Deltares

Conceptual framework for Building with Living Nature

Historical perspectives on the Building with Living Nature concept

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Contents

1 Introduction

As a result of changes in societal demand and technical developments, water management and engineering are moving from hard traditional structures like dikes and dams, to designs in which natural structures and processes are incorporated. One of the underlying factors in this development is the increasing awareness of the impacts of climate change and its effect on water levels and extreme events. Furthermore, water managers are expected to create more safety, opportunities for recreation, and other benefits, with increasingly smaller budgets. This requires infrastructure that combines multiple functions.

In the Netherlands, a country especially prone to phenomena like floods due to its low elevation, a trend of making use of the ecosystem for flood defense is observed in response to these changes. There is a range of concepts associated with this relatively new type of engineering.

Building with (Living) Nature (BwLN) is one of the main concepts to encompass engineering solutions based on ecosystem services, and is currently widely used by universities and professional schools, as well as by other research institutes. Professionals who have to design, construct and manage structures based on this concept however, have not yet been provided with a cohesive overview of definitions and concepts around Bw(L)N. Such an overview could aid in their understanding of the concept, and could eventually lead to the increased practical implementation of Bw(L)N in engineering designs.

The RAAKPro project is aimed at making knowledge on Bw(L)N available for professionals and students. The goal of the underlying document, which was produced as a cooperation between Hogeschool Zeeland and Deltares, is to create a cohesive overview of Bw(L)N concepts.

Goal of Work Package 1 (Concepts): To provide a scientific foundation for the Bw(L)N concept for professionals in order for them to better incorporate Bw(L)N in their designs.

The specific goal of this report is to provide a background on the BwN concept in relation to related concepts, as well as give an overview of the developments in water management that have lead to its origination.

The questions answered in this report are:

- What is Bw(L)N?
- How did the concept of Bw(L)N originate?
- What were the societal and technical developments that facilitated the origination of Bw(L)N?
- Which consortia are involved in Bw(L)N?

The report is part of Work Package 1 (Concepts) within the RAAKPro project, and provides a history of Bw(L)N (Chapter 1), trends in water management as a result of societal and technological developments (Chapter 2), and programs (Chapter 3) in Bw(L)N. In the final chapter, the main conclusions are provided.

2 History of Building with Nature

2.1 Building with Nature

For long, an anthropogenic view of the world dominated, placing humans above nature. In 1969, Ian McHarg made a case for the eco-centric view, in his book 'Design with Nature', in which humans are part of nature. He discusses the relationship between spatial use and ecology with the aim to make optimal use of the opportunities the land provides, which should be taken into account mainly during the building of cities. This has probably laid the foundation for the idea that building and nature could be integrated. Here, an overview of current concepts and theory that aim to do so is given. Next to this, the societal changes that have lead to the generation of separate concepts are discussed. Particular attention is paid to concepts that relate to so-called "Building with Nature" and "Building for Nature".

The concept 'Building with Nature' was introduced by the engineer J.N. Svasek in 1979. The idea is based on morphological theories and uses 'soft' solutions for coastal defense with a focus on using materials and forces of nature (Waterman, 1980-2008). Waterman defines the essence of this concept as follows: 'Flexible integration of land-in-sea and water-into-the-new-land, using the materials, forces and interactions present in nature, in which existing and potential nature values are incorporated, as well as bio-geomorphology and geo-hydrology of the coast and sea floor'.

In 2008 the Ecoshape foundation was constituted to practice 'Building with Nature' and further define and study the concept. Meanwhile, Ecoshape has set up a large research program, which is executed in cooperation with a number of partners, including Deltares.

The 'Building with Nature' research program has a range of focus points (www.ecoshape.nl):

- The collection and development of ecosystem knowledge to make (water)building with nature possible;
- Study how the concept of Building with Nature can be integrated into society and make sure that this happens;
- Developing science based design rules and standards;
- Developing expertise in relation to the use of Building with Nature;
- Concretizing the concept through examples of Building with Nature solutions.

2.2 Building with Living Nature

Building with Living Nature, is part of the Building with Nature concept. Building with Nature mainly focuses on solutions that use natural processes, whereas Building with Living Nature aims at using services of ecosystems that aid in flood risk mitigation, such as wave dampening properties of mangroves and oyster reefs. In Building with Nature projects use is mainly made of abiotic, 'non-living', natural processes, such as dispersion by wind and currents to reinforce the coastal foundation.

