

DuneFront

Report on co-creation new DD-hybrid NbS prototype

10/04/2026



Co-creation of new DD-hybrid NbS prototype

Deliverable information

Title	Report on co-creation new DD-hybrid NbS prototype
Deliverable number	D15. 3
WP number	15
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Contributors	UGent, Arcadis
Type	Report
Dissemination level	Public
How to cite	Report on the outcome of the initiated co-creation activities for the construction of the new DD-hybrid NbS prototype linked to task 15.3.

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Versioning and contribution history

Version	Date	Authors (Institution)	Notes
Version 1.0	30/05/2025	Helena Voet	Draft created by Arcadis
Version 2.0	25/06/2025	Helena Voet	Draft created by Arcadis
Version 3.0	25/08/2025	Helena Voet	Draft created by Arcadis
Version 4.0	11/03/2026	Daphné Thoon	Completed version based on the preliminary design of the pilot project and final stakeholders briefing dated 20/02/2026.
Version 5.0	10/04/2026	Daphné Thoon	Edited version based on review by University of Ghent and VLIZ

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Summary

In DuneFront (HORIZON-CL6-2023-BIODIV-01) work package 15 (task 15.3) Maritieme Dienstverlening en Kust (MDK) is setting up a co-creation process for developing an integrated approach for replacing an existing dune footing reinforcement which combines coastal safety, ecological potential, and recreational value in the coastal zone between the Leopold I-monument and Westerpunt in De Panne, the most western located community on the Belgian coast. The project location is characterised by a transitional zone where natural activities, such as dune formation, and human interventions and activities meet. The project location is unique because of the transition between stable sedimentary zones and areas with dynamic beach and dune systems, such as the Westhoek Reserve. Proceeding from the co-creation process, MDK will gather the wishes, needs, and insights of diverse stakeholders to form a broad-based vision which will connect with local and strategic needs. The strategic policy plan "Kustvisie"¹ "[Coastal Vision in the following] here functions as the guiding objective, aimed at forming a climate-resistant and durable Belgian coast. The DuneFront project is researching possible innovative solutions, including hybrid dune-dike nature-based solutions (NbS), which combine safety and ecology with spacious areas for recreation.

During the co-creation workshops, we will examine four scenarios: 'eco-dike', 'eco-dike + dune', 'dike-in-dune + dune' and 'dune'. The scenarios were discussed, optimised, and evaluated based on coastal safety, natural value, and recreation. The thematic workgroups brought important points for consideration to the fore, such as the role of natural dynamics, the objective of avoiding hard infrastructures, the integration of recreational facilities, and the importance of monitoring to better understand risk. The western sub-zone of the project area was seen as more complex because of safety risks while the eastern sub-zone offers more potential for natural dune formation.

In the DuneFront project, MDK shall carry out a pilot project in different test boxes (for different forms of dike reinforcements) in which innovative techniques and materials will be tested. Whereas, when the design process was started, three test zones of 50 meters each were considered, it became clear after a market study that 4 test zones of approximately 38 meters each would provide more insights. This pilot project received input from the co-creation process concerning the location of the test zones and the most desired or promising natural features. The results of these studies will be critical for the final decision-making process for the future vision of the project location in De Panne, and for assessing the sustainability and impact of the scenarios presented. By combining stakeholder feedback, research, and monitoring of the pilot project, DuneFront strives for a permanent, future-oriented development of the coastal zone, in which safety, nature,

¹ Strategisch beleidsplan kustvisie (strategic policy plan Coastal vision) :
https://assets.vlaanderen.be/image/upload/v1708602861/OO_Strategisch_beleidsplan_Kustvisie_v20240201_O_d6oo3s.pdf

and recreation are integrated in a balanced way. This makes the DuneFront project not only relevant for De Panne, but also for other coastal zones along the Belgian and European coast.

Table of contents

1.	Introduction	8
1.1	Project DuneFront	8
1.2	Description of the project location De Panne.....	9
1.3	DD-hybrid pilot project (eco-dike).....	16
1.4	Vision and ambitions for the project location	17
2.	Co-creation	19
2.1	Concept and objectives.....	19
2.2	Composition of the stakeholders group	20

2.3	Overview of stakeholder consultations	21
3.	Workshop 1: Start-up co-creation.....	23
3.1	Content.....	23
3.1.1	Agenda.....	23
3.1.2	Objectives.....	23
3.2	Summary of input gathered	23
4.	Workshop 2: explanation of vision formation.....	26
4.1	Content.....	26
4.1.1	Agenda.....	26
4.1.2	Objectives.....	26
4.2	Summary of the input gathered	26
4.2.1	Explanation of vision formation.....	26
4.2.2	Explanation of morpho-dynamic character of the study region	27
4.2.3	Completion of vision formation at the project location.....	28
5.	Workshop 3: optimization, vision formation.....	32
5.1	Content.....	32
5.1.1	Agenda.....	32
5.1.2	Objectives	32
5.2	Summary of input gathered	32
6.	Vision document.....	35
6.1	Feedback on vision document.....	35
7.	Stakeholder briefing preliminary draft	36

7.1	Content.....	36
7.1.1	Agenda.....	36
7.1.2	Objectives	36
7.2	Summary of gathered input	37
8.	Conclusion.....	38
8.1.	Look ahead to the preferred scenario	38
8.2	DD-hybrid prototype: eco-dike: the four demonstrators	38
9.	Appendices	39
9.1-	DuneFront_Cocreation Workshop 1_Minutes Arcadis 260624	39
9.2-	DuneFront_Cocreation Workshop 2_Minutes Arcadis 071024.....	39
9.3-	DuneFront_Cocreation Workshop 3_Minutes Arcadis 041224.....	39
9.4-	DuneFront_explanation preliminary design pilotproject_MDK 200226.....	39
10.	References.....	39

1. Introduction

1.1 Project DuneFront

The European project 'DuneFront' is an initiative that is being financed by the Horizon Europe Programme of the European Commission and is being coordinated by the University of Ghent. This project has as its objective improving the protection and safety of the coast by optimising solutions which combine both natural elements (such as dunes) as well as by man-made hard structures (such as dikes). These so-called hybrid dune-dike 'Nature-based Solutions'² (DD-hybrid NbS) embody a new generation of permanent, inclusive, and aesthetic measures for protecting the coast.

DuneFront consists of different work packages, with work package 15 (WP 15) focused on the development and implementation of a new prototype hybrid dune-dike system at a location on the Belgian coast. A particular need is linked with this: combining demands of coastal safety with local ecological functions and the incorporation of recreational activities. This new prototype is also called the "eco-dike" and will take shape in WP 15.

MDK (Maritieme Dienstverlening en Kust) is responsible as the coordinator of WP15 for the supervision of both the activities in the work packet as well as the design, construction, and monitoring of the newly developed prototype (tasks T15.3 and T15.4) via a co-creation process.

