity increases the contributions from ecosystems, as well as the resilience and ecosystem services that they can offer (Cardinale et al., 2012; Tilman et al., 2012; Oliver et al., 2015; Benkwitt et al., 2020; Seddon et al., 2021). As such, addressing biodiversity, which impacts both species and human well-being, is essential for the efficacy of NbS.

In coastal protection, traditional grey infrastructure measures are known to negatively impact coastal ecosystems by degrading habitats and causing biodiversity loss (Van Slobbe et al., 2013; Gittman et al., 2016; Moosavi, 2017; Laurino et al., 2022). To comply with the high standards for flood protection works along the coasts, it is not always possible to solely build with NbS involving only sediment. The extent to which an NbS can be implemented depends on local conditions. Therefore, NbS are also often combined with traditional grey safety measures. There are strict requirements for nature-inclusive flood protection works along the coasts (Sella et al., 2022; Schoonees et al., 2019). This is why concrete blocks are used for revetments as part of flood protection works (grey solutions) along the coasts, such as with dikes. Nevertheless, ecological enhancements can be added by roughening the concrete blocks and/or adding pools and bulges. This results in benefits to biodiversity by providing a suitable substrate for attachment and growth. Ecological enhancements can offer additional benefits, such as for the environment, ecological habitats and society, as well as improved well-being (Suedel, 2021). However, such an approach must prioritize ecology as a key component.

Ecosystems that have deteriorated and lost their natural species assemblages are less robust, stable and resilient than intact ecosystems, making them less capable of delivering the essential ecosystem services that many coastal communities rely on (van Wesenbeeck et al., 2013). The example of Lake Markermeer in the Netherlands in Van Leeuwen et al. (2021) shows that when the created ecosystem is imbalanced, it will degrade over time and eventually lose the capacity to provide these ecosystem services. To solve the problem of poor water quality (excess turbidity) in Lake Markermeer, small islands were built to increase the land – water transition gradients and the heterogeneity in the water depth. By adding the missing elements that are typical for a natural lake, the aim was to increase the primary production while decreasing the turbidity. Similarly, research by Silliman and Bertness (2002) and Gittman and Keller (2013) highlight that ecological imbalances can lead to the degradation and loss of saltmarshes, along with the valuable ecosystem services that they offer, such as coastal protection. This stresses the importance of ecology within NbS to ensure its integrity and sustainability.

In planning NbS, the systematic involvement of diverse expertise and stakeholders, including ecologists, in the conceptualization, co-design and implementation process is widely recognized as a key success factor (Steiner et al., 2013; Nesshöver et al., 2017; Calliari et al., 2019; Albert et al., 2020; Seddon, 2022; Suedel et al., 2022). Borsje et al. (2011) and Lavorel et al. (2014) highlight the critical role of ecological factors, such as plant diversity and the influence of ecosystem engineers, keystone species or functional groups, in maintaining ecological functions. Consequently, involving ecologists, who will also look for opportunities for nature development at every stage of NbS projects, is essential for their success, rather than just complying with the minimal requirements of legislation and regulations. The effectiveness of NbS ultimately depends on the ecological functions provided by the ecosystem (Nesshöver et al., 2017).

‘What is in it for nature?’ is the main question that came up in the “How to ecology” group.

Main findings

Using the experiences gained by ecologists in the myriad of MANABAS COAST pilots, a comprehensive framework has been developed to guide the inclusion of “for ecology” measures in the future. These lessons learned were gathered using the structured framework that, by means of a questionnaire, assessed the effectiveness of implemented beneficial measures for ecology and biodiversity, explored opportunities for additional actions and identified potential obstacles. This was done by considering the key factors such as the resources, contracts of the commissioner and the contractor, policies and stakeholder involvement (see Appendix 1), the results of which are presented below.

What is interesting is that the implementation of ecological values differs per country. Whereas the most northern country (Sweden) prefers a more holistic approach, in which the ecosystem is seen as the foundation that needs to be strengthened, other counties try to produce a more-natural environment by creating breeding grounds, facilitating the development of diverse vegetation types and/or habitats or by increasing the opportunity for fish to migrate (e.g. the Netherlands). There is also compensation of site-specific losses of habitats and/or the preservation of (rare) species. The effect of national policies and regulations often dictates monitoring obligations and mitigation and compensation measures in favor of soft, more-natural solutions. Most measures are taken during the planning phase, but in the realization phase, opportunities for ecology have also been found. While the inclusion of nature by the organizations can certainly be improved, the awareness of the benefits of ecosystem services is growing.

