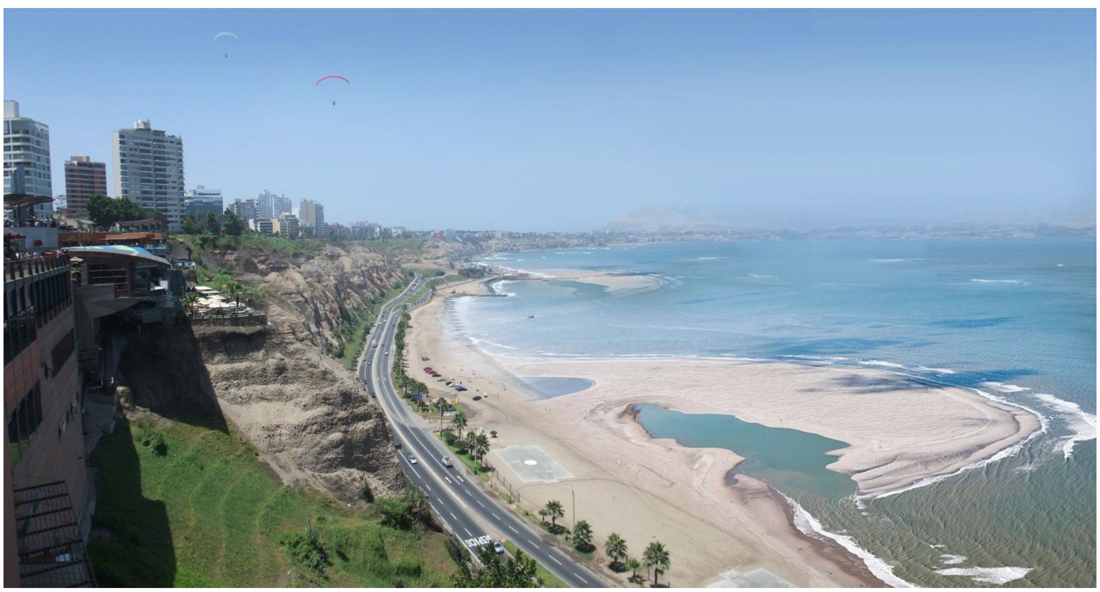
A framework for sandy strategy development

With a quick scan for (co-)financing potential



Courtesy: MAP Urban Strategies

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Deltares

Title
A framework for sandy strategy development

Client	Project	Reference	Pages
Ecoshape	1220140-000	1220140-000-HYE-0009	55

Keywords
Sandy strategies, Building with Nature, coastal management, sand motor, cost-benefit analysis, (co-)finance, business case

Summary
The sand motor is a partly emerged mega-nourishment at the Delfland coast in the Netherlands. It is an example of a Building with Nature (BwN) solution using natural processes to fulfil multi-functional purposes in coastal management, such as coastal protection, beach recreation and nature development. EcoShape wishes to explore the opportunities for sandy strategies like the sand motor in an international context.

To this end, a framework for the development of sandy strategies is developed by a consortium of Deltares, Royal Haskoning DHV and Witteveen+Bos. This framework aims to assist the BwN community to quickly assess whether sandy strategies are feasible and beneficial for projects both in the Netherlands and abroad. The framework consists of five main steps to assess the feasibility of a project. It starts with the context and scope of the project at hand, followed by a system analysis, design and evaluation of strategies and, finally, an assessment of the (co-)financing potential. The framework explicitly accounts for (the capturing of potential) benefits resulting from the strategies from the early stages of the design process in order to increase the potential for (co-)financing for their implementation.

This report presents the framework that has been developed, including guidelines and tools for its application in practice. The content of this report is also published on the BwN wiki-page:https://publicwiki.deltares.nl/display/BWN1/Building+Block++Sandy+strategy+development. The framework has been applied to two practical cases: Negril beach in Jamaica and the sand motor in the Netherlands. These cases are for illustrative purposes only and, therefore, not part of this report, but only made available on the wiki-page.

References
1220140-000-HYE-0001 Sand Motor guidelines & tools and business case

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This is a draft report, intended for discussion purposes only. No part of this report may be relied upon by either principals or third parties.

Contents

1 Project context and background

The EcoShape consortium consists of private parties, public parties, research institutes and universities and is the executive body of the Building with Nature (BwN) program. BwN is a design philosophy with emphasis on the use of natural elements such as wind, currents, flora and fauna for the design of engineering solutions in order to create multi-functional benefits. EcoShape aims tosand motor gather and develop knowledge, expertise and tools to bring BwN into practice.

One example of a BwN solution is the Sand motor at the Delfland coast in the Netherlands (Figure 1.1). The Sand Motor is a partly-emerged mega-nourishment which is not only meant for coastal protection, but also to stimulate beach recreation and nature development. Natural processes such as waves, wind and currents distribute the sand in alongshore direction and into the dunes. In this way, it also provides protection for the adjacent coastline. Sandy strategies like the Sand motor are well-embedded in Dutch practice, policy and legislation. However, they also provide inspiration to parties abroad, such as in Lima (see cover photo), Jamaica and several other locations in the world. Therefore, EcoShape wishes to explore the opportunities for sandy strategies in an international context.

Figure 1.1: Sand motor Delfland, The Netherlands (courtesy Joop van Houdt photography)

In an international context both the physical and societal system can be very different from the Dutch context. Sand availability may not be abundant, beach slopes may be much steeper, hurricanes may be present and sensitive coral reefs or sea grasses may pose additional challenges to the implementation of sandy strategies. Also the societal context in terms of stakeholders, policy and laws and finance can be very different. All these aspects together determine whether a sandy strategy is feasible at all and what strategy is most fit-for-purpose for the area of interest.

In order to assist the BwN community with the development of feasible and beneficial sandy strategies both in the Netherlands and abroad, EcoShape requested a consortium of Deltares, RoyalHaskoning DHV and Witteveen+Bos to develop a framework providing guidelines and tools to support the development of sandy strategies. This framework should enable a quick scan on the feasibility of sandy strategies with special attention to the potential for (co-)financing. To illustrate the use of the framework in practice, EcoShape asked to apply the framework to two practical cases: Negril beach in Jamaica and the Sand motor in the Netherlands. Two workshops with participants from the BwN community have been organized to work out these two cases and at the same time verify and improve the framework.

This report presents the framework that has been developed, including guidelines and tools for its application in practice. The content of this report is also published on the BwN wiki-page: https://publicwiki.deltares.nl/display/BWN1/Building+Block+-+Sandy+strategy+development with the purpose to further detail and update the provided guidelines and tools based on future experiences. Please note that the practical cases are for illustrative purposes only. Therefore, they are not part of this report, but only made available on the wiki-page.

This framework has jointly been developed with the project consortium, Ecoshape and NatureCoast (scientific program funded by STW); the latter exploring the physical feasibility of a mega-nourishment concept worldwide. The framework can assist and guide the exploration of coastal strategies in sandy environments at other locations.

The structure of this document is as follows. Chapter 2 gives a brief introduction on the motivation for the framework, followed by a description of the framework in Chapter 3. Chapter 4 provides a description of each of the framework steps, including guidelines and (suggestions for) tools for practical applications. Finally, Chapter 5 provides conclusions and recommendations based on the lessons learned from this project.

2 Introduction

A large part of the world population lives and works in coastal areas which are affected by natural and anthropocentric changes. Developments such as sea level rise, increasing navigation traffic and population growth put increasing pressure on the coast. To deal with these developments adequate coastal strategies are required. This can be strategies to hold the line, move forward or retreat. Building with Nature (BwN) solutions may be part of these strategies. A distinctive feature of BwN solutions is that they utilize natural processes and look for opportunities for the multi-functional use of hydraulic infrastructure, for example by combining coastal safety, recreation and nature development. The multi-functional usage of these solutions offers additional and/or alternative opportunities for the financing of the project (e.g. parties may be willing to pay for additional/alternative user functions).

To improve the chances for coastal strategies that are feasible and financeable, the financing should be accounted for from the early stages of the project. To this end, a framework is developed to assist the BwN community with the development of coastal strategies for sandy environments. The framework is meant as a quick scan to scout strategies with potential for (co-) finance. Although the framework presented here is primarily set up for the development of coastal strategies in sandy environments, its approach can also be used for the development of (BwN) strategies related to other coastal systems.

The framework is a living (wiki) document that is never fully finished. The community is strongly encouraged to improve and extend the framework based on their expertise and/or experiences with practical applications. In this way, it is hoped that the knowledge base for the Building with Nature community is both extended and strengthened.

3 Framework for sandy strategy development

In order to develop feasible and beneficial coastal strategies for sandy environments with potential for (co-) finance both the physical and societal aspects of the area of interest are relevant. Often the physical system provides the preconditions for user functions or ecosystem services (e.g. beaches, swimming water, sand quality, access roads), but the societal system determines to what extent these functions are actually being used. For example, permits limiting accessibility or a shortage of parking lots may hamper the use of a beach, even when the physical preconditions in terms of beach width and swimming water are there. Therefore, the physical and societal systems together determine the economic and financial feasibility of coastal strategies. In order to assess all these aspects for sandy strategy development, a framework for sandy strategy development is set up. This framework can be used especially in the initiation and design phases of a (BwN) project.

3.1 Why this framework?

The framework for sandy strategies is developed with the following motivations:

1. To explicitly consider (the capturing of potential) benefits from the early stages of the design process of coastal sandy strategies beyond achieving policy objectives. Hence, instead of only focusing on problems (e.g. coastal erosion, flooding), the framework also focuses on opportunities. These opportunities/benefits may generate co-financing for the implementation of the coastal strategy. This requires an approach that explicitly accounts for both physical conditions and societal (e.g. social, economic and institutional) arrangements/settings.
2. To focus on coastal strategies in a sandy environment. Hence, especially processes and benefits related to sand are part of the system analysis and design process.
3. To link coastal strategy development in sandy environments with the BwN approach in the sense that nature and natural processes are predominantly present in the system analyses and in the proposed strategies. Ideally, this implies to steer a system analysis beyond the mere technicalities of civil engineering, such as hydraulic and morphological processes, to include processes like dune formation, geohydrology and related ecology.
4. To provide support to the BwN community in the form of (quick scan) tools dedicated to the above, including tools to make rough calculations of beach development and nourishment needs, dredging costs and (socio-economic) benefits related to sandy strategies.

3.2 Framework for sandy strategy development

The rationale of the sandy strategy development framework is to improve those physical preconditions of the coastal system that actually maintain or generate benefits for the stakeholders, in such a way that the costs of the project are (over)compensated and financeable. The framework has been developed to aid the process of sandy strategy development with potential for co-financing. The framework consists of 1) context and scope, 2) system analysis (both physical and societal), 3) design of sandy strategies, 4) evaluation of sandy strategies in terms of physical, societal and economic feasibility and 5) financing and business case potential. It is noted that the framework is iterative: one may need to go back and forth between the steps of the framework to end up with strategies with potential for (co-)financing. Moreover, the framework can be used in multiple project phases, to check whether additional information in subsequent project phases changes the feasibility and, hence, requires updating of the strategies that have been developed.