The remaining tasks in WP15 (T15.1 and T15.2) concern the research into the development of the form of 1 of the dike reinforcements for the prototype³, executed by the University of Ghent (Expert Group Civil Engineering Structures and Construction Materials). In the framework of these tasks, cement-bonded materials were developed that show an increased bio-receptivity (T15.1) with the objective of fostering the germination of marram grass and other species of grasses. In another aspect,

² The definition of 'Nature-based Solutions in the framework of coastal safety': interventions inspired and supported by nature which use natural processes to reduce coast-related risks. Hereby they provide additional advantages for biodiversity, climate resilience, and socio-economic values. [Bonte D. et al]

³ See paragraph 1.3: The eco-dike shall consist of 4 different types of dike reinforcement of which University of Ghent developed 1 type in T15.1 and T15.2.

the objective was to use 3-D printed materials in complex forms to increase the sand-catching capacity of the structures and thus promote spontaneous dune accumulation on the eco-dike (T15.2).

1.2 Description of the project location De Panne

The existing dune reinforcement in De Panne offers a potential location for the eco-dike and will be referred to in this document as “the project location”. The eco-dike is therefore the “dike”-element in the hybrid dune-dike system, which, together with a row of dunes behind it, plays a role in protecting the coast of the project zone.

The project location in De Panne is located at the dune reinforcement which was installed over the course of the 20th century to stabilise the position of the dune base and prevent structural erosion of the dunes (Figure 1-1). These dunes have always played an important role in protecting the coast and protecting the surrounding residential areas against flooding from the sea. This dune reinforcement is a hardened concrete dike structure located between the overlook at ‘het Westerpunt’ (‘the Western Point’ Figure 1-2) and the beach access road from Dynastielaan in the beach town of De Panne. This area lies in a transition zone between the natural sedimentary Westhoek Reservation (along the French border) and the more erosion-sensitive beach near the town centre of De Panne (Figure 1-3). Some residences are located landward of the dune reinforcement, as well as car parks and an active yacht club (Royal Sand Yacht Club). It is a location where various natural and man-made elements meet, which results in unique dynamics and challenges.



Figure 1-1 Current conditions of the concrete dune reinforcements at the level of Westerpunt (De Panne).



Figure 1-2 Westerpunt (De Panne) is an architectural overlook that borders on the Westhoek Reservation.



Figure 1-3 Situation of the project zone with respect to the Westhoek Reservation along the French border and De Panne, including the location of the project zone on the Belgian coast.

the current dune reinforcement consists of a concrete structure with a slope of ca. 45 degrees, where the top of the dune reinforcement serves as a hardened walking and biking path. The slope is constructed of made of gabions and/or rockfill, penetrated over a part of the length with concrete (Figure 1-4). The dune body landward is bordered by a concrete storm wall of approximately 1 meter in height (Figure 1-5), while other parts of the dune reinforcement were built facing the existing Atlantic Wall. The concrete dune reinforcement is at the end of its operational life and needs to be replaced. The reinforcements assures that the coastline remains stable at this location, although in various ways there is a perceivable beach-and-dune dynamic in the immediate proximity.

13

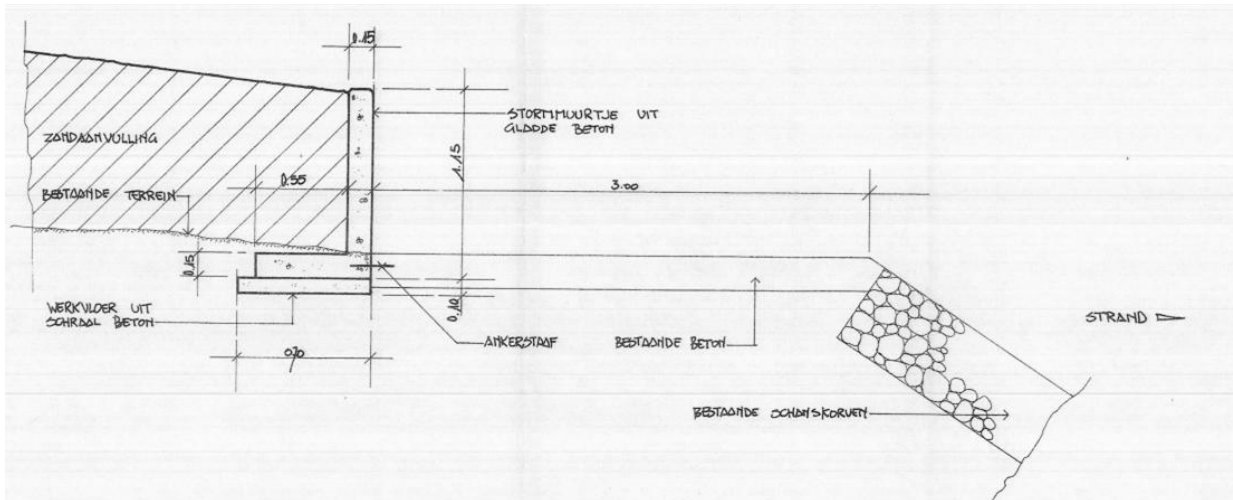


Figure 1-5 Sketch, cross-section of concrete seawall (dune reinforcement + small retaining wall) at De Panne (start of construction of small retaining wall, 1993).

The dynamic of the location is jointly determined by natural processes such as aeolian sand transport (sand movement caused by wind) and dune formation. At the Westhoek Reservation there is a case of a clearly visible but gradual, natural accumulation of sediment at the base of the dune, the beach in front of it, and the foreshore. In the project zone itself, the foreshore is relatively stable, and the beach volume has increased slightly over the previous years, among other reasons from the influence of beach nourishment projects at the De Panne-Beach. These nourishment projects have led to a net increase of the beach, although the long-term trend of this development has yet to be determined with certainty.

In the direct proximity of the project zone, one finds reference points which are of both ecological and recreational importance. The Westhoek Reservation, the oldest nature preserves in Flanders, with its valuable dune belt, forms an important nature area and stands in contrast to the fixed dunes in the project zone. Here, human interventions, such as building the dune reinforcement and the retaining wall, have led to a restriction of the natural dynamics and the near disappearance of dry beach which limits the natural transportation of sand in the direction of the dunes behind it. But in this area, there are also zones with embryonic dune formation (at the line where the dry sand starts), where beach sedge and sand couch-grass contribute to the creation of new dunes. These dynamic processes are being influenced by the factors named above such as aeolian transport and the presence of a stable tide line. The project area overlaps as well with nature conservation areas falling under Natura 2000 (Avian Guideline

Area 'West coast' and Habitat Guideline Area 'Dune Areas Including IJzermonding and Zwin', VEN⁴ ('The West Coast') and borders on land protected by the 'Dunes Decree'⁵ (Figure 1-6).

