Subject: WP5 phase I report
Date: 30th of October 2017
Status: Final

BUSINESS CASE APPROACH lessons learned and contours

1 Introduction

1.1 BwN – The business case

The majority of BwN solutions still find themselves in the realm of pilot projects: the concept needs to be tested and optimized and evaluated on efficiency and effectiveness before they can become mainstream in policies and in practice. In order to support this process of implementation in policy, business cases can clearly outline the arguments for investing in these types of solutions. An additional use of a 'business case' is that it is a useful tool in optimizing the design by maximizing benefits and minimizing costs. In this study, we discuss the role and requirements of the business case in these two applications: towards optimizing the design (achieving the full potential) and towards upscaling of the concept.

The business case approach for BwN projects will be developed in phases. This phase contains lessons learned and the first contours of a BC approach. In the next phase this approach is elaborated as a guidance within this contours to an extent that is can guide the description of high level cases in phase III. These high level cases can be considered as a test of the guidance and will also generate new insights and issues that merit attention when developing a BC. The high level case descriptions will also generate criteria that are useful for opportunity mapping, which is the objective of phase IV. Parallel the guidance will be further elaborated and applied to several more detailed cases, which again provide additional insights that will help to finalize the guidance. The detailed cases have a focus on optimizing the design, so it matches local and project specific conditions and opportunities.

Our goal in this phase is to:

1. Show available methodologies for business case development and valuation.
2. Provide guidance for a BC development approach for BwN projects by assessing lessons learned and critical factors in a number of cases.
3. Demonstrate opportunities of BwN concepts by providing best practice examples of BC

To this end, we analysed a number of BwN cases regarding the application and role of economic tools/ business case in the design process and in implementation of the project.

In the scope of the Interreg North Sea Region project Building with Nature, WP5 will work towards developing a 'business case development guidance document', provide input related to optimizing the design related to the business case, cooperate in building the business cases of for a number of BwN cases in the project, and work out the 'upscaling' business case for 3 BwN concepts.

In the next section the concept of a business case in the context of this report is defined: it is good to realize that incentives to invest may strongly differ for various actors, i.e. private versus public, and hence the scope of the business case as well. We then shortly discuss the two types of business cases applications that will be introduced in this report: scoping and upscaling.

1.1 Business case: definition

There are many definitions of a 'business case', but most entail a formal justification or argument to convince a decision maker of a proposed project or undertaking, generally based on expected commercial benefit. In this report, we define a business case as follows:

‘A business case is a decision support framework that gives insight in two core questions of importance during a design process: 1. Is the project worth investing in? 2. Can we finance it and how?’

To answer these questions, there is a range of economic tools that can be used to evaluate choices and hand and support the justification of investment. For example, in the initial design phase a cost-effectiveness analysis may be used to choose between various measures, or a quick-scan CBA to estimate the economic impact of various design alternatives and make a first selection[1]. Aside from economic tools, there are various ways to how a ‘business case’, or argument for investment, can be focused, differing from the number and character of involved stakeholders or investors. In Table 1 an overview has been provided of economic tools and ‘business case’ models that can be used in building the BwN Business Case.

Table 1: Overview of Economic tools and Business Case models

BC type	Description
CEA	Cost-effectiveness analysis of project alternatives to primary goal
MCA	Multi-criteria analysis
SCBA or CBA:	Analysis comparing costs and benefits of a project of project alternatives from a social welfare perspective.
(Private) business case	Determines whether a project is attractive from a financial perspective (not necessarily profit)
Public business case	Defines the financial consequences of a project to the public investor
Multi-stakeholder (ppp) business case:	Combining all investments from various partners and cash flows and risks related to all partners. Goals and conditions related to multiple investment flows differ.
A business model	Describes how the expected benefits are capitalized, in a ‘value proposition’ a description of partners, activities, inputs, customers, costs and revenues.

In general, an end product of the business case includes the following factors:

- A description of the proposed alternative/ projects and the context (i.e. challenges in the area) in which it is proposed
- An analysis of costs
    - In a pilot project, any additional funding needed for feasibility studies and design are often financed by another source than who will eventually invest in the project. The business case focusses on costs for the investing or responsible party (or parties): i.e. construction costs and operation & maintenance costs.

[1] Cost-effectiveness analysis compares the costs of measures with their effect: how much does a unit ‘effect’ (i.e. % wave attenuation) cost? A CBA estimates the economic welfare effect of the project, including things like total project costs, nuisance from construction, benefits for recreation.

- An analysis of the projects' benefits. Depending on the conditions set by the stakeholder – or stakeholders – this may include a wide range of socio-economic benefits, including ecosystem service valuation (recreation, biodiversity, regulation of water and soil quality, spatial quality). In a multi-stakeholder (and multi-investor) environment, it may be useful to separate the value proposition, and cost and benefit/ cash flow streams to various investors and beneficiaries.
- An analysis of risks and uncertainties related to the investment (i.e. construction risk, project risk, uncertainties in external factors).
- Overall concluding with an argument on whether or not investment is attractive.

1.2 Scoping

The development of a business case for a BwN solution in a specific location follows the general design process in infrastructure projects (Figure 1). With scoping, we mean the process of identifying opportunities, alternative solutions, key drivers in selection of the preferred alternative and overall optimization of the BwN solution to ensure it reaches its full potential and thus strengthens the business case: the argument for investment. In this, the development of the business case acts as a decision framework, providing guiding principles. The first phase in the design process includes a definition of the challenges of problems that are addressed with a project. Other than conventional solutions, BwN solutions often have the potential to address multiple challenges or problems in the project area beyond the primary objective, possibly with various 'problem owners'. After scoping these opportunities, a broad analysis of existing conventional solutions and nature-based solutions (and their costs, advantages and disadvantages) is required to design the best alternatives, with high potential to address the 'value-creating opportunities' in the system. Often, but not always, the costs of conventional solutions set a price limit to the maximum investment in BwN solutions. An analysis of key drivers in the selection of the preferred alternative is important to determine the focus of the design (i.e. costs, specific ecosystem services, maximized social value) and the core of the business case.

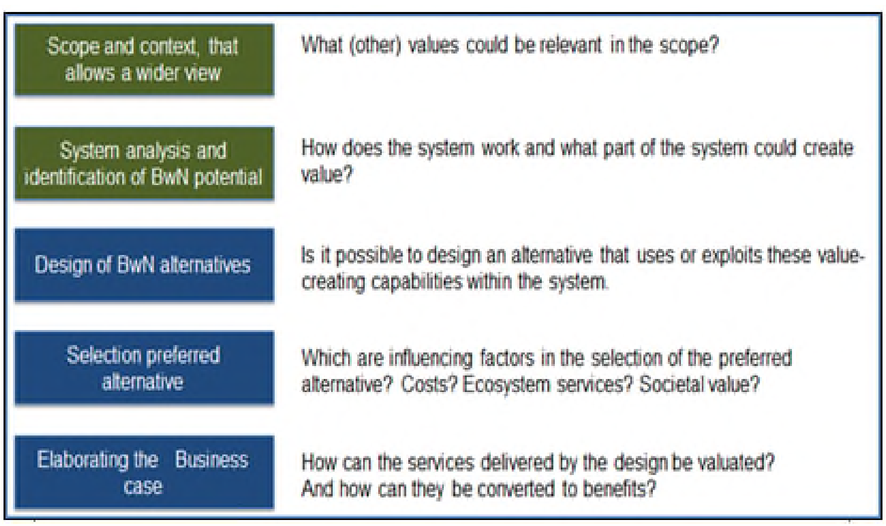

Figure 1 Questions related to optimizing the BwN design throughout the process.

1.3 Upscaling

BwN solutions that have been tested and applied in a specific project may be applicable elsewhere – in order to mainstream the concept of BwN, upscaling is needed: extrapolating an existing concept or application to other locations with required adjustments. There is a wide array of factors that determine the success of a BwN concept in a particular place; some of which may be similar to the pilot locations, but not necessarily. For that reason, we don't aim to transfer a blue print of the original design to another location, but rather use the concept and basic principles of the original design to fit to the logic, opportunities and limitations of another location. In this context, we distinguish:

- **BwN strategies**: long-term development or management options that use nature or natural processes. I.e. BwN strategies for a sandy coastline include managed retreat, 'hold the line' and seaward advance. Similarly, in intertidal coastlines the introduction of brackish water agriculture can be seen as a strategy of managed retreat. The long-term rationale of these strategies depends on the interrelation between coastal processes and coastal communities: how does the strategy address (long-term) challenges of the physical (e.g. sea level rise, increased salinity) and socio-economic environment (e.g. demographic trends, market conditions, the need for more recreational areas).
- **BwN concepts:** these are the different concepts or applications of nature or natural processes addressing challenges. E.g. different forms (in space, time or quantity or character) of nourishment or different ways to increase the through flow capacity, such as lowering floodplains or restoring a tributary.
- **BwN projects;** these are a concrete combinations of one or more alternatives, embedded in a BwN c.q. longterm development strategy.
- **BwN knowledge:** Pilot projects may generate much knowledge that can be used elsewhere; for example on the functioning of certain solutions or monitoring- and evaluation schemes
- **BwN networks:** Not only the solutions, but also the processes and actor networks that have been involved earlier may be activated again and so lead to new, possibly faster and 'better', solutions

Upscaling starts with identifying the potential for a BwN concept in a wider spatial context. This first step in identification a potential can mostly be done on the basis of a limited number of indicators. Once the concept is applied (with tailor-made and location specific designs) in multiple locations, lessons learned, best practices and reaching 'proven concept' will allow further mainstreaming of the concept in general policy.

1.4 Structure of the report

In chapter 2 we present the method and results of our case study analysis, including lessons learned and critical factors in building the BwN business case. In chapter 3 we introduce the general approach for a BwN business case approach. In chapter 4 we discuss key elements in the business case for optimizing the design by 'scoping' various challenges and solutions, and key elements related to the upscaling of the BwN concepts.

2 Lessons Learned

2.1 Cases

To assess the lessons learned from Dutch projects and some European BwN projects, a limited number of cases were analysed to answer the following questions:

- What physical and societal challenges were addressed?
- Was a business case developed, what benefits and costs were taken into account and what type of assessment method was used and in what stage of the planning and design process?
- Did the business case also address flexibility and adaptability, uncertainties and the allocation of costs and benefits?
- Was the business case important to the selection and the design of the BwN alternative?
- Did the business case involve co-financing and financial engineering?
- What were the major success and limiting factors?

Figure 2 Pictures of the seven case studies that were used for the quick scan analysis.

