Valuation of risks and opportunities in BwN

Building with Nature Guideline

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Valuation of risks and opportunities in BwN

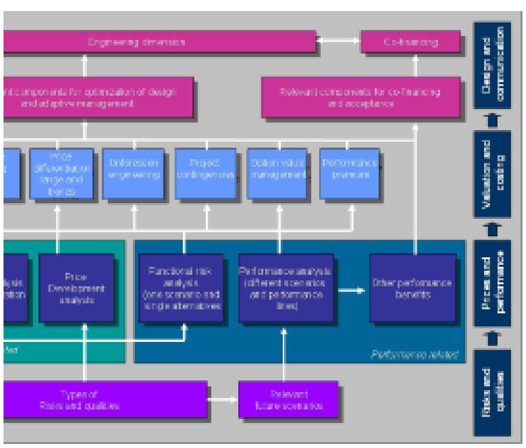
Type: Framework

Project Phase: Initiation, Planning and Design

Purpose: Integrating Finance and Design for improved pricing of risks & opportunities; incorporating ecosystem valuation

Requirements: Expertise from both finance and design

Relevant Software: none



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About

This tool is a framework that helps to identify important risks and opportunities (e.g. for co-financing) and ways to integrate them in the cost-estimates of a project. Cost-effectiveness and cost-efficiency are important criteria that often govern decision-making. Usually the costs are calculated after the design alternatives have become available. However, costs are also an important design criterion, so interaction between designing and costing is important. Yet, this interaction is often not included in the design-process. This tool contributes to the assessment of the financial implications of different design alternatives, by taking different possible scenarios and related risks into account. This framework requires only limited background knowledge in costing and designing. Essential is that different disciplines (especially finance and design) work together in order to make more integrated assessments.

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Costing addresses various components, such as costs related to the implementation, and costs for subsequent maintenance and operation, usually over the functional life-cycle. In the Netherlands, as in many other countries, costing is done according to formal formats, to ensure that all relevant cost-components are addressed and the same discount rates are used. Uncertainties find their way into the cost-estimates, usually on the basis of a risk assessment procedure.

Valuation and costing of uncertainties and specific BwN qualities will identify the project components with major repercussions on:

- project financing - because they represent major investment costs, operation and maintenance challenges, or cost-uncertainties;
- potential benefits and avoided costs for other than the primary functions.

This way, needs and opportunities for project optimisation and possibilities for co-financing become apparent. A more recent development is the use of total life cycle costs, which enables comparing project alternatives over a longer time frame with a focus on functional performance.

Building with Nature interest

Costing and valuation are important in all project phases. As they may put alternative solutions into a financial perspective, it is already relevant in the project initiation phase. Later it may help decision-making and securing co-financing. Examples of cases in which considering uncertainties and long-term life cycle costing is relevant are:

- Coastal engineering works and coastal management strategies that involve substantial sand nourishment volumes, long-term uncertainties related to morphological developments and phasing options.
- Flood protection strategies involving choices between soft and hard engineering, for example in situations with a considerable bandwidth of (e.g climate-induced) long-term design conditions.
- Engineering projects that yield benefits that natural systems may also provide, such as buffering of peak flows, or contaminant filtering.

Although the Dutch standards for costing (SSK) offer a comprehensive framework, some aspects that are important in BwN-type projects merit more attention. To mention the most important ones:

1. Important strategic considerations such as resilience, robustness, flexibility and sustainability can be made more explicit in monetary terms.
2. The effects of hydraulic engineering structures are often complex and affect many ecosystem functions, with consequences for ecosystem-dependent uses such as fisheries and recreation. Most of these effects are addressed in Environmental Impact Assessments for instance, but their valuation is often lacking, just like their integration in the design process.
3. Uncertainties related to external factors, such as climate change, are difficult to predict while uncertainties in ecosystem relations are not well understood.
4. The full potential of using costs as a design criterion is not utilised, as costing is insufficiently included in the design process.

