Memo

Deltares

Date
25 September 2024

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Subject

Integration of biodiversity into infrastructure projects in rivers, deltas and coastal areas

1) Objectives of the infographic:

a) To emphasize the **importance** of the integration of biodiversity into marine brackish and/or riverine infrastructure projects (i.e., projects of any size with a green, gray component) and provide guidance on how to have a positive impact on biodiversity.
b) To guide the **integration** of biodiversity by providing frameworks, guidelines, methods, indicators, and tools that can be used in infrastructure projects.
c) To highlight that the complexity of biodiversity requires a **multidisciplinary team** (including ecologists, GIS specialists, etc.) to monitor biodiversity impacts through every phase of an infrastructure project, from initiation to operation and maintenance.
d) To **promote** the monitoring of biodiversity impacts by using linked indicators through data collection, maps, dashboards, assessments and other available tools in every phase of an infrastructure project, from initiation to operation and maintenance.
e) To provide a list of **tools** for the monitoring of biodiversity impacts through every phase of an infrastructure project, from initiation to operation and maintenance.

2) Scope of the infographic:

a) This infographic serves as a reference for the integration of biodiversity by protecting and enhancing it during the implementation of marine, brackish and/or riverine infrastructure projects with a gray component. These include operations such as dredging, construction, nourishments, and others. The IUCN Guidelines for planning and monitoring corporate biodiversity performance highlight 4 stages of corporate biodiversity performance: establishing priorities as to the significant pressures, species, habitats and ecosystem services (stage 1); developing ambitions, a vision, goals, objectives, actions and strategies for the inclusion of biodiversity (stage 2); determining indicators, core linked indicators, key performance indicators to monitor and report corporate biodiversity performance (stage 3); and the implementation of data collection, dashboards and map evaluation to enhance data-inclusive decision-making and lesson learning (stage 4; Stephenson & Carbone, 2021). The guidance in the infographic should help companies integrate data collection to monitor biodiversity impacts into their decision-making processes (stage 4) throughout all phases of their infrastructure projects. Further, the infographic focuses exclusively on direct biodiversity impacts (e.g., habitat removal due to dredging operations, emission of contaminants, etc.) and does not address indirect or supply chain impacts (Laboyrie et al., 2018). Consequently, activities by external parties, such as material suppliers or logistics providers, are beyond the scope.
b) In the infographic we use the definition of *biodiversity* used by the UN Convention on Biological Diversity (Secretariat for the Convention on Biological Diversity, 2011):
"The variability among living organisms from all sources including, inter alia, terrestrial, marine and other aquatic ecosystems and the ecological complexes of which they are part; this includes diversity within species, between species and of ecosystems."
c) In the infographic we use the definition of *ecosystem* used by the UN Convention on Biological Diversity (Secretariat for the Convention on Biological Diversity, 2011):

"A dynamic complex of plant, animal and micro-organism communities
and their non-living environment interacting as a functional unit."

d) The infographic explains the requirements for good biodiversity: Projects can enhance biodiversity in ecosystems by (De Vriend & Van Koningsveld, 2012; IPBES, 2019; WWF, 2022)
   i) Increasing space for habitats and improving connectivity between habitats.
   ii) Targeting keystone species.
   iii) Reducing anthropogenic stressors like chemical pollution, plastic emissions, noise, etc.
e) Users are made aware about the direct drivers of biodiversity decline (IPBES, 2019):
   i) Land and water use changes (e.g., wetland drainage, mangrove deforestation, river damming, coastal reclamation, etc.)
   ii) Exploitation of biological stocks (e.g., overfishing, bycatch, coral harvesting, etc.)
   iii) Climate change (e.g., coral bleaching, sea level rise, ocean acidification, etc.)
   iv) Pollution (e.g., oil spills, nutrient runoff, plastic debris, etc.)
   v) Invasive alien species (e.g., lionfish, zebra mussels, water hyacinth, etc.)
f) The infographic addresses all phases of an infrastructure project (De Vriend & Van Koningsveld, 2012;Laboyrie et al., 2018):
   i) Initiation
      (1) It is recommended to gather baseline data on the biodiversity status at the project site/system during the project's initiation phase (OSPAR Commission, 2012;Laboyrie et al., 2018;Carvalho et al., 2022). Gathering baseline data would require a multidisciplinary team, comprising ecologists, GIS specialists, and other experts. A system approach should be used (System Analysis - EcoShape) to start exploring the system during the project initiation, and the planning and design phases. For the procedure on the selection of indicators please see section 5.
   ii) Planning and design
      (1) Check the same indicators identified in the initiation phase against the expected outcome from the plans and design to identify the expected biodiversity changes.
   iii) Construction
      (1) Check the same indicators identified in the initiation phase as possible to check progress towards expected biodiversity changes.
   iv) Operation and maintenance
      (1) Check the same indicators identified in the initiation phase to check the baseline against the post-construction biodiversity changes. For more information on post-construction biodiversity monitoring design refer to Stephenson & Carbone, 2021, Carvalho et al., 2022,. Kardamaki et al., 2023.
g) The sooner biodiversity is integrated into a project, the higher the potential for a positive impact. In later project phases there are less opportunities, both physically and in terms of design freedom, to incorporate biodiversity elements (Laboyrie et al., 2018). Nonetheless, this guidance may be implemented retrospectively in case a project has already started.