Factsheets are provided in Appendix I. The following cases have been analysed (Figure 2):

1. Sand Motor: a Dutch BwN project on a sandy shoreline, that consists of a mega-nourishment in the form of a peninsular.
2. Salt Marshes Delfzijl: a Dutch project that uses newly built and developed salt marshes as part of a flood protection system that will also serve as a urban park.
3. Houtribdijk: a Dutch BwN project on the shore of a large Delta lake that consists of a sandy foreshore as alternative to a hard revetment.
4. Room for the river Lent: one of the Dutch Room for the River projects, that combines the construction of an additional river channel in order to reduce peak flood levels with urban development.
5. Twin dike: a Dutch BwN project on the intertidal shores of the Wadden Sea that combines climate resilient forms of brackish aquaculture and a clay ripening factory with a flood protection scheme that consists of the existing and a newly built inland dike.
6. Eddleston: a case from Scotland in which the effects of restoring natural habitats on attenuating floods and ecological status are being monitored.
7. Sigma Plan Kleine Nete: a river restoration case from Belgium in which the river gets more room and wetlands are restored.

2.2 Lessons learned

Below, we describe the major lessons learned that were extracted from the seven case studies in the Netherlands, United Kingdom and Belgium.

2.2.1 A business case is often not leading for the selection and design

The costs or the cost and benefits are often not decisive in the selection and design of a BwN project. This is especially the case for the Dutch flood protection and coastal management cases. There are no financial constraints, so there are no incentives to optimize cost-effectiveness of the design or to create opportunities for co-financing by integrating win-wins that lead to concrete economic benefits. In the BwN pilots especially the ambition to innovate and to conduct meaningful research were important drivers for the design. A clear exception is the Houtribdijk, where the decision to strengthen half of the dike with sand was based on a cost-effectiveness comparison with conventional dike strengthening. It is to be expected that a business case will play a more important role in the non-Dutch cases and in cases that are not an innovation pilot, when cost-effectiveness is more important in the decision-making process.

2.2.2 Multiple variables determine the business case of a BwN solution and its potential for upscaling.

The success of a BwN solution seldom depends upon a limited number of factors. For example, the cost-efficiency of the sand motor depends upon such factors as: longshore transport and whether these can be used efficiently for the natural nourishment of the shoreline, and the availability of sand and the costs of sand nourishment. But just as important was the drive of the scientific community and state department to pilot an innovative alternative to periodic nourishment and of the province of South Holland to create additional recreational areas. On closer inspection many projects are strongly determined by governance.

Because nearly every case is characterised by unique location and project specific features that determine design, decision making and success of a BwN solution, it is not possible to simply extrapolate an existing BwN solution to another location. One needs to break a BwN solution down to its essentials and then see how it could be applicable elsewhere.

The variables that determine the BC for a BwN solution can be grouped into:

- Ecosystem characteristics (coastal system, catchment etc.): Physical-ecological characteristics that usually determine the type of solution that can be proposed.
- Community characteristics: Socio-economical characteristics often locally dependent land use and land ownership that usually determines the public acceptance and potential for wider economic benefits.
- Country characteristics: Legal-political characteristics, that determines whether legislation allows interventions and the way financing by regional and national budget lines is arranged.

One should note that community characteristics and country characteristics are in fact the realm of governance. Within the Interreg NSR Building with Nature project, there is another working package that is specifically directed at governance.

2.2.3 A successful BwN has its roots in the initiation phase

Many cases show that it is essential to scout for BwN alternatives already early in the planning process, for various reasons:

- If not identified early there simply is no time to develop a BwN alternative to its full potential. It is often an innovation so a pilot phase and more research may be needed. It is also a multifunctional solution, so involvement of more stakeholders may enable a win-win, but this takes time. It differs from standard practise, which means that the local community and the authorities have to get accustomed to new ways of thinking. And also much time is needed to discuss and agree upon related management needs and responsibilities.
- Many processes go through several stages, of subsequent decisions, and therefore pass points of no return. It is often very difficult to propose a new alternative when the planning process is already focussing on a specific solution, since this may have already have been landed in agreements between parties, leading to expectations etc.

Many Ecoshape projects were instigated by a group of ecologists and engineers that proposed innovative solutions, often as a potential option, worth considering. Without their drive and intervention most BwN alternatives would never have been studied or implemented as a pilot.

2.2.4 A successful BC addresses specific BwN qualities and uncertainties

It is often said that a BwN solution is more flexible or adaptable so a strategic better option in situations with great uncertainty over future conditions and perhaps also ambitions. But these qualities are seldom quantified. It is however possible to do this and even within the costing procedure since these always include risks as well.

When we look for example at the quantification of risks within the standard Dutch costing procedure for larger infrastructure projects, risks are taking into account in the following ways:

- A bandwidth in quantities that determine the design and therefore initial costs, but also in maintenance. So required quantities can be smaller or larger.
- A bandwidth in prices related to quantities that reflect market conditions. So costs can be higher or lower.
- A list of identified risks of a procedural, legal and technical nature. This list is accompanied by actions to manage and reduce risks. Usually in subsequent design steps, this list becomes smaller and also the risks identified become smaller, due to research or incorporation in the design.
- Unidentified risks, usually a standard percentage of the identified risks.

This general works well, but all risks are in fact considered against one possible future scenario. In order to quantify robustness, flexibility and adaptability one needs to look at the performance and the need and costs of necessary adjustments under different future scenarios. Often this does not has to be very complicated and has to be done for the time period that is relevant also considering the discount rates that are employed. For example at a discount rate of 5%, discounted rebuilding costs constitute less than 10%, after a period of 30 years. At 2% this would be 100 years. So the long term matters, but can be very uncertain.

2.2.5 A BwN solutions ideally address multiple functions and involves multiple stakeholders

A BwN solution ideally addresses multiple functions and the BC involves multiple stakeholders in different capacities: users, managers and investors. This implies that the planning process should be given due consideration. BwN solutions, or nature and natural processes in general may deliver a multitude of ecosystem services, that impact upon many stakeholders. For example, the restoration of a floodplain may offer also recreational benefits.

3 General approach illustrated

3.1 Relevant steps and levels of integration

The general approach follows some basic steps that should be handled not as subsequent steps but in a form of iteration. Elaborating the scope and context of a project should be done simultaneously with system analysis and the identification of possible BwN solutions. There is also a strong relation between designing a project and evaluating it, since both these processes reflect on the same design and assessment criteria.

The optimum is a form of business case optimisation that tackled all steps in an interactive approach. As can be seen there are two different forms of upscaling:

- In terms of **recognizing a potential** that can either be mapped by opportunity mapping or identified as a potential option in the project initiation phase.
- In terms of **realising a potential** by tailor made optimisation, matching local needs, ambitions and often also local politics.

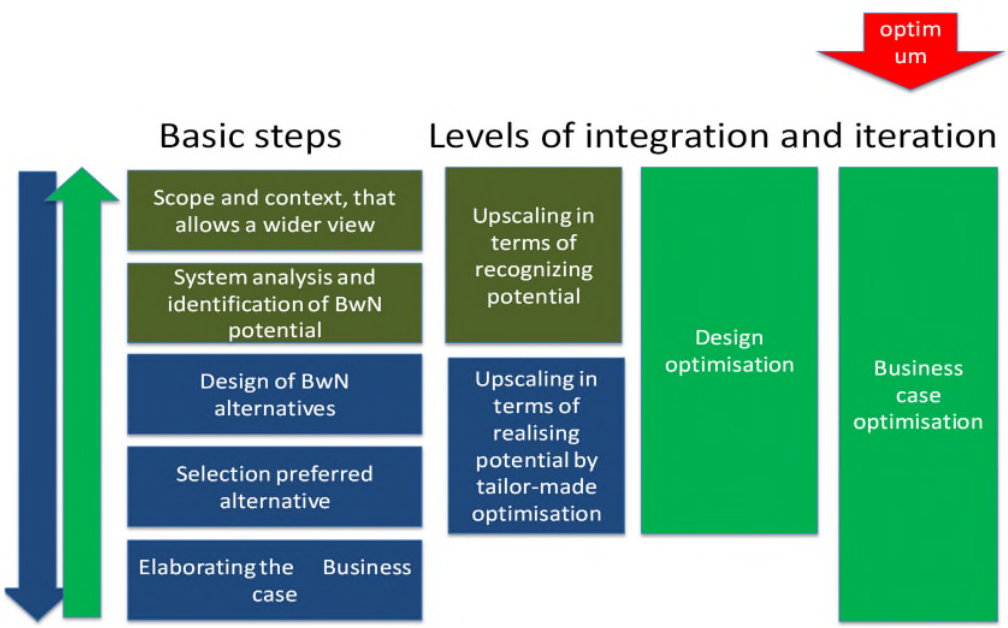

Figure 3: Basic steps and levels of integration and iteration to optimize the BwN design and to facilitate upscaling.

There a number of key issues that need due consideration in the identification and design of BwN projects and in setting the business case (see figure 4).

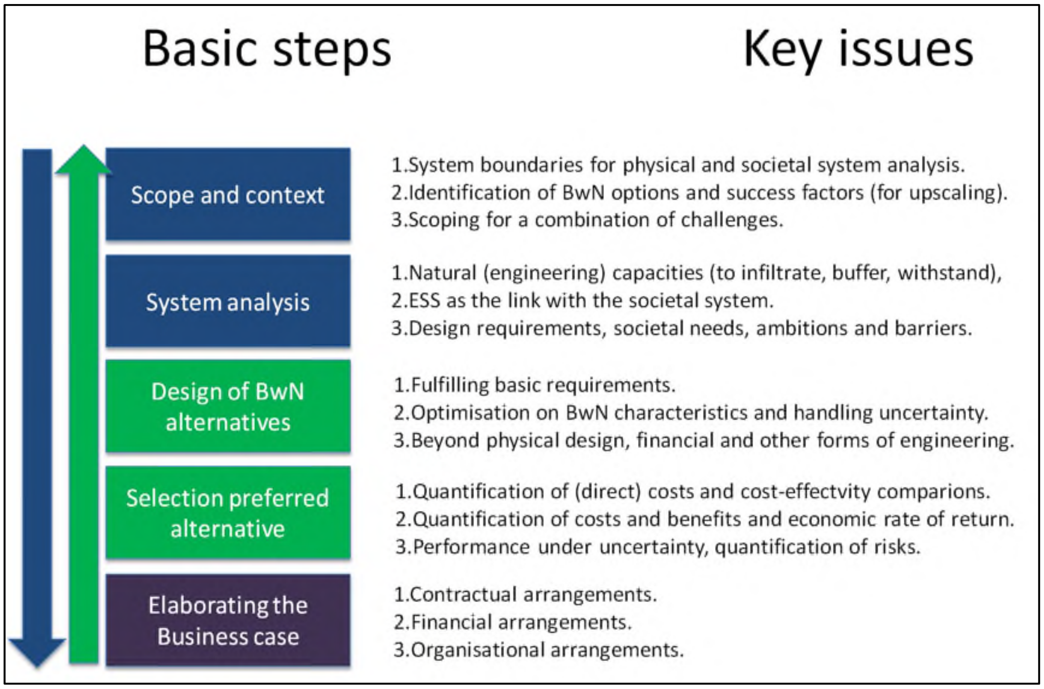

Figure 4 Basic steps and key issues to optimize the BwN design.