The project contract is the key element in the realization of projects and it can be used to add additional measures for ecological enhancements. Additional knowledge about the possibilities on how the contract itself can offer more for biodiversity is essential. There are also not always sufficient, or the necessary, ecological measures taken into consideration during the planning phase. Additional, but non-obligated, ecological measures and monitoring should be standardized within those contracts, which can ultimately increase the opportunities for ecological enhancement.
Subsidies are available for the implementation of measures for nature development, but are not always used. The upscaling to an EU Life project might help increase the access to subsidies.

In general, there are no clear financial barriers, but there are some concerns about future management of nature areas due to possible restrictions on national budgets concerning nature management. In addition, there are some knowledge gaps regarding new techniques being applied due to a lack of experience and specific environmental circumstances. In terms of social or cultural factors, natural development seems to be highly accepted. The main exception is regarding giving land back to nature, which is still a sensitive topic due to scarcity of land.

Many participants have indicated that additional interventions should have been applied to increase biodiversity and enhance ecosystem services.

Experiences and lessons learned

Concerning the current knowledge gaps, 50% of the pilots could use additional data. Although this knowledge is often externally available at universities or from nature managers, it is not always incorporated into the projects. Implementation of this knowledge seems to either be restricted or is not considered to be of high importance to begin with. The inclusion of an ecologist during all project phases, from start to finish, is also a key factor. Resources that might aid in the process for the implementation of additional measures for ecology are identified to be: additional funding; positive results from existing projects used as examples; the recognition of the importance of biodiversity; implemented examples with low costs and high benefits; the guidance to initiate new projects, including for permitting and available designs.

In most projects, there was a lot of attention dedicated to the communication with different types of stakeholders.

Checklist ecology

See also Appendix 2.

Steps	Description
1	Involve an ecologist from start to finish
2	Reduce disturbance to nature
3	Restore ecological functions
4	Arrange funding for ecological development, biodiversity, nature and climate change
5	Check existing databanks for protected species
6	Make use of the IUCN Red List of Threatened Species
7	Define target species/habitat(s)
8	Include monitoring (e.g. sediment samples)
9	Use lessons learned as a reference
10	Make use of the knowledge from the N2000 management plans
11	Include (funding for) maintenance
12	Consider if rewilding is possible

Future directions

- How can the inclusion of ecology in an NbS become standardized?
- How do national and international regulations and policies effect building with nature projects?
- How can new techniques or insights that are beneficial to biodiversity be included?
- How can the MANABAS website and the Storymap(s) be accessed following the conclusion of the MANABAS project?
- How can ecological enhancements more easily be included in project contracts?

The different elements of the "How to ecology" group include: the MANABAS checklist, the Storymap, visits to the project sites, improvement in awareness about the possibilities for ecological enhancements at the different pilots sites, and the collaboration with other ecologists make it more feasible to include ecological enhancements within the project pilots for both the present and in the future. Even after the "How to ecology" group is finished, the information gathered can continue to be used as a resource. In this way, MANABAS will continue to be a plus for nature and biodiversity. Building sustainably, with and for nature, is the ultimate goal of the MANABAS "How to ecology" group.

Appendix 1

Summary Ecological Enhancements Analysis Framework

The components of the analysis framework for ecological improvements are as follows:

- to reflect on (to be) implemented additional measures for ecology,
- to explore what additional measures can be taken for ecology,
- to identify possible obstacles,
- to identify supporting factors.

The framework was filled in by ecologists from the different MANABAS pilots. This gave us information on how ecology was being implemented in the different pilots. From this reflection, several key points in terms of best practices and lessons learned have emerged for coastal managers and professionals to help them include ecology and biodiversity within their projects. We are convinced that water safety and biodiversity can complement each other in the projects.

Assessment of (to be) implemented additional measures.

