Business Case Approach

Subject: Workpackage 5

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HIGH LEVEL CASE description

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Purpose of high level case descriptions

As part of the development of the Building with Nature Business Case Guidance a number of high level cases will be described by the case holders, with help when needed of the BC-team. This document gives information about the purpose and form of a high level case. It is complementary to the guidance document.

A high level case can be considered a rapid prototyping that follows all the steps of the proposed approach but with an emphasis on the scoping phase

The main purpose of the high level case description is to identify possible BwN alternatives and stakeholders that should be involved as well as the major factors and conditions that determine their potential performance as alternative solutions and their potential acceptance by stakeholders.

The High level case can also be regarded as a first inventory of conditions that determine the potential of upscaling a BwN concept.

Upscaling as a term is considered in three dimensions:

- The application of a BwN concept in other locations, e.g. an inundation area that works on the Eddleston catchment may also work on a catchment nearby.
- A design and use of a BwN project that creates more added values and caters to additional needs, e.g. a mega nourishment may also serve as a new recreational area.
- The embedment of the use of BwN concepts in general policies and strategies, in a way that these concepts are considered in planning and design and needed research.

The high level case will identify relevant information and lessons learned on all these three dimensions:

- It will identify major factors that determine the possible use of a BWN concept in other locations; these include physical factors as well as societal factors. This is in essence an exercise in the extrapolation of an existing case to other locations and transferring a BwN concept from one location to another location, which is a first step towards opportunity mapping.
- It will also identify options and possibilities to create more added values by tweaking and optimizing the design and use of an existing case or BwN concept. This is creating added value to more stakeholders. This will increase the potential for upscaling because it may increase acceptance and the potential for financing. It requires however a more complex planning process, involving more stakeholders.
- We also hope to identify barriers to implementation and factors that may facilitate and enable the use of BwN concepts in particular situations and governance settings. This is bottom up, in the sense that barriers observed in a project, give indications for what is needed on the policy level in order to enable its consideration and finally also implementation. There may also be barriers that hinder decision-making, and that may be

solved by addressing them in a BwN project. The most important ones relate to uncertainty regarding its performance ("will it work to a level that it should") and financing.

