IMDC

International Marine and Dredging Consultants (IMDC) is an engineering and consultancy company specialized in a vast range of water related projects. Our highly qualified staff offers advice based on recent research results of leading universities and research institutes and hands-on experience acquired throughout the years.

One of IMDC's activities is presented in this booklet: ecosystem services studies for all water related projects (inland rivers and urban context, wetlands, coastal and offshore water systems, ports).

More information can be found on our website www.imdc.be

Ecosystem Services Studies

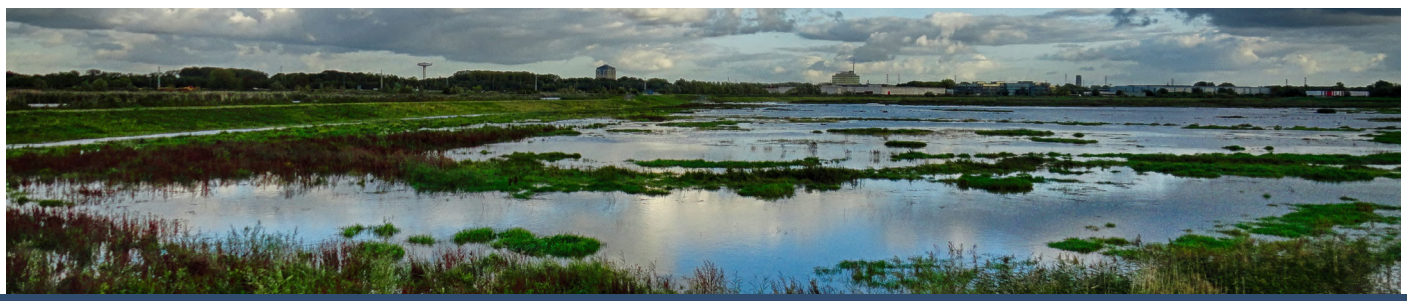
Ecosystem services are, the benefits that humans retain from nature; examples are food, natural resources, coastal protection, climate regulation, air and water purification, and recreation opportunities. Ecosystem services studies are of added value to understand the impact of projects (e.g. construction, dredging, nature restoration…) in various environments (inland rivers, wetlands, coastal, offshore, ports). In any ecosystem service study, there are two main steps: understand how your project affects the environment and make a net assessment of the ecosystem services delivered before and after your project. These studies contribute to the increasing global demand for more sustainable solutions to protect the environment, biodiversity and society (cf. Sustainable Development Goals by the United Nations; EU guidance on integrating ecosystems and their services into decisions for green and blue infrastructure).

An ecosystem service study is meaningful during each step of a project cycle; during the initial concept and preparation phase, design phase, construction and operation, evaluation and adaption phase[1]. In each phase, an ecosystem service assessment (ESA) can serve different purposes:

- To define multiple objectives and select alternative designs;
- To develop a more integrated impact assessment (including environmental, social and economic aspects), taking into account direct and indirect effects (with qualitative information, quantitative data, and/or monetary values);
- To assess the multifunctionality of (marine) infrastructure (benefits for several stakeholders);
- To assess the added value of ecological solutions ("green infrastructure", "nature-based solutions", "nature-inclusive design");
- To involve stakeholders and communicate on and advocate for projects and the positive impacts they can have on the ecosystem;
- To inform monitoring needs.

The Hydro-Environmental Services (HES) team at IMDC has experience with a range of state-of-the art ESA-methodologies. Depending on the goals of the study, data and budget constraints, different techniques can be used; qualitative techniques (with scores based on surveys or expert judgement), quantitative techniques (based on average numbers from literature or modeling), and monetary techniques (such as market value, or a range of non-market valuation techniques). Results can be visualized in spatial maps (with either qualitative, quantitative or monetary data), and added in integrated project assessment methods such as social cost-benefit analysis[2] , cost-effectiveness analysis[3] or multi-criteria analysis. Those methods are being applied for a diverse portfolio of projects linked to the different IMDC products such as Coast and Estuaries, Blue Energy, Marine, Dredging & Port Engineering, and Water Resource Management.