The implementation of ecological values are often country-specific. Some aim for a more holistic approach at the ecosystem-scale, while others focus more on localized approaches, such as habitat and breeding ground creation, vegetation development or the facilitation of fish migration. Where site-specific losses of species or habitats occur, compensation is often carried out. In fact, monitoring, mitigation and compensation measures are all part of national policies and regulations, but these tend to also be carried out instead of soft, more-natural solutions. On the other hand, when it comes to increasing biodiversity, the soft measures are nevertheless recognized as achieving the same effects. It is apparent that many of the measures are already included during the planning phase, but additional opportunities for ecology can still be found in the realization phase. There is certainly still room for improvement, but awareness about the benefits of ecosystem services continues to grow. Subsidies are available for the implementation of measures for natural development, but are not always made use of. This is probably because the measures are sometimes financially negligible in comparison with the whole project budget. There are also projects in which limited funding is a restriction in the implementation of additional measures for ecology. Monitoring was applied at all project sites, but there are often no links made with prior monitoring data (pre-project data/the ecological value of the project site from decades ago). Therefore, there is not always a reference with the original state of those species/habitats (baseline). This can make it difficult to conclude anything about the true and current ecological value of interventions applied for enhancing/increasing biodiversity or ecosystem services.

Exploration of additional measures for ecological enhancements

There was unanimity among the participants that additional interventions should have been taken to increase biodiversity. Moreover, half of the projects would have benefited from additional data. Some of this knowledge is externally available, but it was not always incorporated into projects, either because it was not accessible and/or it was not considered a priority. What is clear is that the project contract is a key element in both realizing projects and also providing the option to include additional measures for ecological enhancements. The latter point is especially crucial when it comes to opportunities for biodiversity. The "additional" ecological measures are not always integrated during the planning phase, but should nevertheless, together with other non-obligatory measures, be standardized within the contracts. This would be a big win for ecological enhancement. Communication of the benefits to key stakeholders is also very important, and was fortunately carried out in most of the pilots.

Identification of obstacles

Financial barriers did not appear to be an obvious limitation, but there are nevertheless concerns regarding the future management of nature areas, such as through possible restrictions on national budgets concerning nature management. The budget for nature conservation in Sweden, for instance, only takes part of the needs of the present situation into account. There is no additional funding to address the effects of future climate change. Fortunately, the social and cultural perceptions regarding natural development are generally positive, but there remain some knowledge gaps when it pertains to the application of new methodologies under specific environmental circumstances. The question of land ownership and the idea of giving land back to nature remains a sensitive topic, in part due to the scarcity of land. Awareness about the importance of prioritization of nature is growing, but could still use improvement. There can be resistance from one or more stakeholders, such as landowners, but the cooperation between stakeholders and project partners has often resulted in a common goal. Nature organizations are sometimes critical about certain projects, but investment in transparency and communication can overcome such

conflicts. Lastly, the technical challenges within the projects, such as in the project design, have not yet been identified.

Identification of supporting factors

Resources that might aid the process for the implementation of additional measures for ecology are identified to be: additional funding; positive results from existing projects used as examples; the recognition of the importance of biodiversity; implemented examples with low costs and high benefits; the guidance to cover the new projects, including permits and available designs. As mentioned before, the inclusion of an ecologist during all project phases, from start to finish, is a crucial success factor. Potential funding could potentially be made available through N2000 or an EU LIFE-program. The latter is the only EU funding program dedicated to environmental, climate and energy objectives. It is divided into sub-programs, including ones focused on the restoration of nature and biodiversity and climate change mitigation and adaptation. Additional subsidies may be available, but are yet to be identified. Political support for biodiversity and the implementation of laws that encourage nature conservation and development are policy changes that can facilitate better outcomes for biodiversity. National policies and regulations on ecology do not yet favor soft, more-natural solutions over the traditional monitoring obligations, mitigation and compensation measures, which could be a point of attention.

The collaboration between project partners can be improved through better cooperation between the commissioner and the contractor(s), researchers or other institutes, NGO's, volunteers and/or coupling with similar goal-oriented projects, such as the EU ResiRiver project. This should also be undertaken with coastal communities to create more transparency. Increasing awareness, through education (of future generations), can also be a supporting factor in creating a better understanding about managed realignments or the need for a reduction in disturbance to the natural environment (e.g., reduction of disturbance). In this way, the "How to ecology" group aims to deliver a positive contribution to biodiversity even after the overall project has concluded.