3.2 First outline BwN framework and principles

This work package takes the framework as was elaborated in an earlier EcoShape project as a starting point. This framework was based on the following principles:

- The BwN business case starts with a good understanding of the physical/ecological and the social/economical/political systems and especially the interaction between both systems. Building with nature is not only about nature, but also about people and the way they use, or may use and appreciate nature. How the identification of potential applications of BwN concepts depend on physical and socio-economic and political systems, is further described in Appendix I.
- The BwN business case does not only focus on the engineering culture of providing a solution to a specific challenge, but also encompasses a more (regional) planning approach, that looks at a wider perspective and regional and economic development.
- The BwN business case approach can be seen as a design process, that aims to generate a design that takes into account the multifunctional character of a BwN solution from the very beginning and sees potential ecosystem services, uses and financing as design parameters, to be identified at an early stage of the process.

3.2.1 BwN principles in practice: Sandy strategies

This first outline was directed at the development of sandy strategies, or in fact coastal development with a critical role for sand. In most cases this could be limited to coastal management by means of sand nourishment, but it can also consist of upgrading and even building new sandy coastal environments that stimulate regional economy and ecology. Hence the term sandy strategies was used in order to indicate that possibilities go beyond mere nourishment and may even include the establishment of an artificial beach-dune systems on places where they do not exist.

This first framework also showed that there are different types of sandy coastlines and that this difference is critical in system understanding and the identification of useful strategies. For instance a beach built up by mineral sand originating from a river poses very different challenges and opportunities than a biogenic beach that has been formed by calcium nodules formed by bacteria on sea grass.

3.2.2 Role of general framework in Interreg NSR project Building with Nature

In the Interreg NSR project Building with Nature also other situations are addressed such as coastal protection alongside intertidal areas, where clay is a more logical building material than sand, and where very different kinds of solutions and strategies can be envisaged. Catchment management such as in Sweden, Belgium and Scotland is also directed at different kind of challenges and solutions.

In general the aim is to develop a general framework for developing a Business Case that can be used also for upscaling of BwN projects, but that is differentiated where needed depending on physical geographical situations and challenges. This enables a more focussed approach which will lead to more concrete and more meaningful results.

4 Scoping: identify potential BwN concepts

4.1 Introduction

Business cases can be used to facilitate the identification of potential BwN solutions as an alternative for conventional solutions for specific challenges. BCs can enable optimization and therefore also acceptance and construction of BwN solutions. The potential for a BwN solution is ideally already recognized in the initiation phase of a project. There are four basic questions that help to identify the potential for a BwN solution in the initiation phase:

1. **What are the challenges for which an alternative needs to be developed?** It often starts with engineering challenges such as coastal protection or peak flood attenuation but scoping should also consider other challenges, such as environmental restoration, nature restoration, economic development and even protecting cultural heritage.
2. **What are the conventional solutions and what are their advantages, disadvantages and costs?** Advantages usually are that it is a proven technology which can be easily designed and implemented as a sectoral solution. The disadvantages usually are that the money spend, only serves the technical objectives and that the spin-off to other objectives is very limited. The costs of a conventional solution usually set the limit also for competing BwN solutions. Different stakeholder groups may have very different views on the advantages and disadvantages of a solution.
3. **What are the possible BwN solutions that form an alternative or optimised alternative?** Scoping should not be limited by considering only one type of BwN solution. Usually a bandwidth of BwN solutions is possible with varying degrees in which nature and natural processes are used, or a combination with a conventional solution is made possible. Also these have advantages, disadvantages and costs.
4. When comparing conventional solutions with BwN solutions, is a BwN solution potentially more cost-effective, more environmentally sound, better catering to local needs and ambitions? A BwN solution may potentially be the preferred option because of its other advantages, although it is not the most cost-effective solution.

4.2 Widen the scope

Projects related to water management are often only defined in terms of safety levels that need to be achieved. The original scope of a project is often narrowly defined sometimes already including the preferred solution that is thought necessary. So the first step is to widen the scope in order to see if there are other potential functions and win-wins with other societal challenges. Widening the scope also refers to the longer-term and regional development strategy and context, and to win-wins with other ongoing or planned projects. Other projects may offer opportunities for integration in planning, execution, contracting, integrated mineral balances etc.

It is important not to focus too much on the specific form and way of execution of a BwN-project, when looking for possibilities for upgrading. The specific forms and ways of execution normally depends upon the location and project specific context. The chance that this specific form may be the best fit also in comparable environments is small.

It is therefore important to look for BwN requirements and success criteria of BwN concepts. For example, the requirements and success criteria of the sand motor are not the form and volume, but rather:

- To use larger volumes of sand that serve coastal management needs for a longer period of time, which can cover a period of 10 to 25 years, depending on what can be expected to be efficient for the considered location.
- To position these larger volumes in such a way that it delivers the sand needed, using longshore transport, in adequate amounts, preferably not too much and certainly not too little and with little unnecessary losses, nourishing above closure depth.
- To choose a form that may create additional win-wins albeit temporary, such as nature and recreation development.
- To seek the economy of scale when nourishing, by a combination of larger volumes, but also simple forms of nourishment with limited handling, in order to keep costs low.

So a sand motor can be a feeder berm, an island, a wider beach and have very different forms. Depending on the location, a different type of BwN for sandy shorelines may be the best alternative.

4.3 Spectrum of potential BwN strategies

Combining the full array of potential BwN solutions and of BwN strategies gives a first overview of potential BwN solutions that may be considered in a specific context. Here, the case of the Negril beach in Jamaica is used to illustrate the diversity of BwN strategies and how their applicability/success is dependent on the local context. This example is from the tropics, but similar overviews can be created for the different natural landscapes that harbour the laboratories within the Interreg NSR project Building with Nature.

General. Negril beach is an international tourist destination that faces beach erosion. Beach erosion can reach several meters per year, and most hotels have built their assets up to the coastline. The basic BwN strategies that can be identified in this context are reducing waves, adding sand by nourishment, restoring natural sources of sand and regulating use of the coastline (Figure 5 Example of a BwN palette of potential strategies and related BwN concepts for the Negril beach in Jamaica.).

Reduce waves. The first, conventional, solution proposed was to create a breakwater on the position of the outer coral reef. It was reasoned that erosion was mainly due to major storms and that it would be far less in the case a breakwater was built. This breakwater would in a way be an upgrade of the existing coral reef, which was seriously damaged by storms but also by dynamite fishing. Similar also the wave attenuating capacity of the reef may be restored by active restoration measures.

Restore natural sources of sand. As the spectrum shows, many more solutions are possible, and their applicability depends on the causes of beach erosion and also on the development ambitions of this area. The beach at Negril is a biogenic beach, mainly consisting of calcium-carbonate grains that are formed by bacteria living on sea grass. Sea grass beds have been removed close to the beach, since these were considered a nuisance to swimmers. Hence part of the erosion may have been due to a reduction in the production of biogenic sand. So a restoration of this natural source of sand may also be considered.

Sand nourishment. Nourishment was also an option, since one may consider the creation of a buffer of sand large enough to limit the impact of successive storms on the beach. However, the sand at Negril beach is very special, it is pure white, and determines also the quality of the beach. Nourishment will be costly if it can only be carried out with sand that has similar qualities, that needs to be shipped in from far away.

Regulate use. The beach erosion observed may have been due to a combination of several storms. Usually the beach would be able to restore itself within 3 to 4 years after a storm. If storms occur every 2 to 3 years, autonomous restoration is limited and the result is ongoing beach erosion. This was in fact the situation at the time the breakwater was proposed as a solution. In the past years the beach has in fact almost been restored to its former extent. A solution may therefore be to designate a zone wide enough to accommodate the inter-annual variation in the position of the shoreline. Within this zone no or only temporary accommodation would be allowed. A fund may be used to buy out and allocate assets that are too close to the coastline and at the same time opt for an upgrade of facilities. This fund can be filled with money that otherwise would have been used for building the breakwater or for beach nourishment.

As this example shows, there are many different BwN strategies and solutions, but their applicability strongly depends upon a clear understanding of the causes of beach erosion. The breakwater as originally proposed may have major adverse effects, such as reducing the self-restoration capacity of the beach which is dependent upon longer waves.

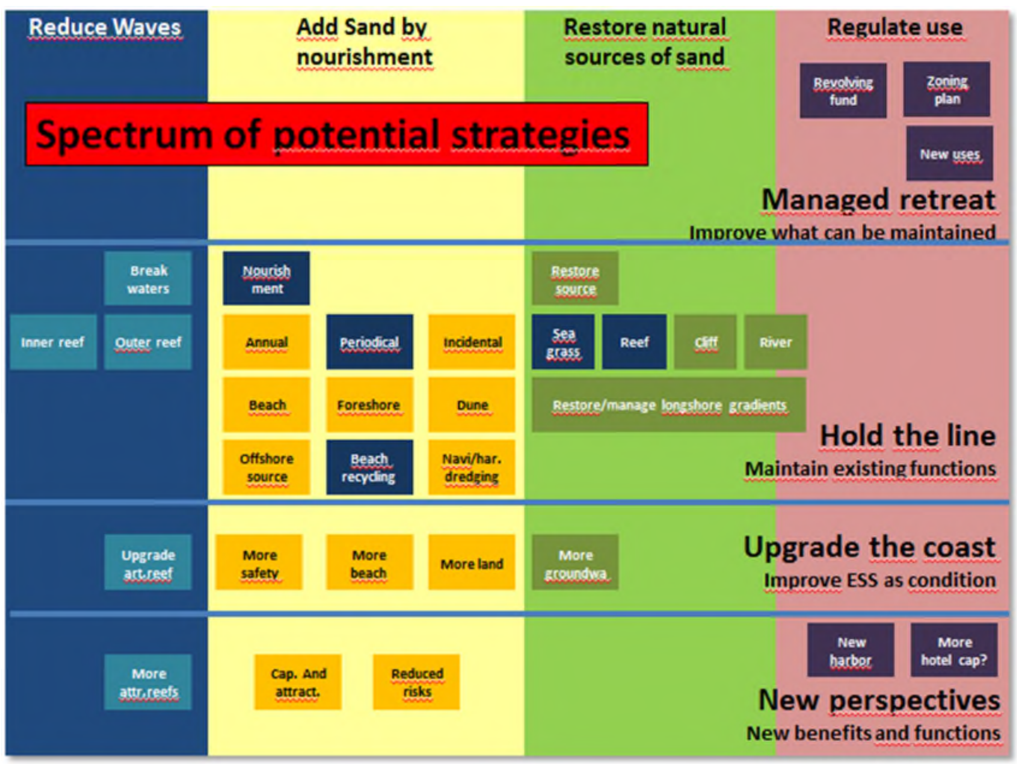

Figure 5 Example of a BwN palette of potential strategies and related BwN concepts for the Negril beach in Jamaica.