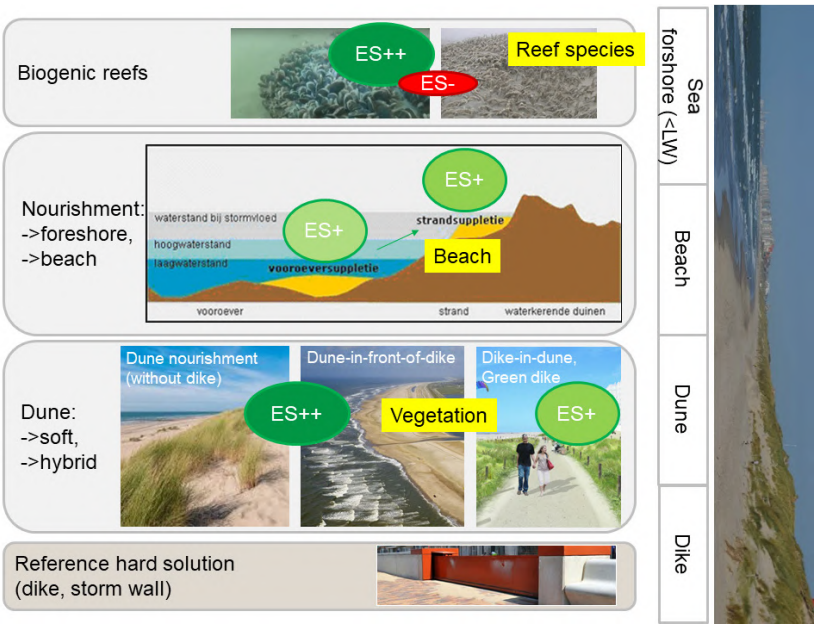
[1] PIANC EnviCom WG 195 report. An Introduction to applying Ecosystem Services for Waterborne Transport Infrastructure Projects. (2021).
[2] Boerema, et al. 2016. Ecology and Society 21(2):10. http://dx.doi.org/10.5751/ES-08372-210210.
[3] Boerema et al. 2018, Ecological Economics 152(2018):207-218. https://doi.org/10.1016/j.ecolecon.2018.06.005



Offshore	Coastal and estuarine		Port	Urban
	Coastal NBS	Estuarine management		
4 – Marine Ecosystem Performance tool	1 - Ecosystem services and building with nature at our sandy coast in Belgium	3 - Ecosystem Services Tool to optimize sediment management	6 – Sustainable tender criteria for port maintenance	7 – Nature Value Explorer
5 - Carbon mitigation framework	2 - Cassandra feasibility study for coastal NBS living lab			8 - SCBA

Coastal and estuarine applications

The coastal and estuarine regions with dunes, reefs and tidal wetlands are valuable in terms of ecosystem services. IMDC is proficient at finding innovative solutions to protect coastlines and estuaries at all levels of design detail and adopts the building with nature principle. Whenever possible natural and nature-based measures - such as nourishments, wetland restoration or sand-filled geosystems - are promoted. Structural interventions are incorporated when absolutely needed. Two applications of ecosystem services studies are demonstrated, related to coastal nature-based solutions and related to estuarine sediment management.



Coastal nature-based solutions (NbS)

At IMDC we have acquired valuable experience in the design and implementation of coastal nature-based engineering solutions. Ecosystem services studies are valuable in this context to assess the socio-economic benefits of such solutions and compare the broad range of benefits between different solutions. IMDC investigated the added value of coastal NbS as part of the Interreg 2 Seas project Sustainable and Resilient Coastal Cities (BOX 1) and VLAIO project CASSANDRA (BOX 2).