Appendix 2

How to Ecology Checklist

It is highly recommended to make use of this checklist during all stages of each MANABAS project to ensure that natural development of ecosystems, biodiversity and ecosystem services are taken into account. Additionally, the greenwashing of "soft solutions" can be prevented by applying this checklist.

- **Involve an ecologist from start to finish** to ensure that knowledge about biodiversity, species and ecosystem services are included during all project stages and the opportunities for embedding are explored.
- **Reduce disturbance to nature.** It is a useful and valuable step with positive consequences for nature to ensure that nature is not disturbed.
- **Restore ecological functions** as part of the project. These functions often go hand in hand with increasing water safety and (local) biodiversity, as well as other topics such as creating a more attractive area for recreation.
- **Arrange funding for ecological development, biodiversity, nature and climate change** to make sure that natural development is part of the project. Most measures are relatively cheap, especially when considering the entire project budget as a whole. Moreover, these measures could have a very positive impact on the ecosystem as a whole and/or specific species.
- **Check existing databanks for protected species** to investigate which specific ones the project might have a positive or negative influence on. In case of a negative impact, mitigative or compensatory measures could then be implemented, as needed.
- **Make use of the IUCN Red List of Threatened Species** to implement measures for the protection of threatened or endangered species. The project site might be an important future habitat for those species. MANABAS project pilots can actively be designed as a suitable habitat for the protection and conservation of these species.
- **Define target species/habitat(s)**, the latter of which is often critical for the said species. If they can survive in a certain area, the habitat is often also suitable for other less critical species, in general. This target species can also be used as a means of communication to stress the importance of a habitat, for example.
- **Include monitoring (e.g., sediment samples)** to learn from the implemented measures. Did they have the desired effect? At a minimum, include monitoring for the sediment (because of the relation between the ground and the flora and fauna) and/or the environmental landscape (for other initiatives).
- **Use lessons learned as a reference** to further improve, work more cost-effectively and make it easier to implement the measures elsewhere. In addition, the present state (e.g., current or latest data) of the species is often an insufficient reference to use as a baseline because in many cases, lots of species are already showing a decline or may even have completely disappeared from a certain area. Therefore, we need to also incorporate data from the past and use these numbers as a reference and for comparison with the present situation to test whether the natural development is strong and/or resilient.
- **Make use of the knowledge from the N2000 management plans** and use the N2000 target species as a starting point. In that way, the MANABAS project pilot sites can increase the value of N2000 areas, which might even help expand these areas in the future.
- **Include (funding for) maintenance.** Once an NbS has been built, proper maintenance ensures that it continues to function properly.
- **Consider if rewilding is possible.** This can be done by giving rivers more space, improving connections between land and water or reintroducing predators into ecosystems. In that way, a plus for biodiversity is possible.

References

Albert, C., Brillinger, M., Guerrero, P., Gottwald, S., Henze, J., Schmidt, S., Ott, E., & Schröter, B. (2020). Planning nature-based solutions: Principles, steps, and insights. AMBIO, 50(8), 1446–1461. https://doi.org/10.1007/s13280-020-01365-1

Benkwitt, C. E., Wilson, S. K., & Graham, N. A. J. (2020). Biodiversity increases ecosystem functions despite multiple stressors on coral reefs. Nature ecology & evolution, 4(7), 919–926. https://doi.org/10.1038/s41559-020-1203-9

Calliari, E., Staccione, A., & Mysiak, J. (2019). An assessment framework for climate-proof nature-based solutions. The Science of the Total Environment, 656, 691–700. https://doi.org/10.1016/j.scitotenv.2018.11.341

Cardinale, B., Duffy, J., Gonzalez, A. et al. (2012) Biodiversity loss and its impact on humanity. Nature 486, 59–67. https://doi.org/10.1038/nature11148

Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., Maginnis, S., Maynard, S., Nelson, C. R., Renaud, F. G., Welling, R., & Walters, G. (2019). Core principles for successfully implementing and upscaling Nature-based Solutions. Environmental Science & Policy, 98, 20–29. https://doi.org/10.1016/j.envsci.2019.04.014

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': https://data.europa.eu/doi/10.2777/479582

