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Building with Nature Business Guidance Report

Deliverable 2 of Work Package 5 - Upscaling: business case development and opportunity mapping, part of the INTERREG Building with Nature project.

http://www.northsearegion.eu/building-with-nature/

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Contents

Building with Nature 1
Business Case Guidance Report... 1
Colophon 2
Contents 3
Introduction 4
2. Scope and context – Societal challenges 8
3. BwN options and system analysis 14
4. Selection of preferred BwN measure... 20
5. Optimizing design of BwN measure 34
6. Implementation: Stakeholder involvement and arrangements 41
7. Conclusions 60
8. References 61

1. Introduction

INTERREG Building with Nature project

The INTERREG Building with Nature (BwN) project demonstrates BwN solutions that utilize natural processes to deliver flood risk and coastal erosion management whilst enhancing ecosystem services. The overall objective of the INTERREG BwN project is to make coasts, estuaries and catchments of the North Sea Region more adaptable and resilient to the effects of climate change through the use of BwN measures. INTERREG BwN creates joint transnational monitoring programmes, uses state-of-the-art analysis methods, develops improved designs and business cases for BwN solutions.

This report is a deliverable of Work Package 5 'Upscaling: business case development and opportunity mapping'. The objective of WP 5 is to: 1) show available methodologies for business case development and valuation; 2) provide guidance for BwN concepts to approach business case development; and 3) to demonstrate opportunities of BwN by giving good examples of business cases for BwN. This report is the draft business case guidance document, the deliverable of phase 2. The guidance will be used in the next phase to "guide" the description of a number of high level cases, quick scans, in order to test the guidelines, enrich it with more examples and important characteristics that determine the upscaling of BWN solutions.

Why a business case for BwN?

BwN is applicable worldwide in a wide variety of settings but still needs to be recognized as a viable strategy that adds value through co-benefits to 'conventional' concepts. An evidence base is needed to illustrate and enhance the (societal) value of BwN projects and to show how these (co-)benefits can be quantified.

The BwN approach is often associated with uncertainties regarding (long term) performance. The evidence base of BwN is small compared to conventional approaches, and ecological solutions are sometimes less predictable than man-made structures. Therefore, dealing with and reducing these (perceived) uncertainties is just as important as valuating the co-benefits to stimulate up-scaling of BwN.

There are many definitions of a 'business case', but most entail an economic justification to provide a decision maker of a proposed project or undertaking, with economic information generally based on expected financial benefit. For public sectors, however, it makes sense to select and evaluate BwN measures on their impact on welfare from (co-)benefits, instead of financial benefits. In this report, we define a business case as follows:

‘*A business case is a decision support framework that gives insight in the answers to these two questions: 1. Does the project provide increased welfare for society? 2. Can we identify sources and mechanisms for financing?*’

A business case is an important tool to stimulate upscaling of the BwN approach. Upscaling can be interpreted in multiple ways: *Horizontal upscaling*, which is the export of existing BwN concepts to new locations; *Vertical upscaling*, which is the recognition and adoption of the BwN benefits by policy makers and their effort to stimulate BwN implementation; and *widening the scope*, using BwN solutions for multiple issues (not only flood risk but also others such as recreation, food production and climate change adaptation).

Scope of this report

This report is a guidance to answer the two questions stated above, this report follows five steps (Table 1). Each step is described in one of the chapters that provides an overview of useful methodologies and products to meet the step’s objective. Developing a business case for BwN is an iterative process, in which successive stages build upon new insights. The five steps form a circle and are mutually dependent (Figure 1). For example, the interests and opinions of stakeholders (Step 5) play a large role in the valuation of co-benefits and should thus be used as input for the selection of a preferred alternative (Step 3).

Table 1 Five steps and their objectives that form the core of this guidance report

Step	Objective
1. Scope and context	Identify key societal challenges for which BwN could pose a solution.
2. System analysis	Analyse the physical, socio-economic and institutional system to identify potential BwN solutions (to address the societal challenges identified in Step 1).
3. Selection of preferred alternative	Select the preferred BwN alternative based on cost-effectiveness and value of the (co-)benefits.
4. Optimize design	Optimize the detailed design, to increase the expected delivery of (co-)benefits and reduce uncertainty.
5. Stakeholder arrangements	Facilitate stakeholder engagement to ensure societal support and explore financial and contractual arrangements.

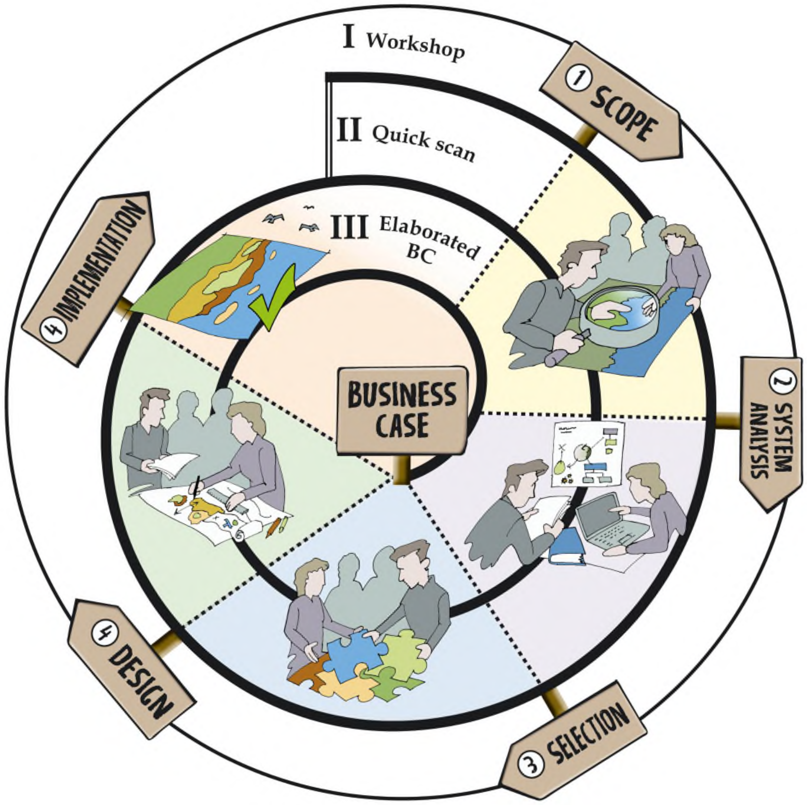


Figure 1 Five steps presented in a circle, showing the iterative process and their mutual dependencies

How to use this guidance report

One of the characteristics of BwN solutions is that they are adapted and designed for the local circumstances. The steps, methodologies and products presented in this report can be used by other INTERREG project partners. The guidance is meant to select the best project that tackles the local problems but also contributes to 'high over' big challenges. As shown in figure 1, the process has three rounds and starts with an overall workshop. After the ***Workshop*** one should be able to answer the following questions:

- What are possible BwN solutions for the local problem and how can they contribute to the global sustainable challenges?
- Which party is interested in the local solutions?
- Which party is interested in the contribution of the global challenges?
- Which financial institutes or instruments can help to make a business case?

The result of the workshop is a complete project-cast (each party that might have interest) and a broad set of opportunities. The next phase is a ***quick scan*** for business cases within their own projects (also called 'living laboratories'). After the quick scan, one should be able to answer the following questions for each of the five steps:

1) What information is already available, that is needed for this step?
2) What are the conclusions for this step if I use the limited data available?

3) What data gaps exist that need more research?

The results of the quick scan form the starting point of an ***elaborated business case***, in which all analyses are executed in-depth and adjusted to the local circumstances. INTERREG BwN Work Package 5 will act as a support desk to perform the quick scan and the elaborated business case (the latter for a selection of projects).

2. Scope and context – Societal challenges

Introduction

The scoping process is visualized below in figure 2. It shows the connection between the global, regional and local level. It is important to emphasize that decision makers often operate on all levels at once: global challenges of climate change or food security need to be implemented in local projects. So the ability to zoom in and out is crucial for decision makers. Therefor this chapter has two main parts: an explanation on the scope of the different levels and an explanation on 'governance aspects' or in other words: how to efficiently get results out of these processes.

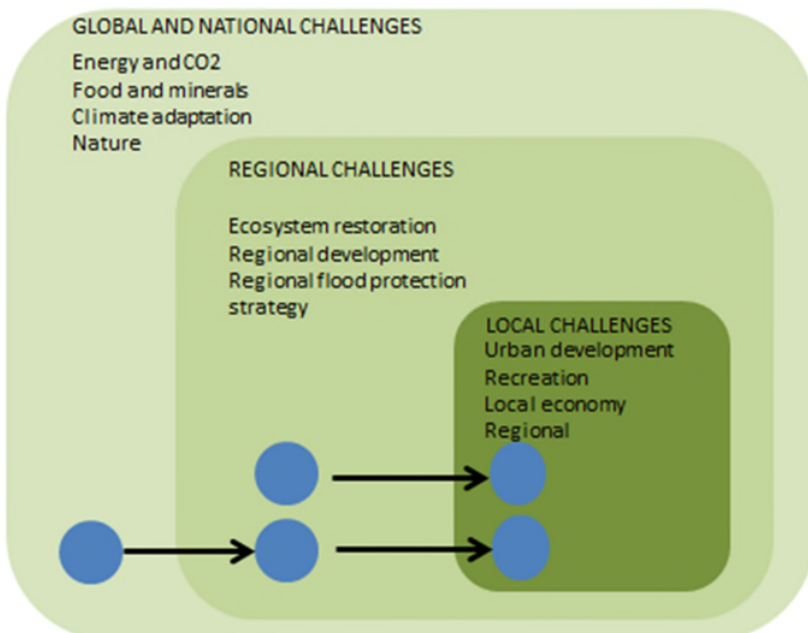


Figure 2 The scope has different levels. On the global level a BwN project should contribute to the sustainable challenges. In order to develop a successful project, the scope on the local level must be down-to-earth, clear, with limited stakeholders who feel responsible for the project.

Global and National Challenges

At this moment, climate change and all consequences play a major role in coastal and river management. Adaptation of the physical system in order to deal with extreme situations is one of the needs at present. But climate change has also worldwide effects on migration. Large areas of dryness and drought expand fast due to climate changes, leading to shortage of food resulting in conflicts and war. This forces people to move looking for food and peace.

Another worldwide trend is the energy transition; governments and companies invest in sustainable energy in order to reduce the CO_2 emission and to be independent of the political instable regions. This trend is becoming primarily a spatial planning issue; finding appropriate places for windmills, solar panels or biomass. Roughly 70% of the earth surface is sea and over 90% of human population lives in delta areas. The pressure on the marine and aquatic ecosystem will increase and some way or another, the rivers, the seas and the oceans will play a major role in the great challenges of the near future. For the short term, there is a growing attention for combinations of Water & Food and Water & Energy. If the BwN concept aims at upscaling, it would be wise to aim to contribute to these great challenges. This guidance helps policy makers and land owners to use the (extended) BwN concept to contribute to these great challenges. This 'high over' scope is subject in the first orientation on the project. So during the first workshop, one has to address how the BwN solution can contribute to the big challenges.

Regional Challenges

In many countries there has been an interest in Building with Nature, Working with Nature, Engineering with Nature or Nature based solutions for some years now. One of the results of the BwN approach is that coastal engineers broadened their view on how engineering challenges could be tackled. They learn not to focus only on safety and hard structures but develop a wider vision and understanding of the whole river basin or coastal system, including the functioning of the ecosystem and the effect of societal and economic pressure on the system.

In the INTERREG project the BwN concept is shared and developed by several countries around the North Sea. A comparison of a few cases learns that the possibilities for, as well as the added value of a BwN approach, depend strongly on the form of the societal organisation (see intermezzo box 1).

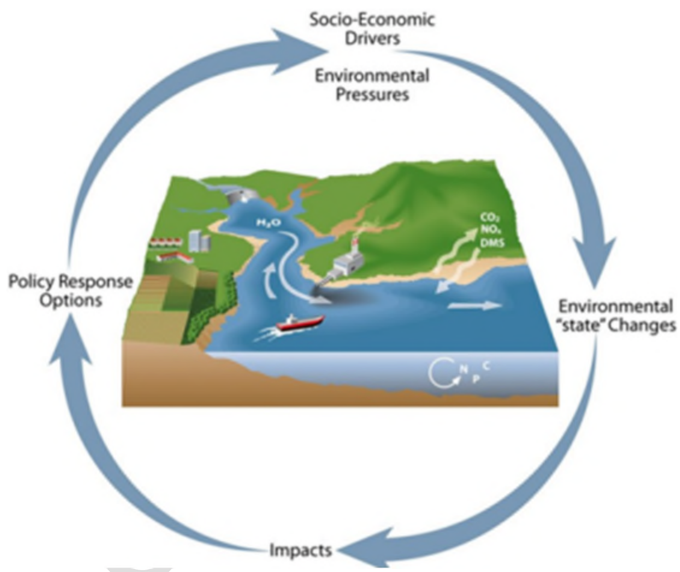
Intermezzo box 1

In Denmark the coastal zone is in possession of private landowners. The level of the main land is above sea level. The need to defend the coast is purely for preservation of land area; there is no serious danger of flooding. Each private land owner can decide to defend his coastal part, for instance with a hard structure. This hard structure can of course result in a problem for the adjacent coastal zones, but that is the neighbour's problem. It is however difficult to define a joint solution.

Applying this governance concept to the Netherlands would be dramatic. The Dutch need to defend half of their country against flooding. A coordinated coastal defence together with a successful river basin management is therefore a must and is arranged on a national governmental level. This causes the development of BwN in the Netherlands into an overall accepted approach for coastal management and for river basin management.

Local Challenges

In the Netherlands this meant that sandy solutions prevailed above hard structures. In tropical areas the BwN approach challenged the sector to develop new techniques that minimalized the turbidity due to dredging. Even techniques to cultivate coral in order to restore coral reefs were part of the BwN program. Ecosystems were not any longer restrictive for coastal projects, but it was a challenge to improve the functioning of ecosystems and to enlarge the societal value of nature.



BwN concepts realign easily with Integrated Coastal Zone Management (ICZM) approaches. ICZM takes socio-economic drivers and environmental pressures to a (coastal) system into account, and analyses what kind of changes are to be expected. These pressures are often man-made, for example because communities want to develop roads, hotels, cut mangroves, extract sand. All these impacts are analysed and discussed with communities, developers and decision makers. The aim of BwN is to become one of the policy response options, next to the more traditional 'hard' infrastructure measures.

How to come to results efficiently (governance)

In order to convince decision makers to choose BwN solutions, it is important to understand their drivers and their arguments. Especially on an international or national level, decision makers need to have a broader view than 'simply' managing coastal erosion or flood control. They will face challenges such as food security, economic growth and decline, climate change, urbanisation, growth and decline of population numbers, growing societal pressures on vulnerable deltas. Especially the regional economic systems have to deal with these challenges. This growing concern can be a chance for upscaling the BwN-concept.

At the same time 'decision makers' are hardly ever a homogeneous group: there are public and private decisions to be made, on a local, regional, national and international level. All these micro, meso and macro decisions are competing in an arena with uncertain rules, based on sketchy knowledge and with huge stakes involved. BwN solutions are competing with other solutions and need strong advocates in order to be heard. At the same time, the advocates of BwN solutions need to understand the policy arena and the playing field they are entering, in order to understand the challenges they are facing.

J.W. Kingdon has developed the 'garbage can theory' to describe decision making. In short, he acknowledges that there are at least three 'arenas' influencing decision making: the arena of 'problems', such as climate change, urbanisation, the lack of food security etc. The second is the arena of solutions, of which BwN is at least one. The third is the arena of decision making itself, where politicians deal with their own convictions and ideals, each other, the next election, the support of the general public.