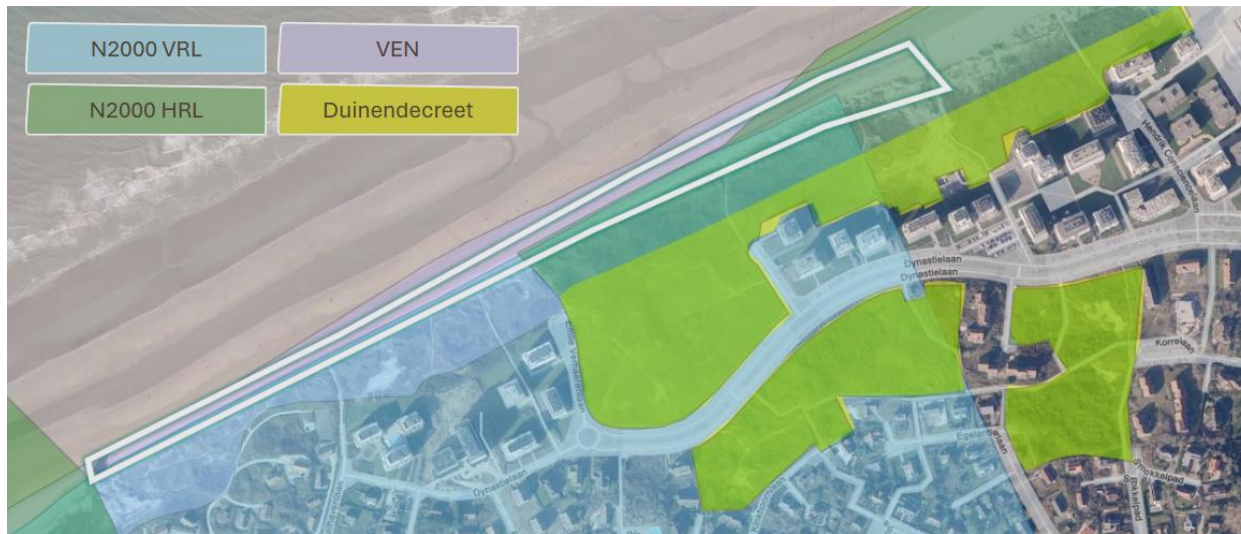


Figure 1-6 Location of the project zone with respect to the Avian Guideline Area 'Wes Coast' (blue area), Habitat Guideline Area 'Dune areas including IJzermonding and Zwin' (green area), VEN-area 'The West Coast' (Large Unit Nature: GEN; violet area), and the area protected by the Dune Decree (yellow area).

Recreationally, the dune reinforcement plays a connecting role. The path on top of the reinforcement functions as a route for hikers and bikers and forms a physical connection between the beach town De Panne and Westerpunt. At the same time, this area is an ecological barrier between the beach and the dunes, where the management and the development must be carefully coordinated to meet the needs of both man and nature.

⁴ VEN: "Flemish Ecological Network": A selection of the most valuable and sensitive nature areas in Flanders, protected by environmental legislation.

⁵ Dunes Decree: Flemish decree with the goal of protecting the dunes in Flanders.

The project location in De Panne is therefore an area where stability and dynamics meet each other. The dune reinforcement offers protection and opportunities for recreation, while the surrounding zones, such as the Westhoek Reservation, facilitate natural processes such as dune formation. The area demands a balanced approach in which coastal safety, ecological value, and recreational functions are coordinated with each other.

1.3 DD-hybrid pilot project (eco-dike)

Given the poor condition of the existing dune base reinforcement, MDK must decide within the next few years regarding a potential renovation. Due to this necessity and the challenges associated with the existing dune foot reinforcement, this location was chosen as a suitable test site for the new prototype within the DuneFront project (the “eco-dike”).

To be able to assess the function of such an eco-dike in various aspects, MDK wishes to test, along with the bio-receptive cement-bonded reinforcement of the eco-dike– developed in T15.1-2 by the University of Ghent Expert Group Civil Engineering Construction and Building Materials – three additional dike reinforcements. These shall consist of classic dike construction, but also with an added ecological value with respect to the existing concrete dune reinforcement. Thanks to the difference in form, material (bio-receptive concrete or other concrete compound and the size of openings (important in ecological development) of the 4 types of dike revetments, the different dike revetments can be compared with each other.

The project shall be installed over approximately 154 meters (that is, 4 test-sections of approximately 38 meters per section each with a different type of dike revetment), parallel to the coastline and shall be monitored⁶ and evaluated after installation. The results of this study can contribute to the definitive choices for designs of future ‘eco-dikes’, whether in De Panne, or at other locations along the Belgian or European coast. Along with that, the results can also give direction for the further realisation of the vision that was presented in the co-creation process (see § 1.4).

The construction and monitoring of the “eco-dikes” with different types of dikes facing shall aid MDK in the selection process for a future approach to the project location. That is why this project is regarded as a pilot project.

⁶ A monitoring plan for the pilot program will be set up in T15.4.

For extended commentary on the already-known details of the pilot project, a contextualisation of the MER-obligation⁷, possible obligations in the case of construction and environmental permits, and an environmental impact study with an assessment of the effects of such a project, we refer here to the report “Permitability of the Pilot Project” by Arcadis (2025a).

1.4 Vision and ambitions for the project location

To make a permanent choice of the way the dune reinforcement will be renovated, it is important to have the renovation contextualised within a vision in which the right stakeholders are involved.

In the DuneFront-project, a co-creation process was established for this reason, to develop a broader landscape vision for the zone between De Panne and the French border. Hereby the various interested parties were involved integrated, who contributed ideas on the future design of the dune foot reinforcement and surrounding dune regions. Along with safety, natural and recreational connections are also considered. DuneFront aims namely to combine and integrate **safety, nature and recreation**.

The priority of the project is assuring the protection of the coast and protecting the hinterland from flooding, mainly with respect to the challenges of a globally rising sea level in combination with local aging dike reinforcement in De Panne. At the same time, the project will also study ecological processes and if possible, restore them, as well as integrate natural dynamics into the coastal zone, as well as fostering dune formation and creating space for biodiversity. Furthermore, it takes space for recreation into consideration, where the landscape will be arranged to be accessible for activities such as hiking, biking, and tourism, and where these activities can go hand in hand with the surrounding natural areas (i.a. the Westhoek Reservation) and coastal safety (i.a. for the neighbours in the landward areas).

These three ambitions—safety, nature and recreation—are thus subject to an integrated approach. Safety takes the first place, since coastal safety always takes precedence and both changes in the sea level and the operational life of coastal protection measures must be taken into consideration. The ambition to protect ‘nature’ plays a guiding role by respecting and enhancing

⁷ MER: Environmental Effects Report. This is an investigation of the possible effects on the environment of a specific construction project.

ecological dynamics. Recreation is treated as a unifying element, by bringing people together and integrating it into the design of the landscape. These three ambitions support each other and contribute to an adaptive and future-oriented approach.

The three ambitions of the project were then transformed into design principles which **are nature-inclusive, trendsetting, and future oriented**. This means that materials and structures are considered and developed which support ecological processes, such as hybrid dune-before-dike-solutions. Moreover, it must be possible to integrate recreational features, such as hiking and biking paths. These features must additionally be integrated in such a way that they can grow along with the dynamics of the coastal environment. Finally, climate change must be considered by developing solutions which can adapt to rising sea levels and which fit into the long-term picture of the strategic policy plan “Coastal Vision” (Kustvisie). While “Coastal Vision” provides measures for protecting the coast against flooding and an increase in sea level from 1 m to 3 m, the goal of the co-creation process was to develop a vision for the period between today and the time when the sea level will have risen 1 m.

