Including natural value in decision-making - Nature Index

Including natural value in decision-making (Nature Index)

Type: Method

Project Phase: Initiation, Planning and Design

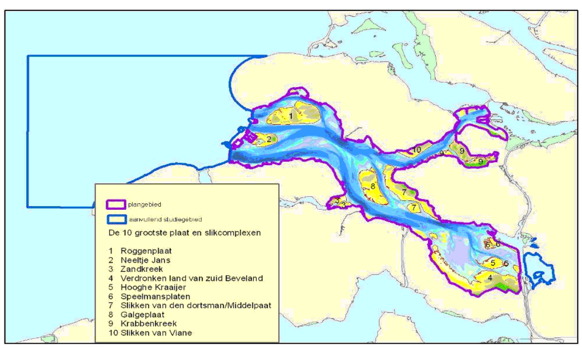
Purpose: Providing a quantitative nature index to include natural qualities in decision-making process

Requirements: Ecological knowledge

Relevant Software: Excel or similar programme

About

The Nature Index tool provides a method to quantify the change in nature value within a project area that results from proposed interventions. The tool translates a nature value into nature points, to allow for a quantified comparison between alternatives. It requires four steps to determine the effect of a certain intervention on the number of nature points. The tool can be used when the feasibility of an intervention or project has to be demonstrated or when an (i.e. cost effective) alternative has to be chosen.



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The Nature Index assesses intervention alternatives by awarding points to areas (hectares) of nature. The higher the quality or the more highly valued, the more points an ecotope gets. The method then compares alternatives by the number of points received. The points are preferably based on (inter) national criteria as set out in policy documents such as the Water Framework Directive or Natura 2000. When objective criteria are lacking, points will be based on expert judgement.

The origin of the nature index tool lies within the Netherlands Environmental Assessment Agency (PBL), the national institute for strategic policy analysis in the field of environment, nature and spatial planning (Sijtsma et al., 2009). The agency has developed a method to assess the permanent effects of policy alternatives for terrestrial nature. In the 'Building with Nature' innovation programme this method has been developed further, which now applies to all natural systems, including aquatic/ marine systems. In addition, anticipated changes over time can be included, which enables valuation of dynamic as well as static effects of interventions.

5 Basic steps towards Building with Nature

Related Building solutions

Ecological landscaping of seabed

Foreshores in freshwater environments

Governance assessment and scoping

Habitat requirements for shellfish

Habitat requirements for salt marshes

Habitat requirements for Seagrass

Inland shores

Innovative contracting for BwN

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Enriching revetments

Strategically placing mud

Related Projects

Eastern Scheldt dike foreshore ecological upgrading, NL

Ecological landscaping of sand extraction sites, NL

Knowledge - Ecosystem services

Related Tools

Contingent Valuation Method for Nature Valuation

Building with Nature interest

1) The system analysis approach facilitates the assessment of changes in ecological quality rather than ecological status:

Building with Nature strives for tuning and optimization of infrastructural designs and natural processes. It also aims at increasing natural values, existing as well as new ones. Quantifying the effects of infrastructural works on natural processes requires a system analysis, which is provided by the Nature Index approach. The overall philosophy of the (eco)system analysis is that nature values can increase if the required abiotic conditions are provided. Large infrastructural projects and/ or measures to improve the ecological status of an area do affect these abiotic conditions. Indirectly - via system relations – they may also affect the relevant indicator species. Therefore, a system analysis is necessary to identify the ecological impact of such projects. Although this may seem obvious, many ecological studies, and sometimes even legislation, focus on the ecological status (by means of indicator species), rather than the change in ecological quality resulting from interventions in the system.