5 Upscaling: Fulfilling BwN potential at a larger scale

Once a BwN concept has proven to be successful in a (pilot) project, one would like to use the lessons learned from this project to facilitate wider implementation. Upscaling is usually done using an existing concept or application of a BwN solution and extrapolating it to other locations, adjusting it when needed. Extrapolating can be done in the form of an opportunity map, but it can also take place within the initiation phase of a project, which usually involves also the scoping of relevant alternatives that merit further study.

The procedures and required assessments for scoping and upscaling are more or less the same. Here, we describe three types of factors that determine upscaling success: physical factors, socio-economic and legal factors and stakeholder arenas.

5.1 Physical factors

Physical factors determine the potential **technical applicability** of a BwN concept, such as a Twin Dike or restoring a natural buffer area in a river valley. There are four components that merit further elaboration: Physical factors, Physical challenges, Competing solutions and BwN alternative concepts.

Physical factors include system characteristics and processes such as the landscape, the presence of dunes, longshore transport, ecosystem capabilities, natural dune formation and the buffering capacity of natural inundation areas.

Physical challenges include safety (standards) to be safeguarded, erosion (rates) to be prevented, preferably in such terms as minimum dune volume needed, and nourishment needs or peak flood buffering volume required.

Competing solutions are the conventional ways in which a physical challenge is normally solved, could be a dike, or a set of groynes, and it usually is a hard engineering structure. In decision making usually a comparison is made between a conventional and a BwN alternative. So conventional solutions can be seen as competing solutions and often their costs are also a cost indication for a BwN alternative.

BwN alternative concepts: In every landscape a number of BwN concepts may be relevant, from hybrid to fully natural alternatives. It should be noted that a BwN concept is often in essence a technical-ecological intervention comparable to a conventional solution. In the case of ground work also the sediment balance of the project is usually a major (cost and design) factor.

5.2 Socio-economic and legal factors

Socio-economic and legal factors implicate a more integrated design and can be used to assess **potential win-wins and added value.** Upscaling on this level requires much more country and location-specific information that may only partly be readily available in GIS. So mapping may require additional “ground truthing”.

Landuse can be very decisive, since it determines potential costs and uses related to a BwN alternative. In nearly all situations it is relevant to distinguish between rural and urban context, in terms of costs and also potential benefits.

Societal challenges: Present land use may already give strong indications of societal challenges that play a role in the project area, such as the presence of an urban centre may indicate the need or potential for water front development. One may want to work on the basis of a checklist, that encompasses such themes as climate resilience (e.g. temperature, salt water intrusion), environmental and ecological restoration (e.g. water quality improvement, nature development, WFD objectives, Nature 2000 objectives), cultural heritance and landscape, recreational facilities and tourism, urban housing and development, public space and living environment, an upgrade of infrastructural access, parking space and networks, (freshwater) supply and regional economic development.

Legal frameworks and policies, especially Natura2000 appears to be important since it may enforce or hinder the use of a BwN alternative or act as an important framework for its design. The interpretation of what is not and what is still possible in Natura2000 areas differs per country and also on the question whether nature compensation is possible and necessary. Relevant policies may relate to permitting systems for mineral abstraction, but also to safety standards, deadlines for projects etc.

Political and financial budget lines are often project specific in spite of national budget lines and financing procedure.

5.3 Stakeholder arenas

With a stakeholder arena we mean a specific and local combination of stakeholders and stakeholder interests. They operate within a wider governance setting, such as laws and regulation but may join in dedicated project related arrangements. These usually require a stakeholder analysis in order to determine the position, ambition, decisive powers etc. of relevant stakeholders.

- For this phase it is envisaged to elaborate the guideline and opportunity mapping for successful upscaling of BwN concepts in more detail for different combinations of natural BwN landscapes and challenges.
- Appendix II will describe in more detail the different types of landscapes that are relevant for BwN upscaling

6 Concluding remarks and next steps

In this report we aimed to highlight methodologies for business case development and valuation and identify lessons learned and critical factors in existing BwN cases. We then build on this to propose a framework for developing BwN business cases.

6.1 Lessons learned

Lessons learned from the case study analysis focussed on important factors for identifying and optimizing the potential for a BwN strategy or concept in a specific project. In most cases the business case or economic evaluation of alternatives were not guiding in choosing the preferred alternative and obtaining funding. The business case of a BwN concept is influenced by multiple variables, as well as its upscaling potential. A successful BC has its roots in the initiation phase and a successful BC addresses BwN qualities and uncertainties. A BwN solution ideally handles multiple challenges and involves multiple stakeholders.

In the context of upscaling, there are three basic levels that influence the potential of applying the BwN concept in another location: physical factors (technical assessment), socio-economic factors (economic assessment) and societal financial factors (financial assessment).

What our assessment has shown so far is that a successful business case depends on a combination of physical and societal factors. Some cases show that there is no potential business case (i.e. a positive cost-benefit balance or positive cash flow) when looking only at the physical environment and costs. Often, societal factors were more decisive in leading to implementation of the BwN project. This clearly shows that a successful business case is not only a matter of costs-effectiveness. Other factors, for example related to governance or planning culture are very important to the design as well.

6.2 BwN business case development framework

We proposed a BwN business case development framework that consists of the following parts:

- ***Scoping:* Optimizing the BwN solutions within a project:** this involves a planning process that looks at the potential for integrated projects with more societal benefits, e.g. by addressing multiple challenges. It also considers the way in which particular characteristics of a BwN solution can best be handled in the design and in related agreements.
- ***Scaling up*: Fulfilling the BwN potential on a larger scale/ mainstreaming the BwN solutions in policy:** Starting with an identification of the potential BwN concepts on the level of different BwN landscapes, in which different natural processes and challenges lead to a specific range of potential BwN concepts. A business case for wider implementation building on experiences in pilot projects may help to make the case interesting for potential investors.

Optimizing the BwN potential in a design process requires a process that enables tailor-made designs that best match the potential of the physical environment with the needs and ambition of (the local) society and the political-financial reality. It is difficult to put this process into concrete guidelines, so the elaboration of this step will focus upon illustrative examples that may inspire others and on methods that enable the identification and valuation of ESS of BwN projects as well as the valuation of inherent qualities as flexibility. This valuation is foremost concentrated on the economic and financial steps in a chain of analysis that usually starts with morphological and hydrological modelling. It will also give examples how agreements between stakeholders may take form. Taxes and use fees are examples of financing mechanisms that often already in place, but new financial arrangements may be needed. Increased protection levels or the development of natural assets may lead to an increase in real estate prices, which through land taxes generates additional income, which can be ear marked upfront for a flood protection scheme. Sometimes new innovative not yet existing ways of paying for ecosystem services may help to generate the necessary finance for a BwN project. An example from the Netherlands, is to auction the undisturbed view of a rural landscape in order to generate the money to prevent further urban development in a pristine landscape.

For upscaling of the BwN concept, a first step is the identification of potential BwN concepts. This entails more work into logical distinctions of different BwN physical (sub)landscapes and socio-economic arenas, the critical factors that determine the applicability of different BwN concepts and a structured and more complete overview of these BwN concepts, linking them to indicative parameters and potential outcomes. The next step in elaboration is to see to what extent socio-economic factors can be identified that determine the functioning of BwN arenas and will play a role in the transformation of BwN concepts into BwN alternatives.

6.3 Next steps

The next step should lead to a framework that can be used by partners in the Interreg NSR project Building with Nature. In our view it should fulfil at least the following criteria:

- It should be specific enough, in the sense that key issues and relevant success factors in different kinds of settings are readily addressed, preferably on the basis of BwN (sub) landscapes.
- It should be simple enough in order to enable case holders to fill in the framework in order to characterise their case.
- It should enable the identification of BwN potential as needed for upscaling.

The framework will be developed in phases. This report marks the ending of the first phase, in which the general outline of the framework was drafted on the basis of first lessons learned, and using a framework developed in an earlier Ecoshape project as a starting point. In the next phase, the framework will be fleshed out and completed, followed by its application by case holders. It will also consist of a manual that gives illustrative examples of how various factors can be handled. In the fourth phase the framework will be used to map the overall potential of various BwN strategies and concepts in support of upscaling/ mainstreaming of the concepts, illustrated by experiences from the cases.

Appendix I: Factsheets Case studies

1. Sand Engine

Introduction

Name of the pilot/cases: Sand Engine
Start date and duration: Planning period 2010-2011- executed in 2011-2012
Status: Completed/
Client: RWS/Province of South Holland
Executed by: RHDHV planning and design, Boskalis/van Oord construction

Figure 1: Sand engine at the coast of Delfland (from: M.D. Taal et al, 2016) and its position between The Hague and Rotterdam.

Short description of the project:

The sand engine is a mega-nourishment, a large volume of sand that by its position uses natural longshore processes to distribute the sand along the sandy coast. It is an alternative to nourishments that take place every 5 year along this coast. The sand engine consists of a volume that is sufficient for more than 20 years. Because of the large volume, the design of the sand motor can also cater to other ambitions, such as recreation and nature development. Although the sand engine is meant to erode, this takes decades, and meanwhile also other functions benefit. The sand engine is a large scale pilot/experiment, since it is the first time such a large scale volume has been deposed in The Netherlands.

Business case development

Has a BC been developed and if so, what type?

No true business case has been developed. As part of the EIA several alternatives have been compared on a wide range of criteria, including costs. The goal of creating more recreational areas was mainly defined in a minimum of 100 ha of additional beach that should result from the project and was proposed as prerequisite by the Province for co-financing.

Nevertheless, as part of the Nature Coast program a business case approach was studied also for the sand engine. In this study a very different approach was taken, assuming that economic benefits and co-financing would be critical to the design and use of the sand engine. This resulted in very different designs, especially with respect to the use of the sand engine e.g. for temporary holiday houses and the use of sand from navigation dredging from the Eurogeul.