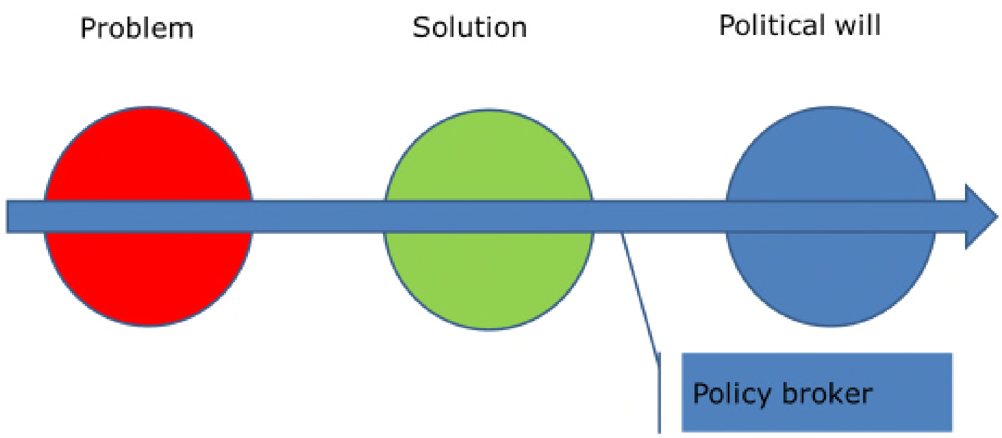


Figure 3 'Garbage can theory' by J.W. Kingdon

In order for a solution like BwN to reach the other arenas and actually come to live, a 'policy broker' is needed who understands the right timing and circumstances to find a window of opportunity. This policy broker can very well be an experienced BwN expert, who understands all three arenas and is willing and able to 'sell' BwN solutions outside his or her natural 'habitat'.

How to assess the societal challenges

BwN needs policy brokers. And an approach to enable policy brokers to assess and discuss societal challenges in such a way that people who deliver BwN solutions come into contact with decision makers and *vice versa*. A couple of steps can be defined in order to assess societal changes:

BwN policy brokers will know BwN solutions intimately. They might need to do research in order to understand societal challenges, and issues and understand the policy agenda and decision-making structures. Therefore, step 1 will be to research these two other arenas.

The next steps a BwN policy broker will have to perform, are:

2. Make a 'photo' of the local environment and situation, with focus on:
    a. Technical challenges
    b. Pressures on the environment
    c. Socio-economic developments
    d. Stakeholders
    e. Governance analysis, policy agenda and decision making

3. Look for smart policy options that will combine perceived issues with BwN solutions, and fit into current and future policy agendas.
4. Focus on agenda setting and implementation.

Example Noorderzijlvest; an entrepreneur as a policy broker

Picture: Noorderzijlvest

In the Northern part of the Netherlands a coastal defense challenge was solved by an innovative approach of a double dike with a field-lab for brackish agriculture in between the two dikes. This zone is frequently flooded by seawater. This brings in nutrients and salt and makes the soil inconvenient for traditional agriculture. However, an entrepreneur in salty vegetables is partner in this project and will exploit the brackish area. This case shows that risks (of brackish-soil) can be changed in a chance for benefits. The perspective of producing food in salinized soils can be a major game changer for the world-food challenge.

Example National Coastal Erosion plan of Colombia.

This assignment is funded by the Dutch government and the Colombian Government (50/50). The Dutch government wanted to include BwN solutions, the Colombian Government had other, more pressing concerns.

The only way to ensure that both clients were satisfied, was to broaden the scope of the analysis, and consider what kind of issues and challenges the Colombian local, regional and national public and private stakeholders where facing. This ranged from the need to protect vulnerable rain forests and coral reefs (ministry of the environment, the Colombian client) with very few local enforcement officers to drug lords wanting to develop mansions along the coast, local indigenous communities being forced of their land, corruption of local governors, erosion of crucial coastal roads, the desire of the middle classes to own an apartment in booming coastal towns (spatial planning, or the lack thereof) to NGO's wanting to protect and develop nature parks.
The other arena needed to investigate, was understanding how the Colombian government works, and how the process of decision making actually moves forward. In this case the solution proved to be to include the former vice minister of the environment and current NGO director in the team as 'policy broker', who was able to find the 'window of opportunity' in the Colombian

political arena to 'sell' the BwN solutions as part of a much broader development plan.

Summary:

So the scope varies between a worldwide scope and the local community with all kind of interests. In order to perform the right amount of scoping, the following checklist is helpful:

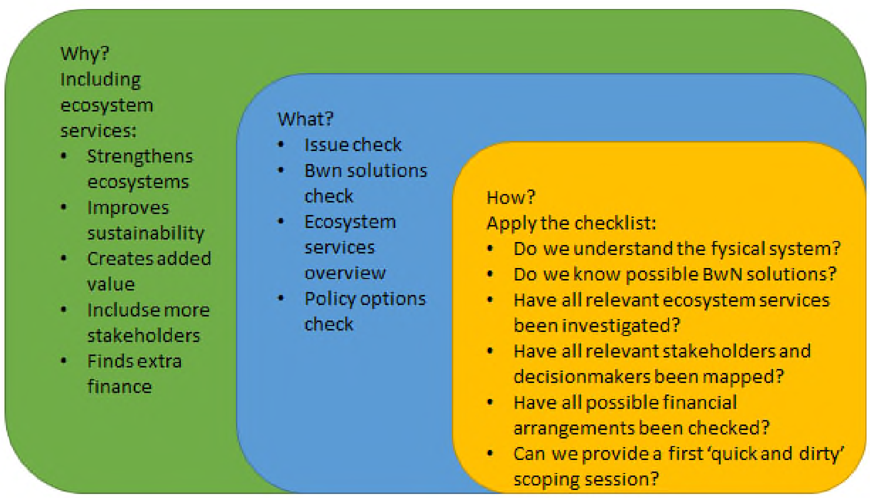
- Do we understand the natural system and the interaction between the environment and society?
- Have relevant system boundaries been drawn for a full assessment?
- Do we know the capacity of the system for delivering critical services?
- Are all possible BwN concepts explored and is the selection we are presenting justifiable?
- Are all related potential (ecosystem) services identified and assessed by relevance?
- Are all relevant stakeholders involved in a way that matches their role?
- Have relevant financial sources been addressed in the process and in the BwN design phase?
- Who acts as a policy broker?

3. BwN options and system analysis

Introduction

In order to benefit from the three arenas mentioned above, it is necessary to view the societal problems that need to be solved, the possible solutions that are being developed and the policy arena of stakeholders and decision makers. Look for 'windows of opportunities' and broaden the scope of BwN experts towards that of policy brokers. A practical way of making the connection is to analyse which ecosystem services can be provided, and how this interacts with BwN and with policy objectives

In the next paragraphs we will present possible ecosystem services. They form the background information for logical combinations with BwN solutions. In order to show the cohesion between ecosystem services and this guidance, the following figure may serve:



Ecosystem services and how they help to solve societal challenges

Ecosystem services are defined on a European level for example by BISE (Bio Information System for Europe, https://biodiversity.europa.eu/) as the direct and indirect contributions of ecosystems to human well-being. They support directly or indirectly our survival and quality of life. Examples of Ecosystem services that have interaction with possible BwN approaches are climate regulation, food production, water purification, regulating pests and diseases, soil biodiversity and cultural services. Standard classification of ecosystem services is CICES: https://cices.eu/

Climate regulation is one of the most important ecosystem services both globally and on a European scale. European ecosystems play a major role in climate regulation, since Europe's terrestrial ecosystems represent a net carbon sink of some 7-12% of the 1995 human generated emissions of carbon. Peat soils contain the largest single store of carbon and Europe has large areas in its boreal and cool temperate zones. However, the climate regulating function of peatlands depends on land use and intensification (such as drainage and conversion to agriculture) and is likely to have profound impacts on the soil's capacity to store carbon and on carbon emissions (great quantities of carbon are being emitted from drained peatlands). Carbon emission is one of the main concerns in the peatlands of the Netherlands ('Veenweidegebieden'), where soil subsidence, salinization, growing urbanization, loss of water quality and destabilization of (peat)dikes due to desiccation pose additional challenges. This cannot be solved with 'hard' infrastructure solutions; a combination will have to be found between changes in land use, spatial planning, infrastructure and BwN solutions.

Fertility of ecosystems for natural production of food is mainly influenced by the interaction of sea and rivers. Estuaries and wetlands are among the most productive ecosystems in the world, due to a continuous supply of nutrients and a natural refreshment. These areas produce loads of organisms as the basic for the marine food-pyramid and form a solid base for a sustainable harvest of healthy human food. The value of ecosystems is estimated to be much higher than the value of agricultural land (which costs much more to maintain and fertilize in order to be beneficial). The challenge for the future is to make salinized arable land more productive and to use the nutrients in the coastal waters efficiently and sustainably. Seaweed cultivation might be one of the future business in coastal systems contributing to the great challenge of food and energy transition.

Water purification by ecosystems has a high importance for Europe, because of the heavy pressure on water from a relatively densely populated region. Both vegetation and soil organisms have profound impacts on water movements: vegetation is a major factor in controlling floods, water flows and quality; vegetation cover in upstream watersheds can affect quantity, quality and variability of water supply; soil micro-organisms are important in water purification; and soil invertebrates influence soil structure, decreasing surface runoff. Forests, wetlands and protected areas with dedicated management actions often provide clean water at a much lower cost than man-made substitutes like water treatment plants. Under the European Water Framework Directive, a combination of ecological and chemical goals has to be reached. These ecological benefits can be very well combined with BwN approaches to improve flood protection. For example, new marshlands can both reduce the threat of flooding, and improve the ecology of water systems.

Pests and diseases are regulated in ecosystems through the actions of predators and parasites as well as by the defence mechanisms of their prey. One example of these regulating services is provided by insectivorous birds in farms that use most of their land for agriculture. More integrated aqua-cultural systems that are partly based on natural regulation processes often are a better alternative to intensive farming methods. Examples are rice-shrimp cultivation systems, mangrove shrimp farms and fish farms that apply cascade systems with different fish species that control disease vectors.

Soil biodiversity is a major factor in soil formation, which supports a range of provisioning services such as food, fiber and fuel provision and is fundamental to soil fertility, being a highly important ecosystem service in Europe. In addition, a diverse soil community will help prevent loss of crops due to soil-borne pest diseases. For water-management, a healthy soil will host a rich vegetation and increase the infiltration capacity of the soil which may increase retention capacity and reduce run-off.

Cultural services provided by ecosystems are also very important to EU citizens. Evidence can be found in the scale of membership of conservation organizations. For example, in the United Kingdom the Royal Society for the Protection of Birds has more than one million members and an annual income of over £50 million. In the Netherlands, the four largest Nature NGO's (WNF, Natuurmonumenten, Bird Protection and the 'Provinciale Landschappen') had a membership of 1.938.054 in 2016.

Although most people associate protected areas mainly with nature conservation and tourism, well managed protected areas can provide vital ecosystem services, such as the ones mentioned above.

Overview of BwN options for different natural systems, with their benefits

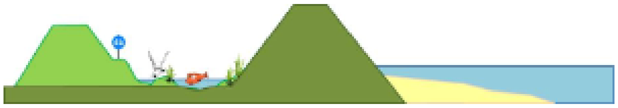
This section provides a brief overview of examples of the combination of BwN solutions and ecosystem services. For a more complete overview please visit https://publicwiki.deltares.nl/display/BWN1/EDD+-+Building+with+Nature+Building+Blocks

Nourishment, feeder beaches

The SandMotor: ***www.zandmotor.nl***

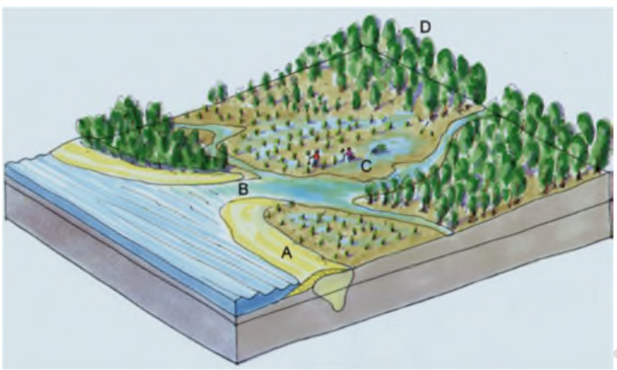
Feeder beaches like the Sand motor strengthen the ecosystem, offer opportunities for tourism and recreation.

Coastal zonation strategies



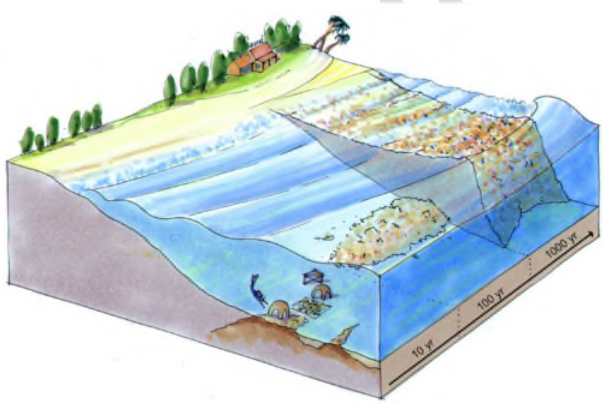
A salt/brackish zone between two dikes can also combine ecosystem services with flood protection.

Ecosystem engineers – Coastal forests



Reforestation, as shown here in Colombia, can be a good example of combining coastal protection via BwN measures (reforestation against coastal erosion and protection against flooding), the use of mangroves for ecosystem improvements and cultural services, and floodplain agriculture/improvement of spawning grounds.

Ecosystem engineers – shellfish and coral reefs



Development of shellfish reefs and coral reefs can be another combination of BwN measures (protection against coastal erosion and flooding) and ecosystem services like the strengthening of natural habitats, spawning grounds for fish (important source of nourishment in large parts of the world) and (eco) tourism

Coastal zonation strategies

Spatial planning is an important BwN measure, that might very well be combined with, for example, cultural services.

Example Haringvlietsluices

Haringvlietsluices (picture: Rijkswaterstaat)

In the Southern part of the Netherlands, just a few km south of the big land reclamation project Maasvlakte 2, there is a storm sluice barrier that prevents that seawater enters the Haringvliet. The Haringvliet is a former estuary closed in 1970 as part of the Deltaworks. With low tide the sluices are opened and the fresh water from the river Rhine flushes via the Haringvliet into the North Sea. This causes large unnatural variation in salinity just outside the sluices. It also forms an obstacle for migrating fishes.

After lengthy discussions, the sluices will be managed differently by the end of 2018. The sluices will be partly opened during a limited period in the whole tidal cycle in such a way that the estuarine gradient is partly restored. Although this was never identified as a Building with Nature project, this project has all aspects of a BwN approach.

Safety against flooding is guaranteed, the ecosystem service is restored and the natural productivity is enhanced. The new situation provides opportunities for migrating fish, for seaweed cultivation in the Haringvliet and for an improvement in shrimp fishery just outside the sluices. So althought this project is not focussed primairily on flood protection, but on ecosystem restoration, we see this as an example of Building with Nature.

Governance of the upscaling strategy

The point at the horizon may be clear, but the challenge is how to get there. Combining different aims (small scale and large scales) implies also the mission impossible to combine all different interests and to find a way to finance. For this there are various techniques and here we elucidate the technique of serious gaming that was developed in order to find added value of a multifunctional approach.