Furthermore, IMDC is committed to not only offer expert engineering advice on NbS, but also to ensure the long-term success of these initiatives. Beyond the initial implementation phase, IMDC aims to provide comprehensive follow-up services to monitor and evaluate the success rate of the deployed solutions. This support allows for the assessment of ecological and environmental benefits, ensuring that such projects achieve their intended outcomes.

Ecosystem services and building with nature at our sandy coast in Belgium

The Interreg 2 Seas project SARCC, Sustainable and Resilient Coastal Cities, aimed to create a replicable approach across the 2 Seas coastal communities to build more climate resilience across their urban landscapes to sea level rise, tidal surges and storms via NbS. IMDC investigated which nature-based measures are useful along the Belgian coast to ensure coastal defense and additionally create a multitude of ecosystem services. The project consisted of three parts. First, a long list of sites along the Belgian coast with potential for nature-based measures was identified through hotspot mapping and an initial screening of ecosystem services was made for a set of nature-based measures at each of the long list sites. Next, a detailed screening of ecosystem services for six nature-based coastal protection measures was carried out, including pre-design and Coastal Safety Tool assessment. In the last phase of the project, the results were presented to local governments to reflect on possible real life applications. This research aimed to promote "building with nature" in the land-sea interaction zone to the policy makers of the coastal municipalities, as well as to clarify to them the broad added value of these solutions.

Table 1. Quantification of ecosystem services for different nature based solution scenarios. For two locations, four scenarios are compared (set S1.x and S2.x scenario's). Per location, highest ES value is indicated in dark green, mid value in light green and lowest values in yellow.

Category	Ecosystem services	Unit	S1.1 Ref	S1.2 Beach nourishm	S1.3 Dune nourishm	S1.4 Dune-ifo-dike	S2.1 Ref	S2.2 Reef	S2.3 Foreshore nourishm	S2.4 Green dike
Provisioning services	Fisheries production	score*ha	6,7	6,4	6,4	6,4	7,7	8,3	7,7	7,7
	Drinking water production	score*ha	0,0	0,0	0,5	0,5	0,0	0,0	0,0	0,0
Regulating services	Air quality regulation	Ton fine dust/ha/y	0,0	0,0	7,4	7,4	0,0	0,0	0,0	2,7
	Sediment retention	Score	3,0	3,0	4,0	4,0	3,0	4,2	3,0	3,8
	Coastal safety, flood prevention	Score	1,0	1,0	1,0	1,0	1,0	1,0	1,0	1,0
	Climate regulation: carbon sequestration	kgC/ha/y	17,2	17,2	206,0	206,0	18,9	-203,5	18,9	111,6
	Water retention	m^3/ha	0,9	1,6	2,3	2,3	1,2	1,2	1,2	1,2
	Water quality regulation: N-retention	kg N/ha/y	8,3	8,3	17,4	17,4	9,2	8,7	9,2	10,6
	Water quality regulation: P-retention	kg N/ha/y	0,6	0,6	3,6	3,6	0,6	0,6	0,6	1,1
	Water quality regulation: denitrification	kg N/ha/y	292,8	281,2	294,2	294,2	336,4	288,3	336,4	339,1
Cultural services	Recreation (ecotourism, outdoor sports activities..)	score*ha	0,6	1,1	1,0	1,0	0,9	0,9	0,9	1,1
	Cultural and natural heritage (archeology, paleontology)	score*ha	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0
	Landscape experience – nature/green/dune	score*ha	0,2	0,5	0,8	0,8	0,4	0,4	0,4	0,6
	Landscape experience – sea view	score*ha	0,6	1,1	0,9	0,9	0,9	0,9	0,9	0,9
	Economic potential, employment	score*ha	0,7	1,2	0,9	0,9	1,0	1,0	1,0	1,0
	Development and transfer of knowledge and research	score*ha	0,0	0,0	0,6	0,6	0,0	1,2	0,0	0,1
Supporting services	Hydrodynamic changes (waves)	score*ha	7,0	7,0	7,2	7,2	8,2	8,4	8,2	8,2
	Habitat biodiversity	score*ha	21,9	21,3	21,8	21,8	25,6	28,4	25,6	25,7