2) It enables a budget approach to nature values, which provides the flexibility needed for multi-functional (integral) design processes:

Building with Nature designs aim at multi-functionality, including ecosystem services and nature values. This means that a balance has to be found between different functions. A budget approach can be of use here, provided that relevant values can be expressed in an adequate ‘currency’. When applied to nature values, with the Nature index as a currency, such a budget approach leaves room for compensating negative effects with positive ones. So far, this budget approach remains to be widely accepted. Now it is still possible that a measure with a positive nature index gets a negative score in an environmental impact assessment because it has a negative effect on a legally protected indicator species. For this reason, we expect budget approaches to become more widely used in the future.

How to Use

The Nature Index tool quantifies the change in nature value due to the design alternatives considered. In four steps, the tool translates the nature value into a quantitative score: nature points, where more points indicate a higher value:

1. Defining the project
2. Assessing the change in ecotope quality
3. Weighting of different ecotopes
4. Assessing the Nature Index

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General information

The tool can be used in situations where the feasibility of a project has to be demonstrated or where the best (cost effective) alternative has to be chosen. Applying the tool requires ecological knowledge. The tool is based on an ecological system analysis with efforts to quantify as much as possible. One should be capable to program and operate a programme like Excel.

It turns out that the system analysis approach requires significant (research) efforts. At first sight, this may make the method less applicable to studies in the initiation phase of a project. Yet, during a project one always benefits from a sound ecosystem analysis, so for projects that survive the initiation phase the effort pays back. The system analysis produces all the information needed for a proper assessment. At first sight, this approach requires more input information than assessments based solely on target species, but note that the latter also require a system analysis.

Quantification of ecological effects has advocates and opponents. On the one hand it can lead to transparent information to support decision-making. However, it also points out what data is available, what information is lacking and what assumptions have to be made. A method like the nature index tool is vulnerable for criticism, as it explicates the information that is missing and that had to be filled in with expert judgement. The more qualitative approaches do have to deal with the same lack of information and uncertainty in evaluating the effects. But these methods have more margin in presenting the results.

Frame of Reference for specialist and end-user interaction

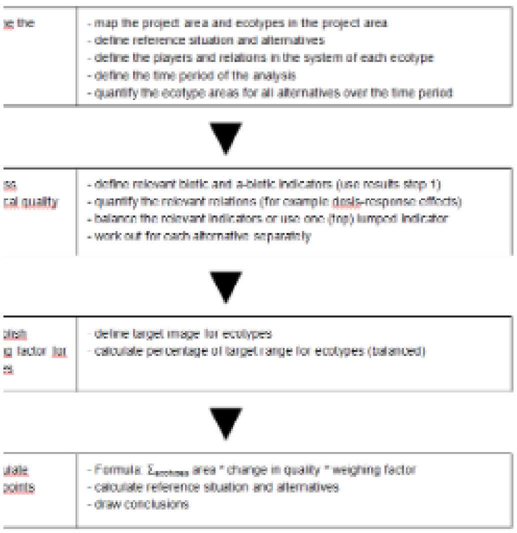
Monte Carlo simulation and Social Cost Benefit Analysis

Probabilistic analysis of ecological effects - Cause-effect chain modeling

System Analysis

Valuation of risks and opportunities in BwN

Visualising and managing uncertainties



Phases to determine Nature Index

Step 1: Defining the project

Step 1 provides the basis for the further analysis. It results in a map of the project area that shows the relevant ecotopes. Step 1 consists of the following sub-steps:

1a) Mapping of the project area and its ecotopes. The project area includes all areas that are positively or negatively influenced by any alternative. The project area is not necessarily continuous, but may consist of separate patches in the landscape. The project area should be the same for all alternatives, in order to be able to compare their nature indices. To define ecotopes in the project area, legislative documents are the starting point. In Europe, these are the Water Framework Directive, Natura 2000, or national legislation derived from these European frameworks. These documents are the preferred basis for nature indexing since they provide a shared and broadly accepted frame of reference. When information from these documents is not sufficient, not available, or reasons exist for not using it, expert judgement may be used to complete the information. In that case it is strongly advised to organize expert meetings, in order to have the ecotope definition commonly accepted. If alternatives affect ecotopes that are not mentioned in legislative documents, they should also be included in the analysis. If only a part of an ecotope is affected, we recommend to split this ecotope into two: a) the ecotope affected, and b) the ecotope not affected. Finally, visualization clarifies matters for discussion and ensures that the entire project area is covered with ecotopes.