Faivre, N., Fritz, M., Freitas, T., De Boissezon, B., & Vandewoestijne, S. (2017). Nature-Based Solutions in the EU: Innovating with nature to address social, economic and environmental challenges. Environmental Research, 159, 509–518. https://doi.org/10.1016/j.envres.2017.08.032

Gittman, R. K., & Keller, D. A. (2013). Fiddler crabs facilitate Spartina alterniflora growth, mitigating periwinkle overgrazing of marsh habitat. Ecology, 94(12), 2709–2718. https://doi.org/10.1890/13-0152.1

Hofstede, J. L. A. (2024). Status and prospects of nature-based solutions for coastal flood and erosion risk management in the Federal State of Schleswig–Holstein, Germany. Journal of Coastal Conservation, 28(2). https://doi.org/10.1007/s11852-024-01042-5

IUCN (2020). Guidance for using the IUCN Global Standard for Nature-based Solutions. A user-friendly framework for the verification, design and scaling up of Nature-based Solutions. First edition. Gland, Switzerland: IUCN. https://doi.org/10.2305/IUCN.CH.2020.09.en

Laurino, I. R. A., Checon, H. H., Corte, G. N., & Turra, A. (2022). Does coastal armoring affect biodiversity and its functional composition on sandy beaches?. Marine environmental research, 181, 105760. https://doi.org/10.1016/j.marenvres.2022.105760

Lavorel, S., Colloff, M. J., Mcintyre, S., Doherty, M. D., Murphy, H. T., Metcalfe, D. J., Dunlop, M., Williams, R. J., Wise, R. M., & Williams, K. J. (2014). Ecological mechanisms underpinning climate adaptation services. Global Change Biology, 21(1), 12–31. https://doi.org/10.1111/gcb.12689

Maller, C. (2021). Re-orienting nature-based solutions with more-than-human thinking. Cities, 113, 103155. https://doi.org/10.1016/j.cities.2021.103155

Melanidis, M. S., & Hagerman, S. (2022). Competing narratives of nature-based solutions: Leveraging the power of nature or dangerous distraction? Environmental Science & Policy, 132, 273–281. https://doi.org/10.1016/j.envsci.2022.02.028

Mercado, G., Wild, T., Hernandez-Garcia, J., Baptista, M. D., Van Lierop, M., Bina, O., Inch, A., Sang, Å. O., Buijs, A., Dobbs, C., Vásquez, A., Van Der Jagt, A., Salbitano, F., Falanga, R., Amaya-Espinel, J. D., De Matos Pereira, M., & Randrup, T. B. (2023). Supporting Nature-Based Solutions via Nature-Based Thinking across European and Latin American cities. AMBIO, 53(1), 79–94. https://doi.org/10.1007/s13280-023-01920-6

Moosavi, S. (2017). Ecological Coastal Protection: Pathways to Living Shorelines. Procedia Engineering, 196, 930-938. https://doi.org/10.1016/j.proeng.2017.08.027

Nesshöver, C., Assmuth, T., Irvine, K., Rusch, G., Waylen, K., Delbaere, B., Haase, D., Jones-Walters, L., Keune, H., Kovacs, E., Krauze, K., Külvik, M., Rey, F., Van Dijk, J., Vistad, O., Wilkinson, M., & Wittmer, H. (2017). The science, policy and practice of nature-based solutions: An interdisciplinary perspective. The Science of the Total Environment, 579, 1215–1227. https://doi.org/10.1016/j.scitotenv.2016.11.106

Oliver, T. H., Heard, M. S., Isaac, N. J., Roy, D. B., Procter, D., Eigenbrod, F., Freckleton, R., Hector, A., Orme, C. D. L., Petchey, O. L., Proença, V., Raffaelli, D., Suttle, K. B., Mace, G. M., Martín-López, B., Woodcock, B. A., & Bullock, J. M. (2015). Biodiversity and resilience of ecosystem functions. Trends in Ecology & Evolution, 30(11), 673–684. https://doi.org/10.1016/j.tree.2015.08.009

Randrup, T. B., Buijs, A., Konijnendijk, C. C., & Wild, T. (2020). Moving beyond the nature-based solutions discourse: introducing nature-based thinking. Urban Ecosystems, 23(4), 919–926. https://doi.org/10.1007/s11252-020-00964-w