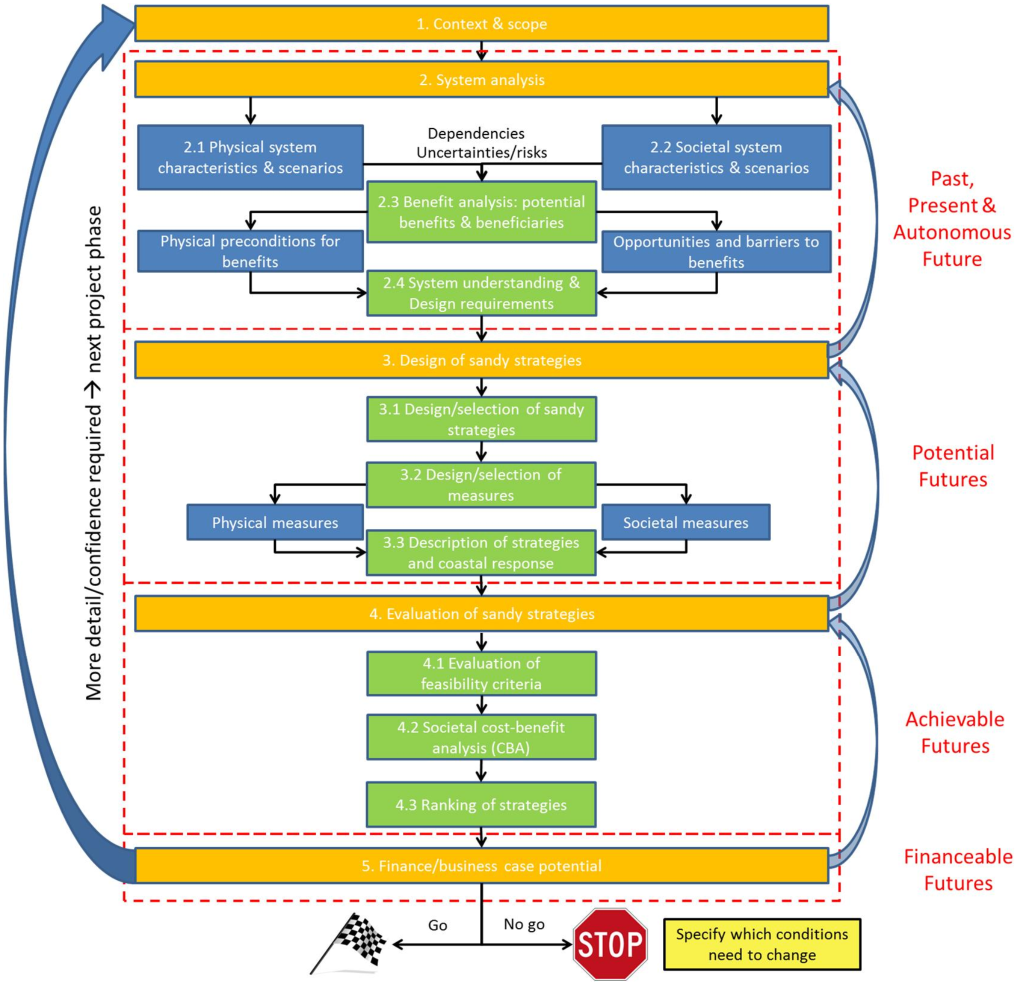

Figure 3.1: Framework for sandy strategy development (to be used in the project initiation and design phases)

The table below provides a basic description of the contents of each of the steps of the framework. A more detailed description of these steps is provided in the 'How to use' chapter (Chapter 4).

Table 3.1: Basic description of the rationale and contents of each of the framework steps

	Step	**Content / Actions**
1.	Context and scope	An initial investigation of the project is performed to identify which phase the project is in. This step should provide insight in information availability, topics on which consensus is reached and decisions that are already made. In some cases it may be necessary to go up a project phase in order to consider a wider scope of potential user functions/benefits that have been overlooked in a previous project phase.
2.	System analysis (past, present & autonomous future)	The physical and societal system are explored and interpreted with the aim to identify potential benefits, relevant physical preconditions and potential barriers to obtain benefits. This information is translated into a set of realistic 'design requirements' for the design of sandy strategies.
3.	Design of sandy strategies (potential futures)	A set of relevant alternative sandy strategies is developed which may contain both physical and societal measures. This includes the reference alternative (e.g. current policy). The physical performance of the strategies is evaluated in order to check whether the strategy indeed leads to the intended coastal response. Objective methodologies or qualitative expert judgment may be used for this check, depending on the phase of the project.
4.	Evaluation of sandy strategies (achievable futures)	The designed strategies are evaluated in terms of physical and societal feasibility. This includes a societal cost-benefit analysis (SCBA) relative to the reference alternative as well as an assessment of the distribution of benefits over the stakeholders in order to identify potential (co-)financiers. In consultation with the stakeholder/potential investors this will result in a ranking of the strategies to identify those strategies that are likely to be physically and societally feasible and have a positive CBA.
5.	Finance/business case potential (financeable futures)	The financeability of the strategies is checked. There are 3 options: (1) there is potential financing for the strategy – summarize all relevant information on the project fact sheet, (2) there is potential financing but still insufficient information - pay special attention for budget allocation for additional research/measurements in the next iteration or (3) there is no potential for financing – stop and summarize what conditions need to change to increase the opportunities for financing (e.g. blockages that need to be removed). Based on this information the project initiators/decision makers can decide on how to proceed with the project.

3.3 Case studies

The general framework described above is applied to two case studies in order to both test/refine the framework and illustrate how it can be applied in practice: Negril beach in Jamaica and Sand Motor 2.0 (hypothetical) in the Netherlands. These cases differ in location, context and relevant user functions, as illustrated in Table 3.2.

Jamaica

This is a case study that acts as a reference for a biogenetic beach in a tropical climate that is subject to hurricanes. The beach is not a coral beach as such but protected by a coral reef. International tourism and beach erosion are major focus points. The beach has the form of a sand spit that protects a lagoon. Flood safety is not an issue neither is water supply, since the beach area is too small. In an existing Environmental Impact Assessment (EIA) a breakwater was considered as a measure to limit beach erosion. Other alternatives that are explored use beach nourishment or a combination of beach nourishment and breakwaters or reef restoration. Furthermore, managed realignment is considered since the overall erosion trend is limited. Because the quality of the sand is so important in this case, also a restoration of original beach forming processes is considered. Regarding benefits, the focus is on maintaining on-going (international) tourism that constitutes the major pillar under the local economy. A second but far less important economic activity is fishery.

Sand Motor 2.0

This is a case study that forms a reference for a sandy shoreline in a temperate climate, with ample availability of sand at low costs. Flood safety is important since the dune and beaches act as a primary defense for a heavily urbanized hinterland. Also water supply (from the dunes) plays a role as well as local tourism. Beach erosion is mainly related to flood safety of the hinterland since no buildings are present close to the beach, with the exception of beach restaurants. The sand motor focuses mainly on an alternative way of coastal maintenance with less environmental effects. Since there are no exceptional storms or hurricanes it is possible to perform longer-term predictions of nourishment needs based on present and past nourishments. Worth considering are schemes that aim at more cost-effective forms of coastal management. In this case this includes also the use of dredged materials from the Eurogeul, which so far, for policy reasons have not been considered as a source for nourishment. Also of interest are schemes that seek co-financing by exploiting the possibility of selling or leasing (semi-permanent) beach houses, an option that also for policy reasons was so far not considered for this coastal section.

Other situations

The selected case studies are just two examples within a wide variety of possible cases. Depending on the physical system and societal systems the system analysis and design process will need to focus on other aspects. It is noted that future applications to other cases in other climates, focusing on different user functions may require updates of the framework in terms aspects that have not been addressed so far.

Table 3.2 Overview of the most relevant differences between the case studies of Negril beach and Sand motor 2.0

Cases: type of coast	**Flood safety hinterland**	**Beach erosion**	**Local recreation**	**International tourism**	**Nature development**	**Water supply**	**Real estate development**
Jamaica - Negril coast: biogenetic, tropical beach	Not an issue	Relevant problem	Limited	Very relevant	Less relevant	Not relevant	Not relevant in terms of new developments
The Netherlands - Sand Motor 2.0: sandy shore in temperate climate	Not an issue now, but is an issue on the longer term without active coastal maintenance	Maintenance issue	Relevant	Less relevant	Relevant	Relevant	Not relevant

3.4 Disclaimer

The framework for sandy strategy development is intended to provide practical guidance to the BwN community to gain quick insight in the possibility of a business case in an early stage of a project. The provided tools should therefore be considered as initial assessments to provide a first indication and not as a recipe for a viable business case. The development of a business case requires input from different fields of expertise, such as governance, coastal engineering, ecology, urban development, economics and finance. This framework is an attempt to cover all these fields of expertise and - at the same time – to provide ‘general’, practical guidelines to the BwN community. In this process simplifications have been made and not all nuances have been addressed. Hence, the framework may not align fully with available literature, tools and best practices for every relevant field of expertise. The outcome of the application of the framework should therefore be considered as a first indication to be re-evaluated in more detail with experts, stakeholders, data and models in subsequent design stages.

The framework is a living (wiki) document that is never fully finished. The community is strongly encouraged to improve and extend the framework based on their expertise and/or experiences with practical applications. In this way, it is hoped that the knowledge base for the Building with Nature community is both extended and strengthened.

4 How to use the framework

This section provides a step-by-step description of the framework. The framework is intended to remind BwN end-users what to consider when developing a sandy strategy. The focus is to keep in mind the opportunities for (co-)financing for a coastal strategy. For each step of the framework first the rationale is given followed by the information requirements and suggestions for how to obtain this information. Please note that the quick scan is not a linear but an iterative process and so is the setup of the framework. Ideally, all information requirements of a step are fulfilled before progressing to the next step. However, in practice this will rarely be the case. There will always be uncertainties that have to be dealt with. Nevertheless, these uncertainties do not necessarily have to be a show-stopper for a business case. Even with uncertainties alternative sandy strategies may be more attractive than current practice. Moreover, these uncertainties may offer opportunities to develop adaptive strategies.

The steps in the framework are addressed in subsequent order:
1. Context & scope
2. System analysis
3. Design of sandy strategies
4. Evaluation of sandy strategies
5. Business case potential

4.1 Context and scope

Rationale: understanding the project motivation and history and determine the focus for the current project phase

A first step in each design cycle is the identification of the starting situation. Often the trigger to start thinking about (alternative) coastal strategies for sandy environments is a problem (e.g. coastal erosion), a policy objective (e.g. coastal maintenance) or an opportunity (e.g. project development). However, the starting situation may also be in the middle of the design process, where stakeholders are asking for a second opinion. In all cases it is wise to gain a good understanding of the project history. Even new projects often have a history of past studies, interventions and decision making.

Firstly, the current project phase is identified. The following project phases are distinguished (see also BwN project phase guideline):
1. Initiation
2. Design
    1. Feasibility (Go/No-Go)
    2. Conceptual design (Select alternative)
    3. Final design (Optimize alternative)
    4. Detailed design (Prepare realization)
3. Construction
4. Operation & Maintenance
5. Monitoring & Evaluation

Although it may be tempting to start from the identified project phase, it is sometimes required to go one (or more) step(s) back in the process. For example, it may be that the original project scope is too narrow and, hence, limiting the potential for Building with Nature opportunities and corresponding benefits and co-finance. In such a case it may be beneficial to go back one step and start with a wider scope.

Subsequently, an overview is needed of the a-priori information availability and history of the project. What are the design requirements from the problem owner or project initiator? What is known on the physical and societal system? What decisions are already made? What are the relevant issue that are heavily debated and for which general consensus is reached among the stakeholders? It is suggested to check these aspects along the following 6 feasibility aspects:

- **Technical** (or physical): this refers to the degree to which the strategy can technically be implemented and performs as intended. Good physical system understanding is crucial for determining the technical feasibility.
- **Ecological**: this refers to the ecological impacts and opportunities of the strategy. Please note that the ecological feasibility may partly overlap with legal environmental regulations.
- **Legal**: this refers to the degree to which the strategy is in line with laws, regulations and policy. In principle, a strategy is only legally allowed if it is in line with all laws, regulations and policy, unless there are opportunities to change these.
- **Social**: this refers to the degree to which the strategy is acceptable for relevant stakeholders. Alternatives that are likely to trigger (large) opposition from the local stakeholders, may not be socially feasible. Please note that stakeholder resistance is often (but not always) related to an uneven economic distribution of costs and benefits
- **Economic**: this is determined by the outcome of a societal cost-benefit analysis (SCBA). In the SCBA the costs and benefits for all stakeholders experiencing (dis)advantages from the project should be accounted for. This includes the costs and benefits in terms of cash flows (e.g. investments, profit, income) but also goods and services that are not sold in the market and have no market price. When the (present value of the) benefits are larger than the (present value of the) costs, the strategy is economically feasible.
- **Financial**: this is determined by a financial analysis in which is checked whether sufficient finance (actual cash flow) can be generated to cover the costs of the strategy. If this is the case, the strategy is financially feasible. Please note that private financiers often require a higher return on their investments than governments. Sometimes a strategy can be economically feasible in the SCBA, but not capable of generating sufficient revenues (cash flow) in a financial cost benefit analysis.