Tool Game theory to find added value

The game starts with all stakeholders at the very beginning of a workshop. It maps all functionalities in a systematic way with the financial results from cost-benefit analysis. Combining all these interests in a triangle result in a common solution area. This area stands for the solution where all partners have a joint optimum added value, but the but the maximum value for the combination. This outcome can be used to design all costs and benefits for each partner and might be a solid base for a business case. This technique is successfully used in BE-SAFE: **www.citg.tudelft.nl/BE-SAFE**

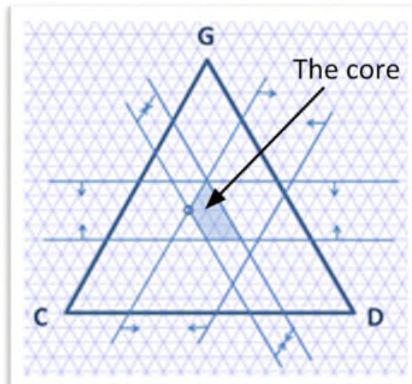


Diagram of game for 3 players

4. Selection of preferred BwN measure

Introduction

Chapters 2 and 3 have guided us through the process of determining the scope, context and system possibilities for BwN flood protection measures. As a result we now have a longlist of possible measures to achieve the desired level flood protection. Unless there is already an explicit policy in place that prescribes BwN measures, this longlist of options can consist of conventional solutions and BwN solutions or a combination of both. This chapter focusses on the economic analyses and tools that can be used in the process of selecting the preferred solution from the initial longlist of possible solutions.

In this selection process, the (relative) attractiveness of the different solutions needs to be evaluated. To do this, two questions should be considered and answered:

i. What are the costs of the identified alternatives?
ii. Does the BwN option provide sufficient additional co-benefits making it more attractive from a (socio) economic point of view?

At the end of this chapter the reader will have gained insight into a selection of economic tools are available and under what conditions best to use them to answer the two questions above.

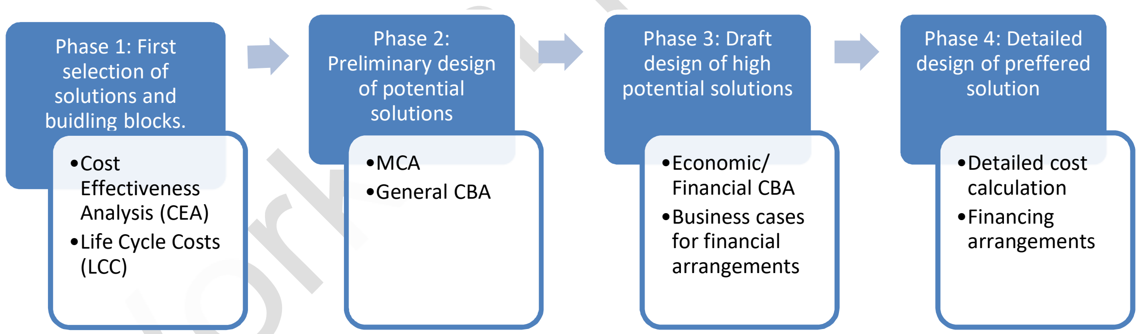


Figure 4: Overview of the economic tools useable in the different phases of the design phase

The structure of this chapter is as follows; firstly we will discuss the variety of different economic tools available in relation to the phase of the designing process (figure 4). Secondly, we will discuss issues of importance we come across when estimating costs and (co-)benefits specifically for BwN solutions. Thirdly we discuss different methods that can be used to include uncertainty in the assessment of alternatives. Lastly, we will provide the reader with an overview of further reading.

The selection process and the economic tools

The selection process refers to the process of selecting the final preferred solution from the initial longlist of possible solutions. The process can be seen as a screening/filtering process in which we can use different economic tools to evaluate the solutions relative to each other and relative to the project goals.

Figure 4 shows a variety of available economic tools for the different phases of the design process. These are discussed below.

Phase 1: First selection of solutions and building blocks.

In this phase there is a longlist of possible building blocks or solutions as a result of the process discussed in chapter 3. There is not yet an actual design and the list may include both BwN solutions as conventional ones. In a 'quick and dirty' analysis the most attractive solutions and building blocks are selected.

The selection of methods depends on the decision criteria: what is the general policy on decision criteria? Is the general policy to decide based on cost minimization or cost effectiveness? Or do other criteria such as social and environmental aspects also come into play? It is important that such questions are discussed amongst key stakeholders and decision makers in an early stage of the project. The answers to such questions form the selection criteria in the screening process and also determine which screening method(s) are most applicable.

In phase 1 we would like to make a first assessment of the efficiency of the different measures (cost effectiveness) to achieve the policy objectives. Furthermore we would like to identify possible co-benefits, provide a first indication of expected costs and the identification of relevant stakeholders.

Phase 2: Preliminary design of potential solutions

In this phase, preliminary project alternatives or strategies are designed by combining different building blocks and solutions. The procedure for selecting the preferred alternative differs per country, spatial scale and purpose of the project.

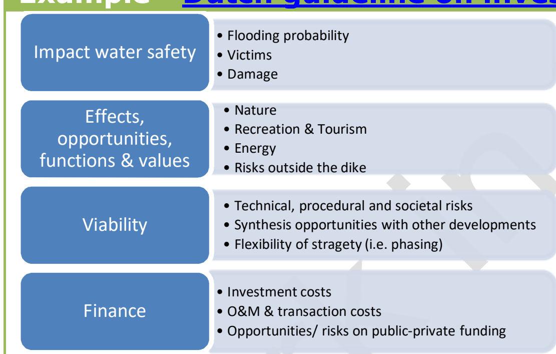
Most countries specify which analyses are required to secure grants from a (coastal) flood risk infrastructure investment program: this often includes an environmental impact assessment and a cost-benefit analysis (CBA). In table 1 we have listed some examples of these guidelines with the corresponding links for further reading.

Set guidelines for these assessments are not always tailored to BwN solutions as they stem from a more conventional frame of mind. Below the table are two examples of projects where the methods of evaluation allow for the full potential of BwN to be considered and compared to the conventional solutions.

Table 1: Further reading for assessment guidelines differing per country/region

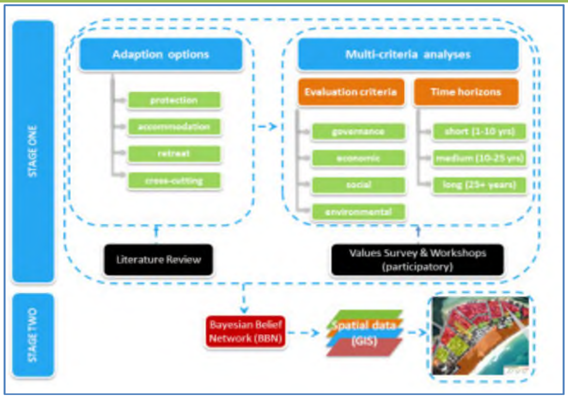
Country	Targeted at/ Scope	Title (hyperlink)
EU	General CBA principles: EU investments in Transport; Environment; Energy; Broadband; R&D	Guide to cost-benefit analysis of investment projects
EU (project)	(proposed) EU transnational cooperation streamlining use of CBA in context of flood risk infrastructure standards development	Integrating CBA in the Development of Standards for Flood Protection & Safety
UK	Mandatory guidance manual for project appraisal in publicly funded projects.	Flood and Coastal Erosion Risk Management appraisal Guidance (FCERM-AG)
Netherlands	Review of the development of CBA approaches/ guidelines used in flood risk management in the future and its impact on society.	Cost-benefit analysis for flood risk management and water governance in the Netherlands: An overview of one century (CBP, 2017)

Example - Dutch guideline on investments in Wadden Sea area



In the Dutch national programme on coastal protection for the environmentally valuable Wadden Sea, decision criteria for projects are outlined, including an overview of which tools to use. The approach includes a qualitative MCA based on expert-judgement. This is done to test the effect on various criteria (nature, accessibility, SKR). Later in the process a CBA is carried out, based on previous findings from the MCA, leading to a further quantification of the projects' impacts.

Example MCA – Sydney Coastal Councils Group



Picture: coastadapt.com

The Sydney Coastal Councils Group (SCCG) undertook a project to provide guidance to decision-makers on the variables that shape response to climate change. It integrated information on exposure and risk, and feasible adaptation strategies. A CBA does not capture local values and perceptions therefor a participatory MCA was undertaken – stakeholders were involved directly, and a range of adaptation options were assessed along a wide array of values, including governance, economic, social and environmental, performance and robustness over a long timeframe.

In phase 2 different building blocks and solutions are combined through combining measures with high CEA or important co-benefits. A general CBA is in place based on general benefits and transfer principles (e.g. not considering specific local context like actual demand or local market prices). Additionally the MCA is effective for increasing stakeholder engagement and support.

Phase 3: Draft Design

The analyses done in the previous 2 phases select solutions that meet the policy objectives and that show varying levels of co-benefits and cost effectiveness. In this phase, location specific data and detailed cost calculations are required. Possibly financing arrangements can be made with stakeholders based on the specific identification of costs and benefits for them. Business cases could be drafted to identify financial gains for stakeholders. The economic tools for the next phase are presented in table 2 below.

Example CBA –Lami Town, Republic of the Fiji Islands

Ecosystem	Type of value	Value (FJD)	Unit/year Hectare	Unit/year Household	Benefits (FJD year^{-1})
Mangroves	Direct[1]	$41	-	200	$8,200
	Indirect[2]	$471	320	-	$150,720
			Ecosystem benefits of mangroves		$158,920
Coral reefs	Direct[3]	$521	-	10	$5,210
	Indirect[2]	$471	1,387	-	$653,277
			Ecosystem benefits of coral reefs		$658,487
Mudflats/seagrasses	Direct[4,5]	$123	-	200	$24,600
	Indirect	$139	330	-	$45,870
			Ecosystem benefits of mudflats/seagrasses		$70,470
Upland forests	Indirect[6]	7	1,151	-	$8,057
			Ecosystem benefits of upland forests		$8,057
Streams	Direct[4]	60	32.5		$1,950
			Ecosystem benefits of streams		$1,950
			Total ecosystem benefits for Lami Town		$897,884

Table: ian.umces.edu

The main threat to Lami Town posed by climate change is the higher frequency and intensity of storms. Four adaptation strategies, ranging from ecosystem-based adaptation (including mangrove restoration and reduced coral extraction and logging activities) to conventional engineering options (i.e. sea walls) were developed. A cost-benefit analysis of the four scenarios including avoided damages (using local historical data as a reference) and ecosystem services. The latter were calculated using a combination of local and global economic valuation studies. A spatial analysis was used to determine the size and extent of the habitats created or lost in the strategies.

In phase 3 a more specific CBA (financial/economical) is necessary, based on location specific data and detailed cost calculation. A possible step is to make financial arrangements with relevant stakeholders receiving benefits or paying costs. A business case could be used to identify and communicate financial gains for stakeholders. Based on the previous analyses at the end of this phase a preferred alternative is selected.

Phase 4: Detailed design

In phase 4 the preferred alternative is developed into a detailed design. This is the alternative that will be used to implement in the project. Detailed cost calculations and financial arrangements can be made. Normally no further economic assessment will take place here.

Table 2 Economic tools for assessment of alternatives

Economic tools	Description	Best applicable when:	Advantages/ disadvantages
Cost-Effectiveness Analysis (CEA)	All options are compared in effectiveness – to what extent do they contribute to one specific (flood-risk related) goal? 1. The investment/ O&M costs of each measure are estimated (quick scan: order of magnitude, based on data/ expert judgement). 2. For each measure a ratio is given for the amount of effect you get for one unit of money: *e.g. how much flood risk protection is delivered for €1?*	1. If there is one **single, clear-defined goal** for the project and it is of interest to find the most attractive alternative from a **financial** point of view. 2. As a first screening of measures	A risk of using CEA is that the method does not take into account any additional benefits a measure might have.
Life Cycle Costing (LCC)	In an LCC all costs for the asset over its entire lifetime, operation and maintenance and if relevant breakdown costs are compared over a fixed (long) time horizon, for example 100 years and discounted.	You want to have an idea of the costs of a solution	
Multi-Criteria Analysis (MCA)	A MCA is a semi-quantitative analysis in which the performance of measures is scored on multiple criteria based on expert/ stakeholders opinions (e.g. natural habitat creation;	There are **multiple criteria or effects** to take into consideration **Increase stakeholder engagement and support**.	+Very good for engaging stakeholders (and using their local knowledge) and increasing support for project - MCA is a

	contribution to flood risk reduction; costs; cultural heritage preserved).		qualitative but relatively subjective approach
Cost-benefit analysis General/Economic/Financial - CBA	The costs of the project are compared to the welfare effects/ benefits. These are determined in relation to a reference situation that includes autonomous development. If possible, all effects are expressed in monetary terms to ensure comparability. In a quick scan, standard numbers from other studies in similar contexts, can give a first insight of the value of certain investments. A full CBA includes more detailed analysis to include local context, is executed for a limited number of spatially explicit designs and includes sensitivity analysis of results.	More objective than MCA: all effects from viewpoint of impact on welfare (increased comparability, more objective)	+ Quantified, more objective overview of costs and benefits; comparable. + there are quite a number of other advantages - False sense of security through quantitative results

Estimating costs and (co-)benefits for BwN

In the tools discussed above costs and benefits feature in varying degrees of detail. Below we highlight some approaches and examples on how to evaluate BwN designs with respect to:

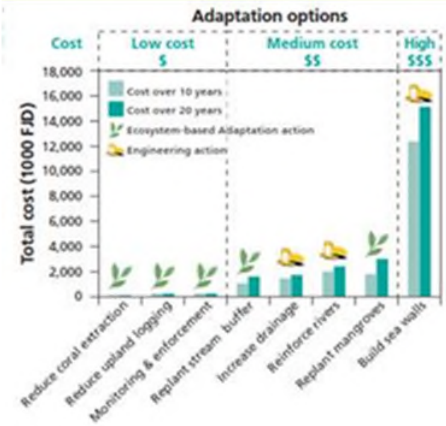
1. Cost estimates of conventional and BwN solutions
2. Estimating the flood risk benefit
3. Assessment of co-benefits: ecosystem services approach

Cost estimates of conventional and BwN solutions

In most countries there are set costing procedures and standard cost estimates for engineering projects. This is even more so when projects are financed by public funding. These procedures and cost databases are traditionally geared towards conventional, 'hard', measures: the smaller experience base and adaptive character of BwN projects makes costing them more complicated and uncertain.

When comparing the cost estimates of different solutions, both BwN and conventional, a lifecycle cost (LCC) approach should be used. In an LCC all costs of the asset over its entire lifetime, including operation and maintenance and if relevant breakdown costs, are compared over a fixed (long) time horizon, for example 100 years and discounted. Other elements of interest when comparing costs of BwN with conventional approaches is how uncertainty, adaptability and flexibility of design are taken into account in the costing process.

Example lifecycle costing –[Lami Town, Republic of the Fiji Islands]



Picture: ian.umces.edu

The main threat to Lami Town posed by climate change is the higher frequency and intensity of storms. Different storm protection actions were proposed, including ecosystem-based adaptation, policy options and engineering solutions. For each strategy costs were estimated, including: installation, maintenance, labour, and opportunity (associated) costs. The costs were determined through interviews, published records, technical papers and general estimates from local experts. In conclusion, a least-cost analysis based on the life-cycle costs was performed. For each option the costs were calculated over 10 years and 20 years at a 3% discount rate: results show no-regret options and give decision makers an idea of the financial implications of implementing specific actions.

Estimating the flood risk benefits

Reducing flood risk is often the primary objective there for the achieved flood risk protection is the main benefit. All other benefits additional to the goal of the project are co-benefits. Quantifying the benefit of flood risk protection is important. The most common way to do this is by estimating the baseline

$$(current) flood\ risk = (probability\ of\ flooding * economic\ damage) /\ loss\ of\ life)$$

and then estimating – depending on the resources at hand e.g. expert judgement or a modelling study – the reduction achieved by a particular design.