2.3 Definitions

For studying the unique aspects of Building with (Living) Nature, it is important to know which (international) definitions relate to this concept and to have a clear view of the playing field. There are many concepts that have similarities with Building with (Living) Nature, such as green adaptation and ecosystem-based management. However, terminology may often be rather confusing and is used inconsistently. Apart from the definition of Building with Nature of

Waterman, a number of other definitions are used. Ecoshape for example defines Building with Nature as ‘Eco-dynamic development and design’. This definition mainly refers to using dynamics of natural systems in building projects. Making use of organisms to strengthen human structures is also called ‘Ecological Engineering’ or ‘Eco-engineering’ (Text box 1). We will discuss the details of differences in definitions, and distil a clear definition of Building with Living Nature, which clarifies the relationship with other concepts.

TEXT BOX 1: Eco-engineering

Howard T. Odum coined the term ‘eco-engineering’ in 1962. He defined it as: ‘the cases in which the energy humans provide is small in comparison to natural sources, but big enough to produce large effects in the final patterns and processes’. The self-organizing capacity of the system is a focus point within this term. Parallel to this, the term ‘eco-engineering’ was also introduced in China in the 60s. This was mainly used in the wastewater treatment sector. Qi & Tan (1988; from Mitsch & Jorgensen, 2003) broadened this by stating that ecosystem design, the main task of ecological engineering, could be used to solve issues on a global scale. In Central Europe and the USA eco-engineering and eco-management also started to establish, and with the creation of the journal ‘Ecological Engineering: The Journal of Ecotechnology’ it was made available to the general public in 1992 (Mitsch and Jorgensen, 2003). In 2003, the definition was broadened by Mitsch & Jorgensen to ‘the design of sustainable ecosystems that integrate human society with its natural environment to stimulate both’.

Eco-engineering is related to the concept ‘Building with Nature’ and has perhaps contributed to its creation. It is debatable where Building with Nature distinguishes itself from eco-engineering. Building with (Living) Nature contains a clear governance component and in projects special attention has been paid to a collaborative decision-making process. Integration between different sectors and stakeholders is a key element of Building with Nature. Furthermore, Building with Nature aims at creating win-win situations. The Building with Nature program of Ecoshape in the Netherlands strives to ‘use the forces of nature to create water related infrastructure and create chances for nature at the same time’. Until now, Building with Nature has focused solely on water issues.

Next to the concepts mentioned above, there is a range of other terms related to Building with (Living) Nature (See text box 2). Since these are less widely used, these are only discussed briefly.

TEXT BOX 2: Concepts related to Bw(L)N

Natural infrastructure
- Improving the nature value of existing infrastructural structures.

Green infrastructure
- The full scale of ecosystem-based approaches in which ecosystem services are an integrated part of the infrastructural solution (Hulsman et al., 2011)

Hybrid engineering:
- Using an ecosystem-based solution for coastal rehabilitation next to large-scale engineering interventions Nature-based flood defense
- A more general term, used to describe natural defense structures and processes against flooding

Green adaptation
- Green Adaptation aims to embed natural functions in land and water use planning in order to not only strengthen livelihoods and support development, but also to enhance ecosystem health. The focus is on adaptation to climate change.

Ecosystem-based adaptation
- A more general term, used to describe climate adaptation measures that make use of ecosystem services.
- Defined as: 'The use of biodiversity and ecosystem services as part of an overall adaptation strategy to help people to adapt to the adverse effects of climate change. This includes the sustainable management, conservation and restoration of specific ecosystems that provide key services'. (ref!)

Ecodynamic design
- Integrating infrastructure into the dynamics of the natural system. The process of EDD (Eco-Dynamic Design) enables professionals and stakeholders to look for opportunities in infrastructural designs.

Ecoremediations
- Bulc & Slak, 2009
  'Protection and restoration of environment using natural processes in ecosystems'.

Biotechnological Management
- By Greenway, used in e.g. wetlands

Environmental biotechnology
- 'The development, use and regulation of biological systems for remediations of contaminated environments for environment-friendly processes'

Living shoreline
- The overall concept of Living Shorelines is to provide habitat which will grow and change as water levels change

2.4 Differences and similarities of concepts in relation to Bw(L)N

In general, it could be said that Building with Nature makes use of natural processes, organisms and ecosystem services for solving problems in delta areas. Building with Living Nature would then be the use of species and ecosystem services to enforce functions/multiple use of space on the boarder of land and water. In
Figure 2.1 most used terms are grouped. The most generally used terms are placed in the middle and other concepts are organized around these.