It is suggested to use the "project progress tracker" (Table 4.1) to assess the status of the project on the feasibility aspects in terms of data availability and (system) understanding. This table is intended to provide quick insight in which aspects are sufficiently understood/covered and which aspects need further attention in the subsequent steps of the framework. This overview should quickly make clear whether essential information/understanding to proceed is missing. If that is the case, the focus should be to acquire the relevant information/understanding before proceeding with the framework. Alternatively, the uncertainty arising from the lack of information/understanding can be accounted for by a sensitivity analysis and/or the development of adaptive strategies.

Table 4.1: Progress tracker (before start of a design cycle)

Feasibility criteria		**No basic data/knowledge is available - needs, effects and costs are difficult to estimate**	**Some basic data/knowledge is available - much depends on general key figures and limited stakeholder understanding**	**Sufficient data/knowledge is available - for design and decision making and estimating public and legal acceptance**	**Nearly full system understanding - enables good predictions, calculations and co-financing negotiations**
		Strategies and design are meaningless	Strategies can be sketched but substantiated comparisons cannot be made	Strategy selection is possible	Design optimization is possible
Physical	***Technical***				
	Ecological				
Societal	***Legal***				
	Social				
Costs & Benefits	***Economic***				
	Financial				
Overall status					

Outcome of this step: project status and context

- Project status:
  - regarding decision making, design alternatives, potential funding and funding criteria and in general the decision making process (who, when and on the basis of what information)
  - regarding the need to reconsider, redo or re-evaluate one or several of the past steps and implicit decisions already taken in order to widen the project scope aiming at a better understanding of the problems situation and opportunities presented
- Physical context and drivers:
  - an overview of relevant information geared towards major design challenges and motives for decision makers
  - an overview of major driving forces and substantial gaps in system understanding that need to be addressed
- Societal context and drivers:
  - an overview of major stakeholder groups and their major interests
  - an overview of consensus and debated issues, the perception and framing of the project by stakeholders
  - an overview of potential benefits that could result from a sandy strategy

4.2 System analysis

Rationale: understanding the functioning of the physical and societal system in the project area in order to identify potential benefits, risks and design requirements

Before developing strategies, the functioning of the present system needs to be understood. This does not only entail the physical system, but also the societal system. Both systems are relevant to identify the present and (potential) new benefits that may be generated by an alternative coastal strategy. Often the present state of those systems is a result of developments in the past. It could for example be that human interventions in the past (e.g. construction of coastal protection works or destruction of coral reefs) have caused the present day's problems. In this case the (alternative) strategies may have to focus on restoration of the coastal system. It can also be that the present state of the system does not require alternative sediment strategies, but the autonomous future state does. Think of developments such as sea level rise and population/economic growth in the coastal zone that may cause problems in the future. Therefore, this section focuses on the past, present and autonomous future of the system.

The sections below describe subsequently:

2.1 Physical system characteristics
  (1) Physical system description
  (2) Uncertainty
  (3) Physical scenarios
2.2 Societal system characteristics
  (1) Stakeholder analysis
  (2) Institutional analysis
  (3) Societal scenarios
2.3 Potential benefits analysis
  (1) Physical preconditions
  (2) Matching and conflicting preconditions
  (3) Potential barriers
2.4 Outcome of this step: design requirements

4.2.1 Physical system characteristics

(1) Physical system description

The physical system consists of all physical aspects of the area of interest such as the hydro- and morphodynamics, but also the ecological habitats and urban infrastructure of the coastal area. The physical system offers the conditions for (ecosystem) services from which benefits can be generated, such as a sufficiently wide beach, sand of good quality, good swimming water and accessible nature areas. A good physical system understanding is essential for the development of effective strategies in step 3. The present state of the physical system is determined by historic developments and (present) relevant processes. The questions below outline the most relevant aspects of the physical system of (natural) beaches:

- Characteristics of the beach?
  - Origin of the beach (i.e. potential sources and geological history)
  - Type of sand (river, coral, cliff)
  - Current dynamics of the beach (i.e. erosion / accretion)
    - What are the typical changes?
    - What processes drive these changes? (e.g. sea level rise, alongshore transport, shortages in supply or offshore losses)
  - Location of structures (e.g. groynes or beach houses)
- Availability of sand? (i.e. costs of nourishment sand)
  - Availability of sand (distance, type, depth, legal barriers, taxes)
  - Potential for replenishment (e.g. which types of sand nourishments given navigation requirements or ecological restrictions)
- Physical conditions?
  - Dynamics of the environment (calm/energetic)
  - Exposure of the beach (open/closed)
  - Erosion conditions (events/systematic)
  - Existing and future beach maintenance
- Ecological habitats?
  - What key species are present? What is their habitat?
  - Where are the nature reserves located?
  - What ecological processes act? Do they have adverse/positive effects?
- Urban infrastructure?
  - Where are residential, commercial or industrial areas located?
  - What about accessibility? (parking lots, roads, public transport)
- Relevance of other coastal functions? (e.g. dune water extraction, mining)

It is noted that the required information availability and level of detail generally increase while progressing in the project phases. Additional measurements or modelling may be required to assess some physical system characteristics. Especially the exploration of the dynamics of the beach may require the use of models to distinguish between the effects of various processes, such as sea level rise, alongshore transport and mechanisms driving sand loss. Modelling approaches with different complexity can be applied depending on the detail of the design phase (tools depending on design phase). This may concern sediment transport formulations for a quick analysis of transport rates (e.g. CERC), quick assessment models of the coastline changes (e.g. NTOOL), detailed coastline models for feasibility and initial design studies (e.g. Unibest) or detailed morphological or storm erosion models (e.g. Delft3D or Xbeach). Wave conditions can be estimated by extracting nearby offshore conditions from available databases (e.g. WTOOL) or by making detailed nearshore transformations of waves towards the shore (e.g. SWAN or Delft3D-Wave).

The identification of potential alternatives (section 4.3) is strongly linked to the system analysis. To structure the identification of (effective) alternatives it may be useful to distinguish relevant beach types (see the following document). The causes for coastal erosion determine which measures can be effective. In general, the following options to mitigate coastal erosion are available:

- *Restore:* restore original conditions and processes (e.g by reef or sea grass restoration or demolishing hard coastal structures leading to significant erosion)
- *Steer:* steer conditions and processes (for example by coastal structures)
- *Enhance:* increase the capacity of the natural system (e.g. usually by nourishments)
- *Prevent:* mainly by reducing longshore transport/wave energy (for example by a breakwater)

Generally, the selection of a strategy for taking action against coastal erosion is in the following order:

1. First consider whether restoration of the original beach dynamics is possible. In this case a (potential) coastal erosion problem is intended to be solved by taking away its primary causes. For example, if erosion can be attributed to a man-induced change in the sand balance and/or longshore processes, consider whether restoration to its original state may solve the problem.
2. If restoration is not possible due to constraints:
    1. In case there is no structural loss of sand, but only a temporary setback: consider patience (wait for natural restoration) or apply a sandy buffer that takes care of temporary shortages and beach set-backs.
    2. In case there is a structural loss of sand and temporary setbacks: consider merging the need for a buffer to cope with storm incidence with a nourishment to overcome several years of anticipated erosion. The functional lifetime should be based on cost-effectiveness estimates that take into account (reduced) nourishment efficiency in case of large volumes and lower unit costs of nourishment.

(2) Uncertainty (in available data and understanding of the physics)

As stated in the introduction, the present state of the physical system will inherently be uncertain to some degree. The uncertainties in physical parameters that are relevant for the development of sediment strategies have to be accounted for. In some cases the physical characteristic itself may even be uncertain (for example when the existence of land subsidence is not clear from available data). Sensitivity and/or uncertainty analyses (with models or by logical reasoning) can be used to assess the potential impact of uncertainties in physical system characteristics. It is noted that variability/uncertainty in physical system characteristics may also be accounted for in the development of adaptive sandy strategies, which is a key characteristic of BwN approaches.

(3) Physical scenarios (potential future states)

On top of the uncertainties in the present system, there is also uncertainty in the (autonomous) future development of the system. Examples are the effects of sea level rise, climate change or ecological changes on the physical system. In order to evaluate the robustness of the (future) coastal maintenance strategy, these environmental scenarios should be accounted for. Climate change scenarios can for example be derived from http://www.ipcc.ch/. The impact of sea level rise on the coast can be approximated with simple Excel sheets for coastlines without direct influence of tidal basins (SLR tool).

Table 4.2 Overview of physical scenarios (example)

Physical scenarios	**Affected parameter**	**Range of uncertainties**
Sea level rise	Water level	+ .. mm/yr to + .. mm/yr
Vegetation coverage	Wave height nearshore	change of 0% (no vegetation) to -..% (if vegetation is successful)
...		

4.2.2 Societal system characteristics

The societal system consists of all non-physical aspects of the area of interest, such as the stakeholders, the institutional context and legal aspects. Whereas the physical system provides the physical preconditions for potential benefits (e.g. supply), the societal system determine to which extent these benefits are actually captured (e.g. demand). For example, when a beach is sufficiently wide and offers good conditions for swimming and surfing, this does not automatically mean that recreational benefits are generated. Societal aspects such as limited accessibility to the beach (e.g. blocking supply) and abundant competitive beaches (e.g. big supply) may prevent people from actually using the beach (e.g. demand) and, hence, hamper the generation of benefits. Furthermore, when the societal aspects are not sufficiently accounted for in the design process, this may lead to resistance/opposition against the implementation of the strategy. Therefore, we need to determine who/what are the stakeholders, institutions and legal regulations that need to be taken into consideration.

The sections below describe what information is required and how this information can be obtained. The (fill-out) tables can be used to summarize this information.

(1) Stakeholder analysis (identify interests/benefits, power and potential financing capacity)

The stakeholders are all the people/organizations that have a stake in the project area. Their stakes can be related to present and future land use and/or the use of goods and services that are offered by the coastal system (e.g. for living, recreation, profits, etc.). As stated before, involvement of the local stakeholders and understanding their stakes is often crucial for the success/feasibility of a coastal maintenance strategy. Some of the stakeholders may be (potential) financiers of the strategy. For these stakeholders it is interesting to also identify their clients and the degree of market saturation (e.g. demand versus supply) in order to analyse the benefit potential. Other stakeholders may obstruct the implementation of a strategy when their stakes are not sufficiently accounted for. All together, the stakeholders are a key factor in the feasibility of a strategy.

There are many ways to perform a stakeholder analysis. A number of these methods can be found here (in Dutch, section 3.1 I.4 and section 3.2 II.1). It is suggested to minimally acquire the following information from the stakeholders:

- For present users/investors: present benefits (or services), new potential benefits, power and paying capacity (e.g. ability to directly or indirectly co-finance)
- For future users/investors (not yet stakeholder): new potential benefits, power and paying capacity

- For clients (i.e. the clients of the present and future users): degree of saturation of services (are there shortages or is the market saturated?) - the extent to which (additional) benefits can be expected

Often the information on present users/investors can be found on land use maps, in environmental impact assessments or occupancy/booking rates of accommodations/companies (if available). Information on potential future users/investors needs to be generated. This can be done by organizing workshops with parties that are already involved in the project or by contacting parties to inform after their expected benefits from the project.