The project DuneFront strives for a balanced coastal landscape in which safety, nature, and recreation can meet and collaborate. By combining these elements, a durable, ecologically valuable, and attractive region is created for both man and nature, which caters to the needs of the Belgian and European coast.

2. Co-creation

2.1 Concept and objectives

An important aspect of DuneFront is a co-creation initiative led by Maritieme Dienstverlening en Kust, in which local stakeholders were actively involved in developing a “vision for the future” of the project site in De Panne. Various interested parties, such as residents⁸, recreational organisations, conservation organisations, and authorities, contributed ideas to this “vision for the future”. This collaboration provides a basis of support and stimulates dialogue about among other things: coastal protection, conservation of nature, and recreation. In this way, local knowledge, expertise, and needs give the project direction for practical, socially responsible visions and solutions. The process of co-creation in DuneFront offers added value by creating a platform for dialogue and collaboration. Stakeholders get the chance to share their insights, concerns, and needs, which not only leads to a richer and more inclusive vision for the design, but also contributes to a better understanding of the specific characteristics and dynamics of the coastal zone in De Panne. This is valuable in a region where natural processes (such as dune formation) and human activities (such as recreation and infrastructure) collide with each other. The stakeholders were asked about their expectations with respect to specific ‘must haves’, ‘nice to haves’ or ‘no go’s’ for their sector. By using this knowledge, the project team can better cater to the local conditions and solutions will be created which are not only technologically and ecologically strong but are also in accord with the wishes and needs of the community.

Moreover, co-creation strengthens the base for the scenarios presented (see § 4.2.3). Stakeholders feel heard and included in the process, which contributes to acceptances of the ultimate choices. Through co-creation, a skilful balance is achieved between the goals of safety, restoration of nature, and recreational functions, which makes the project not only functional, but also socially relevant.

⁸ The residents were represented in the co-creation process by the local administration.

2.2 Composition of the stakeholders group

The co-creation process from DuneFront could count on broad interest. Various sectors were represented and a mix of local, regional, and national interested parties shared their input and helped giving shape to the scenarios presented (Table 2-1).

In the first instance, the **public sector** was represented from different policy levels, including local, provincial, and Flemish authorities which are focused on spatial planning, the environment, coastal management, and heritage. The **academic and research sector** was represented by experts from universities and research institutions with expertise in the fields of ecology, coastal dynamics, climate adaptation, and sustainable technologies. They were supported by the **maritime sector**, with specific attention to coastal safety and the use of the coastal zone. **Nature conservation and environmental organizations** were present and focused on natural conservation and restoration, biodiversity, and sustainable land use. The **recreational and tourist sector** was represented by among others water sports clubs and tourist services which are involved in the use and development of the coastal zone for recreation. Finally, the **culture and heritage sector** was safeguarded by stakeholders who strive to preserve and integrate cultural heritage in land use development in the coastal zone.

Table 2-1 Overview composition of the DuneFront project team and stakeholders' group

Composition of the project team and stakeholders group
University of Ghent
MDK
Arcadis Belgium
VLIZ
Municipal government De Panne
Province West-Flanders
Westtoer
Royal Sand Yacht Club
Wind & Watersports Flanders
Natuurpunt Westhoek
ANB
INBO
VLM

Environmental Department

Department of Immoveable heritage

The composition of the stakeholders group showed a strong representation of experts in nature and technology who presented their insights and opinions in detail and shared them with the group. Also, the policy and advisory agencies, including the local administration, were well-represented, and their input was frequently able to guide decisions about the (im) possibilities or pre-defined obligations. Given the conceptual nature of the vision-building process, the residents of De Panne were not consulted individually but were represented by the municipality. However, when the application for the environmental permit is submitted, the general public will have a direct say in the matter.

2.3 Overview of stakeholder consultations

Workshops were organised in the DuneFront co-creation process which on the one hand explained the progress and developments in the DuneFront project to the stakeholders, and on the other hand, their input was requested for possible optimising measures and insights in shaping the vision. These workshops were held once digitally (workshop 1; see § 3), once physically in Oostende (workshop 2; see § 4) and once physically in De Panne (workshop 3; see § 5).

The following sections provide a summary of the agenda items, the workshop's objectives, and the proceedings of each session. A full report on each workshop can be found in the appendix (see § 0, § 9.2 and § 9.3).

Parallel to the three plenary co-creation workshops, several bilateral discussions were organised between the project team and Flanders Hydraulic Research, the Agency for Nature and Forestry (ANB), and Team Environmental Impacts. This had the objective of getting more detailed information, focused on the project and the developed scenarios. The three plenary co-creation workshops resulted in the vision document (§6) to which the stakeholders also got another opportunity to provide feedback in writing.

Finally--in the framework of the preliminary design of the pilot project--the stakeholders were invited to a roundtable about this preliminary design and the ongoing process which must ultimately lead to the construction of the pilot project. During this stakeholder's moment (stakeholders briefing moment; see §7), the stakeholders were able to ask questions and give comments on this preliminary design.

3. Workshop 1: Start-up co-creation

This first workshop was held digitally on 26/06/2024 and was organised by Arcadis Belgium in collaboration with project partners MDK and the University of Ghent.

3.1 Content

3.1.1 Agenda

- Project presentation DuneFront and partners
- Pilot project De Panne
 - Project zone
 - Problems and opportunities
 - Tasks in the work package
- Start-up co-creation
 - Concept
 - Objectives
 - Interactive conversation “wishes and needs”

3.1.2 Objectives

This first co-creation workshop had as its objective bringing the stakeholders involved together (see § 2.2), acquainting them with the project DuneFront and the project zone in De Panne, as well as explaining the already known ideas with respect to the development of the so-called “eco-dike” in the pilot project in the framework of DuneFront. Moreover, the actual co-creation start-up was explained with the aid of an explication of the concept and the intended objectives. Finally, an interactive discussion with all stakeholders was organised, in which every participant could, if desired, communicate some “must haves”, “nice to haves” or “no go’s” from their sector to the project team.

3.2 Summary of input gathered

The different sectors were informed about the project and asked about their wishes, needs, and insights in the development of a future-oriented vision for the coastal zone between the beach town of De Panne and Westerpunt, and by extension up to the

French border. The project team emphasised combining the three pillars of safety, ecology, and recreation, with attention to the specific characteristics and challenges of the region.

From a **safety perspective**, it was emphasised that the existing dunefoot reinforcement, which is at the end of its operational life, must be replaced. The new solution must protect the coastline against erosion, the consequences of the rising sea level, and severe storms. Here it was urged that innovative, durable, and adaptive technologies are to be used, such as hybrid dune-dike NbS. This new structure must ideally not only have a protective function but also be able to adapt to natural dynamics, such as sand dynamics and natural sand accumulation. Additionally, the design must consider the future vision of the Coastal Vision (kustvisie), which puts climate resilience at its centre.