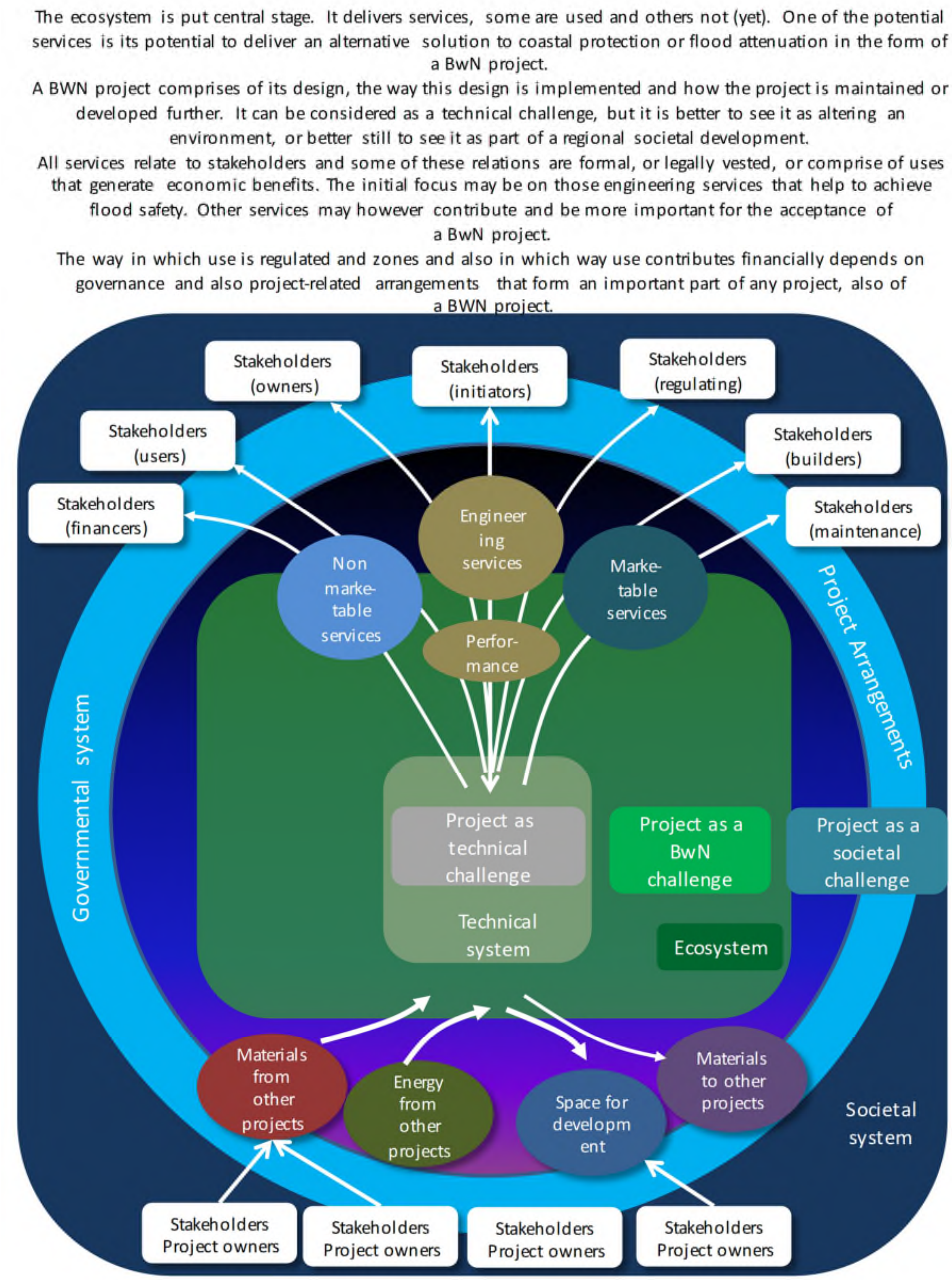

Figure 1. The BWN project and the ecosystem in the centre of a network of relations.

It should be noted that our cases pose very different challenges and are in different stages of implementation. Optimizing periodically nourishment schemes in order to maintain an existing beach may mainly require a better understanding of coastal processes and not a complex planning process that looks for added values. The Twin dike at the other hand is a case that is illustrative how a more complex planning process may result in a more integrated coastal development project with more added values than the conventional solution of dike strengthening.

Projects are also in different stages. Some are in the scoping phase and some have been implemented years ago, allowing for post-evaluation of their performance and of the planning process.

The way we envisage the planning process is illustrated in figure 1. A BwN project can be seen as an opportunity to optimize the relation (network) between the (natural) environment and society. Most of these relations have the form of a function or ecosystem service. The planning process can be seen as a way to inventory existing and identify potential relations, integrate them into the design and finally to confirm these relations in arrangements regarding use, maintenance and further development of these relations.

The overall ambition of a high level BwN business case is to show:

- in what situations a BwN solution is better than a conventional solution;
- how a BwN project may generate more added value to more stakeholders;
- how such a BwN project may contribute to regional and resilient development;
- how to move from a project with legally required minimal to neutral effects to the environment to a project that has an overall positive balance for the environment.

It should be noted that a business case is not only about financing and money. A business case addresses all the relevant effects, costs and benefits that are important in decision making, of which many are of a non-monetary nature.

General approach for Business Case development

The approach can be characterised by 6 steps:

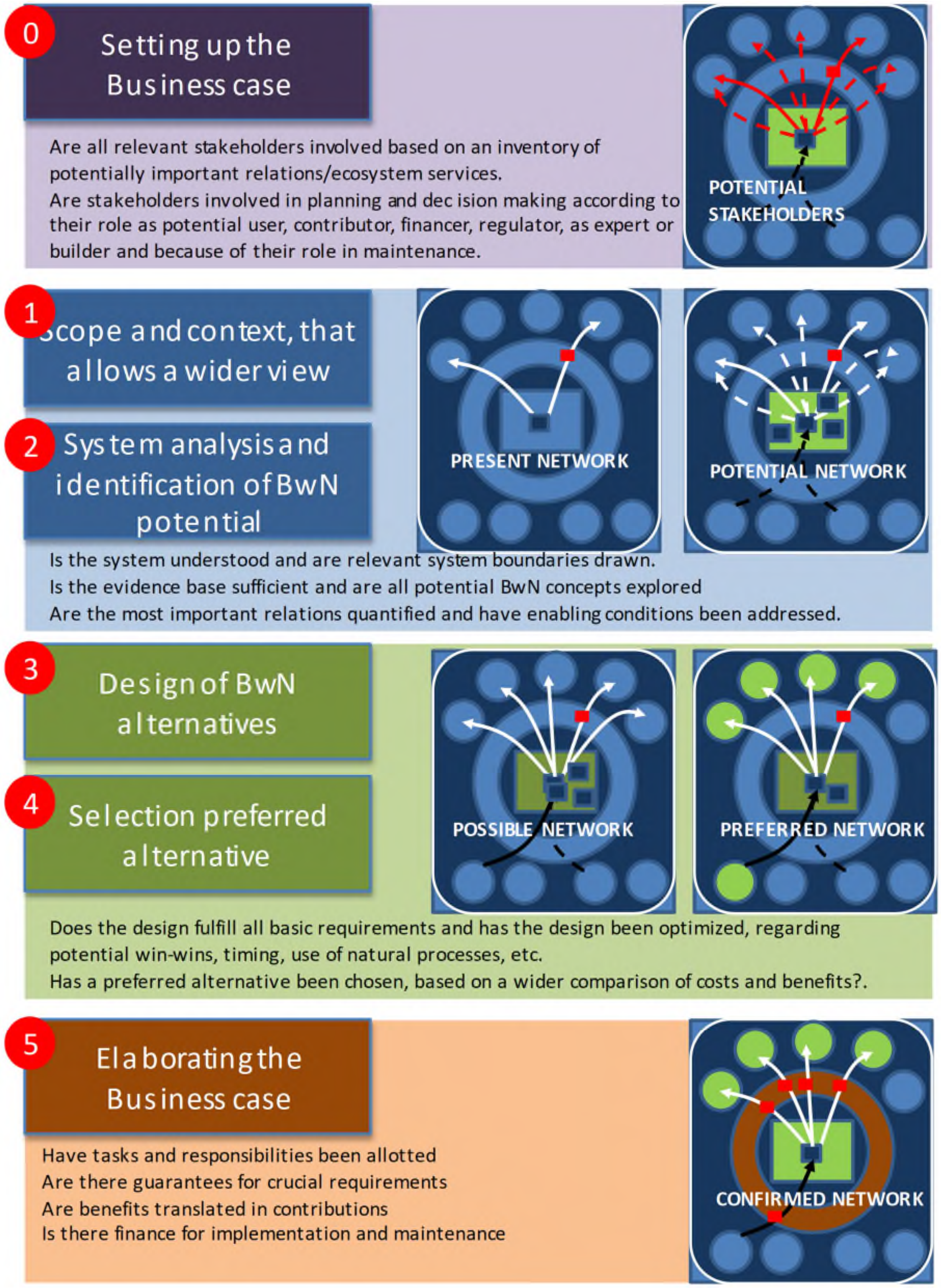

Figure 2. Various steps and some major questions to be answered in the high level case (see also figure 1).

Scoping and system analysis are the first 2 steps in which present and possible interactions between the environment and society are studied. Focus is on the possible role of nature and natural processes in delivering such "engineering services" as flood attenuation and coastal protection. But attention is also paid to other ecosystem services that are influenced and can be enhanced by a BWN project. In this way we also identify relevant stakeholders. So the scoping phase delivers an overview of present and of potential network relations between the environment and society and as a spider in a web, also potential BWN concepts that are worth investigating.

Evaluation, selection and design together form the next 2 steps. To what extent different BwN options deliver the "goods" depends on evaluating and when possible quantifying the relations between BWN and the natural environment. In addition costs for building, maintenance and possibly also exploitation are inventoried. Together these lead to a set of alternatives being possible network relations, of which one is selected as the preferred one. This selection compares different BWN alternatives with one or more conventional alternatives. It makes sense to select a BWN alternative only when it is better than a conventional alternative. But for this a comprehensive assessment is needed that addresses all added values of all the ecosystem services provided by the BWN alternative. So this phase narrows the number of possible alternatives and may come up with one preferred alternative, which also represents a preferred network of relations between the natural environment and society.

Taking potential network relations as a starting point, the design of the preferred alternative BWN designs are elaborated and optimized. This optimization is not only directed at improving "engineering" services, but also at enhancing nature and other important benefits a BWN project may deliver.

The last step is **elaborating the business case**. This is about confirming networks relations in the sense that (formal) arrangements define this relation, such as contracts for implementation, agreements on use and monitoring and maintenance.