Table 4.3 Relevant aspects for stakeholder analysis

Present users/investors				**Future users/investors**			**Clients of stakeholders**
Present benefits	New benefits*	Power**	Paying capacity	New benefits*	Power**	Paying capacity	Degree of saturation***

* Whether new benefits due to the sandy solution are actually captured in practice depends on various physical and societal circumstances, varying from e.g. the effectiveness of the sandy solution itself to the barriers such as substitution (cannibalism) or licensing. This is why we call them potential benefits.
** Power can be in the form of ownership or political or financial support.
*** Is their demand larger than the supply? E.g. are there high occupancy rates, waiting lists, over-bookings? Do they have alternatives that they could easily choose for? These are all indications of substitution risks, i.e. the risk that benefits are shifted from one location to another. Please, mind that such shifts do not only occur at national level; often this also happens at regional and even at local level. This is particularly the case with new benefits that require investments (for example beach houses) on top of the investment in the sandy solution.

(2) Institutional analysis

In order to develop coastal management strategies that are legally feasible, it is important to understand the institutional context in the area of interest. The institutional context either sets the (legal) requirements for the coastal management strategy or provides an overview of which decision procedures to follow and which parties (authorities) to involve/address when these requirements need to be changed.

The following institutional information is minimally required:

- Legal framework: laws to obey, licenses needed, relevant authorities and their (political) interests & powers
- Decision procedures/policy: decisions to be made, their time frame, the parties involved and their tasks, responsibilities & financial means

Typically this information can be found in law books, policy documents or at the websites of relevant authorities. Since reading all these rules and regulations

Table 4.4 Relevant aspects for institutional analysis

Legal situation				**Decision procedures**			
Required permissions	From which authority	Authorities interest or view	Authorities power*	Decisions to be made	Decisive moment (date)	Parties involved	Their role (task, responsibility, means)

* Take political power into account

(3) Scenario analysis:

Like the physical system, the societal system is not static. As the societal system determines to a large extent the magnitude of the identified benefits (and hence the outcome of the CBA), we need to identify the relevant societal driving forces that determine the size of these benefits. These forces can be demographic (e.g. population growth), but also societal such as changes in consumer demands/tastes or oil prices. As benefits can be of very different nature, there is no generic tool to identify the driving forces. Nevertheless, the physical preconditions (see next section) can help to identify the key drivers and indicators.

In some countries information on societal scenarios (such as economic growth scenarios) is published by for example governments (including the European Union), statistical agencies or the International Panel on Climate Change (IPCC). If not, one needs to identify which are the key economic driving forces that determine the size of benefits (e.g. in workshop with involved parties).

Table 4.5: Driving forces and key indicators for benefits as well as scenarios affecting them

Benefits	**Driving force determining the size of the benefit**	**Key indicator to quantity the driving force**

4.2.3 Potential benefits (opportunity) analysis

The previous sections focused on the identification of the stakeholders and their potential benefits (or stakes). This section focuses on the requirements to generate these potential benefits. Which physical preconditions need to be maintained/improved? Are these preconditions matching or conflicting for different stakeholders? And what are potential barriers for the capturing of the benefits? The aim of this analysis is to identify the physical and societal design requirements for the strategies to be developed in step 3 of the framework. The design of the strategies should be such that the physical preconditions for benefits are maximized whereas the potential barriers to the capturing of these benefits are minimized. The (fill-out) tables can be used to summarize this information.

(1) Physical preconditions: what are the physical preconditions that need to be maintained/improved for the sake of the identified benefits, i.e. what are the preconditions to these potential benefits according to the beneficiaries?

Benefits can be generated by improving physical preconditions, such as sufficient beach width, sufficient parking lots and good water quality. An overview of potential physical preconditions can be found here (in Dutch). The "benefit game" may be a helpful tool to link physical preconditions to benefits and measures (follow this link for more information). Different stakeholders may link different preconditions to the same benefit. Therefore, it is important to get an overview of what is important for which stakeholder. The following table may help in this.

Table 4.6 Relevant physical preconditions to be maintained/improved

Main benefits	**Physical preconditions according to:**			
	stakeholder 1	**stakeholder 2**	**stakeholder 3**	**stakeholder 4**
benefit 1 (e.g. coastal flood risk reduction)				
benefit 2 (e.g. beach recreation)				

(2) Summary of matching and conflicting demands in physical preconditions:

The specification of the demands of different stakeholders/beneficiaries in terms of physical preconditions results in an overview of stakeholders with matching and conflicting interests. Interests are formulated in terms of benefits plus the physical conditions that are required for those benefits: e.g. if for recreational benefits both beach width and wider access roads are the key preconditions that need to be improved, these two physical improvements are the key ingredients for the design of a sandy strategy.

Table 4.7 Matching and conflicting preconditions among stakeholders

Stakeholders with matching preconditions:	**These preconditions are:**
Stakeholders with conflicting preconditions:	**The preconditions are:**

(3) Potential barriers: which societal hurdles can hinder capturing of the identified potential benefits in practice?

Potential barriers refer to the hurdles that stakeholders or potential co-financiers may experience to capture the identified benefits in practice (i.e. NOT the barriers to the sandy solution, but the barriers to entrepreneurs i.e. stakeholders who need to invest in order to capture the potential benefit that the sandy solution creates). The list below provides a number of frequently occurring barriers:

- Lack of shortages
- Thresholds
- Legal constraints
- Uneven distribution of benefits
- Fund raising problems

>> Read more for an explanation of these barriers (this is a wiki feature)

- **Lack of shortages:** when there is no shortage of (or no demand for) a particular user function, it is not likely that additional supply of this user function will generate additional benefits. Still the new/improved user function may be used, but is likely to substitute the existing supply of this user function. Hence, it may trigger positive effect locally, which may be interesting for some potential investors. However, the net overall gain on a larger (municipal, regional or national) scale is likely to be minimal. For example, when the availability of accessible recreational beaches is abundant, a new beach may attract (new) visitors. However, as there is no shortage, it is likely that these visitors previously went to another (existing) beach. In that case, there is no net societal gain. Information on shortages is market information. This information can be found in sectorial market research reports, such as 'market consultation for the high end hotel sector'. This type of research reports is not always publicly available. Calling up sector organizations may help finding them. It is also possible that no market research has been done (or is very outdated). In such a case, the easiest way to determine shortages is to call up companies/hotels and ask if they are overbooked or have waiting lists as those are indications of shortages.
- **Thresholds:** sometimes a benefit can only be captured when a threshold (e.g. minimum quantity) is exceeded. A beach club - for example - may only be profitable at a minimum number of visitors. For short overnight stays, an beach area needs to have a minimum number and variety of entertainment types. Information of thresholds can only be obtained by asking stakeholders/companies.
- **Legal constraints:** legal constraints such as required permits may hamper the use of user functions and, hence, capturing of benefits for potential financiers. For example, when it is not allowed to build accommodation on the beach, or when food preparing permits are hard to acquire, benefits from accommodations and restaurants cannot be generated. Information of legal constraints can be obtained from law books or by asking stakeholders/authorities
- **Uneven distribution of benefits:** an uneven distribution of benefits can mean that only a few stakeholders benefit from the user functions whereas a lot of people need to pay for it. It is not always easy to make this transparent, but if it can be made transparent it is likely that those that hardly benefit and have to pay disproportionately will oppose. It can also be a political choice to encourage a more even distribution of benefits to bridge/enlarge gaps between societal classes. Please refer to this report by the Environment Agency of the United Kingdom for further elaboration of the (in)justice aspects in the context of flood and erosion related risk management. Whether an uneven distribution of benefits is relevant to the stakeholder can only be obtained by asking them.
- **Fund raising problems:** it may be that a new or improved user function is very likely to generate benefits, but the funds required for enabling/improving this benefit cannot be raised by the stakeholder. Please note that in this context is not referred to fund raising problems for the implementation of a coastal strategy (i.e. the sandy solution, the objective of this framework), but to fund raising problems for stakeholders to capture benefits, which may eventually also hamper the co-financing for the implementation of the strategy.

The table below can help to summarize the barriers for each potential benefit.

Table 4.8 Identification of barriers to capture potential benefits

Benefits	Shortage? (e.g. substitution effects)	Thresholds? (e.g. minimum quantities)	Legal constraints? (e.g. permits)	Uneven distribution of benefits?	Fund raising problems?

4.2.4 Outcome of this step: design requirements

Please note that the design requirements are not only aimed at solving a (future) problem, but also explicitly to make use of identified opportunities.

The design requirements are a summary of:

- the physical preconditions that need to be improved to generate potential benefits (and - if any information is available - to what extent)
- the societal barriers that need to be overcome to enhance the opportunities to capture those benefits
- the physical and societal scenarios that are relevant for the (size of the) benefits
- uncertainties that are relevant for the (size of the) benefits

This information can be summarized in Table 4.9 and, consequently, be added to Table 4.1. The design requirements are relevant input for the selection and design of sandy strategies in step 3 of the framework.

Table 4.9 Design requirements following from the benefit analysis

Potential benefit	Physical conditions that need to be maintained/improved (and to what extent)	Potential societal barriers	Relevant scenarios (physical & societal)	Relevant uncertainties

4.3 Design of alternative strategies

Rationale: design of alternative physical and societal designs with the focus on saving costs or generating benefits relevant for (potential) investors

Based on the system understanding and design requirements obtained from step 1 and 2 of the framework, this step aims to select and design a number of alternative sediment strategies for the project. The selection and design of strategies consists of both physical and societal measures. The design can be done in interactive sessions with experts and stakeholders. For the effective design of strategies, presence of physical and societal expertise during such design sessions is a prerequisite. Involvement of local stakeholders may help to improve the social and legal feasibility of the strategies. The focus of alternative strategies is to save costs and/or generate additional benefits compared to the reference alternative. The reference alternative is situation-specific and is defined as the most likely alternative if a proposed strategy will not be executed. Generally, the reference alternative is the current management policy. In the

Netherlands it is "hold the line", but abroad it may also be "do nothing" or "managed retreat'. This step includes a check on the coastline response of the strategies (using models or expert judgement) to check whether they lead to the intended response. Usually, the design of strategies is an iterative process, as the estimated coastline response may trigger the requirement for updating of the measures. The cost-benefit analysis (CBA) and/or Environmental Impact Assessment (EIA) typically require the evaluation of a number of clearly distinguishable and feasible alternatives. It is important to take this into account in this step.

The evaluation of the feasibility of the alternatives takes place in step 4. In practice, step 3 and 4 are strongly related to each other, since the sandy strategies need to be designed in such a way that they are technically, ecologically, legally, socially, economically and financially feasible. The process may require a number of iterations between step 3 and 4 to end up with feasible sandy strategies.

The sections below describe subsequently:
3.1 Selection and design of overall strategies
3.2 Selection and design of measures
    (1) Physical measures
    (2) Societal measures
    (3) Selection of measures
3.3 Outcome of this step: description of alternatives and coastal response of strategies

4.3.1 Selection and design of overall strategies

In this approach the design of a coastal strategy is seen as a match between:

- The physical system, its management using nourishment schemes and/or hard structures and the way it enables and improves ecosystem services.
- The societal system, the way it enables the use of ecosystem services and the way related benefits are allocated among stakeholders and translated in co-financing for the coastal strategy.

The ambition of a coastal strategy may be different in different contexts. The focus may be especially on cost-effectiveness and nourishment efficiency in case no real additional benefits can be generated or no additional finance is needed for maintenance, since it is covered by national budget lines. Where money is scarce and potential benefits are large, focus shifts towards enabling these benefits and - in this way - generating (co-)finance for coastal maintenance. It may also be the case that money is scarce but actual benefits are large. Then the focus may be on the design of value capturing mechanisms in order to generate co-finance from those that benefit from coastal management, are able to pay for it and so far do not pay their share in spite of existing taxation systems.

The above indicates that a coastal strategy, just like many other regional development schemes consists always of a combination of physical measures, policies that regulate use and responsibilities and mechanisms that ensure financing. What measures, policies and mechanisms are most appropriate depends on the characteristics of the physical and societal system. At many locations specific physical measures may not have been considered so far, because of a matter of principle, tradition or even prevailing interests of stakeholders. Similarly, also the benefits and uses that may be possible due to nourishment may not have been fully exploited. There may not even be a beach at present, although the coastal system and sand availability make it possible. Financial mechanisms are strongly rooted in tradition and political belief systems, with varying emphasis on such basic principles as polluter pays, user pays or levels of solidarity and cooperation. It is often possible to enrich the mix of measures, policies and mechanisms and in that way enable a strategy that creates added value, more security, a more just allocation of costs amongst those that benefit. However, this requires physical and also societal “engineering”.