From an **ecological standpoint**, it was emphasised, both by the project team as well as by the nature experts present in the stakeholder group, that the natural links between the beach and the valuable dune region (Westhoek) must be strengthened. This encompasses stimulating natural processes such as dune formation, which are crucial for the restoration and preservation of the biodiversity associated with the coast. The importance of sand movements between the beach and the dunes was highlighted, because it offers a great added value for the quality of the marramdunes. The preservation of existing stands of marram grass and embryonic dune areas was presented as an absolute precondition. Where possible, nature conservation organizations and research institutions also advocated for a quantitative expansion of the dune habitat, although the focus was primarily on qualitative improvement. Furthermore, stakeholders indicated that the vision for the area should extend beyond the current footprint of the dunefoot reinforcement, with a focus on ecological corridors and a more natural landscape design.

From a **recreational perspective**, the stakeholders expressed the absolute necessity of retaining the connection between De Panne and Westerpunt and if possible, optimising it, both for pedestrians and cyclists. Accessibility was an important topic in this discussion, with an emphasis on creating an integrated, accessible network is this also suitable for wheelchair users. At the same time, it was suggested that “go-carts” be banned from the area, to protect the natural environment. It was proposed that the recreational path could run partly along the coast (a “balcony on the sea”) and be designated exclusively for pedestrians, to minimise the impact on nature. Furthermore, the need for rest stops and scenic outlooks along the route was mentioned; these should serve as places to relax and possibly offer places to park bicycles.

Another important aspect of the recreational development is linking the area with wider networks. The stakeholders indicated that the network of hike-and-bike trails will be renovated (in 2026 and 2027), and that there is a clear desire to include

Westerpunt in this. This offers not only a better connection to the existing routes but also enhances the recreational attractiveness of the zone. At the same time, it emphasises that safety and the attractiveness of the connection have priority.

This first co-creation workshop thus emphasised the need for a **broad vision of spatial planning**. This means that attention must be focused not only on the direct zone of the dunefoot reinforcement, but also on the surrounding areas, such as the adjoining dune zone, beach zone, and the open terrain between apartment buildings in the project zone. This space can possibly be used for recreation or ecological purposes. Moreover, the stakeholders asked to consider the circular economy and the re-use of existing structures in the design and to avoid hardened and impermeable surfaces as much as possible, unless technically necessary. The stakeholder input emphasised the need for durable and innovative solutions for protecting the coast, restoring natural processes, and at the same time leaving room for human use. Taking the desires and needs of the various stakeholders into account forms the basis for an integrated and broad-based vision for the renovation of the coastal zone between the beach town of De Panne and Westerpunt.

4. Workshop 2: explanation of vision development

The second workshop was held in person in Oostende on 07/10/2024 and was led by Arcadis Belgium in collaboration with the project partners MDK, University of Ghent and the Hydraulic Engineering Laboratory.

4.1 Content

4.1.1 Agenda

- Welcome & framing of DuneFront
- Explanation of vision development, including co-creative stakeholder discussion
 - Coastal vision as guiding final concept
 - Plotline DuneFront
 - Roadmap vision development
- Explanation of the morpho-dynamic character of the study region De Panne, including the co-creative stakeholder discussion
- Completion of vision development for the project location, including co-creative stakeholder discussion

4.1.2 Objectives

This roundtable discussion was an interplay between explanations from the various project partners, followed up by an open and constructive discussion with the stakeholders involved (see § 2.2). The policy-based context of the project and the dominant morpho-dynamics in the project zone were explained in detail and translated into concrete possibilities and design principles. A design roadmap in the direction of the desired image for the future was composed and discussed, along with a presentation of possible fully developed scenarios following from this vision development. Finally, suggestions and optimisations of some examples of recreational connections were discussed.

4.2 Summary of the input gathered

4.2.1 Explanation of vision development

Coastal Vision (kustvisie) functions as the strategic policy framework which guides the DuneFront-Project. Its aim is a safe, climate-resilient, and permanent coast, where natural dynamics and ecological processes are given centre stage. This guiding final picture emphasises **soft and sandy vision for the future** which connects with the natural characteristics of the West Coast, with space for hybrid solutions such as the dune-dike hybrid (NbS). Coastal Vision (kustvisie) serves as a long-term guideline, whereby local interventions, such as the pilot project and the scenarios presented (see § 4.2.3) in De Panne, contribute not only to coastal safety, but also to the restoration of natural dynamics and recreational options. It is essential to, in this manner, link short term actions in DuneFront (ca. 5 years) with the broader long-term objectives which also take climate change into account, including the possible rise in sea levels from 1 to 3 meters.

In DuneFront, the underlying set of problems (stabilising the dune base and the rising sea level), is coupled with certain objectives (restoration of the ecological corridor & expansion of the recreational network) by means of three equally valued pillars: safety, nature and recreation. These pillars outline a **future-oriented, nature-inclusive, and guiding design** for the project zone. The premise here is that safety comes first (replacing the existing dune base reinforcement is necessary), nature provides guidance (restoring ecological corridors is vital) and recreation brings people together (walking and biking trails can be integrated into the design).

A vision development roadmap was presented, which offers a **structured approach** to developing a future-oriented vision for the coastal zone in De Panne. This is based on a thorough analysis of the current situation and aims at the gradual evolution of the coastal zone toward a more natural and dynamic character. Important to the development of this roadmap is also testing new materials and techniques, such as bio-receptive dike revetments in a small-scale pilot project. Monitoring and evaluation thus form an essential part of the roadmap, whereby the impact of the interventions on safety, ecology, and recreation are assessed.

4.2.2 Explanation of morpho-dynamic character of the study region

From the analysis of the Flanders Hydraulic Research, it appears that the Belgian coastline, including the DuneFront project zone, shows various sedimentary and erosive dynamics. The zone around the Westhoek Reservation has seen a net accumulation of soft coastal protection structures over the past forty years, while the project area itself is a transitional zone with a generally stable beach and foreshore, where a growth trend in beach volume has been apparent over the past five years. In the beach town De Panne, long-term erosion made way for a net growth of the beach thanks to repeated beach nourishments since 2011. European research (MANABAS, 2022-2027) indicates that natural coastal erosion is possible if the beach is not structurally given to erosion, there is space for aeolian sand transport, and obstacles such as hard infrastructure are avoided. That there will be natural

accumulation of beach and dune in the project zone is therefore realistic, provided that the infrastructure (the existing dune base reinforcement) shall be removed.

4.2.3 Completion of vision development at the project location

In the context of completing the vision development at the project location in De Panne, land use scenarios were presented and discussed with the stakeholders involved, each with an approach to coastal safety, ecology, and recreation (Figure 4-1):

For simplicity's sake, a dune base reinforcement will always be referred to as a dike.

Scenario 1: "eco-dike"

In this scenario, the entire project area will receive a modernised dike at its current location, reinforced with ecological elements that promote vegetation growth on the dike. The hard infrastructure will thus remain at its current location but will be adapted to better integrate it into the natural environment. In the long term, siltation is possible if the coastline is shifted seaward in line with the strategic policy plan Coastal Vision. This scenario provides a safe option but limits the natural dynamics of the area in the short term. This means that a hybrid dune-dike system is chosen for the entire project zone.