3) Policy supporting the goals of the infographic:

a) The integration of biodiversity in infrastructure projects and financing is supported by international policies, frameworks and targets, such as the Science-Based Targets for Nature, Kunming-Montreal Global Biodiversity Framework (GBF) of the United Nations (UN) Convention on Biological Diversity and the UN Sustainable Development Goals. At the European level, the EU Green Deal, the EU Biodiversity Strategy for 2030 and the Corporate Sustainability Reporting Directive (CSRD) mandate for the protection and restoration of ecosystems and biodiversity, as well as requirements for environmental impact disclosure for companies. At the national level, frameworks such as the Biodiversity Net Gain in the UK and the Nature Program (Programma Natuur) in the Netherlands require positive outcomes for biodiversity. As these national programs are very country specific the infographic will not go in depth at that level, but only mention that these should be further investigated per project.

b) In general, any infrastructure project that could impact biodiversity must consider ratified national, regional and international laws for corporate sustainability and reporting.

4) Hierarchy of biodiversity

a) Biodiversity is a complex, multifaceted concept that cannot be fully captured by a single metric. However, Noss (1990) proposed a Hierarchy of Biodiversity with the following organizational levels for biodiversity:
   i) Composition: Indicators monitor species assemblages in the ecosystem (e.g., species abundance)
   ii) Structure: Indicators monitor biophysical of the ecosystem (e.g., connectivity)
   iii) Function: Indicators monitor the processes taking place in the ecosystem (e.g., primary production).

b) The spatial scales of biodiversity proposed by Noss (1990): It is recommended to begin with a broad scope (e.g., landscape change analysis) based on the project's spatial extent, and then narrow the focus as necessary (e.g., allelic diversity analysis). Some examples of indicators for each spatial scale of biodiversity are listed below. For more examples of indicators for each spatial scale refer to Noss (1990) and Knight et al. (2020).
   i) Landscape: Indicators monitor landscape types (composition); landscape patterns (structure); landscape processes, disturbances and land-use trends (function). Examples include:
      (1) Distribution (composition)
      (2) Connectivity (structure)
      (3) Nutrient cycling (function)
   ii) Community/Ecosystem: Indicators monitor communities, ecosystems (composition); physiognomy and habitat structure (structure); interspecific interactions and ecosystem processes (function). Examples include:
      (1) Species richness (composition)
      (2) Water availability (structure)
      (3) Predation rates (function)
   iii) Population/Species: Indicators monitor species, population (composition); population structure (structure); demographic processes, life histories (function). Examples include:
      (1) Relative abundance (composition)
      (2) Range of dispersion (structure)
      (3) Recruitment rate (function)
   iv) Genetics: Indicators monitor genes (composition); genetic structure (structure); genetic processes (function). Examples include:
      (1) Allelic diversity (composition)
      (2) Effective population size (structure)
      (3) Rate of genetic drift (function)

5) Impacts monitoring framework recommended in the infographic: To integrate the organizational levels and spatial scales of biodiversity in monitoring a project's biodiversity impacts, we aim to follow the Biodiversity Metrics Framework introduced by Knight et al. (2020). This framework allows for the simultaneous evaluation of the entire Hierarchy of Biodiversity from Noss (1990). It offers a standardized approach for biodiversity monitoring through a Biodiversity Scorecard and a Definitions and Descriptions component. This framework captures the complexity of biodiversity and can be uniformly applied across different projects by utilizing the biodiversity indicators outlined in section 7 and the tools detailed in section 8.

a) The Biodiversity Scorecard: a table outlining the indicators needed to address the system, based on the Hierarchy of Biodiversity (Noss, 1990) and it includes:
   i) Three columns, one for each organizational level of biodiversity (composition, structure, function).
   ii) Four rows one for each spatial scale of the system (landscape, communities/ecosystem, populations/species and genetic).

   iii) The cells where rows and columns intersect represent an element of the Hierarchy of Biodiversity, for example, the system's genetic composition. For examples of indicators for each element see the list in section 4b.

b) Definitions and Descriptions: it complements the Biodiversity Scorecard by describing the mitigation program in two ways:
   i) By emphasizing the indicators required by policy.
   ii) By providing information from scientific literature explaining key biodiversity components essential for preserving the ecosystem.