1b) Defining the reference situation and design alternatives. The nature index study considers a number of predefined design alternatives and the reference situation. In most cases the reference situation is the current situation plus the expected autonomous development. The definition of the latter may be non-trivial, especially if other projects are foreseen in the area. Depending on the type of project, design alternatives may lead to a wide variety of ecological effects within the project area. When defining these alternatives it is important to consider the availability of ecological information, such as species numbers, soil parameters and cause-effect relations. Doing so in the very beginning of the design process yields a first estimate of the scale of the nature index study to be carried out.

1c) Defining the system components and relations for each ecotope. Each ecotope is a dynamic system of which the main components and their interrelations and interactions need to be identified and understood. Based on this understanding, it is possible to indicate which effects influence which ecotope quality and to what extent. As this approach treats ecotopes as dynamic systems, it reaches beyond merely satisfying the legal obligation to protect certain species. In addition to the system identification, the driving abiotic factors need to be identified. Natural drivers such as tidal fluctuations and water currents, but also human activities such as nutrient loading or nature management, should be included. Also the time-variation of these abiotic factors, either autonomous or in response to the project, needs to be known.

1d) Defining the time period of the analysis. t=0 is the start of the project, which mostly coincides with the implementation of measures or structures. The time period ends when all effects have materialised, or (for practical reasons) after a maximum of 100 years. Besides permanent effects, a project may causes significant temporary effects. The nature index takes both into account.

1e) Quantifying the ecotope areas per alternative and time period. The area of each ecotope has to be calculated (in hectares) and serves as the basis for the attribution of nature points. The ecotope areas have to be determined for the reference situation and for each design alternative considered. Make sure that the totals add up to 100% of the project area.

Step 2: Assessing the change in ecotope quality

In this step, the time-evolution of the ecotope quality is assessed. This step is probably the most challenging and complex of the tool. The quality of an ecotope may change autonomously or in response to the project. Step 2 consists of the following sub steps:

2a) Determining the quality indicators per ecotope and their state for a 100% intact ecotope. One measure for the quality of an ecosystem is biodiversity (the presence of species). In an international context, considerable effort has been put into standardisation of indicators of biodiversity. UNEP has developed the Mean Species Abundance as an indicator of the quality of ecosystems. The method is based on a widely accepted set of species characteristic for an ecosystem. The nature index tool uses a localised version of the Mean Species Abundance: for every local ecosystem one can define the species that are able to or supposed to live in that system (see also Sijtsma et al. 2009). The Nature Index tool expresses nature quality per ecotope in percentages. A nature quality of 0% reflects absence of species, while a nature quality of 100% reflects abundance of species matching a healthy or intact ecotope. The healthy ecotope is the desired quality of the ecotope and serves as a reference.

To define indicators and their potential value (= intact ecotope), we take legislative documents such as the Water Framework Directive, Natura 2000, or national legislation derived from these European frameworks as the starting point (see step 1.1 for argumentation). The nature index tool is flexible with the level of detail of indicators, e.g.:

- specify one lumped indicator that reflects the quality of the ecotope (in relation to the project goal), or;
- specify indicators directly related to the project goals only, or
- assess the status of the complete ecosystem. In this case it is advisable (for workability) to categorise the indicator species in species groups and take the average of the quality per group. For an example, we refer to Wortelboer (2010) who performs an analysis of nature quality of the Dutch saltwater systems. He categorises the indicator species in the groups phytoplankton, benthos, fish, birds and mammals.