Scenario 2: "eco-dike + dune"

This scenario combines hardened and natural elements. In the western subzone, a redesigned "eco-dike" will be constructed with nature-inclusive features, while the eastern sub-zone will serve as a test area for natural dune formation. Here, nature will be given more freedom by removing the hardened infrastructure, allowing the sand volume to redistribute naturally. Monitoring is essential to ensure the safety of the hinterland, with beach nourishments implemented as needed. This scenario offers a balanced approach between safety and allowing space for natural dynamics. Thus, a hybrid dune-dike system is planned for the western subzone, whereas this is no longer the case in the eastern zone.

Scenario 3: "dike-in-dune + dune"

In this scenario, the existing hardened infrastructure is replaced by a hybrid "dike-in-dune" structure in the western subzone (hardened infrastructure buried beneath the dune body) and natural dune formation in the eastern subzone. Locally, the coastline is shifted to a more landward position to align with the coastline near the Westhoek Reservation. Although this scenario focuses on maximising support for natural processes, hybrid protective measures are necessary in

the western subzone to always ensure safety. A hybrid dune-dike system is therefore planned for the western subzone, whereas this is no longer the case in the eastern zone.

Based on the co-creative discussion, a fourth scenario was developed:

Scenario 4: “dune”

This scenario is aimed at a completely natural sandy coastal landscape in this zone. Here, in analogy to scenario 3, the coastline will be restored to a more landward position to connect with the current coastline in the area of the Westhoek Reserve. The existing hardened infrastructure will be removed from the entire project zone and the area will be completely transformed into a soft and sandy coastal landscape. The natural morpho-dynamics will get the space they need to give the area a renewed form and shape the sand volume into a dynamic dry beach that connects with the landward dune landscape. This scenario means that there will be no hybrid dune-dike system provided in the project zone.

Based on the discussions at the 1st workshop, it was decided to consider not only hybrid dune-dike solutions (Scenario 1) but also scenarios in which (part of) the project area is left unhardened and the coastal protection function must be fulfilled by dunes (Scenarios 2, 3, and 4).

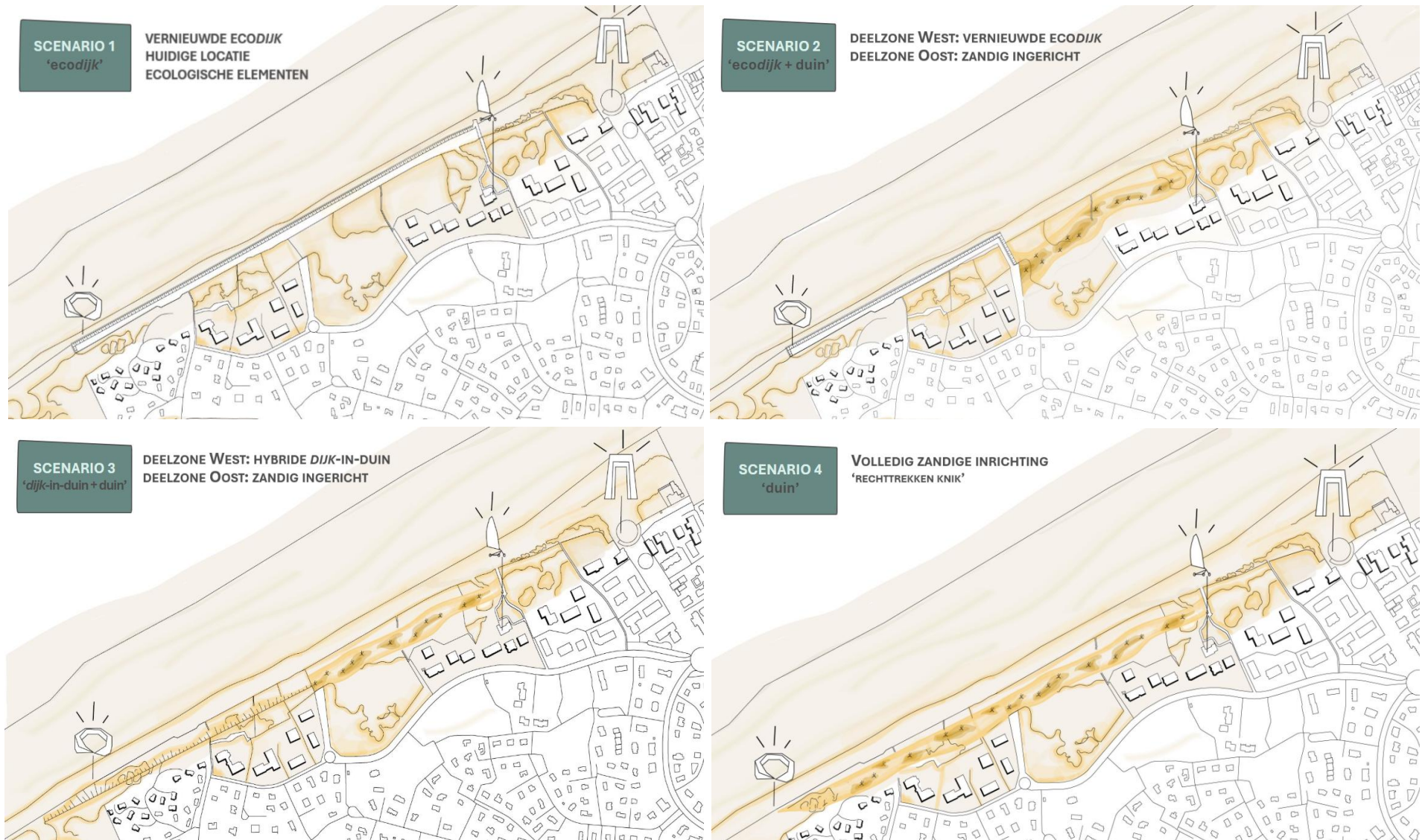


Figure 4-1 Overview of the 4 developed scenario's for the DuneFront project including their main characteristics.

During the discussion, it became clear that scenarios 2 and 3 stirred the most enthusiasm among the stakeholders because of the combined focus on safety with natural dynamics and ecological advantages. It was emphasised that safety and the removal of hardened infrastructure from the zone must be kept in balance with the existing buildings and recreational options. The project team also presented some ideas for recreational connections, where, for example, recreational users can hike and bike along the seaside, or in which recreational hiking and biking can be de-coupled to connect in part with the hinterland. These suggestions were discussed and where possible optimised based on the input provided. In this way new recreational connection was highlighted with on the aim of adapting the access pathway to the local yacht club and an alternative was presented that includes a loop into the recreational routes to encourage through traffic.

During the discussions, potential risks were mentioned with respect to removing hardened infrastructure in scenario 2 through 4: By removing the existing dune reinforcement, it is possible that erosion will occur in the existing dunes, with a loss to coastal safety and dune vegetation as a result. Only in scenario 1, the eco-dike, does this risk not occur, since the eco-dike will prevent dune erosion.