A special dimension is uncertainty. It plays a role in defining measures, policies and mechanisms. Regarding measures there are several types of compensation funds that tackle uncertainties in coastal development in financial terms. Physical measures may include sand buffers that act as an airbag in the case of a major hurricane. Policies may include the designation of zones were building regulations are very strict or even prevent constructions because in future the zones can possibly not be safeguarded against flooding or erosion, or may be needed to upgrade coastal defenses.

In short, the success of a strategy is determined by this mix of measures, which should be consistent, balanced and complete. The success depends also on the way it is tailor made and rooted in the physical and social system.

In order to scope for the full potential it is advised to consider:

- Regarding coastal strategy:
    - The bandwidth between managed retreat and a coastal upgrade or accretion strategy as part of a wider coastal development strategy taking into account possible benefits from maintaining and upgrading existing uses as well as potential new functions
    - An upgrade of the coast in physical terms by an initial nourishment or gradual increase or accretion strategy
    - An upgrade of the use of the coast by realigning and optimizing access and use of beach related functions.
    - An upgrade of the allocation of costs and benefits and (potential) co-financing mechanisms that have so far not been addressed.
- Regarding nourishment needs and nourishments:
    - Possibilities to reduce nourishment needs, by restoring natural sources of sand and pathways of sand that contribute to beach formation.
    - To seek the optimum in a bandwidth from annual to mega-nourishments that anticipate a longer period of nourishment needs especially when annual nourishment needs are low and the foreshore allows for efficient nourishment of larger volumes.
    - To scope for the potential of using nautically dredged materials if available and of beach by passing and recycling schemes in case sand is not readily available.
    - To identify the need for coastal realignment for reasons of nourishment simplicity, or the establishment of fixed nourishment points that also often greater safety for beach assets.
- Regarding combinations of measures:
    - To address possible measures and combination of measures, e.g. hard as well as soft
    - To always aim for the full package and combination of physical and socio-economic measures, so cost and co- financing are aligned with physically and socially enabling use of benefits.

Overall coastal strategy types

An overall strategy should be adopted before measures can be defined. Typically, a distinction between the following potential coastal strategies can be made:

- No active intervention (do nothing)
- Managed retreat and realignment: re-allocating and/or compensating functions that are threatened by coastal erosion

- Hold the line: preservation of the present coastline positions and/or sand volume in the cross-shore profile
- Advance the line (move forward): extent in seaward direction for example by a mega-nourishment or land reclamation
- Initiate from scratch: create a beach or land reclamation where there is no natural beach initially
- Combined strategies: combinations of the strategies above to account for spatial differences along the beach (e.g. zones where erosion is acceptable and zones that need to be protected)

The above strategies range from very defensive (e.g. no actions, managed retreat) to offensive (e.g. initiate from scratch, advance the line). Generally, defensive strategies may be considered when the costs for coastal protection measures are likely to exceed the protected benefits (although sometimes a government may still decide to adopt a protection strategy to prevent social injustice - see this report by the Environment Agency of the United Kingdom), whereas offensive strategies are adopted when the benefits are likely to outweigh the costs. The "Hold the line" strategy aims to maintain the status quo. In some countries, like the Netherlands, this is even a legal obligation. Depending on which strategy is selected, more attention needs to be paid to either the physical implications of measures (generally more important for hold or advance the line strategies) or the societal effects (generally more important for defensive strategies). One of the strategies that at least needs to be evaluated is the reference strategy. The reference strategy is situation-specific and is defined as the most likely alternative if none of the strategies developed in this quick scan will be executed. Generally, the reference alternative is current management policy.

>> Read more on the coastal maintenance strategies (this is a wiki feature)

- **No active intervention (do nothing)**
  This strategy means that there is no (planned) investment in defence against flooding/erosion or the prevention of losses.
- **Managed retreat and realignment**
  Managed retreat comprises a strategy which allows for coastal retreat in zones with a natural tendency to erosion by means of re-allocating and/or compensating functions that are threatened. Hence, it is not the same as "do nothing". Managed retreat is a viable strategy if the costs of coastal management exceed the benefits.
- **Hold the line**
  The 'Hold the line' strategy ensures the preservation of the current coastline position and/or volume in the cross-shore profile (e.g. maintain the status quo). Hold the line is from a point of view of stakeholder management often the least complex, since it aims at maintaining a status quo. Because of sea level rise and other factors that enhance coastal erosion, a hold the line strategy is seldom equal to doing nothing. There are often various factors that lead to an increase in protection standards, such as a general increase in economic activity and real estate value that justifies higher flood protection levels. Land subsidence in urbanised lowlands usually increases the vulnerability to flooding and hence also justifies a higher flood protection level. So, most hold the line scenarios require substantial and increased coastal management. Because of this increase, it is important to assess whether holding the line will still be a viable strategy on the long term. There is a growing number of concepts than match flood protection with other types of functions. So, hold the line is also an implicit development proposition, in which issues of flood protection and coastal erosion can be functionally linked with other specific and general development issues.
- **Advance the line (move forward)**
  The 'Advance the line' strategy aims to extent the coastline in a seaward direction, by widening beaches and dunes, or even by various forms of land reclamation. This strategy

can be considered to strengthen coastal defences in seaward direction, upgrade/develop the waterfront or reclaim new land when inland expansions are not possible.

- **Initiate from scratch**
  The 'Initiate from scratch' strategy aims to create a beach or land reclamation in an area where there is no natural beach initially. This option can be considered in areas where there is a need for urban development or tourism. When considering this strategy it is essential to understand why there is no beach in the first place and whether the physical conditions are such that the beach/land reclamation can survive. As there is no beach initially, it is likely that also all beach related infrastructure (access roads, parking lots, restaurants, marinas, etc.) need to be developed from scratch.
- **Combined strategies**
  It should be noted that coastal erosion can have multiple causes. Some causes are of generic nature, such as an increase in sea level rise, storm frequency and intensity or a shift in general wave patterns that enhance longshore transport gradients and consequently also erosion. Often there are also local causes such as a reduced inflow of sediments, obstruction of longshore currents by dams, diminished source contribution due to erosion prevention and destruction of coral reefs and sea grass beds.
  The combination of generic and local causes usually leads to an alternation in erosion and sedimentation, especially in the case of longer coastal stretches. Erosion and sedimentation are often closely related. A managed realignment that allows for the gradual erosion of a coast line will simultaneously provide sand to down-drift coastal sections, Likewise nourishments will contribute sand to down-drift sections. The reduction of erosion in one place usually leads to enhanced erosion down-drift. So the aim is to define an appropriate and integrated solution for a complete coastal cell. A coastal cell is a coastal section where hydraulic and morphological processes are strongly intertwined.

4.3.2 Selection and design of measures

(1) Physical measures
Physical measures are intended to meet the physical design requirements, for example the requirements related to physical preconditions. These measures can be related to coastal protection, the environment and urban infrastructure and can differ in size, space, frequency and time.
Table 4.10 provides a list of the most common measures. Of course, a wider range of measures can be considered, as the list of potential measures is countless. Preferably the physical measures are intertwined with the societal measures in one coherent and consistent strategy.

>> Read more about aspects affecting nourishment costs (this is a wiki feature)

In order to identify whether nourishments should be considered as a serious option in the design of sandy strategies, it is important to gain insight in the aspects that determine the nourishment costs in an early stage. The following considerations may help in this respect.

Dredging costs are often substantial and location specific. Calculating dredging costs is complex, since there are many variables that determine these costs. In general one may state that dredging costs increase with:

- The number of operational hours of the dredging scheme. Dredgers are expensive. The larger ones have operational costs that exceed 0,25 Million Euro/week. So the higher the production, for example on a weekly basis, the lower the costs per m3 nourishment. The required production and operational hours depend on various factors, the most important being:
  - o The transport distance between sand burrow and nourishment location. In the case of short distances it is possible to nourish directly for example with a cutter. As soon as transport distances become too large large, a hopper is needed or a

combination of a dredger and barges. In those cases the costs become much higher.
    - Type of nourishment and pipeline length. Bottom release on the foreshore requires far less time than beach nourishment or rainbowing. The longer the pipeline, the more power is needed to move sand and the lower the production. Smaller dredgers become inefficient in the case of pipeline length above 2 to 3 km. The longer pipeline is needed when nautical depth is limited because of a shallow foreshore or because of obstacles, such as a coral reef.
    - Handling and profiling requiring auxiliary equipment such as cranes and bulldozers.
    - Downtime related to the weather, tides, environmental restrictions etc. In certain areas, the storm season is off-limits because the downtime becomes too large. Dredging schemes that use a combination of hoppers and beach nourishment are more hindered by waves and for instance foreshore nourishment.
    - Geology and characteristics of the pit and sand characteristics. Sand may be readily available in large quantities near the surface which is ideal. If sand can only be obtained at greater depths, e.g. below unsuitable geology, or if it is only limited in very shallow layers, dredging becomes less effective.
- The initial costs for the mobilization and demobilization of equipment, studies needed to sort out the availability of sand, or to underpin the environmental effects of a dredging scheme in order to conduct a EIA and for obtaining the necessary permits. The latter costs can be substantial especially in environmentally sensitive areas or areas where there is limited information on available sand deposits. Since these costs have to be made regardless of the volume nourished, they may constitute the major part of the dredging costs in the case smaller volumes are nourished.
- Availability of nautically dredged material. Sometimes it is possible to nourish using nautically dredged material, which may substantially cut the costs. Whenever possible this option should always be explored.

(2) Societal measures

Societal measures are intended to meet the societal design requirements. These measures may be related to overcoming the hurdles that may prevent the capturing of potential benefits. Table 4.11 gives suggestions of measures one can think of to overcome barriers related to (1) substitution, (2) thresholds/critical mass (3) legal constraints, (4) uneven distribution of benefits and (5) fund raising.

(3) Selection of appropriate measures

The selection of appropriate physical and societal measures should be aimed at meeting the design requirements identified in step 1 and 2 of the framework, e.g. generating/improving the physical preconditions for benefits (e.g. a wider more attractive beach) and tackling societal barriers (e.g. complex legislation). Table 4.12 may aid in the process of selecting appropriate measures, which should be done separately for each of the adopted strategies.

It is noted that a Building with Nature (BwN) approach differentiates itself from conventional design processes in the sense that (1) more attention is paid to natural processes and their capacity to fulfil engineering services, (2) long-term processes and effects are accounted for in the design for example by adaptive management and 3) a triple P approach (People, Planet and Profit) is applied which aims at serving multiple goals (not just one coastal function). It is recommended to evaluate whether these BwN principles hold for the chosen physical and societal measures.