Two divisions are made between the concepts. First the part below the green line focuses on flood defense solutions and the part above the green line shows more general concepts that can also be used for other types of infrastructure or building projects. Further, the red line divides between concepts that take the infrastructural solution as a basis (on the right) and concepts that take the ecosystem as the basis for the solution (on the left).

Two concepts are not always clear in this respect. Hybrid engineering is a rather new term and refers to using an ecosystem-based solution for coastal rehabilitation next to large-scale engineering interventions. Further, the building with nature concept is in application sometimes more focused on the coastal defense function in combination with using natural processes, such as sand nourishments. Some of these solutions can lead to unwanted side-effects however. For example, ecosystem-based sand mining and nourishing does have negative ecological side effects, although this is not the intention.

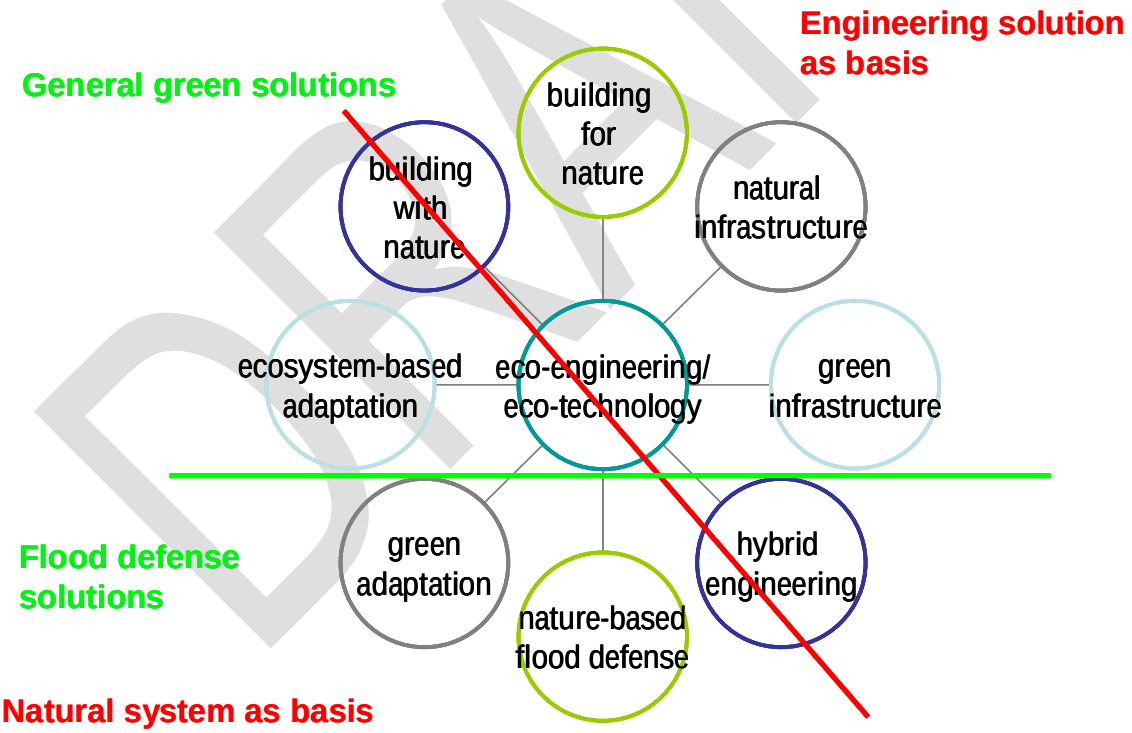

Figure 2.1 Diagram of terminology for concepts making use of ecosystem services in planning and design of infrastructural projects

2.5 Ecosystem services

A recurring theme in all these concepts is making use of natural functions and processes for functional purposes, often in relation to water management. Functions of natural systems that directly benefit humans are also referred to as ‘ecosystem services’. Ecosystem services became common language after the Millennium Ecosystem Assessment (2005). In there they are defined as: “the benefits provided by ecosystems to humans, which contribute to making human life both possible and worth living”. The last years it has proven a very powerful concept that derived considerable international recognition. The concept of “ecosystem goods and services” is usually used as a synonym to ecosystem services (TEEB 2010).