During the discussion, it also became clear that system knowledge is very important to the assessment of the feasibility and impact of these scenarios. Pilot studies and monitoring, such as provided for in T15.4 of DuneFront, can make significant contributions here. The co-creation process offers space for the further integration of the recreational and ecological aspects in the final choice.

At the end of this workshop, it appeared that it was necessary to further evaluate the scenarios, which would be the topic of the following workshop. It was also very clear that scenario 1, based on its less risky character with respect to dune erosion, could prove to be a viable solution for the western sub-zone.

In line with the scenarios presented, it was decided by the project team in consultation with the stakeholder group to allow the pilot project to proceed in the western sub-zone after an "eco-dike" had been designed (see § 1.3).

5. Workshop 3: optimisation, vision development

The third workshop took place in person in De Panne on 04/12/2024 and was led by Arcadis Belgium in collaboration with the project partners MDK and the University of Ghent.

5.1 Content

5.1.1 Agenda

- Welcome & framing DuneFront
- Explanation of vision developemnt
 - New scenario DUNE
 - Completing vision development at the project location
 - Decision-making framework
- Co-creative public comment period in work groups with plenary feedback session
 - Thematic workgroup SAFETY-TECHNICAL
 - Thematic workgroup NATURE
 - Thematic workgroup RECREATION
- Explanation pilot project and permitability
- Explanation cement and 3D elements (T15.1-2)
- Explanation of vision document

5.1.2 Objectives

This third and last workshop with reference to vision development was focused on optimising the four scenarios which had been worked out and discussing the therewith associated decision -making framework. It was decided that the stakeholders present would be divided into thematic work groups, after which each group would present a plenary feedback session to all those present. The progress so far and some preliminary results of the university research within the pilot project (see § 1.3) were also explained.

5.2 Summary of input gathered

The four scenarios which had been developed (see § 4.2.3) were discussed by topic, focused on coastal safety (+1 m rise in the sea level), restoration of nature, and recreational values. Although a definitive choice has yet to be made, the feedback helped to identify the boundary conditions and the gaps in knowledge that require further research.

Specifically, it appeared that the aspect of “working with nature” provided for some uncertainties and questions:

- Uncertainties with respect to the development of vegetation on the eco-dike: to what degree can the vegetation develop permanently, considering the dynamic environment in which this dike is located? By monitoring the eco-dike according to the monitoring plan as provided for in T15.4, an answer can be found for this question.
- Uncertainties regarding potential dune erosion in scenarios where removal of hard infrastructure is planned. These uncertainties can be reduced through continued monitoring of sedimentation and erosion trends in the project area and through extensive morphological modelling.

A decision on the final scenario is expected by 2030, based on the results of additional research and pilot studies. The choice of location for the pilot project (see § 1.3) will be made once the co-creation process has run its course (see conclusion) and the permitting procedure shall also be completed in the short term, so that an implementation can take place between 2026 and 2031.

The discussion in the **workgroup SAFETY-TECHNICAL** was focused on maintaining coastal safety in the face of an increase in the sea level of up to +1 m, whereby innovative solutions such as the “eco-dike” and hybrid structures are considered. The group emphasised the difference between implementing an “eco-dike” (with ecological elements and an operational life of 50 years) or a “dike-in-dune” (located landward and based more on natural processes) in the area of the western sub-zone of the project area. Within the stakeholder group, different opinions prevailed about the options in the area of this sub-zone, in light of the possible connection with the dune landscape of the Westhoek Reserve on the one hand and the more complex safety risks on the other. The stakeholders were of the opinion that, in light of the dominant morpho-dynamics and the more landward position of the existing residences, the eastern zone offers more potential for a test project for natural dune development. The stakeholder group further emphasised the need for detailed morphological modelling and monitoring to better understand risks.

The focus within the **workgroup NATURE** lay on ecological restoration and fostering of natural dynamics, such as dune formation and ecological corridors. The participants were all of the opinion that all the steps within the project must fit within the sandy vision for the future for the west coast, in line with the Coastal Vision (kustvisie). The scenario with completely hardened infrastructure (scenario ‘eco-dike’) was not selected because of its limited ecological value. A completely natural use of the land (scenario DUNE) got the ecological preference but was viewed critically in connection with the safety and permitting aspects. The nature experts who were present brought important points for consideration to the fore in connection with the role of sand couch-rass and marram grass in dune formation and the impact of human interventions on the natural succession. The remaining questions concerned the degree to which the natural processes can be enhanced without losing the desired degree of protection in the framework of coastal safety.

The **workgroup RECREATION** focused on improving accessibility and user comfort in the coastal zone, with particular attention to hiking and biking routes and the preservation of recreational value. The stakeholder group pleaded for a better connection between Westerpunt and the beach town De Panne, whereby it should be possible to integrate recreation without damaging the ecological value of the region. To this end the possible use of dynamic or floating hike-and-bike paths were discussed extensively. Along with that, the need for rest areas and scenic outlooks was emphasised. The remaining questions in the stakeholders group had to do with the way recreation can be combined with ecological restoration and safety objectives.

6. Vision document

A so-called “vision document” was prepared as a summary and reference guide for the conceptual work carried out by both the project team and the stakeholders (Arcadis, 2025b). This is a visual report in which the underlying ambitions, steps taken, scenarios discussed, and conclusions reached were compiled and presented. The vision document contains a general description of the DuneFront Project, as well as a more detailed description of how this translates to the project location in De Panne and what the greatest challenges are at this location. It explains the concept and objectives of the co-creation process and how input from the various sectors represented can contribute to a shared vision for the future. Furthermore, it outlines the DuneFront Project framework, and links it to the narrative of the prevailing issues and the three proposed objectives. Each of these objectives was treated as equally valuable and translated into actionable design principles that the group of stakeholders could work with. Subsequently, DuneFront was positioned within the vision of the strategic policy plan Coastal Vision, and a roadmap toward this guiding end goal was developed.

The visions for spatial planning that were discussed with reference to the project location in De Panne (the four scenarios) were explicated and presented, including some options and variants in the implementation concerning the materials, adaptation of recreational connections, and integration with existing landscape elements. Finally, the opportunities and points of concern of each of these four scenarios were tested against an assessment framework at the strategic level. In this way, it is assured that the visions for land use harmonise with the desires and needs identified by the stakeholders involved, as well as the limiting conditions with respect to safety-technical requirements, ecology, recreation, and the policy framework.

6.1 Feedback on vision document

This vision document was thoroughly reviewed by the city administration of De Panne, and they wish to stay involved in the further process of the implementation of the DuneFront pilot project. Based on the scenarios presented, recreational connections and possible looks of materials, the group expressed its preference for retaining a direct and accessible connection between the Leopold I-monument and Westerpunt, whereby experiential value and the view of the sea were assigned high priority. The realisation of such a recreational connection can, according to the city administration, be achieved in a way the landscape and ecological values can exist in harmony with the objectives in the area of coastal defense and safety. To this end, they aim at, among other things, further research into the legal and technical feasibility of (elevated) board walks, which can be one possible idea which would fulfil the different objectives in the areas of safety, nature conservation, and recreation.

7. Stakeholder briefing preliminary draft

No choice in favour of 1 of the 4 scenarios was made in the vision document (§6), since additional research is needed here.