2b) Determining the required input values for the indicators for different design alternatives. Estimating the current or future quality of an ecotope is often difficult. Note that the absolute value of ecotope quality is not the most important information. More relevant are the relative quality differences between alternatives. One of the most challenging issues with indicator valuation is the fact that it should also be valid in the future, with and without a project. Predicting the effect of the autonomous development and the project on the quality of species, such that alternatives become comparable, requires expert judgement and, where possible, modelling. There is a great variety in modelling tools with regard to ecological processes. For every case or plan area, the selection of suitable tools can be different. Moreover, these modelling tools are very actively being invented, renewed and improved. A summary of the currently existing, useful models is described in the STOWA report (2009). Here, Excel is used as a modelling environment. In addition, information from other tools, such as the dose-effect relations from Deltares HABITAT can be used to describe the interrelations between species groups and the changes of the abiotic parameters over time.

2c) Estimating the current quality of each ecotope (%) and the change in quality over time. The quality of the ecotope at the end of the time period reflects the permanent effects of the project. In addition, temporary effects may seriously affect an ecotope for some time, after which it may recover. To express these effects – and thus enable comparison between alternatives – the Nature Index tool assesses the quality of ecotopes over the complete time period.

Step 3: Weighting of different ecotopes

Step 1 and 2 define the relevant ecotopes in the project area and their quality state, irrespective of their relative importance. Some ecotopes represent a higher nature value because they have a higher biodiversity or include rare species. In the nature index tool, these elements have to be accounted for. For example, changing a precious intertidal area with low-quality brackish water into a widespread deep area with high quality sea water would be beneficial in such an index. Therefore, the nature index tool has to correct for rarity and/ or larger-scale biodiversity. If we don't take the relative value of ecotopes into account, undesired effects may occur.

For terrestrial ecotopes different weighting factors are determined, based on the presence of rare species and biodiversity (Sijtsma et al, 2009). ecotopes get more weight if they include species that are not hosted in (most) other ecotopes and they get more weight if they host a lot of different species (high biodiversity). These weighting factors balance the ecotopes at a larger scale and make nature point values comparable across projects. It is not possible to use this system for aquatic ecotopes, as the data to determine rarity and biodiversity are lacking. For aquatic ecotopes one therefore has to work with a local weighting system. Such a system works on the basis of indicators that account for the relative abundance of ecotopes in the project area. When an ecotope diverges extremely from the target situation (e.g the historic reference situation or the policy objective), than it should be weighted with a relatively high factor.

The use of local weighting factors requires the definition of a so-called target situation, i.e. the ecological situation that we strive for in the project area. It can be the same as the 'natural' situation, but not necessarily. In some cases human intervention cannot be completely overcome. For example, the storm surge barrier affects the ecological conditions in the Eastern Scheldt estuary significantly. Yet, the barrier will not be removed because of its coastal protection function (if it would be technically possible to remove it, at all). This should be taken into account when defining a realistic ecological target situation for the estuary. In Europe, the target situation can be abstracted from existing legislative documents like the Water Framework Directive.

Scheme for determining the weighting factors for the current situation.

	target situation (%)	current situation (%)(part of step 1)	weighing balance
ecotope X	...	...	...
ecotope Y	...	...	...
ecotope Z	...	...	...
total	100	100	

When the (local) weighting factor is established by means of deviation from the target situation, the weighting factor can change over time - for example when the area of the ecotope changes over the years. In that case a new weighting factor has to be calculated (i.e. a new comparison with the target situation).

Step 4: Assessing the Nature Index

With all the data generated - area, quality index and weighting factors - it is easy to calculate the nature points as the formula only multiplies the elements:

relative area per ecotope * index ecotope quality * weighting factor

(where denotes summation over all ecotopes in the plan area).

Scheme for calculating the nature points.