If there is a pre-defined safety norm and a clear conventional alternative, a least-cost analysis compares alternatives based on costs – and possibly some additional criteria, such as robustness. All solutions have to meet the pre-set flood risk standard. However, if there is no pre-defined flood risk goal for the project, the flood risk reduction achieved by each design is estimated, and a cost-effectiveness analysis is done.

Compared to conventional infrastructure, the small evidence base of BwN leads to a disadvantage. First, the direct impact on flood risk reduction is different: where flood risk impact of conventional approaches is often well known (there are design requirements and standards) there is much less known about the flood risk impact BwN, though the evidence base is increasing [1]. The uncertainty may translate in conservative assumptions on the flood risk reduction. Second, the small evidence base on BwN may lead to i) conservative assumptions when estimating the costs, ii) a higher risk premium (over dimensioning) in design.

Example flood risk reduction – Lower Cape May Meadows Ecological Restoration

Table 3. Total damage costs avoided over the next 50 years, Cape May Point

	Lower bound	Upper bound	Mean
Damage costs avoided after the restoration	$2,000,000	$17,300,000	$9,600,000

The restoration of the 456acres LCMM was completed in 2007: the project included freshwater wetlands restoration, construction of a sand dune, and two miles of beach replenishment. In this case there was no pre-defined flood risk goal but the goal was to improve wildlife habitat. A research was conducted post-restoration to estimate the benefit of reduced flood risk by looking at flood damage. It was chosen to study the relationship between storm surge data and total insurance claims; pre-restoration major storms with more than 2 feet of storm surge all led to claims whereas after the restoration only Sandy led to claims. Sometimes a creative approach, influenced by the availability of data is necessary for an estimate of flood risk reduction when no pre-defined framework is in place.

Assessment of co-benefits: ecosystem services approach

Valuing co-benefits of the BwN using ecosystem services approach is key in demonstrating the added value of BwN over conventional approaches. Depending on the physical setting and other characteristics of the project area, a wide array of ecosystem services may be relevant: there are various guidelines and tools that can be used to valuate these benefits (section 4.6). Some examples include the nature points index used in the Netherlands and the INVEST toolset.

In addition to economic valuation of co-benefits it is valuable to identify each benefits' beneficiaries. This can lead to the identification of a broad(er) group of stakeholders. This exercise links to the screening phase previously discussed. interests and concerns of the different stakeholders should be identified included in this process. Subsequently, linking co-benefits to stakeholders can be a valuable input in the process of finding (co)finance sources. Related to the latter, a 'Strenghts, Weaknesses, Opportunities, Threats' analysis (SWOT) can be useful to increase understanding of possible (dis)incentives of various stakeholders to co-invest. Below is an example of a part of a SWOT analysis for the Eddleston water scoping study where the analysis is used to identify the different groups of stakeholders.

Example SWOT –Eddleston water scoping study

Table 3.6 SWOT analysis of potential measures at each site

Site	Strengths	Weaknesses	Opportunities	Threats
A	Topography Potential volume Flood storage for Eddleston Village Ease of embankment breaching at low cost (2 breaches necessary)	Need to negotiate easement Need to engineer flow control device Location of Scottish Water pipe (though depth of pipe probably sufficient to allow embankment works)	Possibility to combine with riparian vegetation replanting	Landowner lack of co-operation to allocate land and/or willingness to maintain area
F	Natural wetland with potential for expansion by drain/ culvert blocking or small scale channel diversions/ creation of ponds	Site is already a wetland so additional storage potential possibly limited Gains in terms of flood attenuation limited for lower points in catchment compared to sites A and E due to smaller catchment area	Wetland expansion and enhancement of biodiversity, possible encouragement of carr (wet) woodland	Landowner lack of co-operation and/or maintenance
G	Land in private ownership	Uncertainties of drainage history of site will require further field survey	Re-expansion of original forest area with continuous cover management	Lowering of water table on bog may lead to erosion and export of carbon to watercourse

The Eddleston Water, a north bank tributary of the River Tweed in the Scottish borders has been classed as 'poor' under the EC water framework directive. Potential measures of natural flood management (source control and slowing the flow) have been listed. A SWOT analysis of the combination of measures was conducted. By identifying the strengths, weaknesses, opportunities and threats of the alternatives the different possible groups of stakeholders are identified.

Assessing performance under uncertainty

The future is uncertain. What if sea level rise turns out much faster than expected? What if global economic changes shrink or expand the local economy – and with it the value at risk? In light of this uncertainty, choosing the 'optimal' design level is complex. To some extent this uncertainty is addressed in common CBA practice, but some additional tools are available as well. Typical uncertainties related to conventional and BwN projects are uncertainty of technical performance and performance under climate change/ future scenarios.

Uncertainty of technical performance

This uncertainty translates in a risk premium/ over dimensioning of measures. There are standardized procedures to address this risk in conventional engineering (e.g. fixed risk premiums). The high uncertainties in performance of BwN lead to high risk premiums in design, and a conservative assessment of the flood risk benefit. In a regular CBA, uncertainty of assumptions on technical performance and co-benefits is often addressed with a sensitivity analysis: analysing the sensitivity of outcome of the CBA to (changing) various parameters – such as estimates for the flood risk impact of a measure. If we use a positive estimate over a conventional one, does it change the outcome of the CBA?

Performance under climate change/ future scenario's.

The future brings more certainty about the development of climatic and economic factors that influence the optimal risk level. Conventional approaches are typically less flexible (*ability to change with environmental conditions*) than BwN: they cannot be implemented in phases, switching to a different approach becomes harder and there may even be a lock-in. By phasing BwN (e.g. increase sand nourishment volume over time) the optimum investment level is determined over time instead of up-front, as the future unveils itself. Changing from one adaptation strategy to the other (BwN to conventional or vice versa) may be difficult. Furthermore, climate change may render specific solutions less robust (*sufficient performance under various climate change scenarios*) in the long term, for example, a dike cannot be increased indefinitely, and is difficult to relocate.

In CBA uncertainty of performance under future scenarios is addressed using scenario analysis: the outcome of the analysis is presented under various scenarios in economic and demographic growth and climate change. Additionally, there are other, more sophisticated approaches such as real options analysis (ROA) and adaptation pathways that specifically address flexibility and robustness of adaptation strategies or alternatives. In ROA, uncertainty and flexibility are taken into account (whereas CBA assumes a deterministic future with no room for changes): valuing flexibility using decision trees and Monte Carlo analysis. Adaptation pathways are a planning tool depicting possible future pathways in adaptation solutions, including 'tipping points' when a solution is no longer viable and a switch to another strategy should be made.

Table 3 Methods to assess performance under uncertainty

Methods	Description	Best applicable when:
Scenario analysis in CBA	The results of the CBA are calculated under various future scenarios, i.e. regarding climate change, demographic or economic developments	In CBA, when it is reasonable to expect significant differences. Commonly used scenarios are SSP (shared socio-economic pathways) and climate scenarios by the IPCC – many countries have defined own scenarios.
Sensitivity analysis	Investigates sensitivity of parameter values and assumptions used in cost-benefit estimation. Common element of CBA	Some uses of sensitivity analysis: makes results stronger/ more credible by testing robustness, increase understanding of system, further development of values and assumptions.
Real options analysis	Quantifies investment risk under an uncertain future – used to value flexibility of projects. Flexible and	Comparing a flexible BwN with inflexible conventional solutions

	reversible options handle deep uncertainty by leaving room for new insights.	
Adaptation pathways	Conceptual and analytical approach where flexible adaptation strategies are build based on decision triggers that signal a next phase or path of adaptation strategy.	Create insight in path dependency, potential lock-ins of various adaptation strategies - how to they perform under various future scenarios?

The key is stakeholder engagement

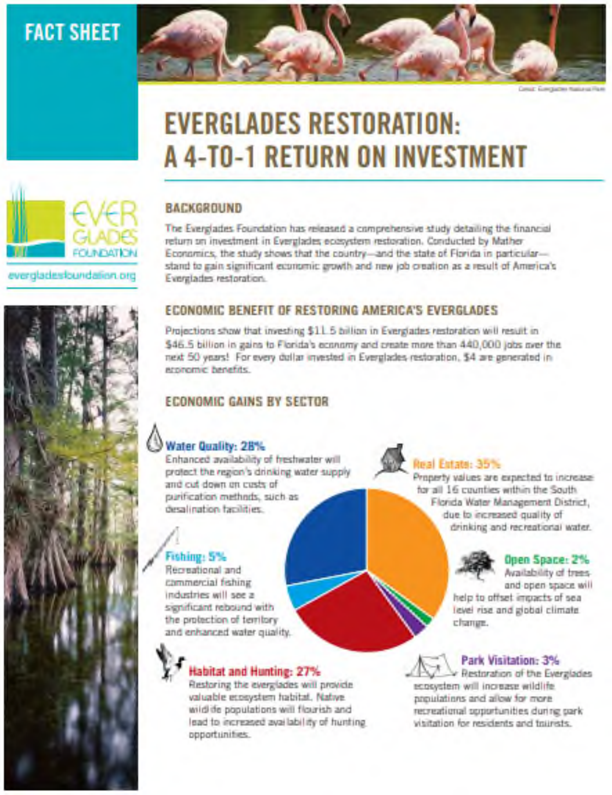
Getting engagement from decision-makers and other stakeholders is often essential for successful implementation of BwN. Their values and interests are essential in the entire designing and selection process and are therefore important to uncover as early as possible. This usually requires a person or team dedicated to managing the process and the stakeholder engagement.

One of the aspects that can contribute to active discussions and stakeholder engagement are understandable and attractive presentation of results. Below are some examples for inspiration.

Example: Benefits of BwN presented in a Cartoon

Source: BeSafe &WWF

Example: Factsheet of key findings



FACT SHEET

EVERGLADES RESTORATION: A 4-TO-1 RETURN ON INVESTMENT

EVERGLADES FOUNDATION

evergladesfoundation.org

BACKGROUND

The Everglades Foundation has released a comprehensive study detailing the financial return on investment in Everglades ecosystem restoration. Conducted by Mather Economics, the study shows that the country—and the state of Florida in particular—stand to gain significant economic growth and new job creation as a result of America's Everglades restoration.

ECONOMIC BENEFIT OF RESTORING AMERICA'S EVERGLADES

Projections show that investing $11.5 billion in Everglades restoration will result in $46.5 billion in gains to Florida's economy and create more than 440,000 jobs over the next 50 years! For every dollar invested in Everglades restoration, $4 are generated in economic benefits.

ECONOMIC GAINS BY SECTOR

Water Quality: 28%
Enhanced availability of freshwater will protect the region's drinking water supply and cut down on costs of purification methods, such as desalination facilities.

Real Estate: 35%
Property values are expected to increase for all 16 counties within the South Florida Water Management District, due to increased quality of drinking and recreational water.

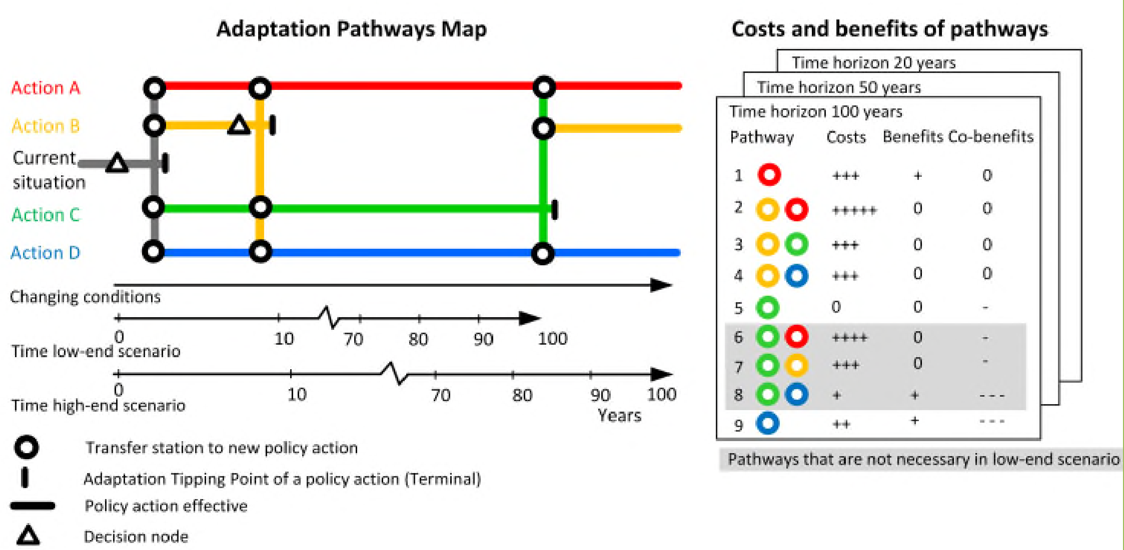
Fishing: 5%
Recreational and commercial fishing industries will see a significant rebound with the protection of territory and enhanced water quality.

Open Space: 2%
Availability of trees and open space will help to offset impacts of sea level rise and global climate change.

Habitat and Hunting: 27%
Restoring the everglades will provide valuable ecosystem habitat. Native wildlife populations will flourish and lead to increased availability of hunting opportunities.

Park Visitation: 3%
Restoration of the Everglades ecosystem will increase wildlife populations and allow for more recreational opportunities during park visitation for residents and tourists.

Example: Visualisation of adaptation pathway map



Further reading

Table 4 Suggestions for further reading

	Source	Method	Title	Content
Costs	NOAA (2013)	Cost estimation	What will adaptation cost? An economic framework for coastal community infrastructure	Chapter 2 discusses how to analyse the adaptation strategies' impact on flood risk, including a number of case studies; chapter 3 on monetizing this impact.
	TU Delft (2010)	Cost estimaton	Coastal defence cost estimates – Case study of the Netherlands, New Orleans and Vietnam	Cost estimates at project and system level for low-lying deltaic coastal areas: unit cost estimates for both conventional and BwN approaches.
FR Impact	NOAA	Flood-risk + ecosystem services	A guide to assessing green infrastructure costs and benefits for flood reduction	Guide for assessing flood risk and co-benefits of green infrastructures (stormwater drainage) to prevent riverine/ rainfall flooding
	Greeninfrastructureenw.co.uk (2010)	Flood risk impact + ecosystem services	Building natural value for sustainable economic development. The green infrastructure valuation toolkit user guide	Calculation toolkit for estimating the benefits of green infrastructure, including impact on flood risk: relevant for riverine/ estuary flood risk.
CEA	Paper; PLOSone (2016)	Costs-effectiveness (quick-scan)	The effectiveness, costs and coastal protection benefits of natural and nature-based defences.	Evidence-based analysis of cost-effectiveness of coastal building with nature projects
	World Bank	Cost-effectiveness; cost-benefit	Implementing nature-based flood protection – principles and implementation guidance	Principle 3 on performance evaluation (needed for CEA); Step 5 on estimation of effectiveness, costs and benefits.
CBA	COASTADAPT (2016)	Cost-benefit analysis	Information manual – Assessing costs and benefits of adaptation	Clear description, explanation and links to other sources on cost-benefit analysis and other approaches in coastal adaptation context.
	Renaud et al (2017)	Cost-benefit analysis	Ecosystem-based disaster risk reduction and adaptation in practice. Part I: Economic approaches and Tools for Eco-DRR/CCA	Number of book chapters discussing valuation of BwN strategies – best practices, existing studies and various case studies.
	WUR (2014	CBA: valuing ecosystem services	Economic viewpoints on ecosystem services	General introduction into ecosystem services valuation and tools – not specific for coastal infrastructure/ ecosystems.
	GIZ (2017)	Cost, benefits & FR impacts	Valuing the benefits, costs and impacts of ecosystem-based adaptation measures – a sourcebook of methods for decision-making	Elaborate guideline on valuing BwN benefits, including case studies, and an overview of tools.
	Ecoshape (Origin: Netherlands	Nature index	This tool outlines a methodology to include nature qualities in planning processes by defining a	Tool description, guideline, practical applications.

	environmental agency Sijtsma et al., 2009)		quantitative nature index	
	Susdrain	BEST	B£ST provides a structured approach to evaluating a wide range of benefits, often based upon the overall drainage system performance.	Guidance, software, casestudies, presentations.
Dealing with uncertainty	CoastAdapt	Real options analysis	Real options for coastal adaptation	Guideline on applying real options analysis to coastal adaptation.
	Coastadapt	Sensitivity analysis + scenario analysis	Information manual – assessing costs and benefits of adaptation	Chapter 5 discusses uses of sensitivity analysis and further links to guidelines on how to do so.
	Coastadapt	Adaptation pathways	Information manual – assessing costs and benefits of adaptation	Chapter 8 introduces adaptation pathways and links to various guidelines/ approaches and examples.