Table 4.10 Overview of a selection of common physical measures that can be used in a coastal strategy

Coastal (protection) measures	**Environmental measures**	**Urban infrastructure measures**
• Maintain the beaches (nourishments) o Regular nourishments (regular type with 1 to 10 yr recurrence interval) o Large scale nourishments (incidental nourishment with large volumes) o Beach recycling and bypassing (permanent & non-permanent systems) • Protect the beach (coastal structures) o Construction of groynes, revetments or offshore breakwaters o Removal of structures o Hybrid solutions (soft and hard measures) • Manage the environment (i.e. sources of sand) o Reef/sea grass restoration o River supply restoration o Allow cliff erosion o Sand bar and tidal flat restoration • Land reclamations	• Habitat creation/restoration: o mangroves o corals o seagrass o salt marshes • Habitat protection o Preventing invasive species • Eco-engineering solutions o artificial reefs o oyster reefs/breakwaters o artificial salt marshes	• Construction of (beach) access roads, connections and parking lots • Real-estate development (urban: houses, shops, offices) • Real-estate development (tourism: hotels, restaurants, bars) • Flood proof buildings • Construction of port/marina (for trade/tourism) • Public green infrastructure

Table 4.11 Overview of common societal measures

Measures to prevent substitution:	**Measures to create a critical mass:**	**Measures to resolve legal constraints:**	**Measures to prevent uneven distributions of costs and benefits:**	**Measures to overcome the lack of initial funds:**
• Identifying shortages • Market segmentation and stakeholder agreements	• Stakeholder agreements to cooperate • Actively inventing 'missing link'-stakeholders • Joint advertising	• Reducing excessive bureaucratic regulations (i.e. red tape) or creating exemptions • Enforcing laws in case of benefit undermining activities	• Turning stakeholders into shareholders (when possible) • Subsidising cost holders or taxing benefit holders (not possible when the coastal strategy is aiming at coastal safety and is a government's responsibility, but may be possible where specific stakeholders (e.g. hotel owners) are disproportionally benefiting from the strategy compared to their contribution in the costs)	• Regular loans • Crowd funding • Revolving funds • Taxing • Donations • Issuing value papers

Table 4.12 Initial selection of appropriate measures

Potential benefit (as identified in Section 4.2.3)	**Required coastal quality (e.g. wider beach) AND/OR Barrier to be removed (e.g. complex legislation)**	**Preferred measures (aimed at grasping the benefit)**	**Arguments for using these measures**

4.3.3 Outcome of this step: description of alternatives and coastal response

The outcome of this step is a set of alternative strategies for the area of interest, including their estimated physical response. The coastal response is often of critical importance for the evaluation of the strategies in step 4. Depending on the project phase and the required level of detail the physical response of the strategies can be based on expert judgments, key figures or (simple/detailed) model simulations. Often the coastal response may not be as intended and requires a redesign of the physical measures in an iterative process. The strategies - including the rationale for selecting the strategy, the physical and societal measures, the estimated coastal response and opportunities for finance - are be summarized in Table 4.13. The evaluation of the strategies on the feasibility criteria is performed in step 4. In practice, it may require a number of iterations between step 3 and 4 to end up with feasible sandy strategies.

Table 4.13 Description of alternatives with basic check on coastal response

Alternative	Overview	Description
Alternative X (Reference)	Picture of the strategy and coastal response	**<rationale and design>** ... **<physical>** ... **<societal>** ... **<finance>** ...
Alternative Y	Picture of the strategy and coastal response	• **<rationale and design>** ... • **<physical>** ... • **<societal>** ... • **<finance>** ...

4.4 Evaluation of strategies

Rationale: evaluation of the sandy strategies in terms of technical, ecological, legal, social and economic feasibility

The strategies that have been developed in step 3 are in this step evaluated in terms of the design requirements and their feasibility. Firstly, the physical (e.g. technical/ecological) and societal (e.g. legal/social) feasibility are evaluated. If it turns out that the strategies are not physically and/or societally feasible, it does not make sense to estimate the costs and benefits as the chances of implementation are close to zero. In that case, one needs to go back to the "drawing table" (i.e. step 3) and redesign the strategies to improve their feasibility. This is an iterative process.

Secondly, the alternatives are evaluated in economic terms using a cost-benefit analysis (CBA). There are different instruments to assess the costs and benefits of a project. Which instrument is most suitable depends on for whom the assessment is made. In this framework a societal CBA (SCBA) is taken as a starting point. Generally, all strategies with a positive balance (i.e. benefits minus costs) are economically feasible. Sometimes, however, there may be other (e.g. noneconomic) considerations to adopt a strategy, such as political preferences. Based on the CBA the distribution of the benefits over the stakeholders is estimated in order to identify potential financiers for the strategy. The outcome of this step is a ranking of alternatives based on the feasibility criteria.

The sections below describe subsequently:

4.1 Evaluation of physical and societal feasibility
4.2 Societal Cost-Benefit Analysis
(1) Costs
(2) Benefits
(3) Cost-Benefit Analysis
4.3 Outcome of this step: ranking of strategies

4.4.1 Evaluation of physical and societal feasibility

The evaluation of the physical feasibility entails a check of the technical feasibility as well as an evaluation of the design requirements in terms of physical preconditions (e.g. estimated beach width, water quality, area for recreation, etc.). This evaluation requires first of all a conceptual model of the area, which basically contains all the understanding of how the system is functioning and where it will go to in the future. A number of tools can then be used to estimate the physical design parameters. The level of detail and complexity of the methods and tools need to match the actual project phase. The effort that needs to be put into the modelling should also match the phase of the project, for example rapid-assessment models that are typically applied in early phases (see tools.pdf).

Besides an assessment of the physical feasibility of the strategies, it is important to assess the legal and societal feasibility of the strategies. This can be done by scoring the strategies on the legal and societal requirements identified in step 1 and 2. Ideally, this evaluation is done together with the local authorities and stakeholders, as they determine to a large extent what is feasible or not. Their role will become more important while the project is progressing towards the detailed design.

The results of the physical and societal feasibility can be summarized in Table 4.14. When certain aspects turn out to be not feasible, this will require a redesign of the strategy/strategies in step 3.

Table 4.14 Summary of strategy evaluation

Feasibility assessment	**Strategy 1**	**Strategy 2**	**Strategy 3**
Technical			
• Aspect 1 (e.g. beach width at hotel 1)			
• Aspect 2			
Ecological			
• ... (e.g. habitat area for species A)			
Legal			
• ... (e.g. compliance with environmental legislation)			
Social			
• ... (e.g. resistance from stakeholder X)			

4.4.2 Societal Cost-Benefit Analysis (CBA)

There are different instruments to assess socio economic or financial performance of a project. Which instrument is most suitable depends on for whom the assessment is made and with what objective. A financier at national government level is generally interested in an assessment at national scale (e.g. national (S)CBA), whereas regional/local financiers are particularly interested in the regional or local scale effects (e.g. regional/local CBA). For example, a strategy that attracts tourists that otherwise would have gone to another beach in the country is economically not very interesting at a national level as the net economic effects are zero (unless the tourists come from abroad). However, for a regional or local government/(co-)financier, tourists that are attracted from other parts of the country may be very relevant as the net effects on their scale are positive. Hence, it is important to realign the cost-benefit assessment with the expected decision making and potential financing for a case. When performing a CBA it is advised to check for (national) guidelines on how to perform the assessment. Those may differ among countries and decision makers.

>> Read more about the different instruments for a cost-benefit assessment (this is a wiki feature)

Table 4.15 provides an overview for the different methods for cost-benefit assessments with different goals and intended decision makers. The table also provides references to relevant literature for further reading.

Table 4.15 Overview of socio-economic instruments for the assessment of strategies

Instrument	Goal / description	For whom?	Basis for measurement of costs and benefits	References
Societal or costs based comparisons				
MCA	Comparing different development alternatives along a number of preselected criteria that each can have an unequal weight	International donors Governments Stakeholders	(perceived) qualitative and quantitative scoring of (resource) costs and (policy) impacts/benefits	http://mediation-project.eu/output/technical-policy-briefing-notes
CEA	Checking which alternative is most attractive given a certain goal/policy objective or at a project stage when project benefits are impossible to estimate	Usually governments; anyone who has set a goal and who does not wish to discuss the goal (or legal requirement), but wants to discuss the measures	Cost per unit impact impact per unit costs	http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf http://www.who.int/choice/publications/p_2003_generalised_cea.pdf
System level in relation to decision making and finance				
Societal Cost Benefit Analysis (SCBA)	Check whether the total benefits (welfare impacts) surpass the total costs for each alternative (e.g. strategy). Can be done from various perspectives: national, regional, local	International donors Governments Stakeholders	Resource costs, National discounting rates over longer time frames	http://ieg.worldbank.org/Data/reports/cba_full_report.pdf, http://ec.europa.eu/regional_policy/sources/docgener/guides/cost/guide2008_en.pdf, Hanley, N. & Splash, C., 1993, *Cost-Benefit Analysis and the Environment*, Edward Elgar, Cheltenham, http://www.teebweb.org/our-publications/teeb-study-reports/ecological-and-economic-foundations/

Instrument	Goal / description	For whom?	Basis for measurement of costs and benefits	References
Finance and distribution of costs and benefits				
Financial (project) CBA (Business Case)	Check whether the total monetary revenues surpass the total costs for an alternative (e.g. strategy) from the perspective of the investor(s)	Private and public investors	Current (market) prices (e.g. not Willingness to Pay)	http://www.caee.utexas.edu/prof/mckinney/ce385d/Papers/ADB_BC_Analysis.pdf
Financial (project) Analysis	Checks how financing for the project can be arranged for each investor	Private and public investors	Current prices, credit facilities, value capturing mechanisms	http://www.fecc.agri.cn/zcfg/201110/W020111008554165246692.pdf http://www.afdb.org/fileadmin/uploads/afdb/Documents/Procurement/Project-related-Procurement/GFA01_Guidelines%20for%20FG%20%26%20FA%20of%20Proj.pdf
Distributional Analysis	Checking the distribution of welfare impacts (positive and negative) over all relevant stakeholders	[redacted]	[redacted]	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf
Stakeholder Analysis	Finding out who has a stake, what is the stake, the determination factors behind the stake, the size of the stake etc. to determine the playing field	[redacted]	[redacted]	http://www1.worldbank.org/publicsector/anticorrupt/PoliticalEconomy/PDFVersion.pdf http://www1.worldbank.org/publicsector/politicaleconomy/November3Seminar/Stakehlder%20Readings/CPHP%20Stakeholder%20Analysis%20Note.pdf http://www.panda.org/standards/1_4_stakeholder_analysis

Table 4.15 shows some key elements of the economic analysis that is used:

- **Cost-based or socio-economic comparisons**: a cost-effectiveness analysis (CEA) is appropriate for comparing alternatives that realize similar goals or policy objectives but in different ways. For example maintaining the coastline may be achieved by different nourishment strategies that in themselves do not create other or additional (potential) benefits. A comparison that takes into account all (economic/welfare) effects is relevant to (governmental) project initiators that try to achieve multiple objectives, such as stimulation of local and regional economies.
- **System/administrative level in relation to decision making and finance**: a cost benefit analysis can be conducted on different levels. Mostly, a distinction is made between the national, regional/provincial and local/municipal level. Depending on financing and related decision making a different system/administrative level may be appropriate. Financing from the national budget requires a CBA on the national level and an emphasis on macro-economic effects. On all levels substitution may play a role. For instance the economic effects generated by recreation can be subject to substitution on the national or provincial/regional level, e.g. a project may attract more recreation but at the expense of other recreational areas. Only an increase in international tourism will generate a macro-economic benefit on national level.
- **Distribution of benefits and finance**: the distribution of benefits over the stakeholders helps to identify stakeholders that have large benefits and, hence, may have the capacity to (co-)finance. However, the capacity to (co-)finance does not necessarily mean that they are willing to (co-)finance. In a financial analysis all options to generate sufficient finance to cover the project costs (including finance from governments, private investment or donors) are investigated (see step 5 of the framework).

It is often difficult to obtain relevant economic data. Therefore, most forms of economic analysis make use of key-figures for initial stages of the project, for example to assess the benefits of additional recreational areas. It should be noted that the use of key figures poses risks to the analysis, especially with regard to benefits that cannot be expressed in market prices and benefits that depend heavily on location specific situations. A coral reef may have little to enormous economic benefits depending whether it is located on a far-off and uninhabited atoll or forms the centre of an international diving and snorkelling destination. So also in the initial stages it is important to be critical especially with respect to potential benefits that dominate the cost-benefit analysis.