How to Use

This framework requires more analysis than standard costing procedures. Quantifying uncertainties and risks is far from trivial, but their absolute quantification is not always necessary. Relative risk assessments may be enough to choose between alternatives, and identifying the most important risks may suffice for further project optimisation. As valuing uncertainties and specific qualities is a complex task, this conceptual framework indicates how to handle and value BwN qualities and related uncertainties. It involves the following steps:

1. Risks and qualities
2. Prices and performance
3. Valuation and costing
4. Design and communication

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Often costing and budgeting is done by experts that have little or no expertise in the technical and practical aspects of a project. Stimulating them to interact, yields better assessments, as the process becomes more iterative and interactive and it also safeguards consistency.There are therefore various levels of using the framework. Most important is an overview of relevant cost key figures for the main design components. For many BwN projects, earth-moving and working with sand and clay are major cost components. Therefore, one needs to have an overview of the possible costs involved, and of the variables that determine these costs, such as transport distances for earth-moving.

1. Risks and qualities

This step comprises analysing and identifying uncertainties, risks and qualities. Uncertainties and risks are related to e.g. market price variations and trends, modelling, design, implementation, (uncertain) performance and environmental design conditions and their time-evolution. Qualities are mainly related to ecosystem services and related functions. This step consists of 2 parts:

1. Analysing types of risks and qualities: some are related to market situation and prices, some are relevant to the functional performance of a project. Relevant categories for e.g. coastal management projects refer to climate change, morphological models, grain size of available sand.
2. Analysing consequences of relevant future scenarios: those uncertainties that are relevant to the functional performance of a project on the long term under different circumstances (e.g. climate change) should be clustered into a limited number of relevant scenarios for further analysis.

2. Prices and performance

Market – related:

1. Market analysis and consultation focuses on the way in which the market situation and also contract conditions may influence the price of the contract. Most of these aspects are part of normal costing procedures, except for the way in which contract conditions may influence market prices. Contract conditions, notably the combination of building and subsequent Operation and Maintenance, can have a large impact on market prices.
2. Price development analysis takes into account the influence of e.g. fuel prices, which constitute an important part of the costs for nourishment, and technological developments on the long-term development of prices. This is not a standard procedure but will be relevant in case of long-term assessment and life-cycle costing.

Performance - related:

1. Functional risk analysis considers the performance and functioning of a project under one scenario, with emphasis on internal factors that may affect performance, such as modeling uncertainties and implementation uncertainties. Often this analysis is included in order to establish a bandwidth for operation and maintenance costs and to identify the need for contingencies or the perspective for adaptive management.
2. Performance analysis considers the performance and functioning under a set of different scenarios, with emphasis on external factors that drive performance, such as climate change and long-term sand availability.
3. Other performance benefits are the domain of ecosystem services that are not directly related to the primary functionality/purpose of the project. They may consist of benefits to safety, recreation, real estate, water supply and other functions.

The assessment should focus on the most relevant risks and qualities only, i.e.:

- Those that have substantial budget implications and are therefore important to financing.
- Those that create marked differences between project alternatives and are therefore important to decision-making.
- Those that depend on project design and should be considered in the design process.

For scenario analysis also the number of relevant scenario parameters should be limited. This can be done by clustering relevant scenario variables that generate similar kinds of uncertainties and have similar effects on long-term performance.

3. Valuation and costing

The next step is to integrate the results of these assessments in the costing sheets. Often this can be done within the standard costing sheets. Long-term performance can be expressed in terms of a “performance premium” in order to enable comparison of different alternatives. Uncertainties can be addressed as:

1. Different discount rates enable incorporating risks and uncertainties. Higher discount rates can be applied to benefits that are more uncertain, so their influence on the total balance is not overestimated. Similarly, lower discount rates can be applied to costs that are less certain, so they are not underestimated.
2. Price differentiation range and trends: the results of the market and price development analysis are translated in a relevant range of component prices.
3. Unforeseen engineering is a standard budget item meant to cover engineering aspects that have not been foreseen. Usually this mainly relates to the complexity of a project.
4. Project contingencies are budget components reserved for mitigating and compensating measures that may be needed because of uncertainties in the project’s functioning.
5. Option value management determines the management or use values, which the option for a specific asset can provide over the entire costing period.
6. Performance premium: given once an alternative has on average lower total life cycle costs compared to a reference alternative when tested under a bandwidth of scenarios.