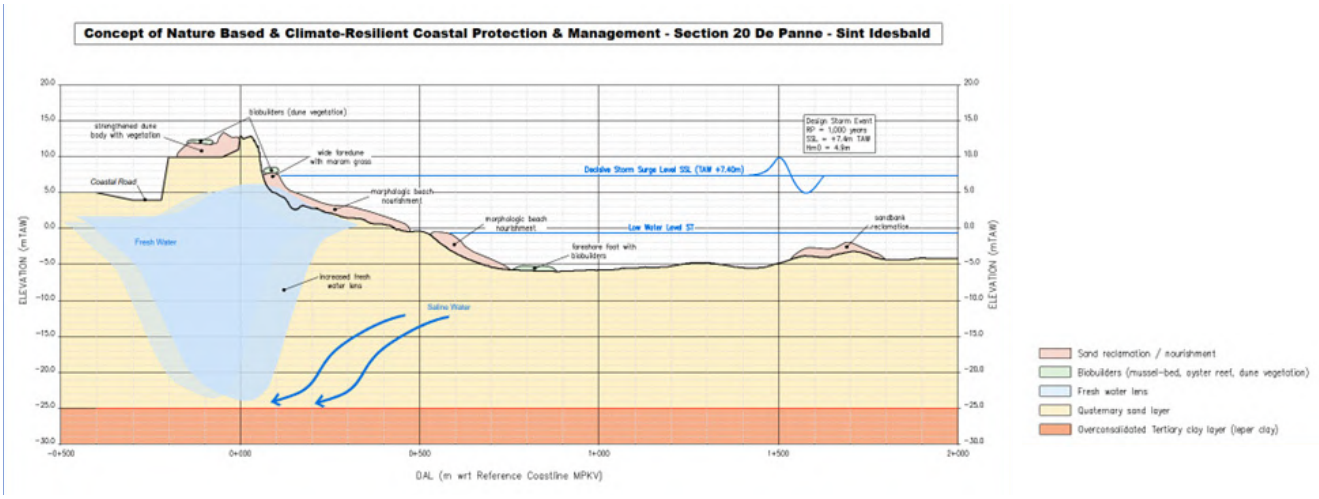
Cassandra feasibility study for coastal NbS living lab

The feasibility study CASSANDRA (VLAIO project, 2022-2024) aimed to explore the missing links and identify the gaps that need to be closed to prepare an ambitious R&D project (VLAIO or European project) to establish a large-scale nature-based solution (NbS) living lab for sandy coasts, on the one hand, and to increase acceptance of the implementation of integrated NbS for coastal resilience, on the other. The main objective was to create a testing ground plan and road map in which technological, economic, societal and administrative aspects are integrated. The general objective was to assess the feasibility and define the boundaries, architecture, location(s) and long-term goals of a large-scale living lab that can serve as an NbS demonstrator in an integrated way. The project investigated how future NbS services can be developed, not only for direct implementation on the Belgian North Sea coast, but also as an international demonstrator.

IMDC explored the technical and socio-economic feasibility of using nature-based solutions (NbS) to enhance both coastal protection and ecological developments in an integrated coastal zone management concept. The NbS identified in this study cover three principal areas of the ocean-beach-land gradient, including (i) nourishment (sandbank, foreshore, intertidal, beach), (ii) biogenic reef and (iii) strengthening of the dune systems.

This study identified the safety of this connected NbS gradient for the current sea-level, the sea-level rise in 100 years (1 m) in addition to storm surges. Regarding the ecological and socio-economic feasibility, attention was paid to the reconstruction of a natural coastline in the proposed NbS living labs which consists typically of a smooth coastal profile in different levels in the foreshore, beach and dune zone. Indeed, such smooth coastline profile also facilitates different ecologic developments. We investigated how the entire coastline profile can be optimised (both for safety and for ecology) by adding different features and management strategies in the aforementioned three principal areas of the entire ocean-beach-land gradient. Some examples are: elevated sand banks with potential for biogenic reefs; depressions at the low water line to create ecological valuable tidal pools; facilitate natural dune development.