In this framework a societal CBA (SCBA) is taken as a starting point. A SCBA is based on all societal costs and benefits of the proposed strategies, preferably - but not necessarily - expressed in monetary terms. Using the SCBA it can be checked whether the proposed strategies are economically beneficial compared to the reference alternative (or baseline). The SCBA explicitly takes into consideration the times at which costs are incurred or benefits are generated. Using a discount rate all costs and benefits can be transformed into a present value, the so-called Present Value (PV). The PV of costs and benefits are compared to arrive at the Net Present Value or NPV. This value is used to compare the alternative strategies. Please note that we attach generally more value to costs and benefits now than those generated in the future (which is accounted for by a discount rate). Therefore, it may be attractive to design the alternatives such that costs are postponed where possible in order to generate a higher NPV. Likewise, the benefits could be brought forward where possible (see also the explanation box).

Explanation box: discount rates and internal rate of return

Time value of money dictates that time has an impact on the value of cash flows. In other words, a lender may give you 90 cents for the promise of receiving \$1.00 a month from now (resulting in an interest of 10 % in one month), but the promise to receive that same dollar 20 years in the future (resulting in an interest of 10 % over 20 years) would be worth much less today to that same person. In order to make future cash flows comparable, these payments are discounted (on the basis of a minimum required interest rate) to their *present value* (PV). The *net present value* (NPV) is defined as the sum of the present values (PVs) of incoming and outgoing cash flows over a period of time (benefit and cost cash flows). The *internal rate of return* (IRR) is the interest rate (or discount rate) for which the NPV equals 0, i.e. the present value of all cost and benefits are equal.

(1) Costs

The costs of the strategies are the direct costs related to the implementation of the strategies. These costs can be estimated using key figures for typical unit costs, for example for dredging (for sandy solutions) and constructions (for hard structures/infrastructure). If no (local) information is available on the estimated implementation costs, the following Excel sheet can be used to estimate the dredging costs. Also the costs for environmental impact mitigation/compensation and societal measures (such as compensation) should be accounted for. It is often best to acquire cost information from (local) literature. If no information is available, some key figures can be found in the database of EVRI (https://www.evri.ca/).

>> Optionally, the costs can be summarized separately in Table 4.16. Alternatively, they can directly be summarized in the overall CBA in Table 4.18. (this is a wiki feature)

Table 4.16 Overview of estimated costs per strategy

Costs :	**Measures**	**Costs**		
		# units (Q)	value per unit (P)	Total (Q*P)
Strategy 1				
Strategy 2				
Strategy 3				

(2) Benefits

Benefits can be both positive and negative compared to the reference alternative. Since the reference can entail deterioration, benefits of alternative strategies often arise from prevented losses. For example, if coastal erosion leads to a loss of beach tourism, a strategy stopping erosion will have a prevented loss of tourism as a benefit. Compared to the reference this is a reduced decrease or increase of visitors. To estimate the benefits for the strategies one needs to determine the estimated quantity (Q) and monetary value (P) of this benefit per unit (e.g. expected expenses per tourist) compared to the reference.

Benefits are calculated on the basis of area specific information (e.g. number of tourist arrivals per year; average expenditure per arrival). This information can be retrieved from local stakeholders. For some benefits, such as ecosystem services one can combine area specific information (e.g. the size of a wetland or the size of a fishing area) with Q-experiences numbers (e.g. the average carbon sequestration per hectare wetland or the average fish harvest per hectare fishing area) and with P-key figures (e.g. the price per kg CO2 or the price of fish species). These key figures can for example be found in the database of EVRI (https://www.evri.ca/). This dataset contains many ecosystem valuation studies from around the world: it consists mostly of price tags for two ecosystem services: the recreational perception benefits and the non-use benefits. The non-use value is the value that people assign to economic goods even if they never have used and/or will use it. This can for example be option values (e.g. willingness to pay (WTP) for keeping the option open) or bequest values (e.g. WTP for maintaining or preserving an asset/resource for future generations).

Please note that benefits are usually estimated quite roughly, especially in the feasibility phase of the project. Nobody can predict exactly how much extra tourist arrivals or how much extra fish the project alternatives will produce, but one can try to estimate the maximum benefits of different project alternatives in order to know whether this maximum does or does not surpass the costs. If the maximum benefits do not surpass the costs, one can be quite certain that the strategy is economically not feasible. If the maximum benefits do surpass the costs, there is a chance that the project is economically feasible. Still, it is recommended to perform a sensitivity analysis (see below) to check whether the project is remains economically attractive when the most uncertain benefits are not (maximally) taken into account.

>> Optionally, the benefits can be summarized separately in Table 4.17. Alternatively, they can directly be summarized in the overall CBA in Table 4.18. (this is a wiki feature)

Table 4.17 Overview of estimated potential benefits per strategy

Benefits : welfare/socio-economic impacts (e.g. safety, nature, social)	**Size of the benefit (estimate the maximum)**			**Strategy 1**	**Strategy 2**
	Quantity in units (Q)	Value per unit (P)	Total (Q*P)		
Benefit 1					
Benefit 2					
Benefit 3					

(3) Cost-benefit analysis

All the cost-benefit information of the strategies can be summarized in Table 4.18 to get an overview on the differences in economic terms. The following aspects can be used to compare the alternatives:

1. **Net present value (NPV):** this is the present value (PV) of the benefits minus the PV of the costs. The NPV should be positive, and the higher the better. In principle, the alternative with the highest NPV is the preferred option as it adds most value to society.
2. **Ratio:** this is the ratio of the PV of the benefits and the PV of the costs. A ratio larger than 1 implies that the strategy has a return on investment. Generally, the higher the ratio the higher the return on investments. When two alternatives score more or less the same on the NPV, generally the one with the highest ratio is to be preferred. This is under the assumption that the financier has the option to invest in other projects and, therefore, aims for the best value for money, so he can invest the money he saves in something else.
3. **Total costs:** if funds are hard to raise, it can be attractive to proceed with the strategy that has the lowest initial investments, even if it does not have the highest NPV or ratio.
4. **Distribution of benefits:** the distribution of benefits shows which parties could have the capacity to co-finance given their share in the benefits. It could also be useful information for parties that are interested in promoting equity or the (financial) position of specific groups in society (see also this report by the Environment Agency of the United Kingdom). Please note that the share of stakeholders in the distribution of benefits does not tell anything about the importance of the benefits to the stakeholders. Stakeholders with a low share in the overall distribution may be very dependent on their benefits, as it may concern their income, profit or living environment. Hence, benefits with a low share in the distribution could be equally or even more important than benefits with a higher share. However, their capacity for co-financing is less likely (step 5).
5. **Sensitivity for key figures:** some of the used key figures may be highly uncertain and at the same time decisive in the ranking of alternatives. Therefore, it is good to check how the NPV, ratio and total costs and benefits are affected by these sensitivities.
6. **Robustness for different scenarios:** this is similar to the sensitivities described above, but now for sensitivities to physical or societal scenarios (e.g. external future developments), such as the development of the oil prices.

Table 4.19 can be used to summarize the stakeholders shares in the benefits for the different strategies and Table 4.20 for sensitivities in key figures and scenarios.

Generally, the NPV is the most decisive aspect in the selection of economically feasible strategies, followed by the ratio and the total costs. The other three aspects are usually less decisive.

Table 4.18 Societal cost-benefit analysis with resulting NPV and ratio per alternative

Present value in $ for a period of .... years at ...% discount rate relative to the reference alternative	**Strategy 1**	**Strategy 2**	**Strategy 3**
Costs			
• Investments			
• Maintenance			
Benefits			
• Benefit 1			
• Benefit 2			
NPV (benefits-costs)			
Ratio (benefits/costs)			

Table 4.19 Distribution of benefits over the stakeholders

Stakeholders	**Benefits**	**Share in the PV of beneftis (%)**
Stakeholder 1		
Stakeholder 2		
...		

Table 4.20 Sensitivities for the most relevant key figures and scenarios in the CBA

	Strategy 1	**Strategy 2**	**Strategy 3**
Original results			
Costs			
Benefits			
NPV			
Ratio			
Results when different prices for			
Costs			
Benefits			
NPV			
Ratio			
Results for scenario .... (climate change or oil price)			
Costs			
Benefits			
NPV			
Ratio			

4.4.3 Outcome of this step: ranking of strategies

The outcome of this step is a summary of the scores of the different strategies on (1) NPV, (2) ratio, (3) initial investment costs, (4) distribution, (5) sensitivity and (6) robustness relative to the reference alternative as well as the other feasibility criteria from section 4.4.1. In principal, the strategies that are physically feasible, acceptable to the stakeholders and have a positive NPV will be analysed in step 5 in order to check the potential for (co-)financing. These strategies are considered to have a net positive effect on welfare. If the strategies all score worse than the reference alternative, there is no sound (economic) basis for implementation of the alternative strategies.

In some cases potential funding parties are willing to pay for the implementation of strategy without having a (quantified) net positive economic impact. This may be because of policy preferences or (legal) obligations to fulfil safety/environmental standards. Governments may for example be willing to pay for flood risk reduction, ecosystem restoration, promotion of social cohesion and/or creation of a safer and healthier environment even when these are hard to express in monetary benefits. Such considerations should also be accounted for.

It may be that more (detailed) information is required before one or more strategies can be selected. This should then be accounted for in a next (design) iteration. When the level of detail/certainty is considered sufficient, the selection of strategies can take place here.

Table 4.21 Overview of strategy feasibility

	Strategy 1	**Strategy 2**	**Strategy 3**
NPV			
Ratio			
Costs (initial investment)			
Distribution			
Sensitivity (key figures)			
Robustness (scenarios)			
Technical/ecological feasibility			
Social/legal feasibility			
Other considerations			

Note:

- **Discount rates:** It is advisable to use different sets of discount rates for the public sector (to determine societal NPV in step 4) and private sector (to determine the financial NPV in step 5). The public discount rate differs from country to country and is often prescribed in national guidelines or regulations. For the private sector the required return on investment is usually higher than for the public sector as private parties generally strive for profit maximisation (and shorter return periods on investments). The higher return on investment for private parties can also be seen in the light of pricing risks for private parties. Normally, the same discount rate is used for costs and benefits. However, sometimes a higher discount rate is used for benefits than for costs to reduce the risks of overestimation of benefits over time and, hence, the NPV.

4.5 Financing and business case potential

Rationale: evaluate the potential to generate sufficient (co-) finance and summarize all relevant information to project initiators/decision makers

In the previous step one or multiple strategies have been identified that are technically possible, acceptable to the stakeholders and have a positive NPV. This means that in principle it is a good idea to implement one or a combination of those strategies. The last step is to check whether there is sufficient potential for (co-) financing to cover the implementation costs.

Subsequently, as a result of the process, it is suggested to summarize all relevant information from the steps of the framework on a project fact sheet. This fact sheet can be used by the project initiators and/or decision makers to decide whether to move on with the project to the next project phase or stop. Please note that the outcome of the framework is a first assessment of the (co-)financing 'potential' for the project. When the potential is there, the next step is to make arrangements with potential individual financiers. This step is beyond the scope of the framework.

The sections below describe subsequently:

5.1 Financing potential
5.2 Project fact sheet

4.5.1 Financing potential

The distributional analysis of benefits helps to identify stakeholders that have significant benefits and, hence, may have the capacity to (co-) finance the strategy. Please note that especially stakeholders with financial benefits may be able to co-finance. For stakeholders where the benefits are largely based on willingness to pay (WTP), their financing capacity may be constrained by the actual ability to pay. Depending on the results of the distributional analysis, the following potential (co-)financers can be investigated:

1. **Governmental institutions:**
For most governmental institutions a positive NPV from the SCBA is sufficient reason to (co-) finance the strategy. As governmental institutions may act on different levels (e.g. national, regional, local), this may require a SCBA on every administrative level. Sometimes, depending on the country in which the project is located, governmental institutions may also require a financial CBA (FCBA). The FCBA is a CBA for the financial costs and benefits, e.g. only those costs and benefits that have a market price. The finance from governmental institutions can be in the form of a.o. existing government budget or subsidies. The government could recuperate investments through additional taxes (such as tourist taxes) or levies on permits.
2. **Private parties:**
Most private parties may be willing to co-finance when there is a positive business case for them. This requires a FCBA for each potential investor from the investor’s perspective to investigate whether they can generate sufficient return on investment. If the NPV of the FCBA is positive, there is a potential business case. If the NPV is negative, there is no business case (unless the deficit can be covered by the government in the form of subsidies). Private parties generally require a larger return on investment and shorter return on investment periods than public parties. The contributions from private parties can be in the form of investments or loans.
3. **Donors:**
Donors can be parties such as the World Bank, Asian Development Bank, United Nations or NGOs that may be willing to (co-)finance when the project is contributing to a certain

objective (e.g. poverty reduction, social justice, nature preservation/restoration). Their contribution may be in the form of gifts or loans. The requirements for such a gift or loan may differ per organization.