3 Water management developments in relation to BwN

At the basis of the development of the Building with Nature concept lie societal and technological developments. In this discussion, the focus lies on development in the Netherlands, since these are considered most relevant for Dutch professionals.

According to Groote et al., (2010, draft) on which this paragraph is based, a change in thinking has taken place from building from nature to building with nature in the last decennia. This change has taken place in three stages, which will be sketched in their historical context: 1) Ecological recovery, 2) Nature recovery in a broader perspective and 3) Nature development as an integrated part of spatial planning in light of climate change. Integrated Coastal Zone Management (ICZM) is also discussed in this chapter since this development focuses specifically in the coastal zone.

3.1 Building with Nature: Ecological recovery (1989-1995)

In the end of the 80s, the Derde Nota Waterhuishouding was adopted, which looks at the water system as a whole and no longer looks at management of separate water bodies. This gave ecological recovery a new impulse, with projects aiming at maintaining and recovering biodiversity, and specifically characteristic Dutch species. The Ecologische Hoofdstructuur (Ecological main structure), EHS, is a result of the striving for connecting different areas to improve biodiversity.

Rijkswaterstaat (Ministry of Infrastructure and Environment) started the program 'Herstel & Inrichting' (Recovery & Installation). Projects under this program are aimed at creating foraging and resting areas for water birds. Some of these projects have the secondary goal of creating different zones for recreation and nature. In this phase the cooperation of different ministries on nature recovery also starts, i.e. in the program 'Nadere Uitwerking Rivierengebied (NURG)'.

3.2 Transitional phase: Nature recovery in a broader perspective (1995-2005)

In 1993 and 1995 high water levels were measured in the Netherlands. This drew attention from within the NURG program to water safety through the Deltawet Grote Rivieren (Delta Law Large Rivers). The Vierde Nota Waterhuishouding also builds on this and places nature recovery in a broader perspective.

Next to the NURG-program, 'Room for the River' for the river Rhine and 'Maaswerken' for the Zand- en Grensmaas evolved. Furthermore, the first time that nature development was the endpoint of a project, rather than economic arguments (mining) took place in the shape of the Maaswerken project.

At the start of the 19990s the Basis Kustlijn (BKL, Basic Coastline) was laid down. This meant that from then on, there is a reference line for the extent of the coast, which should be maintained by nourishments. As a consequence of the installation of the BKL, Zwakke Schakels ('Weak Links') are identified; places where coastal defense should be combined with measures that have a positive effect on the surrounding landscape or economy.

In the South-Western Delta recovery of freshwater-saltwater transitions was developed in order to recover characteristic landscapes. Rich rivetments ('Rijke Dijken') delivered technological knowledge on how foreshores and water level fluctuations work, but also played a role in improving flood defense of hard structures by creating habitat for marine organisms.

The first project in which multiple parties cooperate to maintain and strengthen the equilibrium between recreation, nature and economic stakes was 'Integrale Inrichting Veluwemeren' (IIVR) in 1996. The program 'Herstel & Inrichting' in the meantime got an impulse by the

creation of the Water Framework Directive, which should bring Dutch water into 'Good Ecological Status'.

3.3 Building with Nature: Nature development as integrated part of the 'gebiedsgerichte' benadering (regional approach)

From 2008 onwards, the attention for climate change is increasing, which is demonstrated in the Nationaal Waterplan (2009) and Deltaprogramma (2010). In these documents, 'moving with nature' is explicitly mentioned as a water management strategy. Problems occur however due to the difference in time scale of climate change (50-100 years) and long-term plans (30 years maximum).
The firs steps in joint decision making for 2030 for the Lake IJssel area was made in the 'Randstadbesluiten Amsterdam Almere Markermeer'. Many stakeholders came together for this plan to practice a new way of operating and managing the lake. This new way of thinking is in line with the Gebiedsontwikkeling 2.0, in which public and private parties cooperate, working from the ecosystem based approach.