4. Design and communication

The logical next step is to see how cost figures may hint to design optimisation by identifying those components that represent the largest investments, cost uncertainties and/or additional benefits.

1. Elements for design optimisation: based on the valuation, design elements allowing for optimisation and risk management are identified and related recommendations are made.
2. Elements for co-financing and acceptance: based on the valuation of extra benefits (in addition to the primary function) elements in the design can be identified that may yield co-financing and broad acceptance of the project. One may consider design optimisation in order to increase co-financing opportunities.
3. Engineering: design optimisation that takes into account uncertainties and important cost components.

Innovative elements compared with the ongoing practice of costing are:

- The differentiation in discount rates. The use of lower discount rates in order to attribute more weight to future costs and benefits is a point of discussion among ecological economists.
- Functional risk analysis where interdependencies play a role. Many BwN projects include natural processes that often involve mutual cause-effect relations.
- A lifecycle performance analysis that assesses the performance of a project under various scenarios.

Advice and recommendations

Costs are an important argument in decision-making and consequently should also be important in the design process. Uncertainties, risks and qualities that govern costs and benefits are therefore important, as well, and should be given due attention. Most large projects should start with a risk assessment in order to identify major project management needs. There are possibilities to connect these risks assessments with design frameworks and costing sheets, which will help to identify important risks that need to be handled. Also in the initial and scoping stage of a project, risk analysis will help to identify major risk components as a design challenge. Often risk analysis starts when a project has already been designed. However, risk analysis can and should start by assessing risks in the existing (ecological, economic and social) system, yet without a proposed intervention, as a starting point.

Practical Applications

1. Case Sand Motor Delfland
2. Case Long-term nourishment strategy
3. Conclusion

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1. Case Sand Engine

In the design process of the Sand Engine several alternatives were compared with respect to costs and effects as part of the EIA procedure. Costing was done using a standard budgeting protocol. The most important cost components are the mining, transport and deposition of the sand and subsequent operation and maintenance. Adjacent sections of the coast need additional nourishment until the moment the sand is delivered by the Sand Engine. Other operation and maintenance costs relate to safety (because of rip tides), monitoring and nature management. A significant part of the budget consists of contingencies that cover the potential costs of mitigating measures in case undesirable effects take place. One example is mud sedimentation on recreational beaches, another formation of a fast flowing lagoon feeder channel next to the beach.

Most uncertainties relate to morphological development. The morphological development of the sand engine was predicted using a regional long-term model. In order to run the model over a 20-year period, input parameters such as incoming wave and wind conditions and sand properties of the existing shore and the nourishment were simplified. As a consequence, predictive capacity of the model was limited, especially for the timescale of the morphological evolution.

This case was used for an ex post -evaluation focusing on uncertainties in the comparison of different alternatives in the EIA. Applying the framework showed the following:

Step 1: Uncertainties, risks and qualities

- Various qualities and uncertainties were already addressed in the design of the project itself. Focus was on uncertainties related to morphological development, mud sedimentation on beaches, development of rip tides, effects on adjacent dunes and groundwater and ecological development. Most operation and management uncertainties were translated in contingencies. Uncertainties regarding the morphological development were partly solved by complementary nourishment at critical locations.
- Many uncertainties are related to model assumptions and the implementation of the project. Most uncertainties probably don’t discriminate between nourishment strategies. The most important uncertainties are related to sediment properties and wind and wave climate, which determine the morphological development of the nourishment itself. Additional modeling with different sediment properties showed an influence on the morphological development, indeed.