Based on the above the finance potential can be estimated. Ideally, this is checked with the potential financiers themselves. Alternatively, one can try to estimate the financing capacity of the stakeholders (for example by assuming that a certain percentage of their benefits can be made available for (co-)finance). The estimated finance should be sufficient to cover the total project costs for the project to be financially feasible.

After checking the financing potential, there are three options:

1. There is a potential for sufficient financing: summarize all relevant information on the project fact sheet (section 4.5.2)
2. There is a potential for sufficient financing but still insufficient information: all relevant information should be summarized on the project fact sheet (section 4.5.2) with special attention for budget allocation for additional research/measurements
3. There is no potential for sufficient financing: stop and summarize what (design) conditions need to change or blockages need to be removed to make sufficient financing feasible

4.5.2 Project fact sheet

The project fact sheet contains all relevant information needed for decision making. It typically summarizes the results of the preparation work in the previous framework steps (i.e. system analysis, strategy development and cost-benefit evaluation). The fact sheet should provide an overview of all societal, physical and financial conditions of the project, such that the project initiators/decision makers can make a well-founded decision on how to proceed with the project. If the initiators decide to proceed with the project, the project fact sheet can be used as a basis for the context and scope (e.g. step 1) of a next project phase. Typically, subsequent project phases should pay special attention to the critical uncertainties, risks and unknowns that have been identified in the previous project phase. Usually, this requires activities such as data collection, (detailed) modelling studies and (intensive) local involvement of local stakeholders and potential financiers.

It is proposed to use the following fact sheet sections:

1. **Present situation**
   The physical and societal system analysis for the present situation can be explained in a concise way. For example, by means of an overview picture/map of the most relevant processes of the physical system and a summary of the most relevant stakeholders.
2. **Design requirements and objectives**
   The objectives of the business case and design requirements provide the basis for the judgment on the future strategy. The objectives and requirements show the need and logic of the proposed sandy strategy. To this end, the project progress tracker can be presented here (see section 1).
3. **Future strategy**
   The physical and societal characteristics of the future strategy are addressed here. The expected impact on the physical and societal system can be explained either by a picture/map or summary of the most relevant specifications (which can be combined with the progress tracker above). Special attention should be paid to the differences with the existing situation as well as the confidence in the expected developments. A benefit is only accounted for if a real demand is fulfilled (i.e. no substitution takes place). The benefits should also be achievable/attainable given the user possibilities and societal architecture.

- Physical design:
  - See map, relevant cross sections, volumes of sand, habitat created/lost etc. (this map shows the physical characteristics in such a way that the physical design is clear/understood.
  - Changes in functions/ecosystem services, what does the strategy entail for coastal erosion/safety, beach availability etc.
- Societal design:
  - See map, zoning of user functions, beach access if relevant, additional potential measures (e.g. beach bars), swimmer safety, etc.
  - Changes in societal activities, expected use of ecosystem services by different groups
- Financial design:
  - Allocation of costs and benefits over stakeholder groups
  - Financial architecture/strategy/funding

4. **Implementation and costs**
   The main activities, phasing and costs are provided in this block. Preferably in the form of an activity schedule with the phasing, responsible party and costs. This schedule should also account for the maintenance phase (e.g. who is responsible, what are the costs, who is going to pay). Apart from this schedule attention should be paid to the main construction/implementation considerations of the sandy strategy (e.g. where is the sand coming from, consequences for beach accessibility/navigation during construction, etc.).
5. **Cost-Benefit Analysis**
   The costs of the project are assessed relative to the current management strategy as well as potential existing design alternatives). The difference between the present value of benefits and costs is assessed (NPV), as well as the benefit over cost ratio. Costs need to be specified as basis or incremental costs (given that other measures are adopted). It is noted that benefits can only be accounted for if no substitution takes place. Relevant non-tangible benefits and costs are also assessed.
6. **Risks mitigation strategy**
   This contains an overview of the major risks and potential (financial) impacts on the business case as well as mitigation measures.
   Risk mitigation measures can be:
   - Embedded/taken care of in the design itself, such as:
     - phased and adaptive implementation, development and forms of management
     - robust design elements,
     - mitigating measures during implementation, in order to limit effects on nature, land use etc.
   - Needed to support (a risk free) implementation of the strategy, which could have the form of:
     - additional research needed to optimize specific components of the design that represent a risk to performance,
     - inventories of sand and ecology to optimize dredging strategies, that present a environmental and legal risk.,
     - steps needed to construct legal and financial guarantees or buffer funds,
     - negotiations in order to get necessary support and commitments from essential stakeholders
     - risks for which contract/commitments are needed between different parties/stakeholders

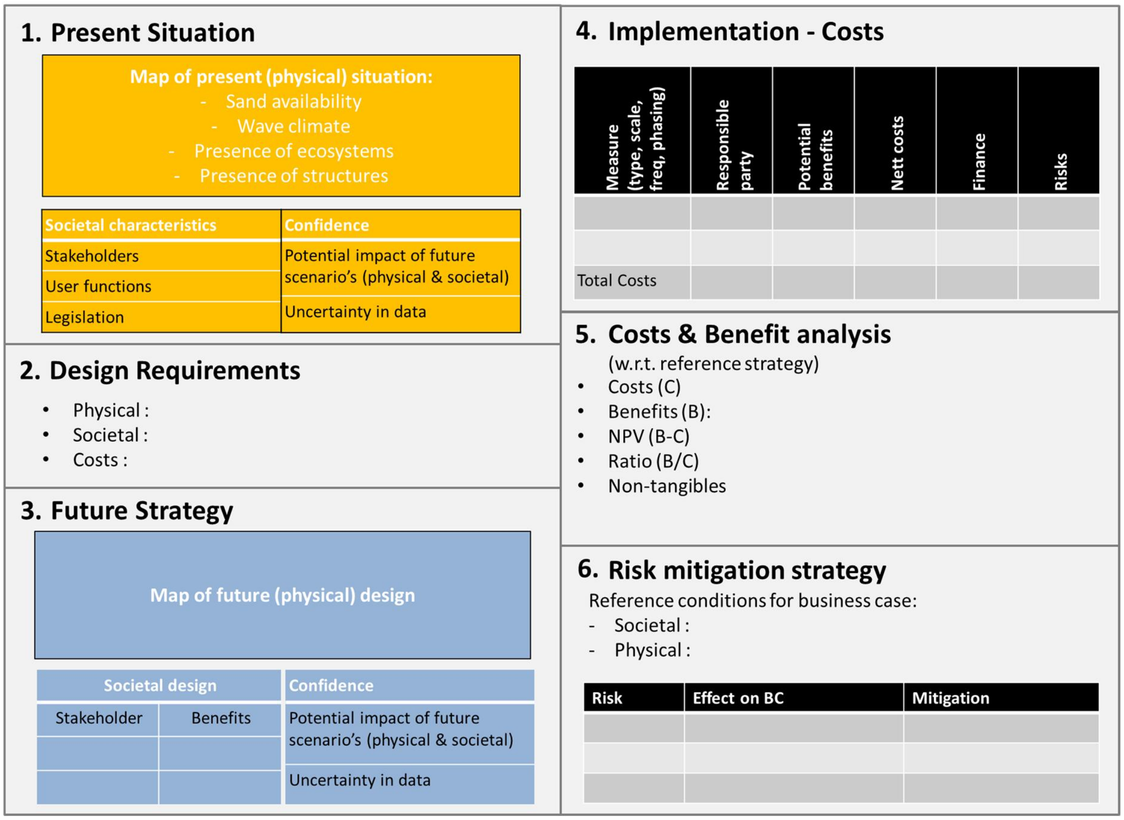

Figure 4.1 Project fact sheet

5 Conclusions and recommendations

5.1 Conclusions

A quick scan framework has been developed to assist the BwN community with the development of sandy strategies with potential for (co-)financing or a business case. This framework consists of the following steps:

1. Context & scope: understanding the project motivation and history and determine the focus for the current project phase
2. System analysis: understanding the functioning of the physical, ecological and societal system in the project area in order to identify potential benefits, risks and design requirements
3. Design of strategies: design of alternative physical and societal solutions with the focus on saving costs or generating benefits relevant for (potential) investors
4. Evaluation of strategies: evaluation of the sandy strategies in terms of technical, ecological, legal, social and economic feasibility
5. Business case potential: evaluation of the business case potential in terms of the feasibility to generate sufficient (co-) finance and summarize all relevant information to project initiators/decision makers

The distinguishing features of this framework are as follows:

1. The framework explicitly accounts for (the capturing of) benefits and finance from the early stages in the design process of coastal sandy strategies. Hence, instead of only focusing on problems (e.g. coastal erosion, flooding), the framework also focuses on opportunities. These opportunities/benefits may generate co-finance for the implementation of the coastal strategy. Therefore, the approach explicitly accounts for both physical and ecological conditions and societal (e.g. social, economic and institutional) arrangements.
2. The framework focuses specifically on coastal strategies in a sandy environment. Hence, the framework pays specific attention to the processes and benefits that are related to sand and its potential user functions.
3. The framework explicitly links sandy strategy development with the BwN approach in the sense that nature and natural processes are more predominantly present in the system analyses and proposed strategies.
4. The framework provides support to the BwN community in the form of (quick scan) tools dedicated to the above, including tools to make rough calculations of beach development and nourishment needs, dredging costs and sandy related benefits.

The two workshops with BwN end-users that have been organized around the Negril beach (Jamaica) and Sand motor 2.0 (The Netherlands) case studies indicated that most of the relevant aspects are covered in this framework. The BwN end-users indicated that the framework provides them with support on what to think of when developing a sandy strategy both in the Netherlands and abroad. Most end-users believe that the general steps of the framework may be applicable to any type of coastal system. However, it is noted that the guidelines and suggested tools provided in this document focus primarily on sandy coasts.

It is noted that the framework has been applied only to two case studies. It is likely that future applications of the framework may identify aspects that need to be added to the framework. Also the framework may not cover all relevant literature, tools and best practices for every relevant field of expertise that is addressed. The framework is a living (wiki) document that is never fully finished and the BwN community is strongly encouraged to improve and extend the framework based on their expertise and/or experiences with practical applications. In this way, it is expected that the knowledge base for BwN is both extended and strengthened.

5.2 Recommendations

The BwN community is encouraged to apply this framework in practice and extend and improve its contents. When applying the framework in practice, it is recommended to pay special attention to the following:

- Instead of only focusing on problems (e.g. coastal erosion, flooding), also explicitly look for opportunities (e.g. tourism, recreation, nature development) in the design of sandy strategies.
- Try to identify potential (co-)financiers for the sandy strategy and what are relevant aspects for them in an early stage of the design process.
- Explicitly account for both the physical and the societal aspects in the design of sandy strategies with special focus on the generation of benefits and/or savings of costs.
- Involve relevant experts and local stakeholders in the design process to improve the chances to end-up with a feasible and financeable sandy strategy.

Please note that the Negril beach and Sand Motor 2.0 case studies included on the wiki-environment are primarily intended to test and illustrate the use of the framework and not quality reviewed. Within the scope of the project, budget, time and information were lacking to gain sufficient system understanding, detail in modelling and/or stakeholder/financier involvement. The results should therefore be seen as a first, indicative assessment. When continuation of these cases is considered (for example by the NatureCoast post-docs), it is strongly recommended to verify these results with relevant experts and stakeholders.