5. Optimizing design of BwN measure

Introduction

After selection of one or more preferred alternatives based on the societal challenges (H2), system analysis (H3), cost effectiveness and benefits (H4), it is possible to improve an initial design of the BwN alternative. A good design will match the potential of the physical environment with the needs and ambitions of society, within the policy objectives and financial boundaries. The design should be informed by the risk reduction target, the required integration of the measure in the existing environment and by identified ecosystem management and restoration methods (World Bank, 2017).

BwN approach	Traditional approach
Optimize design to achieve multiple benefits, making use of the ecosystem services and aiming for win-win solutions.	Optimize design to meet one objective (e.g. flood risk reduction), while minimizing or mitigating detrimental effects on the environment.

Optimizing BwN design

In this chapter we distinguish six dimensions that play a role in optimizing the design of BwN measures. These dimensions are functionally related and should therefore be handled as one coordinated network (Figure 5). Whether it would be logical to steer the design into a specific direction will depend upon the expected added value, whether it will bring additional finance, public or private acceptance, and the expected costs for implementation and maintenance.

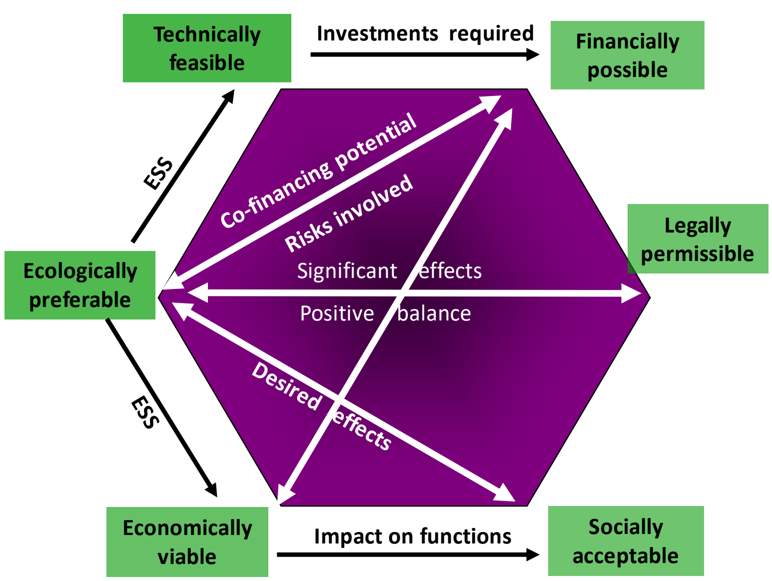


Figure 5 Network of six factors that play a role in optimizing BwN design, and their mutual relationships

Technical feasibility

Technical feasibility of BwN design is largely determined by the local physical conditions, together with the level of required knowledge and skills. Important physical parameters are bed slope, hydrodynamic energy, and salinity (de Vriend et al., 2014). With flat slopes, so called 'soft solutions' are possible that are completely sediment-based. High energy systems (sandy coasts) demand larger volumes of sediment and have a low vegetation cover (the sand engine), while low energy systems (lakeshores) allow soft solutions of a smaller area and typically have a dense vegetation cover (sandy vegetated foreshores).

Ecological optimization

Ecological optimization is about Improving environmental conditions and ecological processes. Integrate the required physical conditions for potential benefits (ecosystem services) into the design process. Habitat requirements of the desired species are part of the physical conditions for the design.

Nature development is often difficult to predict. It is key to make use of existing ecosystems, native species, and comply with basic principles of ecological restoration and conservation (World Bank, 2017). Ecosystems that have a higher biodiversity are also more productive and more resilient to disturbances (van Wesenbeeck, B.K. Griffin et al., 2017). Sometimes it can be beneficial not to be too specific in the habitat description in the project objectives. If, after construction/restoration the natural development is slightly different than envisioned in the project plan, it might be better to adjust the goals to what spontaneously is developed than to interfere with the habitat for high costs.

Further reading

- For ecological optimization of a project, one should be aware of the habitat requirements of the species that are part of the design. The Ecoshape BwN wiki gives information for the habitat requirements of shellfish and saltmarshes, but also seagrass, corals and mangroves.
- When building in a muddy environment, turbidity can have negative ecological effects. Smart handling of fine sediments can help to reduce negative effects and instead make use of the sediment characteristics.

Example Markerwadden

Picture: Ecoshape

The Marker Wadden project is a large nature development project that consists of a number of islands that are built with locally available material. Because the surface level is difficult to predict (the island will be built on unconsolidated sediments), creating a pre-set landscape design would be very costly and require a very long time. So it was decided to define a bandwidth in surface areas to be developed, without specifying where what habitat should be situated. If the habitats develop properly, this option will be far less costly. The total area of the desired habitats that can be developed with the available budget will be

larger.
https://www.ecoshape.org/en/projects/marker-wadden/

Legal and policy requirements

In many projects formal safety standards or nature legislation (e.g. Natura2000) play an important or even decisive role in the design process and the choice for a specific alternative. For example, if a project site is designed as a protected area for birds, the project may be executed as long as it has no effects on the protected bird populations. It becomes more difficult when the area is designated as a protected habitat area. In this case the possibilities for intervention are very limited. In addition to European legislation, national legislation and policy requirements can set tight conditions that have a large impact on the design possibilities. For example, deadlines for project results can be very demanding and decisive for the selection of the final solution. Ideally deadlines are adjusted to the natural building capacity of natural processes, under the condition that safety or other functions are not compromised in the short term.

Further reading

- BwN designs should not only be effective, but also fit into existing regulations. Here you can find more information about how to scan regulations and deal with emerging regulatory barriers. Once formal requirements and their practical implications are clear, possibilities can be sought to adjust and fit the BwN design to this regulatory context.

Example Sand engine

Picture: Ecoshape

The design process for the sand engine was a time-constrained project. This limited the scoping for more integrated alternatives. One could have been the positioning of the sand area in front of the village of Ter Heide, were in fact the nourishment needs are the largest. This would however result in total new coastal landscape that would seriously impact the present use of the beach, but would also have created new opportunities. However, the municipality of Ter Heijde was more in favour of maintaining the status quo, in which the beach is mainly used by local residents.
http://www.dezandmotor.nl/en/

Economic viability and market conditions

It is important to know how the design affects the economic impacts and opportunities for different stakeholders of the project. An increase in economic benefits from BwN measures will more likely lead to project support from the stakeholders. Economic benefits are for example a higher job availability due to recreational opportunities and improved agricultural production (Forbes et al., 2015). A project is economically viable when the economic benefits meet the costs (also taking into account changes in the future benefits and costs).

However, in some countries different discounting rates apply and there, the project needs to have a larger positive rate of return. A project needs a benefit/cost ratio of at least 2.2 to 5 depending on socio-economic “status” of the impacted population.

Example Mayes Brook river restoration (Barking, Londen)

Picture: Environment Agency

This river and floodplain restoration project helped to transform park in east London. The Mayes Brook had been brought out from the concrete channel into the park. As a result, the flood risk in the park and the neighbourhood has been reduced. The calculated benefits are around 27 million pounds. (Burgess-Gamble et al., 2017)

Social acceptance and stakeholder involvement

To ensure social acceptance of the BwN measure after construction, stakeholders should be involved in all phases of the project. In the design phase, they can help to select between different design alternatives. The stakeholders can for example contribute to the criteria that the final design should meet.

Projects consist of a physical design and a societal design. The societal design are the arrangements, contracts, licences and more that determine compensation, use and access, tasks and responsibilities in implementation and maintenance and financial contribution of different stakeholders. In spite of the fact that the physical design can be challenging, because of uncertainties in its future development, the societal design is often decisive. It can also be even more challenging, since it has to reconcile the many often competing ambitions and interests of various stakeholder groups as well as their often very different perceptions of the uncertainties and opportunities the physical design is offering.

Further reading

- Stakeholder analysis is a valuable tool that gives insight in how to deal with stakeholders in BwN project development and design.

Tool: Interactive Design Tool

Picture: Deltares

The Interactive Design Tool for the Holland Coast (ITHC) is a MapTable application aiming at assisting decision makers, project developers and stakeholders in the early development stages of coastal maintenance strategies for the Holland Coast (Ecoshape, 2015a). The tool has the ability to evaluate (mutual) interactions between new interventions and existing coastal structures in both space (small- vs. large-scale) and time (short- vs. long-term). This enables stakeholders to get insight into the consequences of their choices, to determine their position, and to provide input into the design process.

	https://publicwiki.deltares.nl/display/BTG/Interactive+Design+Tool+-+Holland+Coast

Financial possibilities

Co-financing opportunities can be integrated into the design, by optimizing the design in such a way that co-benefits for potential investors are included. The most creative solutions are often developed when there are financial constraints, since this triggers the search for additional functions, beneficiaries and added value as well as ways to cost-optimize the design. It is easier to find finance for a BwN measure if the costs are lower than a conventional (non-BwN) design. The construction costs depend on e.g. the type of material, the duration of the construction and the construction technique. All these factors are determined in the design phase. But the design will also impact the maintenance costs on the longer term. So a maintenance plan should already be drafted in the design phase (World Bank, 2017).

Example State financed flood safety

Picture: Rijkswaterstaat

In The Netherlands flood safety and strengthening of primary flood defences is the shared responsibility of the national government and local water authorities and based on legal safety standards, based on economic criteria. In this situation there is little incentive to involve private investors and adjust a design according to their wishes and requirements. So in the past decades most dikes were built as constructions with a single purpose. More recently, the flood protection projects in the Netherlands also scope for supporting other goals, albeit most of these goals are of a public nature, such as nature development, furthering recreational activities and urban development, as planned by municipalities.

Handling uncertainties

Although Building with Nature solutions have the advantage of catering several objectives, their performance (especially on the longer term) may hold uncertainties. The level of uncertainty may depend on past experiences in reference situations, in morphological and hydrological models and whether the proposed solution is very sensitive to unknown variables (e.g. a migrating tidal channel close to a sandy primary flood defence), or assumptions (e.g. what is the chance that a new heavy rain event happens, at the time natural buffer areas are still full). Besides incomplete knowledge and unpredictability, also multiple interpretations of the situation or problem (so-called 'knowledge frames') can be a source of uncertainty (Brugnach et al., 2008).

Methods for dealing with uncertainties

In general uncertainties can be met in one of the following ways:

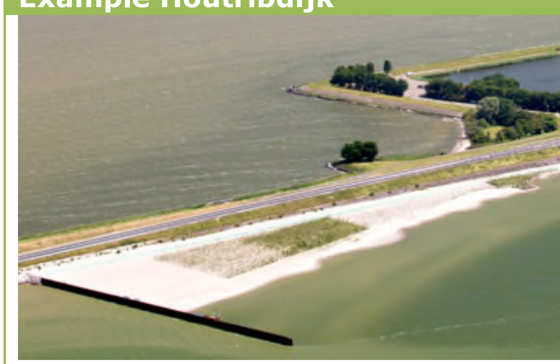
- Many BwN measures are innovative and work needs to be done to improve the **evidence base**, how well does it perform, what added values are created. Sometimes there is time do to dedicated pilot research prior to the final design stage.
- **Robust design,** so there it becomes more certain that the design fulfils its objectives, albeit often at larger costs.
- **Adaptable design and development,** changing and altering depending upon its prior uncertain development. This can be viable option as long as it does not comprise vital goals. Can often be used to steer management or future use but also the incremental development of a project.
- **Flexible project goals and contractual requirements,** flexibility in project objectives can be introduced (e.g. by extending a deadline or being less specific about when and where certain habitats will be developed). Flexible goals are best combined with adaptive management and development, as well as with contractual arrangements, that give ample scope to the contractor in case the implementation of a project may offer win-win opportunities.

Example Willow forest at Fort Steurgat

Picture: Deltares

The wave attenuating willow forest at Fort Steurgat has been planted with 5 different species, to reduce potential impact of a disease on its performance . This example also shows that in case wave attenuation depends on natural vegetation several factors need to be considered, not only diseases, but also the impact of forest management, and the risks of being uprooted by wind, a reason why the willows were planted in a thick clay layer and management of the forest is adapted to the wave reduction function of the willows.

Example Houtribdijk



Picture: Ecoshape

Use of sandy reinforcement of the coast is well studied and accepted in the Netherlands. This is not the case, however, for sandy foreshore in lakes. Because formal protocols and validated models were not (yet) in place, the design of the pilot Houtribdijk was 'overdimensioned': Much more sand was included into the design, in order to reduce uncertainty in meeting pre-set goals. Because the design is robust, it is considered an adequate solution. If after construction, morphological studies show that it is too robust, the excess volume can still be considered a volume available as wear layer, which will forestall the need for maintenance nourishments, while increasing the evidence base for performance of the measure

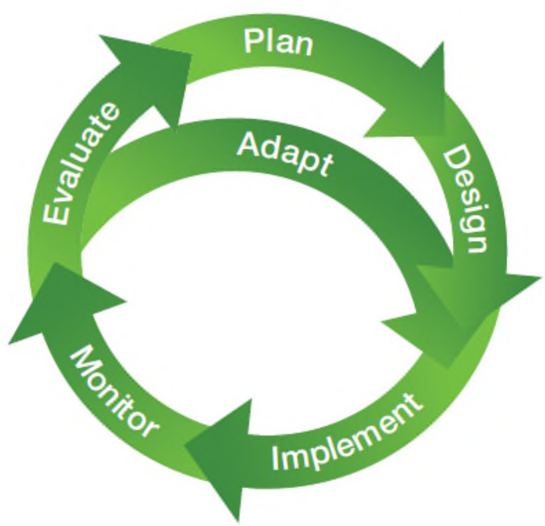
Flexibility and adaptability to deal with uncertain circumstances

Flexibility and robustness are often cited as major attributes of BwN solutions. Especially in situations where there is uncertainty regarding the development of environmental conditions such as sea level rise, required standards (in most cases safety standards become stricter and are never reduced) and socio-economic ambitions and development potential. In these situations, flexibility and robustness of the design are a pre-condition. Adaptive management is a way to monitor the effect of the BwN measure. It gives space to adapt the measure when the circumstances change, or when the performance is different than expected.