3.4 Integrated water resource management

The concept of Integrated Water Resources Management (IWRM) was developed as an approach to manage the scarcity of the earth's fresh water resources. The approach first appeared on the international agenda at the 1977 UN Conference on Water, held in Mar del Plata, Argentina (Rahaman & Varis 2005). It was a response to water management approaches that were thought to be failing. These water management approaches were mainly sectoral; each sector (agriculture, industry, domestic water supply, environmental management), managed water resources separately managed, with little or no coordination between sectors. Not only the coordination between sectors was lacking, there was also little or no coordination between geographical areas. The problem caused by such a lack of coordination is illustrated by the case of river basins, where upstream land and water use practices have a direct impact on water quantity and quality downstream. As a result, water management was usually fragmented and uncoordinated, leading to unforeseen and unintended social and environmental effects (Mei Xi 2006).
Also, water management approaches have generally been dominated by top-down management, with little attention for local needs. Sometimes, central governments also tend to focus more on the increase of water supply, and not so much on demand management. This leads to inefficient and unsustainable water development projects.

IWRM is seen as a means of addressing global water problems and working toward a sustainable future for water management (Mei Xi 2006). It is defined as '*a process, which promotes the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems'* (GWP, 2000). The GWP emphasizes that water should be managed in a basin-wide context, under the principles of good governance and public participation.

The United States Agency for International Development (USAID) offers a more detailed and functional definition: *"IWRM is a participatory planning and implementation process, based on sound science, which brings together stakeholders to determine how to meet society's long-term needs for water and coastal resources while maintaining essential ecological services and economic benefits."*

From these definitions, a few key elements can be distilled (Mei Xi 2006):
- IWRM is a *coordinated* process that *brings together stakeholders*. It is also a river basin approach.
- IWRM is a sustainable approach. It focuses on both *economic and social welfare and equity* as well as *protecting ecosystems*.
- IWRM is a scientific approach, using *scientific data* /tools to provide sound base for judgment.
- IWRM emphasizes *proper governance.*

The Building with Nature approach as such is a technical approach, that incorporates elements of the IWRM approach: it pays attention to functions/stakeholders, even aiming at creating additional benefits/functions/ecosystem services and it is a sustainable approach as well as a scientific approach.

3.5 Integrated coastal zone management

In the mid 1990's integrated and multidisciplinary design and planning efforts began to emerge. Awareness was rising that socio-economic interests were not always opposing nature conservation goals. These developments formed an ideal stage for the emergence of Integrated Coastal Zone Management (ICZM) (launched in 1994). The main purpose of ICZM was to integrate safety against flooding with other functions of coastal areas.

Lately, IWRM and ICZM approaches have been integrated into one approach: Integrated Coastal Area and River Basin Management (ICARM); the ICARM approach has been adopted by organizations such as UNEP and the EC.

4 Programs involved in Bw(L)N

There are may different programs, both in the Netherlands and worldwide which are involved in Building with Nature. Some involve multiple types of organizations, others focus on one group of professionals (Table 4.1).

In the Netherlands the two main programs are Ecoshape and Natural Climate Buffers. Internationally, Living Shorelines in the USA is a program working on Building with Nature.

Table 4.1 Overview of programs involved in Bw(L)N

Consortium	Goals of program	Partners	Types of organizations involved	Website
Ecoshape	Constitute a paradigm shift Strengthen the image of the image of the Dutch water sector Collect and develop ecosystem knowledge Study how BwN can be embedded in society Develop scientifically founded design rules and norms Develop expertise in relation to the BwN concept Concretize the concept by using BwN examples	Van Oord, Boskalis, IHC Merwede, Shell DHV, Arcadis, Witteveen & Bos, Royal Haskoning Deltares, Imares, NIOZ (including NIOO-CEME) TU Delft, University of Twente, WUR RWS-building service ASTRO (Lofar), VBKO, the city of Dordrecht	**Executers** **Consultancies** **Knowledge institutes** **Universities** **Management** **Others**	http://www.ecoshape.nl/
Natural Climate Buffers	Realize climate buffers to improve water safety in the Netherlands	De 121Landschappen, Natuurmonumenten, Staatsbosbeheer,	**NGOs**	http://www.klimaatbuffers.nl/index.php

		Vogelbescherming Nederland (Bird Conservation Netherlands), Waddenvereniging, Wereld Natuur Fonds		
Living Shorelines	The overall concept of Living Shorelines is to provide habitat which will grow and change as water levels change	U.S. Fish and Wildlife Service	**Government**	http://ccrm.vims.edu/livingshorelines/index.html

The overall program for Building with Nature in the Netherlands is executed by Ecoshape. The Ecoshape foundation involves partners from different sectors; executers, consultancies, knowledge institutes, universities, management and others. However, there are some important players in the field of Building with Nature that are not involved in Ecoshape, such as Main Port Rotterdam and NGOs.