One needs to stress, that in the Netherlands, flood defences and also coastal maintenance works are fully financed by the state. There is no need for co-financing, as such, and there is no need for a business case either. Often a societal cost-benefit analysis complements the EIA but this is mainly in order to optimize the potential alternatives, scoping for win-win opportunities beyond merely strengthening of the coast. In the case of the sand engine, the available budget was also determined prior to the design process, since it was mainly considered as a large scale experiment. Similarly, the sand engine was not optimized with respect to the most cost-effective form of coastal management, but optimization only on the basis of costs-effectivity, would not do justice to the potential it has for several functions.

However, it can also be argued that the design process was primary also a time constrained process, which offered little opportunity for more complex, more integrated designs. As a consequence, the sand engine was planned on a location that did not require complex planning.

What types of benefits have been valued in the project, and with what methods?

Benefits valuated as part of the design and decision making phase include:

- The development of coastal dunes, and its benefits to nature and coastal safety.
- The opportunities for nature development. The sand engine was expected to offer opportunities in the form of larger beaches, a lagoon and a dune lake. The large form led to quiet beaches, frequented by seals that are seldom seen on this coast. The lagoon forms a habitat to benthic communities and fishes.
- The reduced frequency in nourishment, and its benefits to the shallow coastal ecosystem.
- The increased opportunities to coastal recreation. Recreation benefits were valued very generally, since it was not known whether this new coastal form would be attractive, and whether recreation on this location would lead to a lot of substitution in other locations nearby.

How did the project take 'uncertainty' into account to value the costs and benefits?

As the finance was already secured, uncertainty in the morphological development and performance of the sand engine was not considered an uncertainty that needed to find its place in the costs calculations of the project. Uncertainties did however influence the design of the sand engine and the arrangements regarding its management:

- Potential risks of unknown morphological development and the formation of undertows to swimmers.
- Effects on the movement of potentially (historically) polluted and saline waters from the outer part of the coastal dunes, in the direction of the drinking water wells of the Water Company Dunea.

- Uncertainty in longshore transport before it could deliver sand to the coast. So there was a risk that erosion would occur in recently strengthened parts of the coast. This was not acceptable to the water board, and hence two foreshore nourishments have been included in the design.

How did the project take 'flexibility' into account to value the costs and benefits?

Flexibility was not taken into account when valuating costs and benefits. The morphological development of the sand engine was uncertain, but not crucial for coastal safety since this was ensured by the recent strengthening of the coast. Furthermore, the budget was fixed and the contract was set up with a maximum available budget. Part of the budget was set aside for contingencies, monitoring and for the beach guards.

Did the project also involve financial engineering as part of the design?

No, the budget was fixed, regardless of the economic benefits of the sand engine. Also the co-financing by the province was set up as a fixed percentage, regardless of potential economic benefits, but with the requirement that at least 100 ha of beach should be created.

What timeframe did the project take into account to value the costs and benefits?

The comparison of the alternatives was primarily done within a 20 year period, mainly because the volume of the design was based on a 20 year nourishment need. The total volume calculated is in fact double the volume needed for only shoreline management. The consequence is that the functional lifetime of the sand engine is in fact much longer than 20 years.

2. Salt Marshes Delfzijl

Introduction

Name of the pilot: Salt Marsh Delfzijl
Start date and duration: 2017 -2019, 3 years
Status: Ongoing
Client: Marconi: an extensive project on redevelopment of the outer-dike areas in Delfzijl, funded and executed by Waddenfonds, Seaport Groningen, Gemeente Delfzijl and other public authorities.
Executed by: Ecoshape
Short description of the project:
The city of Delfzijl is located on the western side of the Ems-Dollard estuary. This city borders the estuary but the sea view is blocked by a large dike that protects the city from floods. The estuary has large areas of intertidal flats (sandy and muddy). Salt marshes are present along the fringes of the estuary but they are not abundant; most land-water boundaries consist of hard engineering structures like rock-protected dikes. The ecological state of the Ems-Dollard estuary has been declining the last few decades: there are high suspended sediment concentrations; there is sea level rise and land subsidence due to gas extraction. Thus, apart from improving the spatial quality in the area, there is a desire to improve coastal safety and ecological values in the area by creating salt marshes. A salt-marsh area improves the water-land boundary from abrupt to gradual, provides habitats, decreases wave impact on existing coastal defence infrastructure (thus lowering reinforcement requirements) and may locally improve the suspended sediment concentration. Locally dredged sediment from the harbour will be used in creation of the marsh. In 2017 the sandy base layer of the marsh has been constructed; the pioneer salt marsh is planned by mid 2018. Monitoring of morphological and ecological development will run until end 2019.

Business case development

Has a BC been developed and if so, what type?

No. In the design phase, two BC-related studies were executed: a first study by Gautier (2010) developed and compared three alternative designs including a mudflat in front of the Schermdijk on costs and ecological potential, including a comparison with the (undesirable) traditional reinforcement of the primary dike, without a mudflat. This study contributed to formulation of potential strategies and the substantiation of the attractiveness of a BwN alternative. In a later stage, in 2013, a feasibility study was done (Dankers et al, 2013) on various elements within a broader project focusing on improvement ecological, spatial and flood protection quality of the outer-dike area. This study contributed to the selection of preferred alternatives, including an analysis on effects relating to stakeholders' wishes/ aims in the area, such as ecological quality, spatial quality and recreational potential. Furthermore, as part of a MsC thesis a cost-benefit analysis has been made.

What types of benefits have been valued in the project, and with what methods?

The benefits of the project were evaluated with an ordinal scale (+/-) in the feasibility study. The following benefits were considered:

- Morphology: discharge speed, effect on estuary, concentration of suspended material
- Ecology; Natura2000 conservation goals, contribution to the ambitions of the program 'Rich Wadden Sea', fauna, maintenance of the salt marsh.
- Spatial quality: contribution to policy goals, experience value, alignment with existing landscape.
- Safety: robustness, flexibility, contribution to current and future safety targets.

In the thesis of Evers (2015) an economic valuation of the marshes' benefits is included based on standard key figures for the value of the ecosystem service delivered by salt marshes, such as carbon sequestration, water quality improvement, increased habitats and biodiversity, recreation and tourism.

How did the project take 'uncertainty' into account to value the costs and benefits?

A risk premium was included in the cost estimate of the feasibility study. Designs were tested against uncertainties regarding future scenarios, but this was not reflected in the valuation of costs and benefits.

How did the project take 'flexibility' into account in the value the costs and benefits?

One of the effects/ benefits which were considered (ordinal scale) in the feasibility study evaluating the designs was flexibility: adaptability of the design to a slower or higher than expected sea level rise.

Did the project also involve financial engineering as part of the design?

No

What timeframe did the project take into account to value the costs and benefits?

20 years

Did the project have a 'closed' business case, in which the investment costs are returned and the final design meets the project objectives?

No. The alternatives were measured on their effectiveness in achieving the flood risk protection goals and their contribution to increasing spatial quality. The conventional engineering solution, reinforcement of the dike, scored badly on flexibility and has difficulties in feasibility due to limitations in available space. The solution with salt marshes was the preferred alternative.

What was the major driver for the final design?

In Natura2000 areas the value of newly created nature has to be higher than the 'lost' habitats. Saltmarshes are assigned a higher ecological value than earlier considered mudflats. Nonetheless, there is still some criticism as the project decreased the present tidal area, which is already under pressure in the Ems-Dollard estuary. In this case, compensation is achieved within the Marconi Buitendijks project.

3. Houtribdijk

Introduction

Name of the pilot/cases: Strengthening of the Houtribdijk
Start date and duration: Planning period 2013-now
Status: Completed/ongoing in the phase of construction
Client: RWS/Hoogwaterprogramma
Executed by: RHDHV planning, Boskalis/van Oord construction
Short description of the project:
The Houtribdijk is in fact a dam that divides two large lakes, Lake Ijsselmeer and Lake Markermeer. It was originally designed as a dike of a new polder, the Markerwaard that was never built. It major functions are to prevent wind/wave upset over larger areas, which would worsen hydraulic conditions at both ends of the system, so at the coasts of Friesland and North Holland along the Lake Ijssel and along the coast of North Holland and Flevoland along the Lake Marken. To strengthen the dike, a sandy foreshore has been proposed.

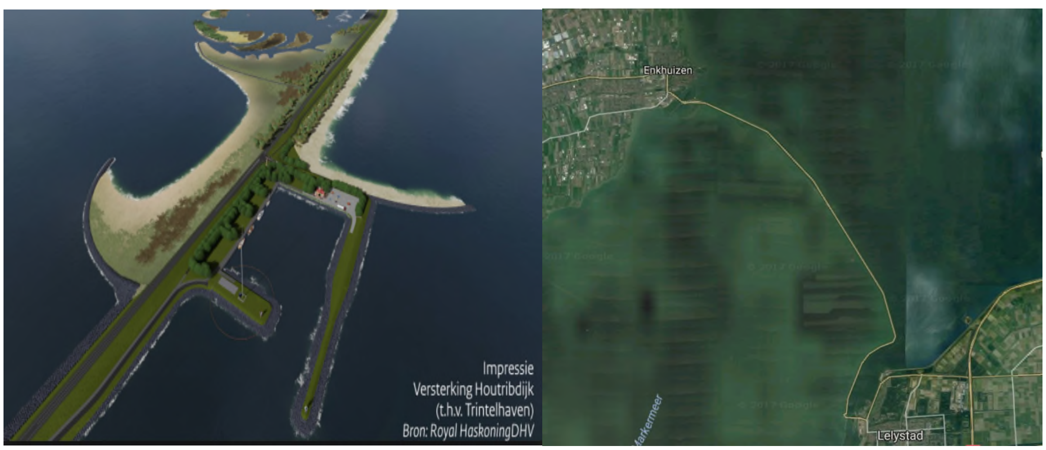

Figure 1: part of the design for strengthening the HRD and its location between the cities of Enkhuizen and Lelystad and between Lake Marken (to the south) and Lake Ijssel (to the north).

Business case development

Has a BC been developed and if so, what type?

Alternatives have been compared on investment and life cycle costs for various sections of the dike, which showed that a sandy foreshore would be more cost-effective than a stone revetment for half of the dike.

No business case has been developed in the sense of combining co-financing possibilities linking to specific ESS. However, the design of the breaker dams was altered in order to enlarge the potential area for nature development. On the basis of a cost-effectiveness analysis an enlargement was designed that was cost- neutral when compared with the existing design, and was subsequently made part of the basic design as well. Also cost calculations have been done in order to specify the costs of a kite surf beach, to be financed by the Province of Flevoland.