Overall, the study provided a framework for the verification of the design of NbS in the living lab proposals, with a focus on the technical and socio-ecological feasibility of using these solutions in a particular context. However, final site selection for the Cassandra living lab project hinges on evaluating needs, urgency, and integrated functionalities (i.e. ecosystem services), while also considering stakeholder expectations (municipalities, authorities).



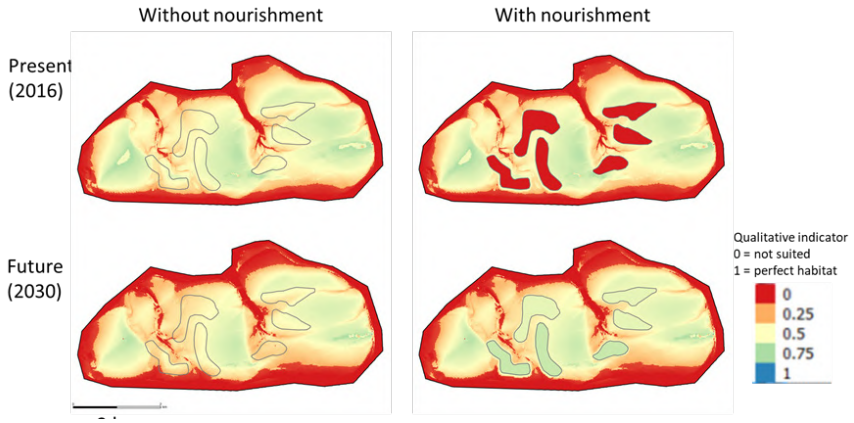
Estuarine sediment management

Sediment measures, going from dredging to nourishing areas, impact the environment by changing the system's hydrological and morphological characteristics. These abiotic changes in their turn change the biotic environment and ecotopes. These do not only impact for example the macrobenthos availability and bird populations, they also have an impact on the provisioning of ecosystem services (ES). IMDC supported in the development of the spatially explicit ecosystem services tool to evaluate sediment management Smartsediment (BOX 3).

3

Ecosystem Services Tool to optimize sediment management

The Interreg (Flanders – Netherlands) project Smartsediment evaluated different management strategies executed in the Scheldt estuary and Oosterschelde and investigated how sediment can be used in a smart way to optimize biodiversity and ecosystem services in these systems. Inside this project, a sub task concerned the development of a conceptual tool and spatial tool to link the direct effects of sediment management to the supply of ecosystem services. By means of scenario analysis the effect of present and future sediment management strategies on the supply of ecosystem services have been evaluated. The QGIS plug-in was developed by the University of Antwerp.



IMDC contributed by providing specific expertise regarding impacts of sediment strategies in the Western Scheldt and Lower Sea Scheldt. The tool allows for scenario evaluation and the outcomes are presented in maps and data tables. The tool is described in the IADC dredging journal Terra et Aqua[4].

[4] Boerema, A. et al. 2020. The smartsediment tool: a QGIS plug-in for evaluating ecosystem services in estuarine and delta systems. Terra Aqua 161, 20–33 (2020).