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

It all starts with **setting up the business case.** This is foremost an organisational step in which the involvements of relevant stakeholders and experts or knowledge institutes is defined. This can be at the initiation of the project, but often it depends on the scoping phase. With a BwN alternative, the scope widens, which has consequences for the project organisation ad envisaged planning process.

Below we give a first list of issues that merit our attention in every kind of business case, so they are also included in the description of the high level case/quick scan:

1.Scope and context

Scope (is it wide enough)

Most project start with a scope that suits the project initiator and often it is too narrowly defined, such as offering flood protection, reaching and maintaining a certain flood protection level, or maintaining a coastline in a certain position. Sometimes there are additional objectives, mostly related to the quality of the solution, that it is cost-effective, sustainable or low in carbon emissions.

In the case of public spending it is logical to look whether an alternative can serve other societal needs and ambitions as well. This requires that additional objectives are formulated, initially perhaps very general, such as that the project should contribute to nature, the local economy, social cohesion etc. The next step would be to see whether these objectives can be related to the project and be made more concrete. So the starting point can be general societal objectives, like working with a general checklist: did we consider carbon emission?, did we consider recreation? Etc. But of course one should also look at the local societal challenges that have already been identified, such as the need for ecosystem restoration, the need for more accessible beaches etc.

Please formulate the scope of your project and consider whether additional objectives e.g. societal challenges may be served by the project as well, especially if a BwN alternative would be considered.

Does the formal scope allow to incorporate other objectives, or can these merely be seen as criteria when comparing alternatives?

2.BwN options and system analysis

Physical system (ecosystem functioning and understanding)

As Goethe already remarked: “One can only understand something, if one knows how it came into existence”. Man has changed his environment frequently and often profoundly. As a consequence many river valleys and coasts do not display a natural environment that is free of human intervention. Often the effects of past interventions may still need years before establishing a new equilibrium, whilst simultaneously one needs to anticipate the effects of new interventions, such as climate change. Basically a BWN design process starts with a good understanding of the physical as well as the related societal system (next section), which should at least include:

- Historic development, related human interventions and natural processes.
- Autonomous development both physical and interventions that were taken.
- Major processes that determine the “engineering” potential of a BwN solution.
- The influence of sea level rise and climate change on processes and “engineering” potential.
- Uncertainties related to expected performance.
- Important ecosystem services and the factors and processes on which these services depend.
- Other

Please indicate for your case to what extent physical processes are known and what the evidence base is for the proposed BwN alternative.

Processes and characteristics differ depending upon the environment. We wish to distinguish between different types and perhaps even subtypes of physical environments when useful, on the basis of differentiating criteria that determine the "engineering" potential of a BwN concept.

Possible relevant factors and processes:

Intertidal areas:

- Tidal characteristics, such as tidal range that determine the height and width of salt marshes.
- Presence of tidal channels, observed migration, that may limit the extent and use of salt marshes.
- Wave attenuation by salt marshes and mud flats and how this relates to wind and wave set-up during design storms.
- Natural development of salt marshes in relation to sediment balance and hydraulic conditions (e.g. exposure to waves and currents).
- Human interventions undertaken that positively influence the development of salt marshes.
- Status and type of the existing flood defences and most relevant failure mechanism (e.g shortage of height, revetments, stability etc.) for which salt marshes may offer a solution.
- Soil type and lay/height of the adjacent land compared to sea level and expectation regarding salinity intrusion.
- Other factors and variables as found to be of importance in your case.
- Other.

Sandy shorelines:

- Longshore transport, both gross and net and inter-annual variations.

- Presence of active breaker bank systems and their major characteristics and what role they can play in nourishment strategies.
- Shore cross profiles and the presence of (migrating) tidal channels
- Depth of the active zone, preferably time dependent.
- Natural dune formation and major factors and thresholds (e.g. D50 of sand, width of dry and wet beaches).
- Human interventions that positively influence dune formation (e.g. planting of helm grass).
- Location of potential sources for sand, exploitable long term volumes vis a vis nourishment needs.
- Status and type of the existing flood defences and most relevant failure mechanism (e.g shortage of height, revetments, stability or in the case of dunes volume etc.).
- Other.