6) **Biodiversity indicators:** Provide information about the state of biodiversity and ecosystems. These can be proxy indicators for biodiversity (i.e., total area of protected areas, surface water quality, etc.) that give information about the ecosystem and indirectly about the biota. The selected indicators cover the various levels and spatial scales of biodiversity (Noss, 1990; Knight et al., 2020; Dalton et al., 2024). We recommend a minimum of three indicators be used (See indicators bolded in Table 1). List of biodiversity indicators (The full list of tested indicators can be found at the Convention on Biological Diversity website: https://www.cbd.int/indicators/testedindicators.shtml)
   a) Examples of Indicators for general application.
      i) Total area of protected areas (use IUCN definition of protected areas)
      ii) Number of endemic/threatened/endangered/vulnerable species by group
      iii) Population growth and fluctuation trends of special interest species
      iv) Change in habitat boundaries
      v) Change in presence, location, area, numbers of invasive plant or animal species
   b) Examples of Indicators of marine and coastal biodiversity. Additional indicators can be derived from the Marine Strategy Framework Directive monitoring requirements.
      i) Change in proportion of fish catches by species per specific season
      ii) Threatened fish species as a percentage of total fish species known
      iii) Coral chemistry and growth pattern
      iv) Annual rate of mangrove conversion
      v) Algae index
   c) Examples of Indicators of inland waters biodiversity. Additional indicators can be derived from the Water Framework Directive monitoring requirements.
      i) Surface water quality: Nitrogen, Dissolved oxygen, pH, pesticides, heavy metals, temperature
      ii) Changes in vegetation type along water courses
      iii) Fish diversity
      iv) Benthic macroinvertebrates: communities
      v) Macrophytes: species composition and depth distribution

7) **Tools for biodiversity monitoring**: The same indicators should be used to monitor biodiversity throughout all of the phases of the project. The goal is to compare the baseline state of the ecosystem (before the project) to the post-construction status (after project implementation).

Table 1 *Example of biodiversity monitoring indicators linked to examples of available tools. The three bolded indicators are recommended as a minimum for biodiversity monitoring.*

Biodiversity monitoring indicators	**Examples of existing standards, methods and tools**
Total area of protected areas (use IUCN definition of protected areas)	World Database on Protected Areas, Natura 2000 Network Viewer, Integrated Biodiversity Assessment Tool (IBAT)
Number of endemic/threatened/endangered/vulnerable species by group	IUCN Red List of Threatened Species, World Wildlife Fund's Living Planet Report
Population growth and fluctuation trends of special interest species	eDNA, DNA databases, ShellBank

Change in habitat boundaries	Global Swimways – Fish Migration around the globe, Maps - Dam Removal Europe, Linkage Mapper | Linkage Mapper
Change in presence, location, area, numbers of invasive plant or animal species	Tools for Understanding Biodiversity Impacts | NatureServe, Invasive Alien Species in Belgium: Species List (biodiversity.be)
Change in proportion of fish catches by species per specific season	Global Fishing Watch
Annual rate of mangrove conversion	Including Local Ecological Knowledge (LEK) in Mangrove Conservation & Restoration, Freshwater Ecosystems Explorer, World Database of KBAs (keybiodiversityareas.org)
Surface water quality	UK Environmental Change Network (ECN) Monitoring protocol, Freshwater Ecosystem Explorer
Changes in vegetation type along water courses	Vegetation Monitor, Tree Registrer, Satellite data analysis with Google Earth Engine,
Species diversity (i.e., fish diversity, benthic macroinvertebrates communities)	FishBase, Standardize Monitoring Protocols

A full list collected for this infographic on monitoring tools available is available here:

8) References

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9) Definitions

a) Water infrastructure: “infrastructure (structures and facilities) situated in or along a water environment (e.g. seas, rivers, lakes, coasts, shorelines)”(Laboyrie et al., 2018).
b) Habitat: “the place or type of site where an organism or population naturally occurs” (Secretariat for the Convention on Biological Diversity, 2011).
c) Protected area: “a geographically defined area which is designated or regulated and
d) managed to achieve specific conservation objectives” (Secretariat for the Convention on Biological Diversity, 2011).

10) Explanation EcoShape and contact information

EcoShape is a consortium that focuses on developing and sharing knowledge on the *Building with Nature* approach. The approach is “a new philosophy in hydraulic engineering that utilizes the forces of nature, thereby strengthening nature, economy and society.”

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