ESS Roggenplaat and its surroundings	Without nourishment		With nourishment	
	Present (2016)	Future (2030)	Present (2016)	Future (2030)
Food provision				
Shellfish (kg/y)	176	=	=	=
Crustacea (kg/y)	5225	++	=	++
Fish (number x1000)	120	++	=	++
Regulation of flood risk	Ref.	=	=	=
Regulation of water quality				
Denitrification (tonN/y)	303	=	=	=
Nitrogen uptake (tonN/y)	161	=	=	=
Phosphorus uptake (tonP/y)	45	=	=	=
Silica release (tonSi/y)	303	=	=	=
Climate regulation (tonC/y)	1420	=	=	=
Recreational shipping (passages/y)	8	--	=	--
Habitat & biodiversity				
Seals (m² potential habitat)	179	=	=	=
Waders (m² potential habitat)	671	-	-	=

Table 2 - Smartsediment quickscan output. Different scenarios are compared with "present 2016 without nourishment" as reference. The differences are indicated as: no difference (=), weak or strong decrease (- or --) or weak or strong increase (+ or ++)

Blue energy - offshore applications

IMDC is an engineering and consultancy company specialized in a vast range of offshore studies, including Environmental Impact Assessments (EIA) (e.g., offshore wind farms and platforms, offshore aquaculture farm), designing and evaluating nature-based solutions and nature inclusive design, ecosystem services studies, Life Cycle Analysis studies.

IMDC is lead partner of the Marine Ecosystem Performance (MEsP) Framework (BOX 4). Furthermore, IMDC develops expertise to advise on reducing projects' carbon footprint and enhance the ecosystem service climate regulation (BOX 5).

4

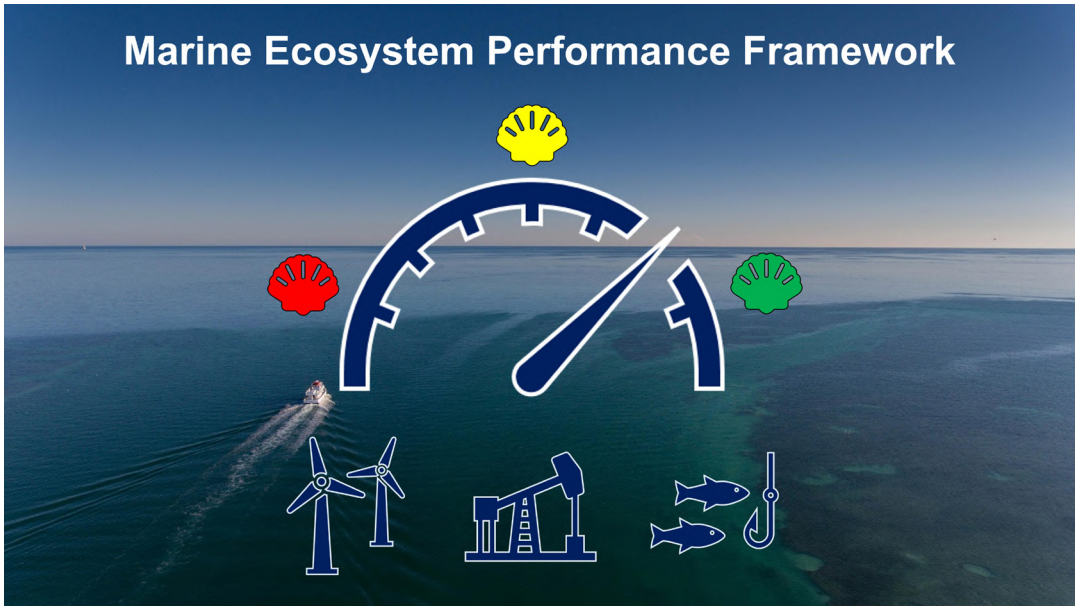
Marine Ecosystem Performance framework (MEsP)

Sustainable development of the blue economy requires businesses to understand and manage their impacts and dependencies on marine ecosystems. However, unlike terrestrial sectors, marine industries lack standardized tools to assess environmental performance in relation to ecosystem services and natural capital. The Marine Ecosystem Performance Quantification (MEsP) project addresses this need to quantify impacts on the marine ecosystem.