What types of benefits have been valued in the project, and with what methods?

Construction and maintenance costs have been calculated based on offers from private market parties, while the value in recreational opportunities and nature development have been assessed in a qualitative manner using expert judgment. The ESS quantified are basically engineering services of a sandy foreshore as an alternative to conventional dike strengthening. The additional area for nature development was only quantified in terms of costs and surface area of habitat. The possible positive impact on ecosystem functioning of the lake was also not quantified. Cost comparisons were done on the basis of initial investment costs and a LCC for a 100 year period.

How did the project take 'uncertainty' into account to value the costs and benefits?

Uncertainty was set to costs for the following components of the project:

- Uncertain morphological development of the sandy foreshore and how this translates to maintenance needs. This was tackled by using robust assumptions in the calculations.
- The uncertainty related to the morphological and dune erosion models that have not been validated for larger lakes. Also this was handled by a set of robust assumptions leading to a larger required volume.
- The uncertainty regarding the availability of the necessary volumes of sand close by in potential new sand pits, taking into account not only the geology but the chance of encountering archeologically interesting sites, which would limit the area for sand mining. This was quantified assuming that part of the sand would need to be extracted and transported over a longer distance.
- Restrictions posed by licenses in order to limit disturbance to birds.
- Operational costs of dredging equipment available to construction and fuel prices.
- Future risks, such as the price of sand needed for maintenance, were set to net present value, including a probability of occurrence.

Parallel to the design process a pilot of a sandy foreshore was created at the section with the heaviest hydraulic conditions. This pilot consists of a 500 meter long sandy foreshore, which has been intensely monitored in the past years. These monitoring results have let to design criteria for the sandy foreshore. However, after 4 year of monitoring it was still not possible to upgrade and validate a tailor-made set of models. Monitoring will continue after construction on the newly created sandy foreshores, in order to understand morphological processes better, for the optimization of nourishments strategies and for the validation of models.

How did the project take 'flexibility' into account to value the costs and benefits?

Flexibility was not taken into account when valuating costs and benefits, because it is always possible to add sand where needed, the lake is not subject to sea level rise, and it is expected that the safety standard for this dike will become lower in future leading to a smaller volume needed in the sandy foreshore.

Did the project also involve financial engineering as part of the design?

No additional financial mechanisms were needed since the project is financed based on ear-marked budgets for dike strengthening and at a later stage also for WFD goals. A financial agreement was made with the Province of Flevoland, for the construction of a kite-surf beach, more or less simultaneously with the project of dike strengthening. Trintelzand, a large nature area in front of the dike is partly financed by Water Framework Directive funds. However, this stakeholder came to the table after the project had already been contracted. Based on the additional funding and WFD criteria the design for Trintelzand was changed and enlarged.

What timeframe did the project take into account to value the costs and benefits?

For cost calculations initial investments and a LCC for 100 years was made.

How could the design process be improved?

The design process could have been better if the opportunities to other stakeholders were addressed earlier in the process. To a certain extent this requires a more open scope, but also active involvement of other stakeholder groups. It must be said that the possibilities for beach recreation have been explored in different ways.

In the end especially the opportunities for nature development have found their place in the design. However, the project started with dike strengthening as a major focus and nature development only when needed because of legally required nature compensation. A wider scope at the beginning would probably have identified other options for nature and recreation much earlier and may in this case also have attracted third parties, such as the WFD fund.

4. Room for the River, Lent

Introduction

Name of the pilot: Room of the River Lent
Start date and duration: 2012, 4 years
Status: Completed
Client: Deltaprogram
Executed by: SPV I-Lent (dura Vermeer en Ploegam)
Short description of the project:
A side channel or 'bypass' of the main river branch is created on the northern shore of the Waal River opposite Nijmegen. The purpose of this project was to solve the 'bottle neck' problem: at the city of Nijmegen urban development has led to a comparatively narrow floodplain. With the construction of the side channel, a new urban island is created in the river Waal with high spatial quality: a prime recreational, natural and residential location. In the coming decade, real estate will be developed on the island. The project has been completed in August 2016 and costs €358 million.

Figure 1: Impression of side channel at Lent, Nijmegen

Business case development

Has a BC been developed and if so, what type?

Yes: there was a CBA based on which the project was approved and funded. As the central government was fully financially responsible for the Room for River program, in this case and in most other cases within this program there was a CBA to substantiate the economic rationale of the public investment and support in selecting the preferred alternative, but no business case regarding financial flows and risks were conducted. The alternatives were developed beforehand, without economic input, based on stakeholders' wishes and safety standards. The primary goal of the project was to increase robustness of the flood risk protection infrastructure: though this delivers high socio-economic benefits, the target is not to generate a return cash flow.

What types of benefits have been valued in the project, and with what methods?

In the cost-benefit analysis, the following benefits have been included:

- *Increased property values of existing houses:* House prices of existing houses in the neighbourhood have increased significantly during and after realisation; however, it is hard to distinguish the impact of increased spatial quality from the general housing market upward trend (also in Nijmegen) in the same time.
- *New property:* The project has not created new land, but has upgraded existing land to a prime residential location: an island in the river Waal, with views on the river and urban city front Nijmegen. The realisation of real estate will be part of a bigger real estate development plan in Lent: De Waalsprong.
- *Recreation:* Calculated based on expected visitor numbers and available standard numbers on economic value of specific recreational activities: events, water sports, beach visits, walking/ cycling.
- *Nature*: Increased nature habitat surface water and increased surface area of existing outer-dike meadows (Natura 2000)

How did the project take 'uncertainty' into account to value the costs and benefits?

The CBA included a sensitivity analysis on the project horizon and the discount rate. It was concluded that the development of real estate, by far the most important benefit in the analysis, is key to the societal benefit of the project. Uncertainty regarding climate was not included directly in the project, but considerations regarding this topic contributed to the setting of the desired goal of the project: a decrease of backwater flow of 24 cm.

How did the project take 'flexibility' into account to value the costs and benefits?

Flexibility in valuating costs and benefits was not included.

How did the project handle the allocation of costs and benefits?

The allocation of costs and benefits was not addressed in the project; as in the entire RvdR project the central government funded the projects in full, where possible executed by a local public authority. Later on in the decision making there were discussions on how to redistribute land to project stakeholders after realization of the project, fed by conclusions in the CBA. Following the high estimated benefits in the CBA, there was discussion on who should receive those benefits as the project was fully funded by the central government, but most expected benefits were to the municipality (e.g recreation, real estate development). This led to a dispute between the Municipality and the 'Rijksvastgoedbedrijf' (state landowner company), as the latter wanted to share in the expected benefits. However, socio-economic benefits are not the same as actual revenues (cash flow): according to the Municipality, these are not significant.

Did the project also involve financial engineering as part of the design?

No.

What timeframe did the project take into account to value the costs and benefits?

50 years.

Did the project have a 'closed' business case, in which the investment costs are returned and the final design meets the project objectives?

No, in the sense that the investment costs by the central government are not returned: the expected socio-economic benefits however outweighed the costs by far. The final design also fully met project objectives: the objective was to reduce backwater flow in the Waal by 24 cm – instead 32 cm was realized which led to the cancellation of a similar project downstream.

5. Twin dike

Introduction

Name of the pilot: Twin dike
Status: Ongoing, planned to be constructed in 2018-2019
Client: Regional Water Authority Noorderzijlvest, Province of Groningen, works are subsidized and included in the programme HWBP (High Water Protection Programme)
Executed by: Regional Water Authority Noorderzijlvest, Ecoshape, Province of Groningen**.**
Short description of the project:
Along the fringes of the Waddenzee the dike needs strengthening. The conventional solution is strengthening the revetments and where necessary increase the height of the existing dike. The Twin dike proposes a different approach. In proposing a second inland dike a combined flood protection system is created that requires less strengthening of the existing dike. Behind the existing dike a new smaller and lower dike will be built with clay which is excavated from the area between both dikes. The area between both dikes will be converted to a brackish area with brackish agriculture and an area intended for the controlled sedimentation of fine sediments, possibly turning into the Clay-ripening factory. The fine sediments may be converted into high quality clay, which is an important building material for dike strengthening. Because it is a low intense form of land use, this sedimentation area is expected to support local bird populations as foraging area. Furthermore, it is expected that the brackish agriculture will generate three times as much net income than the existing agriculture (seed potatoes). A third project coupled to Twin dike project is the creation of a bicycle route.

Figure 1: Overview of both sections with a double dike. The nearest section will be used as a clay factory/nature area and the second one for brackish agriculture. The area is situated north and south of Nieuwstad.

Business case

Has a BC been developed and if so, what type?

Yes, several business cases have been developed looking at different aspects of the project:

- *Cost-effectiveness comparison:* The costs of twin dike compared to a conventional way of strengthening in order to assess whether this innovative solution would be more cost-effective. In the twin dike, the cost of strengthening the existing dike are far less, than the additional costs, related to the building of a smaller newer dike inland. This new dike will be built with local clay from the area between both dikes, reducing its costs.

- *Business model comparison:* A comparison between the economic returns of the existing form of agriculture and a new brackish form of agriculture showed that the new brackish agricultural has potentially a much higher economic return. This would translate into a higher land fee which would be used to pay for the additional costs of providing the necessary infrastructure for the area between the dikes, such as one or maybe even two expensive sluice gate(s).
- *Business model:* The economic benefits of a clay-factory have been studied in order to see whether clay from this facility could compete with other sources of clay. This is not yet settled, but the clay-factory can foremost be seen as an experiment.

The business cases were set up early in planning stage, since they would determine whether a Twin dike would come out as the preferred option, to local land owners, farmers, but also to the HWBP program, which intends to finance mainly cost-effective projects.

What types of benefits have been valued in the project, and with what methods?

- Flood Defense: it is expected that the use of a Twin dike will reduce the overall costs of sea defense works for this section. So this is a comparison on investments costs for the original scheme and the Twin dike scheme.
- Agriculture: move from conventional agriculture to brackish agriculture (sea weed and mussels). Salt-brackish production farmers are expected to lease the area, as they do already in the present situation, and the amount of lease is set depending on the expected net gain. Probably the present lease of 2500 Euro/ha may go up to 7000 Euro/ha, if the system functions optimal. This will generate additional income that is used to pay for initial investments to make brackish agriculture possible. The expected income is based on experiences on production from other pilots in the Netherlands and expectation regarding market prices for brackish produce.
- Clay production: good quality clay is expensive but needed locally for a dike strengthening program. The aim is to produce a good quality of clay under controlled conditions and to sell this to for dike strengthening nearby, since transport costs are an important variable. The clay can be sold for a price close to, but still less than, the prevailing market price.
- Recreation: as part of the Twin dike project additional bicycle routes are established.
- Nature: the potential benefits are mainly related to the fine sediment quality of the Eems-Dollard estuary. By creating a Twin dike with a clay factory, it becomes possible to reduce the volume of fine sediments in the estuary without having to pay the full costs of removing in order ways that do not generate income.