Further reading

- Read more about adaptive management at the Ecoshape BwN wiki: https://publicwiki.deltares.nl/display/BTG/Knowledge+-+Adaptive+Management+Strategy

Tool: Adaptive management



Picture: CEDA

Adaptive management is a systematic approach that facitates flexible decision-making (CEDA, 2015). It follows six steps:

1. Plan: *Defining the desired goals and objectives evaluating alternative actions and selecting a preferred strategy with recognition of sources of uncertainty;*

2. Design: *Identifying or designing a flexible management action to address the challenge;*

3. Implement: *Implementing the selected action according to its design;*

4. Monitor: *Monitoring the results or outcomes of the management action;*

5. Evaluate: *Evaluating the system response in relation to specified goals and objectives; and*

6. Adapt: *Adapting (adjusting upward or downward) the action if necessary to achieve the stated goals and objectives.*

6. Implementation: Stakeholder involvement and arrangements

Introduction

This chapter discusses the need to involve different stakeholder in the design process, how to identify potential relevant stakeholders and how these are best involved. Whether or not to involve them in co-creation or only to inform them is to a certain extent a matter of logic, but often also dependent upon political views regarding the need to involve local stakeholders in decision making. Furthermore, it describes potential ways of funding a BwN project, mainly by translating benefits through ecosystem services into co-financing by stakeholders as well as by exploiting the various funds that are earmarked for habitat and ecosystem restoration. It also describes various modes of contracting the construction, maintenance and potential further development of a BwN project and organisational arrangements needed to contract, finance, use and maintain such a project.

Who to involve and in what way?

A marriage of ambitions, knowledge, responsibilities and perceptions

Scoping, designing, implementing and the (adaptive) management of BwN projects should be the joint effort of all stakeholders that can contribute knowledge, experience and finance, those that are direct or indirect users or beneficiaries. Not all of these are actors, in the sense that they will directly influence the design and decision making process.

Working together depends on communication, of facts, data, alternatives, effects and more and that in the most appropriate form catering to the interests and level of expertise of relevant stakeholders. Communication with stakeholders, especially those outside of the project, is crucial for obtaining public and obtaining political acceptance.

It should be noted however that communication in the “kitchen” is as important. The communication between different disciplines and direct interest groups is difficult, but also crucial, since the kitchen determines the menu and the flavours of the dishes and how they are presented. This also involves many interim decisions, some taken within a project group, some taken explicit on the basis of consultation with the “outside world”.

The implementation of BwN is often more complex than that of conventional solution. For this reason the governance aspects of BwN projects are a major research theme in many research and innovation programmes. Notably the governance of green infrastructure and nature based solutions in cities has gained much momentum, mainly because urban environments are even more complex arenas.

Further reading on the governance aspects:

- The Governance and Politics of Nature-Based Solutions Filka Sekulova & Isabelle Anguelovski (UAB) (https://naturvation.eu/sites/default/files/news/files/naturvation_the_governance_and_politics_of_nature-based_solutions.pdf).
- Nature-based solutions to climate change adaptation in urban areas, Linkages between Science, Policy and Practice (https://link.springer.com/content/pdf/10.1007%2F978-3-319-56091-5.pdf).
- Public Engagement in NatureBased Solutions (http://www.casi2020.eu/app/web1/design/conference/session-8/0801.pdf).

Example Sand Engine - organisational arrangements

The sand engine is a major innovation project along the coast of Delfland. It consists of a large volume of sand built as a peninsula of sand that will gradually erode and provide sand needed in adjacent coastal areas that are in need of nourishment and it will do this for a substantial period, 20 years or more. Several organisation arrangements were needed in order to implement and monitor this project. A special steering group was formed that looked at its development etc.

The following organisation arrangements played a role:

- *Project organisation:* initiated by the state directory and the province, with participating members the adjacent municipalities and water boards as well as the scientific community.
- *Steering group:* that was made up of mayor and directors of participating organisations.
- *Monitoring group*: this group conducts monitoring and assessments needed for daily maintenance needs but also for scientific research. It consists of scientific institutes, firms that monitor and end users, that are in need of monitoring information.
- *Users groups:* this group includes municipalities, province, water board and groups that use the beach, such as surfer and sailing organisations, beach restaurants. The group looks into the need for zonation and potential for new uses.
- *Maintenance group:* includes all the groups that have tasks and responsibilities regarding swimmers, beach and coastal safety. The group is coordinated by the provinces, included water boards, municipalities, the local beach watch and more. They use WhatsApp for daily communication.

There is a *risk protocol* that defines actions in case one of the 25 identified potential risks occurs. There is a *maintenance protocol* and a *communication protocol*. And there is a *monitoring plan* that caters to the monitoring needs related to maintenance and management, legal requirements and scientific interests.

The sand engine is a large project which also justifies a good organisational set-up. A number of groups and protocols will however also be use in the case of other BwN projects, even if they are smaller, but when they face similar kinds of management challenges.

How to identify possible stakeholders at the project level and how to involve them

A stakeholder analysis is the first step in identifying potential stakeholders. There are many groups:

- **Project initiators,** often water or coastal authorities with responsibilities for flood protection and coastal management. These often follow formal sectoral goals but may also tend towards conventional solutions.

- **Project financing organisation,** can be other regional or national authorities that set funding requirements, deadlines, design protocols that need to be fulfilled in order to be eligible for financing.
- **Public authorities that have licensing powers**, such as municipalities, water authorities and provinces regarding physical planning, flood infrastructure and nature laws. Especially requirements related to Nature 2000 may prove to be important in design and implementation.
- **Land owners and land users of the project and adjacent areas**. These often constitute the most important wider public that determines public acceptance but may also determine overall added values a BwN project can generate. It is however a very diverse groups, with different interests.
- **Project owners of projects nearby and economic activities** that may have functional links because they need ecosystem services, or may contribute resources and services. These could for example be operators of sand pits and hotel owners.
- **Public and private funds** that wield potential financial sources e.g. for bio-offsetting, habitat restoration perhaps also for maintenance of cultural inheritance. It is good to have an overview of potential habitats and funding criteria.
- **Private contractors** that will construct the project but may be involved in planning and design but may also be identified early in the project if this has major advantages. Often their experience and knowledge is valuable upfront and can sometimes be made available with contests or other forms.
- As may organisation that are eligible as **nature managing organisation** after construction; they may have specific requirements that enable and facilitate the necessary management.
- **Scientific community and experts**; this may be a group that is independent from the groups above which can be very important in terms of credibility of an innovative alternative, but also for attracting additional funds. Ecoshape is such a group in the Netherlands that was instrumental in identifying pilots and in attracting also the necessary funds for conducting pilots.

Type of relation with the project *(actual and potential)*	License	Use	Owner	Know ledge	Con tractor	Funds
Are these related to the design *(consent, requirements, effects, innovation)*	●	●	●	●	●	●
Implementation and maintenance (requirements, timing, materials)	●	○	○	○	●	○
Can these lead to added values	○	○	○	○	○	○
that are substantial	○	●	○	○	○	○
that require specific designs	○	●	○	●	○	○
And to co-finance or cost-savings	○	○	○	○	○	○
by dedicated funding	○	○	○	○	○	●
by general taxation	○	○	○	○	○	○
by joint development	○	○	●	○	●	○
Best way to involve them						
by informing	○	○	○	○	○	●
In consultation	●	○	○	○	○	○
by joint designing	○	●	●	●	●	○
By joint implementation	○	○	○	○	●	○

Figure 6 scoping for potential relations and arguments for involvement.

So there are many potential stakeholders. How they should be involved depends upon their negotiation powers, their potential contribution to the project but also on formal procedures that stipulate stakeholder participation. What is important is that their potential to contribute or criticise the project should be recognized early in the project. That is also the main reason for conducting a stakeholder analysis. From a business case perspective important questions are:

- What are the **actual and potential relations to the project:** is it ownership, (economic) use, licensing powers, the opportunity of joint development, the contribution of essential knowledge, their responsibility for future management or can they contribute necessary funds. This relation may depend on the design or on its implementation.
- **Are these relations related to the design** and in what way? It could be by criteria posed by ear-marked funds for flood protection, requirements of specific users or owners.
- Can the involvement of specific stakeholders open **up new lines of added values**? Added values are not limited to financial or economic values. These values van be substantial but may also depend on specific components or characteristics of the design.
- May a stakeholder **potential contribute to the project financially or in other ways**? If yes, consider how financing requirements may be accommodated in the design and involve them in the design process. A stakeholder, such as a contractor, may bring in knowledge that would lead to **considerable cost savings or a more environmentally benign design?**

- Finally, consider what **would be the best way to involve them**. If a stakeholder may significantly contribute in a way that strongly depends on the design, it is best to involve them in the design process. Their involvement may be different in different project phases.

BwN projects require that new alliances are forged between stakeholders that so far had no business case together.

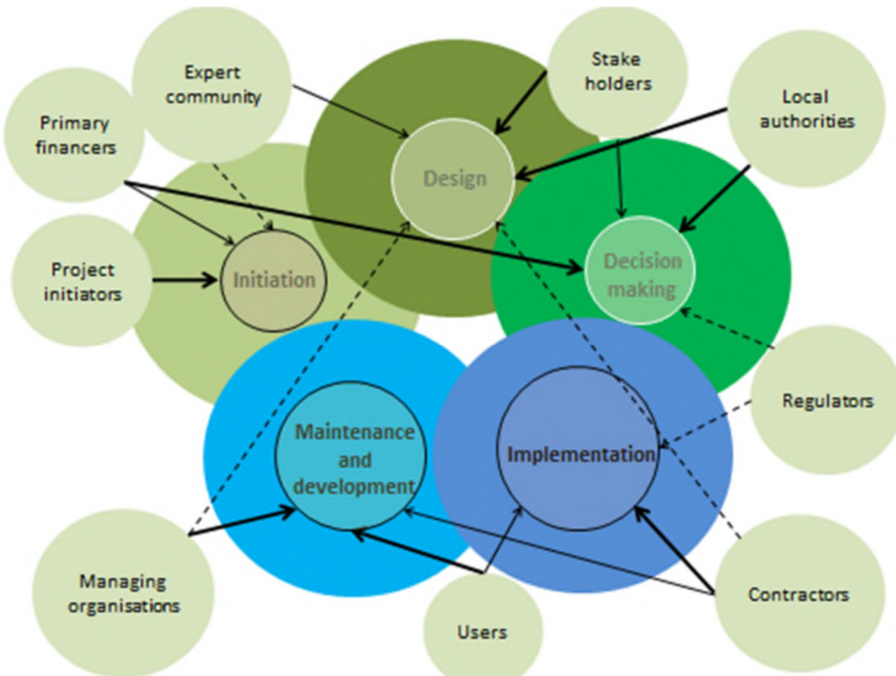


Figure 7 Various groups need to play their role in various project stages

Forming a dedicated project group

One of the first organisational decisions to be taken regards the building of a (building with nature) project organisation. This is not unlike in other projects.

The project organisation will at last consist of a project group, that prepares design (alternatives) and a steering group that makes interim and final decisions regarding the preferred alternative. For the project group is important that:

- **Relevant stakeholders are participating** or are represented with strong relation to the project, its implementation, use and maintenance.
- The **right mix of disciplines** is at the table, also the ones that can identify possible BwN alternatives. This will require the involvement of ecologists, environmental engineers and preferably also of environmental economists. In many BwN projects a representative of the scientific community can act as a catalyst for identifying BwN options. A landscape architect will add quality and synthesis.

The group needs a clear organisation structure that detailed tasks and responsibilities, specific mandates also vis a vis decision making procedures.

Wider embedding: policy making on behalf of BWN

Sometimes new policies are set based on the results of pilot projects. Pilot projects can be instrumental in this. However in order to facilitate BwN projects, organisational arrangements and policies are needed at a higher level that facilitates and advocates the use of BwN solutions. The chances for BwN projects become greater when:

There are **policy guidelines** that demand that BwN options should also be considered and not just standard engineering practise. These guidelines can be put into operation in for example SEA and EIA policy guidelines or can be made part of design protocols for specific type of projects such as flood protection works. Policy guidelines can be powerful advocates for using nature based solutions. They are more important than a guidance document.

Intermezzo box 2 - The impact of policies on BwN initiatives and projects

Examples of policy guidelines that stimulated exploring BwN-alternatives are:

- The management principle, "use sand where possible and only stones when needed" (zacht waar het kan, hard waar het moet) as advocated in a national policy document on coastal management and protection in The Netherlands had far reaching consequences, such as flood protection projects where dikes were replaced by dunes. Also the policy to maintain the 1991 shore line with nourishments is related to this.
- Apply a priority cascade of "first retention, than buffer and finally discharge", as advocated in the WaterManagement21 century policy in the Netherlands. This policy guideline triggered an avalanche of regional stream restoration projects that combined flood protection with hermeandering and the restoration of inundation areas. It also stimulated water infiltration projects in urban areas.
- The requirement that a most environmentally benign alternative should be created as part of an EIA (former in EIA legislation in the Netherland). This could perhaps be converted into the requirement to consider also a BwN alternative as a design option.

So policy guidelines are a powerful tool. It should be noted that the examples above does not require that a BwN alternative is chosen, but only that in scoping for solutions that one should also consider more natural ways of providing flood protection.

Also the availability of **research funds for pilot projects** and increasing the evidence base is vital. Without appropriate research into especially the "engineering" capabilities of BwN alternatives, such as wave attenuation by salt marshes or peak flow reduction by natural inundation areas, it will be difficult to develop trust in nature based solutions and without this knowledge it is also difficult to develop a cost-effective design. A nature based community platform that exchanges knowledge and lessons learned will contribute to this.

Promoting **assessment procedures** that include a comprehensive assessment of all potential benefits of BwN solutions is also very important. The first step is to consider wider societal benefits and not only initial and recurrent costs. These assessments should look at short- and long term benefits, within appropriate time and geographical system boundaries. For coastal projects, this is the entire coastal cell, for flood protection projects it may need to include the entire catchment area. The quality of a wider Societal Cost Benefit Analysis depends upon in depth knowledge on the value of ecosystem services in different physical and societal situations. It is not possible to conduct in depth studies in every project, it is important to develop a database of key figures and a concise system of rules how these key figures can be used. Also this requires a programmatic effort.

Habitat banking and biodiversity offsetting is not an established practise in most countries. It can however contribute to the funding of BwN alternatives, since it offers a co-financing in case specific natural habitats are part of the design.

Many ecosystem services are for free. Enabling **payment for ecosystem services** may increase the potential for financing nature based solutions. Opening up new paying mechanisms is subject to political decision making and it may not be possible to redefine existing systems that easily. However, it should be noted that a potential revenue stream is not the only criterion. Many natural habitats are formally protected and their restoration and maintenance is therefore not directly related to the ecosystem services these habitats can provide.

Where and how to get the necessary finance?

It is not easy to finance green

It's the motto of Kermit the frog:" it is not easy to be green". It is however neither easy to finance green, for a number of reasons. Green projects often fail to deliver concrete marketable assets and products since its value depends on more general effects, such as regulating services or a beautiful landscape that are not easily converted into finance. Furthermore the benefits are often long-term, uncertain and do not fall under existing ways of taxing and financing. It has often been hinted that the design of a nature based project is the least of our worries, financing is the greater challenge, especially if a nature based alternative proves to be a more costly solution than a conventional one.

Because of this there have been some recent studies that looked into innovative financing mechanisms for nature based project. The CBD (Convention on Biological Diversity) indicated several potential private financing schemes that merit further exploration. These include e.g. business-biodiversity partnerships, biodiversity off-set mechanisms and payment for ecosystem services (PES).

Further reading on financing nature based solutions and green infrastructure:

- Alternative business models for flood risk management infrastructure by Claire Walsh, Steven Burke,, Stephanie Glendinning and Richard Dawson (http://eprint.ncl.ac.uk/file_store/production/232624/C014601C-B6ED-451B-94F1-D3B5830B6A52.pdf).