The first MEsP framework(MEsP 1.0) enables companies to assess both negative pressures and positive contributions to marine ecosystems, including opportunities for nature-inclusive design. It incorporates a tailored set of state and pressure indicators relevant to offshore activities, an inventory of accessible marine data, and a performance assessment methodology. The methodology includes a scoring system that aligns corporate performance with the current ecological status and local marine objectives. A key innovation is the development of a demo-tool architecture that supports diverse data types and quantification methods, tailored to offshore business needs.

The second generation of the MEsP framework (MEsP 2.0) is currently under construction and will provide a tiered-approach with the choice for a rapid semi-quantitative assessment (Tier 1) or detailed quantified assessment (Tier 2). The framework also incorporates cumulative and indirect effects, offering a more holistic view of ecosystem functioning and business performance. Validation is foreseen through expert workshops and a hypothetical test case relevant for the Belgian part of the North Sea, ensuring the tool's relevance and usability for offshore constructors and suppliers of nature-inclusive design solutions.

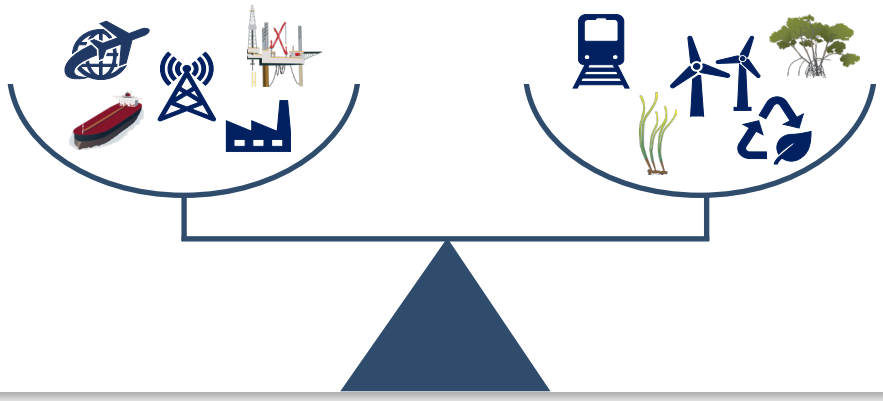
Future development will include both an open-source community version and a commercial version with extended functionalities, alongside business support and training services. Recommendations will be provided to enhance the tool's applicability beyond the initial geographic and sectoral scope. Ultimately, the MEsP tool aims to support environmental accountability, improve tender competitiveness, and foster ecosystem-based management in the blue economy.



5

Carbon mitigation framework

Carbon related services are currently a crucial part of Ecosystem Services and include a variety of topics (e.g. climate change adaptation and mitigation, biodiversity restauration, GHG emissions and measurements, Carbon capture and storage (CCS), Carbon capture and utilization (CCU) and Carbon dioxide removal (CDR)). IMDC can perform an LCA on basically any infrastructure construction project in an estuarine or marine environment, going from offshore wind farms and platforms, including infield and export cables and landfall, construction of artificial islands (caissons and revetements), flood protection structures, breakwaters, etc. This allows investors or project sponsors to choose between more or less sustainable projects, project execution methods and/or contractors in order to optimize their material selection, work methodologies and equipment. Furthermore, IMDC provides solutions for reducing projects' carbon footprints. Carbon offsets and insets are part of a comprehensive strategy for corporate social responsibility, thereby combining efforts to address climate change with contributions to other public goods. A combination of these approaches is integrated into a carbon mitigation framework which aims to reduce projects emissions to within EU guidelines or other protocols depending on the client (i.e., World Bank).



Port applications

Ports and marine facilities provide a vital role in the economic development of a region. This can be everything from the development of small fishing harbours and marinas, up to large LNG facilities and power plants. We help our clients to plan future port development, optimise the design of port infrastructure and obtain the necessary licenses and consents. The environmental aspects of any port development have become increasingly important.