Step 2: Prices and performance

- In the EIA for the Sand Engine no price development analysis was included. Yet, an assessment of the market situation led to an update of cost figures and a budget estimate that nearly coincided with the ultimate tendered prices. It is expected that there is a limited increase in prices in the coming 20 years, with little effect on the comparison of alternatives.
- Various uncertainties were integrated into the budget in the form of contingencies. This was underpinned by complementary modeling and uncertainty analyses, as well as by comparative studies looking into reference situations, e.g. dynamic coasts with similar contour lines. Contingencies included mainly budget allocations for mitigating and managing undesirable effects on beach recreation (e.g. because of mud sedimentation) and groundwater in the adjacent dunes. Implementation uncertainties were potentially very relevant, especially those related to the sediment properties. The application of finer grades of sediments would speed up expected morphological development and influence long term performance. However, a faster morphological development would be a characteristic of all meganourishments, leading only to limited differences in long-term performance. Ultimately, the Sand Engine was constructed with sand very similar to that assumed in the morphological model.
- Long-term performance was only tested against a single expected climate scenario. Performance analysis over a wider group of scenarios would probably show that mega-nourishments are only a better option if they are situated on top or very near the coastal section that needs nourishment. Implicitly the design is based on one scenario for storms and sea level rise. A scenario with a faster changing climate would mainly reduce the functional lifespan. More important is the potential shift in dominant winds which would alter the way sand is transported along the coast. In this case there is a risk that the sand will not reach critical sections in case the sand engine is located further away.
- Differences between different forms of mega nourishment alternatives, e.g. such as an island or peninsular based on the same volume and same location, are small regarding morphological development. After 5 to 10 years very similar morphological forms, notably wider beaches and active dune formation are expected. The form does however determine the potential for recreation and nature development on the short-term, so these aspects may differ widely between different alternatives.
- Uncertainties and qualities are strongly related. Qualities such as flexibility are in fact a way of handling risks, but can also be seen as a quality of a soft engineering solution. So some BwN qualities can be valued in a similar way as risks and in fact may strongly overlap. Other BwN qualities mostly relate to benefits for other functions, mainly recreation and nature.

Step 3 Costing and valuation

- The sand engine is considered to have a functional life span of at least 20 years. Consequently long term uncertainties, price development scenarios and also different discount rates do not alter the comparison between the alternatives for the sand engine.
- In terms of costs, the valuation of uncertainties may be in the order of 10% of the total costs, similar to the costs of the additional adjacent nourishments. We expect that differences would have been larger if alternatives would have been considered that mainly focused on cost-

effective maintenance of the location of the legally defined coastline. The volume of the sand engine is larger than needed, so the design is very robust and therefore not very susceptible to uncertainties and different scenarios. However, a robust design also implies greater costs, larger than needed for coastal management per se.

Step 4 Design and communication

- Most relevant uncertainties and related risks were already identified as part of the EIA. The design has been optimized accordingly. Risks that could not be handled by design optimisation have been integrated as contingencies for operation and maintenance.
- Communication on uncertainties could have been more explicit. In this case maps were used that showed expected morphological developments in time steps of 5 year. The degree of certainty regarding the contours on these maps was very difficult to indicate

2. Case Long-term nourishment strategy

Another example for which the framework has been used is the long-term nourishment strategy for the Dutch coast. This is an ongoing project. The framework was mainly used in order to define costs and identify cost-related optimisation aspects.

Step 1 Uncertainties, risks and values

- Many uncertainties related to project alternatives are less relevant on a regional and long-term scale. Location, volumes, contract conditions, policies especially with respect to coastal management and fundamental discussions regarding discount rates are the most important.
- Since all scenarios work with mega-nourishments with functional time steps of less than 20 years, uncertainties regarding morphological development and climate change are expected to lead to adaptations on the long term. If more sand is needed, the next mega nourishment probably will come earlier and have a larger volume. If less sand is needed, the next mega nourishment will be phased later and may have a smaller volume.

Step 2 Prices and performance

- Contract conditions are very important for market prices. Mega-nourishments will generally lead to a lower price per unit sand, but one may assume that, depending on the type of contract, also for periodic smaller-scale nourishments attractive unit prices can be negotiated.
- Price development shows that the combination of fuel price development, nourishment efficiency related to technological development and discount rates govern the total costs of long-term strategies. The differences in costs in the long run are very large and those between alternative strategies are substantial. Decisions on seaward coastal extension strategies, but also on strategies to maintain the present coastline are strongly dependent upon policy and principal decisions regarding the discount rate.
- Functional risk analysis was less relevant in this case, since the morphological model used did not provide sufficiently detailed information. Long term performance mainly depends on price development and coastal maintenance objectives.
- An analysis of other performance benefits shows that they play only a minor role in defining coastal strategies, since the economical benefits produced are very small compared to the costs of coastal maintenance.