Reuss, M. (2005). Ecology, Planning, and River Management in the United States: Some Historical Reflections. Ecology and Society, 10(1). http://www.jstor.org/stable/26267724

Schoonees, T., Gijón Mancheño, A., Scheres, B., Bouma, T. J., Silva, R., Schlurmann, T., & Schüttrumpf, H. (2019). Hard Structures for Coastal Protection, Towards Greener Designs. Estuaries and Coasts, 42(7), 1709–1729. https://doi.org/10.1007/s12237-019-00551-z

Seddon, N., Smith, A., Smith, P., Key, I., Chausson, A., Girardin, C., House, J., Srivastava, S., & Turner, B. (2021). Getting the message right on nature-based solutions to climate change. Global Change Biology, 27(8), 1518–1546. https://doi.org/10.1111/gcb.15513

Seddon, N. (2022). Harnessing the potential of nature-based solutions for mitigating and adapting to climate change. Science, 376(6600), 1410–1416. https://doi.org/10.1126/science.abn9668

Sella, I., Hadary, T., Rella, A. J., Riegl, B., Swack, D., & Perkol-Finkel, S. (2022). Design, production, and validation of the biological and structural performance of an ecologically engineered concrete block mattress: A Nature-Inclusive Design for shoreline and offshore construction. Integrated Environmental Assessment and Management, 18(1), 148–162. https://doi.org/10.1002/ieam.4523

Silliman, B. R., & Bertness, M. D. (2002). A trophic cascade regulates salt marsh primary production. Proceedings of the National Academy of Sciences of the United States of America, 99(16), 10500–10505. https://doi.org/10.1073/pnas.162366599

Steiner, F., Simmons, M., Gallagher, M., Ranganathan, J. and Robertson, C. (2013), The ecological imperative for environmental design and planning. Frontiers in Ecology and the Environment, 11: 355-361. https://doi.org/10.1890/130052

Suedel, B. C. , L. A. Naylor, T. Meckley, C. Cairns, J. Bernier, E. Morgereth, W. Mears, C. D. Piercy and R. ter Hofstede. (2021). Enhancing Structural Measures for Environmental, Social, and Engineering Benefit. In J. K. King, J. D. Simm, M. W. Beck, G. Collins, Q. Lodder and R. K. Mohan. Vicksburg. T. S. Bridges (Ed.), International Guidelines on Natural and Nature-Based Features for Flood Risk Management.

Tilman, D., Reich, P. B., & Isbell, F. (2012). Biodiversity impacts ecosystem productivity as much as resources, disturbance, or herbivory. Proceedings of the National Academy of Sciences of the United States of America, 109(26), 10394–10397. https://doi.org/10.1073/pnas.1208240109

UNEA (2022). Resolution adopted by the United Nations Environment Assembly on 2 March 2022 - Nature-based solutions for supporting sustainable development. Fifth session. UNEP/EA.5/Res.5. https://digitallibrary.un.org/record/3999268?v=pdf

Van Leeuwen, C. H., Temmink, R. J., Jin, H., Kahlert, Y., Robroek, B. J., Berg, M. P., Lamers, L. P., Van Den Akker, M., Posthoorn, R., Boosten, A., Olff, H., & Bakker, E. S. (2021). Enhancing ecological integrity while preserving ecosystem services: Constructing soft-sediment islands in a shallow lake. Ecological Solutions and Evidence, 2(3). https://doi.org/10.1002/2688-8319.12098

Van Slobbe, E., de Vriend, H. J., Aarninkhof, S., Lulofs, K., de Vries, M., & Dircke, P. (2013). Building with Nature: in search of resilient storm surge protection strategies. Natural hazards, 66, 1461-1480. https://doi.org/10.1007/s11069-013-0612-3

van Wesenbeeck, B., Griffin, JN., van Koningsveld, M., Gedan, KB., Mc Coy, M., & Silliman, BR. (2013). Nature-based coastal defense: can biodiversity help? In S. Levin (Ed.), Encyclopedia of Biodiversity (pp. 451-458). Academic Press. https://doi.org/10.1016/B978-0-12-384719-5.00323-3

https://www.nationaalgroeifonds.nl/. (n.d.).

Interreg North Sea

Co-funded by the European Union

MANABAS COAST

MANABAS COAST
NATURE-BASED SOLUTIONS