Another large program involved in Building with Nature in the Netherlands is Natural Climate Buffers. This program focuses on natural flood protection. There are a range of projects within this program in the rivers and Lake Ijssel, on the coast, in low-lying marshland and on sandy soils and hills. In this consortium, only NGOs are involved, but there is a lot of cooperation with partners from other sectors such as Royal Haskoning and Alterra.

Living Shorelines (US) is an alternative strategy to prevent coastal erosion, by creating nature based shorelines. The program is promoted by state governments, as well as local governments and state agencies.

While most of these initiatives focus on practical applications, in which professionals and scientists work together, the RAAKPro project aims at developing and deepening knowledge on Building with Nature and making the link to education and to professionals in their daily work.

5 Conclusions

Bw(L)N

Building with Nature makes use of natural processes, organisms and ecosystem services for solving problems in delta areas. The main difference between Building with (Living) Nature and Building with Nature is that Building with Nature makes more use of natural processes in coastal defence, whereas Building with Living Nature utilizes living structures, such as mangroves and oyster reefs for coastal protection.

Building with (Living) Nature is not a unique concept. There is a range of associated concepts, in which the main differences lie in focus; some are based more on the natural system, whereas others have been designed from an engineering perspective, concepts can be more general green solutions, or specific flood defence solutions.

There is one main concept that binds all concepts related to Bw(L)N, and that is making use of ecosystem services.

Origin and developments

The term 'Building with Nature' was first used by Svasek in the late 1970s, but was further developed and defined by Waterman in the following decades. The development of the concept is affected by a range of developments such as:

the transition from designing nature and flood defense separately into an approach where functions were combined,

the increasing interest in public-private cooperation as well as multi-disciplinary cooperation,

external factors such as climate change, which pose new technological challenges to existing and future designs

The overall trend that can be observed underlying these developments is 'system thinking'; looking at the socio-economic and ecological system as a whole. Even though the BwN approach involves stakeholders, and a range of different ecosystem functions, it still has more ties to the ecological system than the socio-economic system and is essentially a technical approach. Ecosystem services is the term that connects socio-economic benefits, such as flood defense or revenues from aquaculture, and the ecosystem itself.

Bw(L)N programs

There are two main programs involved in Building with Nature in the Netherlands; Ecoshape and Natural Climate Buffers. In Ecoshape, a range of private and public partners cooperate in projects, whereas in Natural Climate Buffers, the organizations involved are only NGOs. Living Shorelines in the USA is also involved in Building with Nature, and is funded by local governments and agencies.

Ecosystem services

Making practical use of ecosystem services in planning and design remains a challenge. Although there is considerable knowledge on ecosystem functioning, this knowledge was initially obtained from a different, non-engineering perspective. So, although we often know how to restore and manage ecosystems for the sake of conservation, there are no general rules (yet) on how to manage ecosystems to perform certain functions. Moreover, data on ecosystem functioning have generally been collected by ecologists and therefore, do not always translate to spatial planners, engineers and water managers. Making use of ecosystem services for functional purposes requires people with different backgrounds to start speaking the same language. In this respect, there is still a world to win.

6 References

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To be completed

7 Projects under Ecoshape

Ecoshape
The cases that were studied by the Ecoshape consortium are grouped as follows:

- Case Singapore

This case aims to study the effects of turbidity on the ecosystem. The focus lies on corals, mangroves and sea grasses.

- Case South-West Delta

The challenge within this case is to make sure that the erosion of the tidal flats and area in the Eastern Scheldt is halted. A sustainable solution that leads to a new equilibrium state of the estuary is sought.

- Case Hollandse Kust (Dutch Coast)

Within this case the way in which sand nourishments are taking place are innovated, for example through the Sand engine. Nourishments such as these should guarantee the safety and development of the coast in a sustainable manner.

- Case Lake IJssel/Marken

The challenge in this case is to come with Building with Nature solutions to execute the ecological and planning goals for Lake IJssel and Lake Marken.

- Eco-dynamic design

Ecoshape strives to integrate Building with Nature into design processes for new projects. The creation of new chances for nature are integrated in this method.

- Public Wiki

In order to improve knowledge- and data management, Ecoshape has created a public Wiki/Open Earth platform.

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