How did the project take 'uncertainty' into account to value the costs and benefits?

A distinction can be made between project related risks (e.g. related to constructions, land acquisitions etc) and land use related risks (e.g. production and benefits from brackish agriculture and clay production and benefits from the clay factory). The first risks are substantial and higher than for a conventional strengthening of the dike, especially when compared with the expected reduction in overall costs, compared with conventional strengthening of the dike. The risks in land use benefits are covered by the province and are also considerable. In spite of these substantial risks, it is generally felt that the project will have an overall net positive balance.

- A Twin dike is a novelty for which there is no formal protocol how it can be tested. The present design is robust in the sense that it trusted as a sufficient solution, but it still cannot be formally tested. Additional studies are ongoing in order to create a formal protocol.
- Another uncertainty related to the hydraulic conditions for the dike in the future and the way in which e.g. salt marshes could be taken into account in testing the strength of the dike and in its final design. Because of these uncertainties the functional lifetime of the dike strengthening program between Delfzijl and the Dollard was set to 25 years, in order to prevent a very costly and also profound strengthening program that may prove not to be necessary at a later moment in time.

How did the project take 'flexibility' into account to value the costs and benefits?

There is no explicit relation to flexibility. However there is some no regret, especially with respect to the clay factory since it initially also provided clay at low costs, for building the new dike. If it does not function as a clay factory, it will eventually also function as a nature area or it may also be converted to brackish aquaculture/agriculture.

What timeframe did the project take into account to value the costs and benefits?

25 and 100 years

Did the project have a 'closed' business case, in which the investment costs are returned and the final design meets the project objectives?

Yes in the sense that the Twin dike is cheaper than a conventional dike strengthening. However, this still depends on the question whether the original dike also requires substantial upgrading of the outer revetment. Since it is an innovative concept, also other questions still need to be answered.

6. Eddleston

Introduction

Name of the pilot: Eddleston Water Project
Start date and duration: 2009 – 2020
Status: Ongoing. Implementation and monitoring of the measures
Executed by: Tweed Forum, Scottish Government, Scottish Environment Protection Agency (SEPA), University of Dundee, Scottish Borders Council (SBC) and British Geological Survey (BGS).
Short description of the project:
The Eddleston Water is a tributary of the River Tweed in the Scottish Borders, with a catchment of 70 km2 draining south to join the main river at Peebles. It is typical of rural Scottish catchments of this size, with a mix of forestry, rough grazing and improved grassland. The Eddleston Water Project aims to reduce flood risk and restore the Eddleston Water for the benefit of the local community and wildlife. A series of practical works (such as remeandering, **Figure 6**) are now taking place throughout the Eddleston catchment as part of an overall plan to restore the river and valley. It will also be explored how changes in land management might reduce flood risk for downstream communities. These practical works are being closely monitored by the project partnership.

Figure 6 Two of the remeandering measures, implemented in the Eddleston catchment area.

Business case development

Has a BC been developed and if so, what type?
Yes, the project assessed the costs and benefits linked to the measures, which cover ecosystem services and multiple benefits:

- In the problem identification and first system analysis, benefits of BwN measures (multiple ecosystem services) were considered to widen the scope. Stakeholders were already involved in this stage to investigate their willingness to make their land available to implement BwN measures.
- A SWOT analysis has been used in the selection process to analyse the combination of measures available at each site. Stakeholder perspectives were part of this analysis.
- The potential costs and benefits of different NFM (natural flood measures) measures were calculated as part of the design process.
- After the implementation, for one measure the actual costs and potential benefits were calculated to investigate if the measure has a closed business case.

What types of benefits have been valued in the project, and with what methods?

Ecosystem Services and Multiple benefits

Early work looked at the theoretical impact on ecosystem services of restoring Eddleston Water's natural meandering stream course and potential afforestation of the whole floodplain. The Scottish Land Use Strategy (LUS) mapped the key ecosystem services in the Eddleston catchment area that are best valued by the local stakeholders (**Figure 7**).

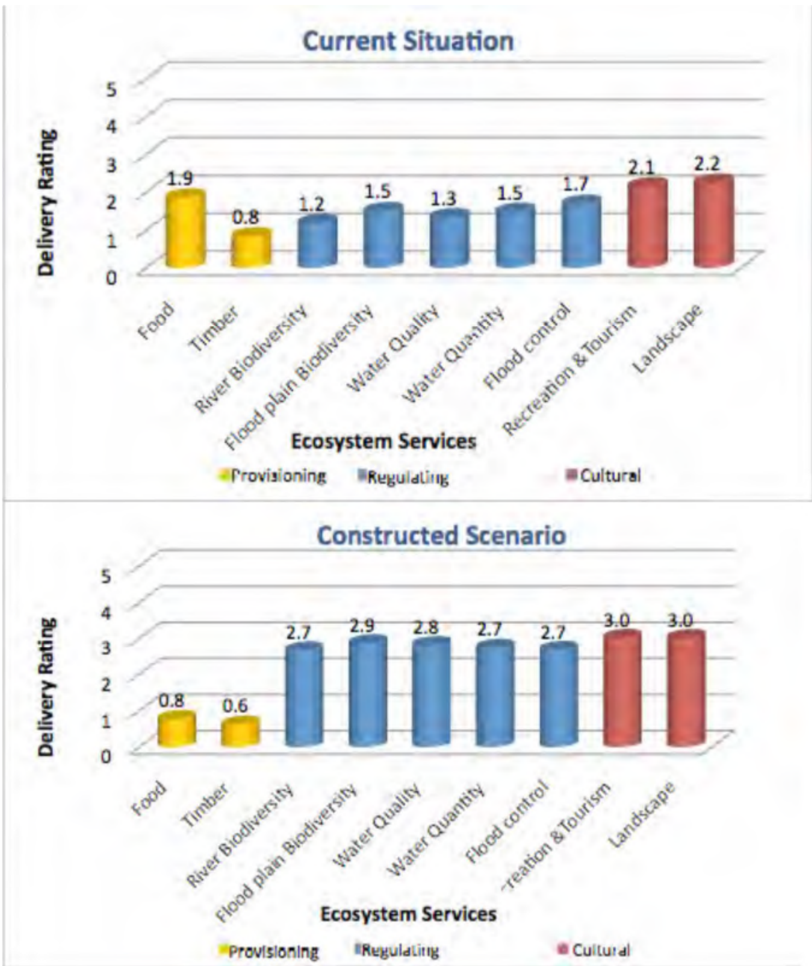

Figure 7 ***Ecosystem service values for the current situation (left) and hypothetical scenario that favours NFM to maximise flood risk regulation (right)***

- The Eddleston floodplain currently has a high delivery rate for only one of the nine ecosystem services evaluated (food provision from agriculture)
- The theoretical 'restoration' of the river course and floodplain led to improvement in seven ecosystem services, including forestry, water quality, biodiversity and landscape, alongside the targeted service of flood risk reduction, though agricultural production decreased.

Ex Post Costs and Benefits

Parallel to the implementation and measurement of works on the ground, the Eddleston project has used both direct measurements and models to assess the potential costs and benefits of interventions to reduce flood risk and improve habitats.

For the measure ‘planting riparian woodland’ a complete cost and benefit analysis was conducted. For this case, the potential monetary benefits of NFM cover a range of future climate change scenarios in addition to recording actual financial costs of implementing each measure. The study relied on benefit transfer for ecosystem valuation originating from other studies. Benefits from reduced flood risk were calculated using hydraulic models and the methodology utilized for assessing costs and benefits in the Multi-Coloured Handbook from the Flood Hazard Research Centre. The main results are:

- Under all climate change scenarios, a positive net present value from NFM planting is shown, indicating that the riparian woodland is worth implementing. Annual benefits of c. £80k per year were estimated, with a high average benefit-cost ratio for the riparian woodland of 12.5, though full benefits will not be realised for some 15 years after implementation.
- The positive results are mainly driven by improvements to ecosystem services other than flood regulation, demonstrating the important multiple benefits delivered through NFM, including enhanced water quality, carbon regulation and biodiversity.
- Flood alleviation benefits are lower in the future due to climate change impacts, which are projected to lead to increased peak flows and thus reduce the positive impact of woodland on flood risk.
- If only flood reduction benefits are considered, the investment in riparian woodland is still positive under some of the flows in 2016, but flood regulation benefits are provided in all climate scenarios, and are greater for higher frequency flood events.

How did the project take ‘uncertainty’ into account to value the costs and benefits?

- When deciding on a location for a remeandering measure, a key concern was the uncertainty if the new channel would not trigger a local instability. To assess the level of uncertainty in the future flow of the stream and the impact of the measure, they looked at historical data.
- A SWOT analysis was performed to identify potential strength, weaknesses, opportunities and threats for each location.
- Multiple climate scenarios were used to assess the costs and benefits for the measure ‘planting riparian forest’.
- It is a main objective of the project to develop knowledge on the effect of the measures to reduce uncertainty. Monitoring aims to assess the impact of specify types of NFM measures and the impact of restoration on flood risk and habitats at a whole catchment scale. Additionally, the programme investigates the costs and benefits of NFM and WFD interventions, including additional multiple benefits through wider measures of ecosystem services, and to explore the social and economic barriers to uptake of key measures.

What timeframe did the project take into account to value the costs and benefits?

The timeframe for the cost-benefit analysis is 75 years, discounted at 3.5 % for year 1 to year 30 and 3 % for year 30 to 75.

Did the project have a 'closed' business case, in which the investment costs are returned and the final design meets the project objectives?

Yes, for the specific measure of riparian woodland planting. Under all climate change scenarios, a positive net present value from NFM planting is shown, indicating that the riparian woodland is worth implementing. That is, the monetary benefits as calculated for the ecosystem services provided by the measure, are higher than the financial costs of implementing. It is not stated if maintenance costs are also included in this calculation or not.

For the other measures this calculation has not been made.