- Green Infrastructure and Flood Management Promoting cost-efficient flood risk reduction via green infrastructure solutions. Of the European Environmental Agency. (https://www.eea.europa.eu/publications/green-infrastructure-and-flood-management).
- Natural Flood management handbook (funding opportunities in Scotland) (https://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf)
- Innovative financial mechanisms for coastal management in the Pacific: a state of the art (http://www.spc.int/wp-content/uploads/2016/12/Financial-mechanisms-pacific.pdf).
- Who should be responsible for the provision and financing of flood defences in the UK? By Edgar Deverell. Discusses differences between UK and the Netherlands. (https://www.uea.ac.uk/documents/953219/7433356/Edgar+Deverell.pdf/5732ade2-68f6-40a3-abb3-ccfbe9ac87b1).

Funding by principle or on the basis of economic benefits

The possibilities for funding differ per country and situation. Cases and countries within the Intereg project show the following bandwidth:

- In the **UK as in Scotland,** national public funds for flood protection need to be justified on the basis of a minimum benefit-cost ratio. Benefits include capitalized avoided damages to properties, infrastructure and the economy.
- In **the Netherlands,** coastal flood protection is backed up by national funds. Till recently investments in coastal protection as well as beach nourishments were paid for by the State. The water boards are responsible for maintenance of dikes and dunes, which is paid for by water fees, generated within the water board. At the moment the water boards contribute also partly to initial investments in coastal protection. The investments in regional flood protection infrastructure and its maintenance are also paid for by water fees. The water boards are large entities and raising the necessary money does constitute only a limited claim on the budget of local households or land owners.
- In countries like **Denmark,** large parts of the coast are privately owned. Coastal protection is paid for by land owners. There is often no cooperation between land owners, so coastal protection has a piece meal character and may not be the most cost-effective. Many private properties are mainly larger estates and villas and the costs of coastal protection can often be easily paid for by the owners.

So there is a large difference in funding situations. In the Netherlands, money for flood protection is available but a BC approach can be instrumental in creating design with more added values, in terms of nature development, WFD objectives, recreation amenities but co-funding by users and beneficiaries is not a requirement. In Scotland, a BC approach is also instrumental in identifying benefits that add up in the benefit-cost assessment and in finding co-financing opportunities. For Denmark a BC approach may help to identify coastal protection alternatives that are less costly and provide additional benefits to the local landowners.

Also **the financial mechanisms** that are available to authorities are different in different countries. In some countries, municipalities can impose local taxes, such as a property tax, a sales tax or tourist tax or even a flood protection fee.

In other countries investments in flood protection come from national budget lines, so there the link between the finance for a local project and local benefits is weaker.

There is also a difference in the way different countries look upon **the responsibility of public authorities** (proving flood protection) and the responsibility of private firms and individuals to get proper insurance, flood proofing or pay for local flood protection. In areas where there are comparatively few households directly affected, the costs of protected are comparatively high and can often not be paid for by individual households. So in these situation flood protection depends very much on solidarity principles. Since nature areas are considered as a public good, perhaps more so than local flood protection, BwN alternatives may offer more opportunities for financing also local flood protection schemes.

Sources for finance and integrating them into the design

This brings us to a natural sequence in looking for financial opportunities. BwN alternatives that are more cost-effective than conventional solutions are the most simple to finance because this will be done out of the earmarked budgets for flood protection or coastal management. The essence is to have sufficient knowledge and confidence in the proposed BwN alternative, that is will deliver the goods or performance required. This is often difficult, since empirical knowledge is often lacking and building the necessary evidence base takes time.

It becomes more complicated when a BwN alternative costs more or has uncertain costs or uncertain performance that cannot be handled by a more robust design that is still more cost-effective than the conventional alternative. One may have to look for additional finance. Examples of potential "easy money" are: avoided costs or earmarked budgets for functions or habitats that can be performed or provided by the BwN alternative. Examples are funds that are targeting specific habitats in need for restoration or compensation. If these habitats can be created as part of a BwN solution, co-financing may be possible.

If no additional finance can be found based on avoided costs or by targeting earmarked funds, one may need to look at direct economic benefits. Direct economic benefits can be related to the economic use of (parts) of the BwN alternative. A BwN alternative may create an opportunity for real estate development, with financial gains for the developer. If these opportunities are provided by the BwN alternative and not by the conventional alternative, there is a possibility of co-financing. This needs to be identified early in the process, and the design may have to be optimized in order to make the desired use possible.

In addition to direct economic benefits one should also target more general societal benefits, such as stimulating the local economy or enhancing the living environment. It are the regional and local authorities that are willing to co-invest when the BwN alternatives offers more societal benefits.

A BwN project may be a pilot which generates knowledge that may lead to further cost-savings or more societal benefits in the future and for which a dedicated fund is available.

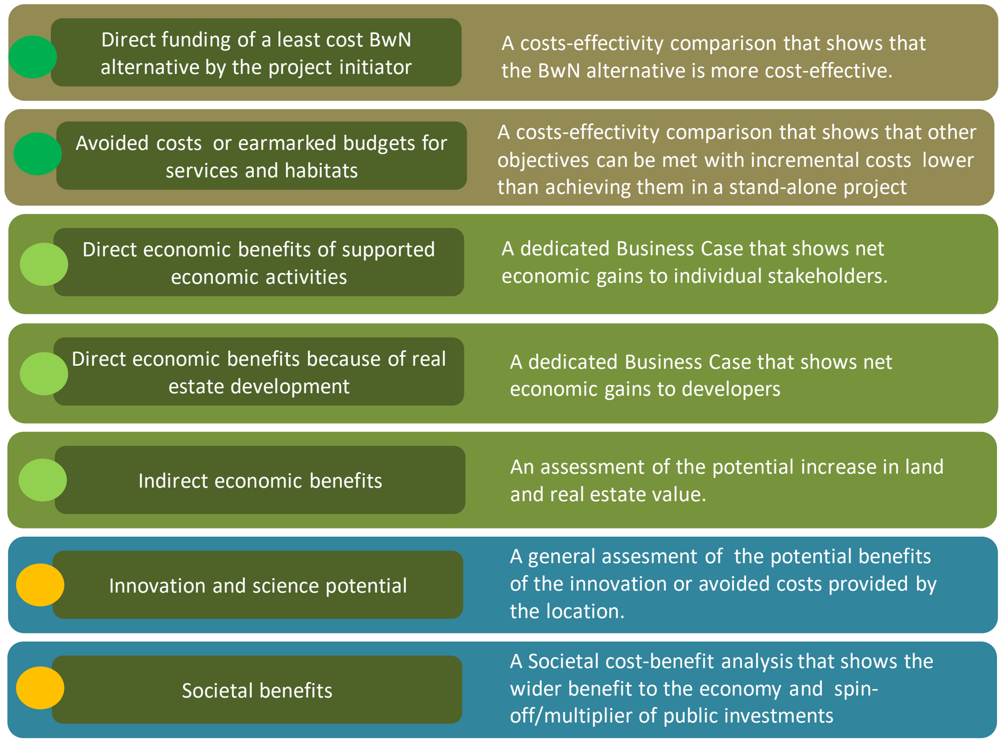


Figure 8 Possible ways of (co-) financing and required assessments needed to convince potential co-investors.

Example: Sand engine as an investment in innovation

Innovations come in different forms and the arguments for co-financing a pilot out of innovation budget is diverse. For the sand engine the following played a role:

- Better understanding of coastal processes: the sand engine in combination with an extensive research program will generate more in depth knowledge about critical processes, such as natural dune formation, long shore transport, erosion in the case of major storms. This knowledge can be instrumental for improving models, assessment procedures and design guidelines for beaches and dunes that act as a primary defence. So there is a potential gain that we will be able to make more cost-effective designs. Even if enhanced knowledge would show that we got it wrong and in fact more sand would be needed to protect the coast, this would still be regarded as beneficial, since it will help us do what is necessary in order to prevent major storm damages.
- Developing a better nourishment alternative: the sand engine may prove to be a more cost-efficient form of nourishment. If this is the case and it would be implemented more often, this would also constitute a major gain. However, in order to underpin this potential gain, one needs to know whether it is more cost-efficient and how often and where a similar concept may be used. Important are also the costs of nourishment. These costs depend on the market, dredging operation, location of the sand pit and the volume supplied and also the form of contract. All these factors vary in time and space.

Enhancing the Dutch water sector profile: indirect benefits are related to the export potential of the concept, the branding of the Dutch water sector as innovative problem solvers and more.

The co-funding landscape

It is important to know how economic values and revenue streams operate in the present situation. Three dimensions of the co-funding landscape merit attention:

Private revenue stream that support public funds. Private individuals already contribute to public funding, that are either linked to land and real estate values (e.g. sewer fees, land taxes) or economic activities (e.g. income taxes, sales taxes) or directed at specific user groups (e.g. tourist taxes, entrance fees). It is good to have some idea about the existing financial fluxes and potentials. This helps to see how benefits of a BwN alternative accrue to revenue streams for example to local authorities, which may help convincing them that co-financing is appropriate. It also gives an overview of existing financing mechanisms that may be used.

Public funding landscape. This encompasses earmarked funds for flood protection, habitat restoration, water framework directive funds. These are the first to look into, but there are many others that may be of interest, especially if there are opportunities to develop a more multifunctional BwN projects. There are for example funds for (regional) economic development, infrastructure development for innovation and research, for furthering sports, public green spaces and more. The landscape differs depending on country, region and municipality and location.

Real estate value. The major aim of flood protection is to save human lives and to prevent damages to buildings, infrastructure and the economy. It is good to have some idea of the geographical overview of real estate values and potential damages. Often a map with flood risks is already available.

Financing mechanism and cost-and benefit allocation

The previous section discussed potential sources for funding. The most direct financial mechanism is direct funding or a grant. There are a number of financial mechanisms that can be used by:

- A public authority in order to co-finance a BwN alternative with public money, such as local taxes based on real estate value.
- A private consortium to raise money for implementing and maintaining a BwN project.

The table gives an overview of different financing options that can in principle be available for financing. What to choose depends on the potential benefits and costs of a project. If there are potential revenues other options are logic than in the case that only a form of cost sharing is needed.

There are many different forms, but the essence is that costs and benefits are converted into contributions. This is not always easy. Grants are most cost-based, for example depending on the costs of creating a habitat or using a fixed price for specific benefits, such as a carbon credit or a subsidy for habitat management.

It becomes more difficult when there is for example a private investor that may see opportunities for developing an urban area, or to build a hotel. One may opt for cost sharing, in case additional costs have to be made in order to create the space needed to build a hotel. One may opt for revenue based contributions, for example a percentage of the value created, or of the turn-over or profits the hotel is making. If revenue streams are uncertain it would be better to look at cost-based sharing.

A municipality often has a local tax in place in order to pay for public services, such as waste collection. **Local property taxes** can be based on household size but also on the real estate value of a house. In the case a BwN project would lead to an increase in real estate prices, because of higher flood safety or a nicer landscape, this would automatically lead to a higher contribution in local taxes. The funding of the over 3 billion Euro flood protection project in Sacramento is based on an increase in property taxes. There are also examples of local sales taxes, often meant for managing streets and public spaces, sometimes also for flood protection, if national funding is absent. A BwN alternative may offer a much more attractive local flood protection alternative that also enhances the quality and recreational use of the landscape. So imposing or using such a tax for flood protection would become acceptable.

The use of local taxes for flood protection is common in countries like the US, where most flood protection works are financed by the municipalities. Often it are water authority that invest in flood protection, either with the help of national funds, or by raising **flood protection fees**. In The Netherlands all the water boards finance investments in regional flood infrastructure in this way. These water boards are democratic institutions and a raise in fees needs to be agreed upon in the regional assembly. There is sometimes discussion about the contribution of households, vis a vis land owners, and between those living in or outside flood prone areas.

From public, to public-private to private financing

Most BwN project that are directed at regional flood protection or coastal management is mainly financed by public funds. Even when there are economic benefits via recreational use or an increase in real estate prices, these normally constitute smaller co-funding opportunities often directed at providing some ease in maintenance costs or they provide additional investments for recreational facilities.

There are however exceptions, for example in the case there is no state authority that is fully responsible and the solution requires the cooperation and finance by a group of private land owners.

The simplest form of financing is based on single public, such as most nourishment schemes in the Netherlands. It already becomes more complex in the case of multiple public financing, such as the sand engine. The Twin dike is an example of a multiple public-private funding arrangement, albeit simplified by distinguished separate components.

The Tweed River Entrance Sand Bypass Project is an example of private-public financing of scheme in Australia. The innovative aspect of the project lies in linking project performance to volume of sand pumped and the unique collaboration and contractual agreements behind the initiative.

Further reading:

- Funding coastal protection in a changing climate: Lessons from three projects in Australia (https://www.nccarf.edu.au/settlements-infrastructure/sites/www.nccarf.edu.au.settlements-infrastructure/files/Funding%20Coastal%20Protection_ACCARNSI_Discussion_Paper_1_Final.pdf).

	Principle	Cost based sharing	Based on direct economic revenues	Based on benefits, not economic
General co-financing funds and mechanisms				
Taxes and fees	Those who benefit pay	Tourist taxes, local sales taxes, property taxes, flood protection fees, water management fees		
Public and private funds and grants for environmental objectives	Contribute to the specific objectives of funds that are available for general purposes	Grants (EU and national) and funds for habitat restoration (e.g. LIFE), National or local WFD-funding, private and public funds		Related to restoring specific habitats, CO2 sequestration, contribution to WFD objectives
General public funds for flood protection, infrastructure, utilities, regional development	Contribute to the objectives of funds that are available for general purposes	EU regional development funds, EU infrastructure funds.		
Project-based co-financing mechanisms				
User fees	People and enterprises pay for the use of the area.	Entrance fees in the case of recreational facilities. Long-term leases for hotels and restaurants.	Produce (e.g. fish, food, forest) based or income (e.g. increased turnover due to increase in	
User rights	Shares and licences that grant access and use	License costs for beach houses and restaurants. Shares coupled with user rights.		
Contributions of private developers	Private enterprises and (local) authorities co-finance because of development potential offered	Cost sharing of incremental costs because of specific design requirements.	Long-term leases. Profit sharing on initial investments.	
Direct contributions	Co-financing based on avoided costs	Contributions of utility companies, private enterprises, public authorities		
Revolving funds	Up front investments that are paid back and re-invested in further developments	Initial investments determine the amount put into the fund.	User fees and leases and local taxes are input to the fund.	
Crowd funding	Capital raised from a large number of people, with local or general interests	Can have the form of a grant.	Can have the form of a share	For restoration, preservation of landscape.

Example Marker Wadden - multiple funding

Marker Wadden is a large scale nature development project in Lake Marken. It aims to develop several islands and contribute to ecosystem restoration of this lake that is plagued by very high fine sediment concentrations. The basic idea is to create islands that immobilize fine sediments because of the wave sheltered conditions they offer, but that they can also be built with fine sediments that are trapped in specially designed sediment trenches close to the island.

Debate about possible measures was already ongoing for more than a decade. Finally a NGO, Natuurmonumenten made a proposal and got their first 15 million Euro form the national lottery. This proposal could be seen as a combination of a story line with a global business case, setting out volumes, hectares and costs. The first stage of the project had a budget of 75 million Euro.

The 15 million Euro of the national lottery was used as seed money. The NGO advocated that they would only undertake and use the 15 million Euro, if it would be complemented to an amount that would make the implementation of the first phase possible. Subsequently two ministries were donating also 15 million Euro each, because both of them had formal tasks and responsibilities regarding Lake Marken, and if a NGO was going to invest 15 million Euro, without having formal tasks, they certainly would need to make a contribution. With 45 Euro in the bank, the preparations started. Meanwhile this sum has been enlarged with further contributions from provinces and there is an ongoing activity to also involve larger Dutch firms.

Ministries are not allowed to directly invest in the activities of a private enterprise so there was a risk that their investments could be earmarked as state aid. In other to avoid this risk a formal consortium was created, and its existence was published through state media, indicating that third parties would be welcomed to the consortium. Since the state money was now in principle available to all interested parties, it could no longer be considered as a single donation to one private entity. It was also tried to attract EU-LIFE funds, but that was so far not successful.