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	etc.
area ecotope X												
area ecotope Y												
area ecotope Z												
quality ecotope X												
quality ecotope Y												
quality ecotope Z												
weighting factor X												
weighting factor Y												
weighting factor Z												
total												

The nature points are calculated for the reference situation and each design alternative. In principle the nature points are calculated per year (as the scheme for calculating nature points illustrates). The question is how to determine nature values for the whole time period from these yearly ones. There are two options:

- by adding up the yearly results;
- by discounting and determining a ‘net present value’.

The second option is more familiar to economists than to ecologists. By discounting one takes into account that short-term effects are preferred over long-term effects. Discounting also reflects the uncertainty whether the rated effects will materialise. A high discount rate therefore corresponds with a strong preference for short-term effects and a high uncertainty. Although in principle there is nothing wrong with discounting ecological effects, it seems too far fetched for current nature valuation practice. Moreover, there is no accepted practice to determine realistic discount rates.

Recommendation and Advice

A major challenge in the process of nature valuation is to determine the necessary level of detail, especially in the assessment of changes in ecotopes and ecotope qualities. This requires thoughtful consideration before carrying out the actual analyses. The challenge is to find a balance between the necessary detail for proper representation of the system and the data, time and money available for the analysis. This level of detail will be different for each case, but in general ecotopes, species groups and driving abiotic parameters need to be included to allow for the execution of the above described steps.

Practical Applications

The nature conservation plans in the Dutch Eastern Scheldt estuary serve as an example to illustrate the application of the Nature Index tool. The illustration follows the consecutive steps of the Nature Index tool.

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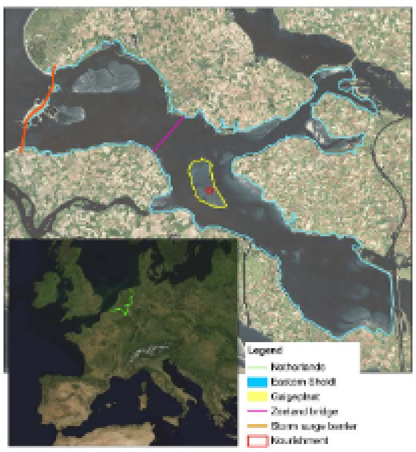
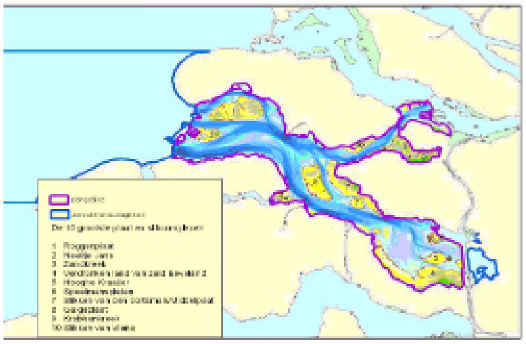
Step 1 Defining the project: sand deficit in the Eastern Scheldt estuary



After the 1953 flood in the southwest of the Netherlands, a movable storm surge barrier was built in the mouth of the Eastern Scheldt, at that time a branc

The Dutch government, represented by its agency Rijkswaterstaat, aims to develop a policy for conservation of the intertidal areas. Scientists expect that - without intervention - almost all intertidal area will be lost by the end of this century. Sand nourishment on top of the intertidal shoals is one measure to compensate for erosion, be it only with a temporary effect. A pilot application has been realised on the Ga lgeplaat, one of the major shoals in the basin. Shoal nourishment will have a positive effect on nature in the long run, but a negative short-term effect (burial) in the nourished area. This case description is real, but some of the numbers in this document, especially those for the ecotope quality, are necessarily fictive or based on an educated guess. The nature valuation presented below was performed in 2012, which was still early days for the ecological part of the sand deficit study.