Both clients (project owners) and contractors are confronted with environmental requirements becoming ever more stringent. With a thorough knowledge of relevant international legislation IMDC can provide assistance for a wide range of applications. Specifically related to the ecosystem services air purification, waste treatment and climate regulation, IMDC supports in the writing of sustainable tender criteria (BOX 6).

6

Sustainable tender criteria for port maintenance

IMDC provides advice for the development of sustainability tender criteria for construction contracts, e.g. maintenance dredging. In order to draw up the criterion, we first map out the chain of activities with the typical equipment. For each piece of equipment, an overview is given of the common types and emission standards (e.g. Non-Road Mobile Machinery (NRMM) and Central Commission for Navigation on the Rhine (CCNR)). Based on this information, a criterion is built up to judge the contractors on their sustainability. As such, the sustainability criteria are measurable, provable and verifiable.

Urban applications

IMDC can help your organization identify opportunities for blue-green infrastructure. Based on a detailed geographical inventory (including infiltration suitability, existing water management infrastructure, Spatial Implementation Plans, and bottlenecks), a vision and prioritization are developed in consultation with all stakeholders, based on a detailed blue-green network. In developing the vision, opportunities for de-hardening, rainwater utilization, infiltration, buffe-ring, and delayed drainage are explored, starting from the principle of reclaiming space for and by water. Ecological opportunities are also considered to fully utilize the added value of nature-based solutions. Using the ecosystem services approach, multifunctional solutions (e.g., source control measures, blue-green infrastructure) are evaluated for the positive and negative impacts of the natural elements they create on society (e.g., climate, air, and water regulation, food supply, cultural values, and health impacts). IMDC can conduct ecosystem services studies for urban and rural areas based on state-of-the-art knowledge and tools such as the Nature Value Explorer (BOX 7) and Social Cost-Benefit analysis (BOX 8).

7

Nature value explorer

IMDC makes use of state-of-the-art ecosystem services assessment and mapping tools, such as the Nature Value Explorer from VITO (natuurwaardeverkenner.be). The tool provides results in three ways: a qualitative evaluation, a quantitative evaluation and a monetary evaluation (but not for each ecosystem service). The results are a comparison between the current situation (without the measures) and the one envisioned in the future with all measures in place. The tool remains a nature value explorer, best used for gaining an idea of values and not for taking the calculated values as fact. IMDC developed in house expertise to work with the tool and provide a correct interpretation to support other studies or decisions.

Quantitative value	Unit	Current		Future		Difference	
		Low	High	Low	High	Low	High
Food production	Kg vegetables, fruit and nuts/year	0	0	0	0	0	0
Air quality	kg PM10/year	20,7	20,7	33,1	33,1	12,4	12,4
Air quality in city canyo	µgPM10M²	-	-	-	-	-	-
Avoided runoff water	m³/year	6 870,1	6 870,1	12 765,6	12 765,6	5 895,5	5 895,5
C-storage biomass	ton C/year	0,5	3,6	0,9	6,7	0,4	3,1
Cooling effect	lower local air temperature during heat (°C)	0,2	0,2	0,5	0,5	0,3	0,3
Recreation	Number of visitors/year	0	0	0	0	0	0
Added value houses	% increase property value	0,2	0,2	0,1	0,1	- 0,1	- 0,1
Alternative method calculating cultural services							
Health effects green environment	DALY/year	0	0	0	0	0	0

8

Social Cost-Benefit Analysis (SCBA)

In a SCBA, all current and future, beneficial and adverse effects that society experiences as a result of project or plan are weighed against each other by expressing them in monetary terms. If the balance of the costs and benefits valued in monetary terms is positive, the project contributes to social welfare.

IMDC has conducted SCBAs for water-related projects with inclusion of ecosystem service benefits. In case of unquantifiable and/or unvalued costs/benefits (e.g., environmental impacts), a Multi-Criteria analysis (MCA) could be used together with the SCBA to make sure to weigh all relevant impacts.

Scan the QR for more informaton on Ecosystem Services @IMDC