Since additional knowledge is needed and on the potential of scenario 1, the eco-dike, MDK has contacted the consulting company SWECO for the technical design of the demonstrator eco-dike.

To conclude the co-creation process, a final meeting was held in Ostend on February 20, 2026, with the entire group of stakeholders focusing on the aforementioned technical design. This meeting was led by MDK in collaboration with SWECO.

7.1 Content

7.1.1 Agenda

- Overview co-creation process
- Overview existing situation
- Design of the pilot project
 - Market study + applicability
 - Selection
 - Design of the pilot project
 - Execution of the pilot project (2026–2027)

7.1.2 Objectives

This briefing had a three-part goal:

- To inform the stakeholders about the design of the pilot project for the Eco-dike
- To gather feedback from the stakeholders
- To create a broad base for support among the stakeholders

To achieve these objectives, the meeting began with an overview of the co-creation process (sections 2–5) that had been completed earlier. This included a review of the three pillars (safety, ecology, and recreation) as well as a summary of the stakeholders' key "must-haves," "nice-to-haves," and "no-go's." Next, a report was presented on the market study conducted and the options explored for the eco-dike's revetment. These options were evaluated against several criteria (see Appendix 9.4) established at the start of the technical design phase. This was followed by a presentation of the design for the various types of eco-dike revetment (hereinafter referred to as "demos") for the pilot project, as well as the planned, now more precise project location. The decision to implement the pilot in the western half of the project zone was a direct result of the three co-creation sessions, which indicated that the eco-dike would have greater potential there.

Finally, the timeline for the realisation of the demonstrations for the eco-dike was presented, before granting sufficient time to ask supplemental questions about the design and to express possible reservations and/or suggestions.

7.2 Summary of gathered input

The stakeholder briefing was well attended and well received by many stakeholders. There was a great deal of interaction within the group and a broad understanding of everyone's interests and concerns. There was anticipation for the translation of the vision document already shared and the results presented by Ghent University regarding the developed 3D-printed dike element "Hexabloom" (see Workshop 3), into concrete demonstrations for the future eco-dike. The discussion revealed that the proposed designs enjoyed broad support from the stakeholders present, who agreed with the considerations made. The stakeholders asked several practical questions about the design plans (dealing with potential asbestos, ecological anchoring options, bicycle route, etc.), which were answered in detail and substantiated. Although there were no concrete objections or suggestions for a modified design, the following conclusions can be drawn based on this session:

- There were concerns about accessibility and the safe use of the eco-dike, given the fact that one of the dike structures presented (mini-HARO blocks) has relatively large openings. The consulting company that is to prepare the technical design was able to guarantee that it complied with the norms governing the design of public spaces. Furthermore, it was discussed with the stakeholders that the project documents shall leave room for the implementation of possible necessary safety measures.
- The objective and the value of the eco-dike is clear to the stakeholders because they received sufficient background information through the co-creation process. It was, however, remarked that this would not automatically be the case for the residents of the community of De Panne and visitors to the project zone. With an eye on the construction and environmental permitting request and the public research that will be done in this framework, the necessary communication shall therefore be provided. MDK will take this on in collaboration with the community of De Panne.

For a report on the other points that were brought to the table, we refer the reader to Appendix 9.4, the report from the stakeholder briefing.

8. Conclusion

8.1 Outlook to the preferred scenario

The stakeholder group did not express a clear and unambiguous preference for any one specific scenario or recreational connection; however, there was a consensus on the importance of an integrated approach that prioritises safety while combining nature and recreation. In this regard, a renovated eco-dike in the western subzone appears appropriate, as it provides the necessary safety guarantees and can be combined in the short term with the desired recreational opportunities, while offering ecological added value in the longer term through siltation, with room for ecological development. It was also decided that the potential for natural dune development in the eastern subzone should be utilised and tested, as this aligns seamlessly with the sustainable vision for this area. Through the implementation of pilot studies, including those on the eco-dike and hybrid NbS, and intensive monitoring to reduce knowledge gaps and risks, a final choice for a project design for the entire study area can be developed and made possible.

8.2 DD-hybrid prototype: eco-dike: the four demonstrators

Based on the co-creation process led by MDK—specifically the “must-haves,” “nice-to-haves,” and “no-go’s,” as well as the vision developed for the project zone—and the bio-receptive 3D-printable dike element developed by Ghent University, design work for the various eco-dike demonstrations began in September 2025. To arrive at this design, SWECO (the contracted consulting company) conducted the necessary market research into various options for (eco) blocks, based on several pre-established criteria. For the design, the final decision was made to create four demos, each approximately 38 meters long, in which the first eco-block developed by Ghent University, “Hexabloom,” will be compared with three other blocks, namely: (2) Eco block Forte (Martens group)⁹, (3) Basalton Quattroblock (Holcim)¹⁰ and (4) Mini Haro. While the Ghent University block will be 3D-printed, blocks 2 and 3 are readily available on the market (risk mitigation), and block 4 will need to be manufactured. This preliminary design, which will be developed into a full technical design in the coming month, was positively received by all stakeholders present during the stakeholder briefing (§7). The only comment here is that for demo four (Mini Haro), measures will still need to be taken to ensure safety when accessing the dike slope. The location, namely the western side of the project zone, was also determined as a direct outcome of the co-creation.

8.3 Co-creation

⁹ Or an equivalent block

¹⁰ Or an equivalent block

Overall, the co-creation process can be viewed as a successful and educational experience. The participants were enthusiastic and proactive, and the insights gained by Maritieme Dienstverlening en kustregarding stakeholder interests will also prove useful in future projects. In addition, the process has also contributed to a better mutual understanding among the stakeholders involved and provided insights into potential collaboration.

The most significant outcome of the co-creation process is, above all, the support it has generated and the clear understanding among all stakeholders of the various considerations MDK must consider in coastal management and similar coastal protection projects. Important initial steps have also been taken toward a widely supported vision for the future of the project area.

In addition to building support and fostering a better understanding among all stakeholders, the process also yielded a great deal of valuable input regarding the feasibility of obtaining permits for the eco-dike. This was made possible by the fact that the relevant government agencies were also involved in the discussions. Finally, although the co-creation process did not directly result in a detailed design for the eco-dike, it made an important contribution to: formulating the necessary criteria against which the options could be assessed, the final selection of the demo locations, and the realisation that certain measures must be taken to ensure safety.

Stakeholders will be kept informed about the construction of the demos as soon as more information becomes available.

MDK also plans to engage stakeholders after the DuneFront project concludes by providing feedback on the monitoring and evaluation of the demonstrations. These insights, together with those from the co-creation process, will contribute to a long-term approach to dune base reinforcement in the project area.

9. Appendices

9.1-DuneFront_Cocreation Workshop 1_Minutes Arcadis 260624

9.2-DuneFront_Cocreation Workshop 2_Minutes Arcadis 071024

9.3-DuneFront_Cocreation Workshop 3_Minutes Arcadis 041224

9.4-DuneFront_briefing preliminary design pilotproject_MDK 2026

10. References

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