Tributaries:

- Peak flow characteristics, such a forms and volumes compared to the natural buffer capacity of the flood plain.
- Water level characteristics and the presence of natural and artificial bottlenecks.
- Sediment balances and transport in average annual conditions but also during peak flow events.
- Development of sand during peak flow, relevant factors (e.g. channel form, duration of the event) and its effect on channel bed roughness and water levels.
- Presence of flood plain vegetation and its influence on roughness, water levels and local sedimentation processes.
- Geology of the river bed and flood plains, are these for example unconsolidated sediments (gravel, sand or fine sediments) and the presence of rocky sills or sandy river banks.
- Relation between river regime and geohydrological characteristics (e.g. recharge, groundwater level dynamics)
- Human interventions that influenced peak flow hydraulics and morphodynamics, such as groynes, (nautical) dredging activities, summer dikes, clay extraction areas, building of dams for infrastructure and bridges etc.
- Land use of river and floodplains, and critical thresholds for inundation frequency and depth for nature and agriculture.
- Status and type of the existing flood defences and most relevant failure mechanism (e.g shortage of height, revetments, stability, piping).
- Other.

Catchments:

- Peak flow characteristics, such a forms and volumes compared to the natural buffer capacity of the flood plain.
- Water level characteristics and the presence of natural and artificial bottlenecks.
- Sediment balances and transport in average annual conditions but also during peak flow events.

- Land use in the catchment area and rainfall- runoff characteristics and the influence of land use and drainage, and is present also dams, on peak flow characteristics and base flows.
- Status and type of the existing flood defences and most relevant failure mechanism (e.g shortage of height, revetments, stability, piping).
- Other.

Societal system (use of ecosystem services)

Man, land use and cities are dependent upon technology and ecosystem services. Onward from the industrial revolution and later agricultural revolution the importance of a well-functioning ecosystem has been overlooked. We could built in floodplains, by keeping them flood free with dikes, harvest regardless of soil ecology because of fertilization. Gradually we become aware of our dependencies of natural processes, our appreciation of the natural landscape and the potential of nature and natural processes to solve our engineering problems but also to create added value.

The first step is to identify the present uses, followed by a wide scoping of potential uses that may be made possible by a BwN solution.

Please describe in what way present and potential uses were identified and taken into account.

Please indicate what factors are enabling and what factors act as barriers or constraints and how they influence(d) the choice for a BWN concept, its design and its acceptance.

- **Are these factors important in the process of opportunity mapping?**
- **How should we address the scoping for potential uses in the guidance.?**
- **Would it be advisable to be able to indicate when and when not potential benefits and stakeholders should be included, since it also increases the complexity of the planning process?**

Some questions:

- Land ownership and how this does influence or has influenced basic choices in the planning process or in the design.
- Present (land) uses, such as housing, agriculture or recreation, the related limitations and engineering challenges but also potential benefits that may be the result of a BWN solution.
- Potential uses, not yet considered, but that may be of importance in economic terms, or in terms of social acceptance.
- What stakeholders were involved in the planning and design process, and on the basis of what considerations?
- What was the form and intensity of their involvement, was it consultation or perhaps also joint fact finding and designing?
- Did you do an assessment of present and potential uses?

- What are the present uses and dependencies and related stakeholder groups.
- It is the present use already fully exploiting potentials or is there scope for improvements.
- What are the major barriers and constraints that prevent the present use to be fully developed?
- Can these barriers or constraints be lifted by the BWN project and in what way this needs to be taken into account in the design.
- Can the BWN-project provide new services and new uses, and are these potentially relevant for the design, implementation or maintenance?
- Do these new services and uses involve new stakeholders and are they already involved?

Governance system (laws, policies, budgets, political ambitions)

Governance is a term that comprises many definitions that cover even more interpretations. The essence is that there are policies, rules and laws that determine the relation between stakeholders and between stakeholders and the natural environment, in terms of tasks and responsibilities and institutions, of rights to use space and (ecosystem) services and obligations and mechanisms to pay for these services. Governance also includes formal protocols and traditions how we conduct planning and decision making and how we involve stakeholders in these processes. For this reason governance is very important for the design process, the way we contract projects and how we finance them.

We wish to know in what way governance played or may play a role in your case. It could be facilitating specific solutions, but hindering others to the extent that these become unrealistic. Please indicate major barriers and constraints, and how preferably these could be overcome. And what are facilitating or enabling governance factors in your situation? Could these be considered tips and tricks to be included in the guidance document? And to what extent do these barriers and constraints determine the applicability of a BWN concept in other locations?