Natuurmonumenten also organises special campaigns to attract more money by sponsoring, especially for dedicated elements, such as a boat to ferry to the islands. They have opened up the area as a living lab, which also attracts money for monitoring and lab facilities. The latter provide also some basic accommodation.

The projects also includes areas that are designated to receive earth from other projects, of they are looking for a depot for materials they cannot use. This can be considered as a form of physical sponsoring and meanwhile also volumes have reached Marker Wadden through this portal.

It should be noted that there is already a policy guideline into place, that demands that at a large part of the clayey top layer is used for nature development in any commercial sand pit.

Finally they are looking into the possibility of commercial exploiting a sand pit nearby, offering sand in return for building part of Marker Wadden, using the clay layers that are on top of the suitable sand layers.

Another part of the Marker Wadden project consists of Trintelzand. This is 280 hectare large area with shallow wave sheltered water and marshland. It is created as part of the strengthening of the Houtribdijk, which for 14 km on both sides will be strengthened with sand. A basic design of Trintelzand was based on a cost-neutral alternative for strengthened this section of the dike. So this part is financed by flood protection money. The strengthening of the dike was contracted as a Best Value contract, and the winning contractor scored points for enlarging Trintelzand, as part of their implementation plan. Additional money was attracted by means of a WFD fund, that is meant to create more vegetated shorelines, and which enabled to enlarge the basic design for Trintelzand. Incorporating these funds required a small alteration of the basic design, so the desired WFD habitats could be accommodated.

Marker Wadden is a unique and large project. The case however shows that many different sources can be found for financing and building a BwN project, and that contributions need not always to be limited to project finance, since also building materials can be a valuable addition. It is however a case that strongly depends on public funds.

Example Twin dike - dedicated business cases

The Twin dike is an alternative for conventional dike strengthening along an intertidal area. The concept consist of constructing a new, or using an existing older, dike so the existing dike needs no or only limited strengthening. In between both dikes is a land area that provides the clay needed to build the second dike and that is converted into an area for uses that match its position, such as brackish water aquaculture.

The financial and economic logic of the Twin dike is based on the following assessments. A cost-effectiveness comparison was made in order to compare the costs of conventional strengthening and the cost of the Twin dike, looking at the costs for the dikes, so the components that are needed for coastal protection only. In this way the HWBP, the program responsible for flood safety, got an indication whether the new BwN alternative can be implemented at similar or lower costs.

An overall business case was set up for the area between both dikes. This assessment looked at the additional costs for preparing this area for its new uses, such as the costs for providing secondary infrastructure and culverts that enable the required brackish water dynamics, the costs of the land and the benefits expected from the new uses. This overall business case provided information to the province, in order to see what the total investments and related financial risks would be to the province, that as an authority would invest in the pilot as an innovation in coastal development.

Since the exploitation requires also the involvement of private firms, an additional business case was set up to provide information to them. This business case looked mainly at the production costs and potential benefits of different forms of brackish water aquaculture.

The costs of the culverts are very high compared to the other costs. The costs are higher in case one wants more tidal dynamics, for example in order to enable mussel cultures. So there is a direct relation between these costs and the type of production systems that are made possible. The project is still assessing what type of production systems to install.

At a late stage of the project a new potential user or contributor the project was identified. Close by a google data centre will be built that has excess heat available. With this excess heat also other production forms can be envisaged.

There are several financial risks identified, mostly related to the proposed innovations. Part of the area will be use to convert mud into clay that is suitable for dike construction. Providing clay for dike construction is potentially a large benefit, but it is uncertain, since the quality of the clay can only be ascertained at a later date. There is a contractual arrangement that the water board will buy the clay for dike strengthening if it proves to be of good enough quality.

The expectations, based on experiences elsewhere, are good regarding different forms of brackish aquaculture. However, especially over a time scale it is difficult to predict market values, or potential environmental conditions that may limit expected production. The land is leased for a period of 20 years from the present land owner. As part of the contract it was agreed that the land would be restored into its original state, in case the new land uses would not prove to be profitable enough. Restoring the land entices additional costs, and are also a financial risk to the project, that is covered by the province.

This case shows that different business cases are needed for different uses and partaking stakeholders. It also shows that undertaking innovative projects is not without financial risks. It is best to identify them upfront and construct guarantees and contractual conditions that show how these risks will be handled.

Tasks and roles in implementation

Reconsidering project requirements

In the first stages of the project it makes sense to reconsider deadlines and design requirements that have been imposed, often by the financing agency, constructing a framework within which the responsible authority has to deliver its project. However, these frameworks often limit the possible use of a BwN alterative from the onset of a project.

Allow time for a BwN alternative to be developed. Most flood protection works, whether on the coast or along rivers, have set deadlines. These deadlines define when the required flood safety standards must be achieved. Often these deadlines are part of legal frameworks or policy guidelines, and responsible water authorities need to work within these frameworks. However, often these deadlines are set having a conventional alternative in mind, for which the time needed for planning, procedures and implementation are known. A BwN alternative may require more time, the BwN alternative:

- is an innovative concept, so additional research and perhaps also pilot studies may be needed to underpin a final design. This costs more time.
- requires a more complex planning process, because it is multi-functional and addresses more objectives and stakeholders.
- may require also formal changes in policies and laws that define tasks and responsibilities, formal assessment procedures and more.
- may require more time for implementation because natural processes are used that have a specific but limited capacity, such as natural dune formation.

So allowing time creates more opportunities for the development, design and use of BwN alternatives. A pre-screening of the time needed that would enable the development of a BwN alterative needs to be made in the project initiation stage.

Define matching and logical requirements. Especially engineers that are used to designing dikes may extent similar requirements to BwN alternatives as well. However, a dike is a hard structure that is meant to last and perform during its entire functional and technical lifetime, as it was built initially. A BwN alternative is not hard, and over the years it may be developed gradually. With periodical nourishments, one can develop dunes and wider beaches over a longer time period, for example making use of navigation dredging material. Vegetation needs to time to grow as will its role in wave attenuation. So it makes no sense to define design requirements as would be needed 30 or 50 years from now. Due to sea level rise and climate change the required performance grows over time, as may be the delivered performance of a BwN alternative.

Types of contractual arrangements

There is a large number of different forms of contracts for building and maintaining projects. Typical examples are:

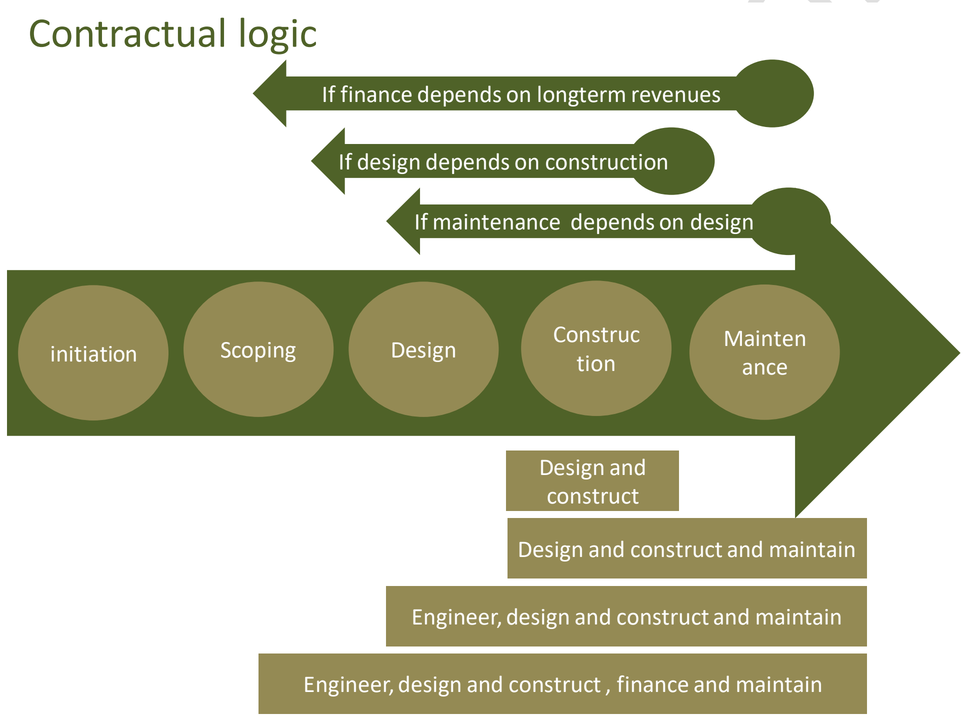
- **Design and build** is the most common form of builders contract for all kinds of hard infrastructure, such as dikes or dams. It can be based on a detailed design made by the Client organisation, but also on functional specifications that set building requirements and or performance requirements. This is a contract form that can be used when the basic design involves conventional engineering and maintenance is taken care of by the contracting organisation. Nourishment projects, and single purpose groynes and dikes, but also inundation areas can be contracted in this way. Also the sand engine was contracted in this way based on a detailed design based on (cross) profiles for the more stable parts and volumes for the more dynamic parts.
- **Design, build and maintain** is often a suitable contract form for BwN project, especially if there are strong relations between the design and its maintenance, which is often the case with projects in dynamic environments such as sandy coast lines. The Hondsbossche Pettenmer Seadike was contracted in this way. There was a tight set of functional specifications because the dune and beaches to be built are a primary defence structure with mainly degrees in freedom regarding the development of nature and recreation and especially regarding its maintenance. Maintenance could be achieved by nourishing an expected nourishment need for the coming 20 years as part of the initial construction, or it could rely on more frequent nourishments in this period.
- The **Design, Build, Finance, Maintain and Operate** is a contract form that covers all the bases and gives the contractor, or a consortium that may include a contractor and financing organisation, far reaching responsibilities and also opportunities. It is a suitable form when there is some degree of certainty regarding future income to maintain and operate. It is not a contract form that is very suitable for BwN projects, but there are some exceptions. Examples are certain types of by passing schemes (……)
- **Engineering and consult,** which gives the contractor much influence in the design process based on a first feasibility design. So detailed design and also supporting studies and getting the licenses are the responsibility of the contractor. This kind of contract can be used if the way the project can be built is uncertain or may strongly influence the design. It may also lead to an organisation that enables the joint development by contractor and client. The Markermeerdijken project is done in this way. The original budget for the project was determined based on detailed designs. However, since there was ample opportunity to further optimize the design in close consultation with stakeholders and the science community, this form was chosen.

It is important to note that the contract form strongly influences the design process and also the ultimate design. It contract form is preferably chosen early in the project cycle, but with due consideration of all its consequences.

Contractual logic

So there are very different forms in which a building contractor can be involved. Involvement can be done on the basis of a detailed design, or design and built, but it can also include maintenance after building or even co-financing its construction . The choice of a contract form, or the contractual logic, should depend on the kind of BwN project:

- In the case of a simple nourishment project, that is meant only to maintain the beach, only delivering a volume is needed and a simple contract suffices. There is no need to involve the contractor in the design.
- When however the design depends very much on the way it will be constructed it makes sense to involve contractors earlier in the design process. This implies that the contractor is contracted early in the project cycle on the basis of functional specifications, by putting forward a design and construction method that is the most cost-effective, environmentally benign or beneficial to stakeholders.
- In the case the financing of the project is also done by the contractor and may in part depend on long-term revenues, the contractor should be even involved at an earlier stage. In these cases the contractor can be selected on capabilities after which he may join a consortium together with the Client. This is a common arrangement for example for building infrastructure, such as bridges, in which there is a revenue stream (toll). BwN schemes or nourishment schemes may have this form, in which the revenue stream is based on annual nourishment needs. A beach upgrade may in part be financed based on revenues from tourist taxes or from the use of parking lots etc.



Using contractors creativity

Conventional projects can often be contracted within a design and built contract, since the building of dike is a known technology and there are no specific risks related to its performance or long term maintenance. BwN projects are different and often is makes sense to use a different kind of contract.

There is a number of different contract forms that can be used to implement, but also to involve the contractor and the managing organisation also in the design phase of project. The logic to use a specific kind of project strongly depends upon the type of project and often also on the philosophy of the contracting agency.

BwN projects that involve substantial capital dredging works and maintenance, are best contracted in a way that:

- Enables early involvement of the contracting firms. This is especially vital in the case of projects in which the way of building it, is strongly reflected in the design.
- Includes also long term maintenance. This comprises of projects in dynamics environments such as sandy shorelines. In this case the contractor can optimize between capital and maintenance dredging works.
- Uses win-wins with other projects, which may require extension of deadlines in order to optimize timing.

Using contractors creativity requires also that there are specific degrees of freedom that allow the contracting party to optimize the design depending upon the way he can use the equipment he has available in the most efficient way.

Example Marker Wadden - using contractors creativity

Marker Wadden is an archipelago of islands that is built in Lake Marken. Its primary functions that of a bird paradise and of immobilizing fine sediments can be met in very different concepts and designs. Since local material are used to build it, the way of building it, the equipment used and the choice of the sand pits would to a large extent determine the most cost-effective design. So an EIA was written on the basis of functional specifications that also led to a license with a lot of flexibility for the contractor. The contract specified only the location where the islands should be built, a large area where the sand pit could be placed. The habitats the be created were only functional specified, with a bandwidth in percentages between shallow water and marsh areas. How the rims could be built and protected, by sand, or with rock, was left open to the contractor. As a consequence a large number of different types of designs was put forward by different contractors, all exploiting the equipment available to them and applying very different model and concepts for design and building.

The contract set out that the contractor would be responsible for the maintenance of the rim for a longer period, but that the nature management of the inner core areas would be the responsibility of Natuurmonumenten that has much experience in nature management.

7. Conclusions

This guidance report presents five steps to come to a 'quick scan' business case of building with nature solutions. Using the definition of a business case in this report, one should be able to answer the following questions: *1. Does the project provide increased welfare for society?; and 2. Can we identify sources and mechanisms for financing?*

Chapter 2 Scope and context and Chapter 3 BwN options and system analysis presented possible interaction between the environment and society. Focus is on the possible role of nature and natural processes in delivering such "engineering services" as flood attenuation and coastal protection. But attention is also paid to other ecosystem services that increase the welfare of society. In this way we also identify relevant stakeholders. So the scoping phase delivers an overview of present and of potential future network relations between the environment and society and as a spider in a web.

Chapter 4 Selection of the preferred BwN measure and Chapter 5 Optimizing design of BwN measure form step 3 and 4 of the business case. Several methods can be used to select the best BwN solution, based on costs, effectiveness and (co-)benefits. Taking potential network relations and habitat requirements as a starting point, various BWN designs are elaborated and optimized. This optimization is not only directed at improving "engineering services", but also at enhancing nature and services that benefit society.

The last step is Chapter 6 Stakeholder involvement and arrangements. This is about confirming networks relations in the sense that (formal) arrangements define this relation, such as contracts for implementation, agreements on use and monitoring and maintenance. The chapter also describes ways to identify potential sources and mechanisms for financing a BwN project.

Following these five steps, the focus shifts from system understanding, towards identifying added value and finally ensuring that implementation, maintenance and finance are arranged. However, these are not strictly sequential steps, it could well be that it is a tango or paso doble. The earlier one identifies possible constraints that need to be lifted by an agreement, or potential sources that are dependent upon specific design features, the earlier these can be mixed into the "cooking" process.

A quick scan is a rapid process of developing a business case. It follows all the steps but with an emphasis on the scoping phase. The main purpose is to identify possible BwN alternatives and stakeholders that should be involved as well as the major factors and conditions that determine its potential performance as an alternative solutions and its potential acceptance by stakeholders. This guidance documents provides you with points of attention, tools and project examples to apply the business case approach for your own BwN project.

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