•

7. Sigma Plan Kleine Nete

Introduction

Name of the pilot: Sigmaplan Kleine Nete
Start date and duration: 2006 – present
Status: Initial designs have been made, implementation between 2018-2020
Client: Flemish government
Short description of the project:
De Kleine Nete is a fresh water stream in Belgium in the catchment area of the Scheldt. Changing precipitation patterns and sea level rise due to climate change lead to higher river discharge in the future. Furthermore, historical changes to the course of the river and land use changes have reduced the ecological value of the catchment area. In order to make catchment area of the Kleine Nete resilient against climate change and to reduce flood risk, a building-with-nature approach has been taken to increase the water retention capacity of the catchment. In the project the river gets more room and wetlands are being restored. The Kleine Nete has been assigned as 'Special Areas of Conservation' (SAC). The measures taken come from 6 different initiatives:

1. Gewestelijke ruimtelijke uitvoeringsplannen (regional spatial plans).
2. Bekkenbeheerplan (water management plan).
3. Sigmaplan: This sets the goals to make the Scheldt resilient against climate change, reduce flood risk and increase the natural values of the river.
4. Natura2000 sets the conservation objectives of the Natura2000 sites in the Kleine Nete catchment area.
5. Cultural heritage – landscape atlas.
6. Kempische North-South connection.

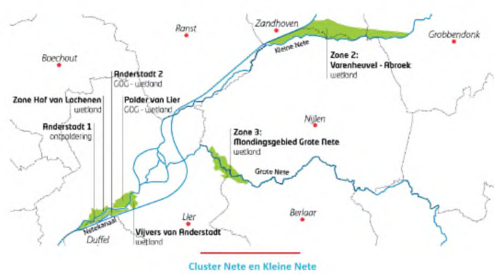

Figure 1: Kleine Nete and three zones of interventions

Business case development

Has a BC been developed and if so, what type?
Although the boundary conditions for natural values, cultural/historical values and flood risk reduction are clearly identified from the relevant laws and regulations, the available reports did not show any kind of cost-benefit analysis that can be described as a business case.

Nevertheless, an 'Opportunities report' of 2016 identifies the projects that are already planned or implemented in the region, and presents 22 toolkits to connect these projects together and strengthen their role and impact. An action program was developed to select ‘primary projects’ that can serve as an accelerator for the development of the region.

An analysis of the environment and the sectors was used to select which areas were suitable to implement the Sigmaplan. The analyses were based on the regional policy, existing rules and regulations and on the presence of physical suitable areas (including areas that form a potential suitable habitat that is large enough for the Bittern).

What types of benefits have been valued in the project, and with what methods?
Natural values, mainly scored against objectives from the Sigmaplan and Natura2000 compensation objectives. Furthermore, effects on flood risk reduction are determined.

How did the project handle the allocation of costs and benefits?
A ‘Landbouweffectrapportage’ (agricultural impact study) was used to investigate the impact of the proposed measures on the local farmers. The results lead to the decision to relocate some of the proposed measures because the negative effects on the agricultural sector were too large. In the areas where the measures are being implemented, additional measures are being taken to compensate for any negative (side) effects for the farmers (‘Flankerend landbouwbeleid’).

How did the project take ‘uncertainty’ into account to value the costs and benefits?
The available reports did not mention how ‘uncertainty’ was taken into account in the various project phases.

How did the project take ‘flexibility’ into account to value the costs and benefits?
The available reports did not mention how ‘flexibility’ was taken into account in the various project phases.

7 Appendix II: BwN Landscapes and arenas

BwN physical landscapes and BwN arenas characterise a situation where a BwN concept may be applicable. These can be described as follows:

- **BwN physical landscapes,** in essence the physical-ecological setting that determines what type of BwN concept may be applicable. Its boundaries depend on the scale of physical processes, and could be a morphological cell along a coast or catchment area.
- **BwN societal arenas,** these are a combination of a BwN landscape and a specific societal setting. The highest level for distinguishing BwN arenas are countries, since national policies, budget lines and planning culture determine the applicability of a BwN solution. Within a country, local land use and configuration of stakeholders, such as land owners, but also local politics determine different arenas. In practice the boundaries of an arena are not only geographical but mainly societal since it may include not only the stakeholders that are impacted directly or indirectly but also those that have roles and responsibilities in financing, decision making and maintenance.

According to the cases, the following **BwN landscapes** (combinations of physical landscapes and arenas) can be distinguished for North West Europe:

- ***Sandy shorelines:*** often adjacent to low-lands, polders or even lagoons. The system of beaches and dunes often have the function of primary defence, are important as nature habitats, to recreation and tourism and in places also for drinking water supply. On certain coasts the first line of dunes is prime real estate, but in countries like the Netherlands, building on dunes is prohibited because of its function as a primary defence and nature area.
- Sand is the major building material and important processes to work with are longshore transport, cross-transport, dune formation, formation of groundwater bodies/lenses. Major challenges for the short term are coastal erosion and management, flood protection, beach width and quality and swimmers safety. For the long term, these challenges growth depending upon sea level rise, storm incidence and possible shifts in dominating wave fields that may influence longshore processes.
- Risk of flooding, an increase in groundwater, insufficient drainage and an increase in salinity as well as prolonged droughts may pose challenges in the adjacent areas at present and more so in future. The adjacent dunes are often part of primary defence systems and under the protection of Natura 2000. Also the adjacent sea may be designated as a Natura2000 area. Several cases, such as the sand motor and nourishment interventions such as of the German Wadden Islands and Danish coast belong to this group, but possibly form different physical landscape subsets.
- ***Intertidal shorelines:*** often adjacent to low-lying land, consisting of a pattern of salt marshes and tidal channels, sometimes protected by barrier islands, like the Wadden Sea, sometimes part of a tidal river estuary, like the Westerschelde.
- Clay is the predominant building material, and important processes are the formation and often transmigration of tidal channels, the scouring processes in tidal channels, the formation of sand banks and mud flats up to the formation of salt marshes. Critical are sediment balances that are strongly related to sources, relative sea level rise but also tidal asymmetry that may have been changed due to navigation dredging. Dune formation is often very limited as is the long shore transport of sand, most sand is transported by tidal channels.
- Major challenges are the maintenance of navigational channels and harbour siltation, but also ecological restoration vis a vis water quality problems or problems with excessive fine sediment concentrations, like in the Ems estuary. Because of the adjacent low lying areas,

also flood protection is a major issue. Nearly all intertidal areas are under the protection of Natura2000. A major concern for the long term is the sediment balance and whether the existing areas will be able to cope with sea level rise. Especially in the case of adjacent polder areas upward seepage of brackish water is a major concern agricultural areas, and a problem that may increase with sea level rise. The case of the Twin dike belongs in this group.

- ***Catchment areas***; the upper part of the catchments of larger rivers or the catchment area of smaller rivers, can be forested and deforested with varying influence of urban and impervious surfaces and agricultural drainage on hydrology that changes rainfall-runoff characteristics. The rivers may be completely, or partially natural or strongly altered for urban and agricultural drainage. The flow regime may be strongly influenced by dams, abstraction and also discharge of effluent especially in summer.
- Major building materials are determined by the supporting and underlying geology, which can be peaty, rocky, karstic, clayey and sandy having very different rainfall runoff characteristics and groundwater dynamics and which lead to different water quality.
- Major processes are rain-fall runoff, channel hydrology, floodplain dynamics, interaction surface and groundwater, interaction channel morphology and shoreline vegetation. The ratio between peak flow volumes and potential river valley storage volume is an important indicator for the potential of BwN alternatives. The run-off and formation of peaks is often complex since it also depends on the timing of peak flows in tributaries and hence the way in which a major rain event moves through the catchment area.
- Major challenges relate to urbanisation and flood safety, water supply, effluent discharge and water quality, interaction between land uses and hydrology and water quality. Water originating from peat areas is originally very acid and in karstic systems is it more basic, which influences also the toxicity of many pollutants. In many catchments historic or new dams and impoundments play a role and sometimes there is the ambition to further small-scale hydro-electric plants. There is always a strong relation with the WFD and the intent of ecological restoration. Some catchments have undergone major changes due to human interventions for centuries which pose a challenge when formulating nature restoration objectives.
- In the long-term especially the shifts in rainfall and evapotranspiration may increase aforementioned problems in terms of droughts and major rainy periods. However on the short-term the influence of land use and water management on flow regimes is usually more important. Long term trends in hydrology and water availability will also trigger shifts in land use and natural vegetation cover that have an impact on rainfall-run-off and consequently on base flows and peak flows. However, it should be noted that on the short-term market conditions have a strong influence on land use as well, which may have led to large scale intensification but also to the abandonment of agricultural lands. The cases in Scotland and Belgium belong to this group.
- ***Lowland river tributaries***: the lower part of major river systems, mostly in between dikes, with varying width of natural floodplains and influence of tidal activity and salinity, in sections closer to sea.
- Major building material is clay in the lowest sections and mixtures of sand and clay in sections more upstream. Major processes are the interaction of unconsolidated river beds and peak flows, floodplain vegetation and morphological development and peak flows, channels scouring and the development of dunes and their influence on peak water levels.
- Major challenges flood protection, peak discharge, navigation especially in times of low river rivers and salinity intrusion. Often natural vegetation successions need to be balanced with required through flow capacity, but forested sections may also be instrumental in attenuating wave heights on wider river stretches. Because of the very large discharges, the use of inundation areas usually has a very limited and short impact on peak flow levels, so focus is mainly on increasing through flow capacity by restoring and new creation of tributaries, lowering of floodplains etc.

- Most challenges increase with climate change, especially salinity intrusion and flood levels may increase due to sea level rise and lower base flows. Sea level rise will increase flood levels close to sea, often in areas where the rivers have been harnessed by urbanisation and infrastructure. Another challenge is the balance between maintaining sufficient water depth for navigation in summer and sufficient flow capacity during peak flows. The problems are further exacerbated by natural and man induced land subsidence due to drainage of unconsolidated clays and peat areas, geological tilt etc. This is the arena of Room for the River projects on the rivers Rhine, Waal and Meuse.
- ***Large Delta lakes:*** these are often former lagoons and intertidal areas, such as Lake Marken and Lake Ijssel. Because of their size wind set up and wave heights are considerable. They are usually situated in coastal and deltaic lowlands and flood protection is an important issue and hence most larger lakes are circumvented by dikes, and the length of natural land-water gradients is limited.
- Major processes are wave and wind-circulation driven transport and non-tidal cross section processes. Dune formation and beach formation are very limited to non-existing and are very different from those at the coast. Most of these lakes have fixed water levels. When they are part of the flow-ways of major rivers discharge water level management is a challenge in the face of sea level rise. This also indicates a relevant subdivision in Delta Lakes. Water quality and ecosystem functioning are major challenges as well, since the transformation of a former brackish into a freshwater environment often comes with specific problems, such as high fine sediment concentrations.
- This group is mainly represented by the cases Houtribdijk and Marker Wadden.