Step 3 Valuation and costing

- Discount rates have an overwhelming influence on the long-term cost-effectiveness of nourishment strategies. Although trends in the unit costs of nourishment are also important, the discount rate is the most important single factor that influences the economic comparison between periodic small-scale nourishments and mega-nourishments.
- Future developments in price differentiation range and trends have a large bandwidth. Like the discount ratio, this aspect is also implicitly governed by political decisions.
- Unforeseen engineering and project contingencies do not play a role in long term strategies. Option values are strongly related to policies regarding coastal management, such as the maintenance of the coastal foundation.

Step 4 Design and communication

- The efficiency of a mega-nourishment in terms of coastline maintenance depends very much on its location and not so much on its form. Clearly, the financial implications of uncertainties regarding morphological development are larger if a mega-nourishment is not placed at a location were the sand is needed. So also in the case of a long-term nourishment strategy, the present sections facing erosion are also the best locations for a mega-nourishment.
- A seaward shift of the coastline is usually very costly. The coastal functions that can act as a driving force of a seaward shift are the same as those of land reclamation (harbor development and housing). Recreation, water supply and nature may be incorporated in more integral plans but are by themselves no single (economic) motive for a seaward advance. One should note that a sea ward advance will lead to an adjustment of the coastline over a longer stretch of coast. Here in time possibilities arise for nature and recreation, without implying additional costs.

- The project used a tool to show the consequences of a nourishment strategy over a longer time frame. This offered good information to stakeholder discussions. The tool also showed effects on coastal functions and the costs of nourishment strategies. However, uncertainties were not made explicit. Especially on the longer term uncertainties are large, but perhaps not that relevant to most stakeholder groups that mainly focus on short-term effects and benefits.

3. Conclusions

Overall one may state that decisions and assumptions regarding price development and discount rates are more important to the comparison of long-term nourishment strategies with strategies that involve more frequent forms of nourishment than fine-tuning morphological projections.

The cost-efficiency of a nourishment-based strategy is mainly related to volume, location and longevity of the nourishments. From a coastal maintenance point of view the most relevant locations can easily be pointed out, but whether these also fit local socio-economic and environmental ambitions regarding the coast is another issue.

Mega-nourishments that are maintained are far less efficient than nourishments that are allowed to erode and contribute most of their volume to coastal maintenance. Purely on the basis of costs and benefits of maintaining the coastline, a more permanent character of a mega-nourishment is usually not defendable. One possible exception are urban areas on the coasts, with expensive hardware such as boulevards and hotels, another one is a wave-attenuating shallow sandy foreshore in front of a dike that one does not want to raise.

The optimal volume from a coastline maintenance point of view depends on the coastal erosion rate, nourishment efficiency, costs and discount rates. Erosion rate estimates can be based on past experience, the efficiency of a nourishment depends mainly on its location and longevity. The costs of nourishment are to a certain extent related to the economy of scale, but contract conditions are also important.

Larger nourishments at a single location are substantially less costly if they are placed on the beach, but overall foreshore nourishments are the cheapest to place, but they are usually less efficient in terms of the percentage of sand reaching the dry beach.

Discount rates are the most important economic factor, but also a matter of principle. So one may state that financial aspects, such as contract conditions and discount rates, are the key factors that drive a decision between nourishment-based coastal maintenance strategies, more so than long-term morphological projections.

The monetary benefits to other functions are small compared to the costs of a nourishment, so decisions based on economic considerations will be largely determined by the primary function, in this case coastline maintenance.

For long-term strategies there are many factors that may influence the functional performance of a strategy. However if individual mega-nourishments involve volumes that anticipate expected nourishment needs for periods up to 20 or 25 years, there still is ample opportunity to steer and redirect if the expected performance does not materialize. So implicitly the relevant uncertainties consist mainly of the uncertainties in the expected lifetime of the initial project. The influence of uncertainties increases as this expected lifetime is longer, so with increasing volume. Hence in the case of very dynamic coasts, comparatively smaller mega nourishments are the better proposition.

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>> Read more

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