Some relevant aspects:

- Nature laws and regulations, such as Natura 2000, and related policies, and how these influences the planning and design process.
- Environmental laws that may influence design and implementation.
- Cultural heritage that is or has been of influence to the planning process.
- Procedures and protocols for contracting.
- Procedures and protocols for financing.
- Other.

Projects with potential functional relations (demand and supply)

There may be projects nearby that can contribute or that may depend on the BWN project in different ways:

- Contribution of materials (e.g. recycled stones, beneficial use of dredging sludge from nautical dredging).
- Exchange of energy (e.g. excess heat, biomass for energy production).
- Timing of the execution of work, using for example the same machinery or contracts.
- Combination with water front development or urban development.

Please indicate for your case if these kinds of project relations have been considered or inventoried and if they played a role in your case.

Possible concepts (scoping for BwN alternatives or hybrids)

We know that in most situations different BWN concepts may work separately or in combination. It is interesting to know what BWN concepts you did consider and whether your scoping phase focussed on specific choices.

Please indicate for your case what BWN concepts did you consider, why certain concepts were not considered upfront (too expensive, not effective, no potential financing, not possible because of land use or nature laws etc.). Why were certain concepts discarded or selected (physical conditions not suitable, costs probably too high, uncertainty about performance, finance could not be guaranteed).

We wish to establish a complete tool box of possible concepts that range from pure BWN concepts up to all kinds of hybrids with conventional solutions that make sense depending upon conditions.

Possible concepts are:

<u>Intertidal areas:</u>

- Existing, enhanced (made wider, higher, more resistant) or new salt marshes in combinations with dikes.
- Wider dikes with lower slope gradients using local materials.
- Twin dike with various type of landuse between both dikes

<u>Sandy shorelines:</u>

- Nourishment on the foreshore, beach or dunes. Annual, periodically or incidental.
- Different sources for sand: offshore, bypassing and back passing, use of nautical dredging materials, intended erosion of sandy shorelines.
- Various types of meganourishments and feeder beaches, such as the sand engine.
- Combinations with hard structures, such as groynes, (harbour) dams, wave breakers, perched beaches that steer longshore transport and limit erosion.
- Combinations of wide beaches with sea walls, foreshore revetments etc for dune protection.

<u>Tributaries: (see various measures from Room of the River)</u>

- New high or permanent river channels.
- Lowering of flood plains.
- Lowering or reallocating summer dikes.
- Deepening the river bed.
- Removing obstacles, such as narrow bridges.
- Shortcutting wider meander bends
- Removing or reallocating vegetation.
- Redesigning groynes.
- Use of flood plain forest to attenuate waves in wider sections.

Smaller streams and catchments (see for example Eddleston case)

- Increasing retention by reforestation of the catchment area and by reducing drainage in the catchment, reduction of impermeable pavements, rain water gardens, and infiltration zones/swells along roads and pavements.
- Increasing buffering capacity, by hermeandering, restoration of natural inundation areas, creation of active inundation areas, use of swells and dams in order to create cascades, use of falling trees to slow down flow.
- Shoreline protection using vegetation, combinations of stones and vegetation, redirection of flow paths.

3.Evaluation, comparison and selection

Problem-solving performance (physical-technical evidence base)

Several cases struggle with the proof of concept. The evidence base is often slim or when it is substantial it is often difficult to transfer and translate the results to other areas. Nevertheless this evidence base forms the core for any form of opportunity mapping and upscaling a concept or project to other areas. There are other factors that determine the potential, such as the potential added value provided by other ecosystem services, or the financial criteria and funds available.

Please describe your evidence base, is it sufficient and does it allow for extrapolation to other areas? What are the major factors that determine performance, and are there any concrete thresholds that determine the applicability of the BwN concept considered? To what level should we include the evidence base in the guidance document, or provide useful links to background information?

Specific questions are:

- To what extent can you quantify the performance of a BWN solution (e.g. the effect of a reforestation on peak flow reduction, the effectiveness of foreshore nourishment).
- To what extent do you understand the major processes and conditions that determine this performance?
- Is it possible to extrapolate the application of a BWN solution to other areas and what are the relevant conditioning factors?
- What is the degree of confidence? Is it sufficient for a first selection of potentially useful BWN solutions?
- Is it sufficient for supporting cost-benefit assessments?
- Does this performance or the related design have the potential to deliver additional services simultaneously?
- And if yes, how would that influence the design?
- Other.

Added Value ecosystem services (economic evidence base)

The evidence base regarding the value of ecosystem services can be as important as the evidence base that underpins the performance of a BWN vis a vis coastal protection or flood protection. Some of these added values are directly related to an increase in safety levels, such as an increase in real estate values. When conventional and BWN alternatives are compared that aim for the same level of safety, safety related benefits, such as avoided flood damages, will be the same. It makes sense to limit and simplify the comparison to those aspects in which alternatives differ. However, in countries like the UK, the explicit benefits of flood protection need to be addressed since these constitute an important part of the benefits that need to convince authorities to invest money. This is a requirement for a conventional as well as a BwN alternative.

It makes sense to make a complete inventory of all relevant ecosystem services that can be provided by a BwN project or BwN-solution, since every services may potentially help your case.

So please describe all the benefits identified, and how these were valued or could be valued. Also indicate if potentially relevant benefits could not be quantified or set on monetary terms for lack of information, or because such benefits are not included in formal assessment protocols. What aspects or kind of information should be addressed by the guidance?

BWN projects can cater to many more needs and hence the assessment of the true value of a BWN alternatives requires a comprehensive assessment.

Specific questions:

- What ecosystem services are directly related to flood protection and coastal protection.
- Are you able to quantify these services in monetary terms, e.g. for your cost-benefit assessment?
- What services or added values are part of your (formal) cost-benefit assessment?
- In what way can or have these services play(ed) a role in the design?
- What other ecosystem services are substantial from an economic point of view but are not related to the flood or coastal protection.
- Can these services be valued in monetary terms and with what degree of confidence?
- In what way can or are these services be taken into account in the design of a BWN project.
- What ecosystem services are important but (probably) cannot be set on monetary terms;
- In what way can or are these services valued?
- In what way can or are these services be taken into account in the design of a BWN project?

So we wish to see what ecosystem services are:

- directly related to flood protection and safety and to what extent these were set in monetary terms and if these benefits influenced the design, decision making and finance of the project;
- economically important but not directly related to flood protection and safety, if these were quantified also in monetary terms and if these influenced the design, decision making and finance of the project;
- important but not directly related to flood protection and safety and cannot be expressed in monetary terms.

Finance (financial construction)

The potential for financing BwN alternatives, or even flood protection, differs between countries. In some countries finance is guaranteed because flood and coastal protection is vested in laws together with required safety standards or a coastline that should be maintained. In other countries finance is only forthcoming when there is a (very) positive benefit cost ratio.

We would like to know to what extent finance, and the related requirements, have influenced the planning and design process and ultimately the selection and implementation of a BWN solution. And if co-financing was important at what stage of the planning and design process was this option considered? What aspects should be dealt with in the guidance?

Specific questions:

- In what way did you have to underpin the performance of the BWN solution in order to be eligible for financing?
- Did the requirements for financing influence the design? And in what way?
- Did you attract other financial sources, and if yes on the basis of what conditions and for what kind of benefits (e.g. avoided costs, economic benefits)?
- Did these other financial sources require a change in the design, in order to fulfil their requirements for financing?
- Did this influence the performance of the design and/or lead to additional costs?

The design and decision making process)

If your case is already implemented or at a stage where a final decision has been reached, it is of interest to see how the design and decision process led to this final decision and what were the major factors that governed this decision.

Please indicate how alternatives were identified, optimized and finally selected and what the major factors were, which determined these choices. Also indicate whether there were moments that you had to reconsider past choices, because new information became available or new stakeholders were identified.

Please also describe the basic planning process and involvement of stakeholders therein. What were the most critical moments? In what ways could the process of planning and decision have been improved and in what way could this be addressed in the guidance document.

Setting up the business case

Initiating a business case can be done in different phases of the project. Ideally it is done early, but one needs to have at least a first understanding of the system, possibly relevant existing and potential relations and effects in order to identify potential stakeholders.

Potential stakeholders may relate to present uses, they may be regulators, experts or even builders or organisations that take care of future (nature) management.

Normally one would initially look at the stakeholders that use the project area and its ecosystem services or that have formal tasks and responsibilities in flood protection and related physical planning and licensing.

With a BwN alternative, a wider scope is envisaged that comprises more present and future potential stakeholders. When moving from a more conventional solution to a BwN alternative, nature management becomes important, and also physical planning. Hence different kinds of organisations may be needed at the table.

But one should also consider that a BwN alternative may create new ecosystem services that enable new uses, for which perhaps not yet stakeholders can be identified.

Please indicate how the project was organised, what stakeholders were part of the team that defined the project and what stakeholders were involved in the decision making process.

Was a stakeholder assessment conducted in order to identify potential stakeholder and did this assessment also include an analysis of how these different stakeholders could contribute to the design and decision making process?

Was this selection based on formal procedures and rules, or based on what would potential lead to the best project result?

Please describe if the project organisation also included stakeholders for potential uses and if that would be the case, how have these been identified and selected.

Elaborating the business case (enabling implementation)

Elaborating the business case is not a final step but more or less a continuous effort that already starts with setting up the business case.

Elaboration the business case is about making the implementation possible. There are many factors, such as sufficient finance, that will have played already a major role in the design and decision making process that has led to a preferred alternative.

Enabling implementation is about contracting construction and involvement of a builder, about the division of tasks and responsibilities, about financing and who contributes.

Your case may not yet have entered this stage.

Please indicate what contract form would be the most suitable or has been chosen in order to implement and maintain the project?

What organisational form was chosen in order to guide implementation, maintenance and possible also future adaptation?

Was a monitoring plan drafted in order to supervise construction and supporting management decisions after implementation, and what were its major components?

How was the project financed, and under what kind of conditions? Was there also private money involved and on the basis of what criteria was a cost division decided?

Upscaling potential (factors for identifying useful concepts)

The final questions relate to the upscaling potential of your BWN project/case. As hinted before upscaling can be done on the basis of physical parameters, but mostly combinations of physical, societal and governance parameters are decisive. We are interested in upscaling potentials taking into account all these factors.

Please indicate the upscaling potential as you see them for your case and describe also what are potential constraints and enabling factors. Describe also whether you have observed some critical thresholds for the use of a BWN concept in order to make it work. These constraints and enabling factors can be clustered in physical factors that determine the engineering potential, physical and societal factors that determine added values and factors that relate to governance setting and project-based arrangements between stakeholders. Should major factors that determine upscaling be included in the guidance document? For example to enable a quick scan of potential BWN concepts.

The Twin dike may serve as an illustration, since its upscaling potential depends on many factors. The most important **physical factors** related to physical performance compared to conventional alternatives are:

- The conventional alternative, determined the cost-levels with which a BWN has to compete. This depends upon **hydraulic conditions, safety standards and present status of the dike**, the required upgrading and also the extent in which stone revetments may be reused.
- The **lay and geology of the land,** determined the availability of suitable clay that can be used to build the second dike at comparatively low costs. Simultaneously this excavation created conditions that allow for tidal interaction with the sea without additional excavation needs.

Additional added values were identified that make the project more attractive as a pilot and also in order to look for additional finance:

- The brackish water aquaculture envisaged in between both dikes, requires **tidal dynamics** and requires also an expensive culvert. The cost of this culvert depends on its size, which depends mainly on the tidal range. So in situations with little tidal amplitude the costs of a culvert will be higher.

- The most profitable form of aquaculture is the cultivation of bivalves. Bivalves grow better when (mineral) **suspended solid levels** are low, but the **content of green algae** is high. The combination of both factors determines the filtering efficiency and growth. Furthermore, there should be a minimal risk of toxic algae blooms. So there are water quality plays a role in the potential benefits of a Twin dike and hence should play a role in opportunity mapping as well.

Above, only a listing of some of the most relevant physical factors is given. There are however many other factors that have driven the design process and that are very location- and project specific:

- Since it is expected that the low-lying lands will in time face the risk of salinization, the province was willing to invest in the pilot for brackish aquaculture. At the same time the area between the dikes acts as a fine sediment sink, which will lower suspended solid concentrations in the nearby estuary which is good for its ecological functioning. The province was also willing to take the **financial risks** in case the pilot did not work economically as expected.
- There was one landowner willing to cooperate and a **special arrangement** was set up that stipulated a long term lease of the land.
- There are farmers that lease the land from the province and that are willing to invest in brackish aquaculture, based on a **positive business case** that depended also on the willingness of the province to bear the costs of the culverts.