1a) map the project area and its ecotopes



The figure on the right outlines the boundaries of the project area of the shoal nourishment case study (the Eastern Scheldt estuary) in purple. The total a

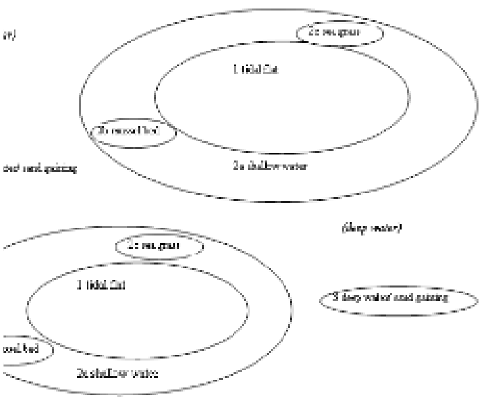
Natura 2000

The Eastern Scheldt estuary is a Special Protected Area (SPA) within the Natura 2000 network. Natura 2000 is an ecological network of protected areas in the territory of the European Union. Member states are required to maintain SPAs in favourable state of conservation. The shoal nourishment aims at contributing to the Natura 2000 goals of the Eastern Scheldt estuary for the ecotope (habitat) ‘large shallow inlets’ profile document H1160. The quality objective for this ecotope is the conservation of the present tidal flats and channels in both variance and area. Essential for the ecotope quality are gradients in morphology (tidal flats vs. deeper channels), processes (dynamic vs. sheltered) and soil conditions (sand vs. mud). The conservation of the ecotope ´large shallow inlets´ is a precondition to (and serves to) maintain bird populations, another Natura 2000 goal in the area. The quality of the ecotope is mainly judged in the light of conservation of these bird populations. The Natura 2000 profile document (2008) provides a description of this habitat in a good state regarding structure and function:

- presence of tide;
- presence of natural channels;
- variation of sandy and sludgy parts, including transition areas;
- variation in height with both tidal flats and permanently flooded area;
- variation in high- and low-dynamic area;
- good water quality (transparency, salt);
- presence of sea grass and ruppia fields
- presence of rich mussel beds;
- presence of algae or a layer with diatoms and cyanobacteria;
- presence of species: benthos, fish, birds, mammals.

Water Framework Directive (WFD)

All water bodies in the EU have received a classification as WFD water type. The Eastern Scheldt estuary is a WFD water type ‘coastal water, shielded and polyhaline (K2)’. The WFD sets nature conservation goals for each of its water types. The following goals of the Eastern Scheldt estuary are relevant for the shoal nourishment case study: a balance between intertidal area/ shallow water/ mussel beds, % of natural coastline and hectares of sea grass area. The WFD sets target values for the formulated goals based on a realistic reference situation, which is deduced from the natural (historic) reference situation. The degree of goal realisation is expressed in % of the target value.



The level of detail of the WFD conservation goals fits this analysis best and therefore it is taken as the basis for further analysis. The description of the hal

1b) Define the reference situation and the design alternatives

Scenario 1: Reference situation: autonomous development without tidal flat nourishment

In this situation no tidal flat nourishment takes place and therefore the tidal flat area (ecotope 1) in the Eastern Scheldt basin decreases strongly. In addition, the sand deficit reduces the duration of the dry stage and increases the speed of flooding. So there will be less food and less time to forage on it. Both effects are detrimental to the wading bird population. In 1986, the tidal flat area was more than 11.000 hectare. By 2011, about 1.100 hectare had been lost. Without interventions, half the intertidal area will have disappeared in 2050. Before 2100, scientists expect the intertidal area to have come down to 1500 hectare, at which point a new equilibrium state will have established (Van Zanten & Adriaanse, 2008). The submergence of tidal flats increases the shallow water area (ecotope 2). The deep water area (ecotope 5) will not increase or decrease significantly.

Scenario 2: Shore alternative: nourishment of tidal flats along the shoreline

In this alternative the nourishment is limited to the tidal flat areas directly adjacent to the shoreline, 500 hectares in total. The nourishment contributes to nature value as well as flood safety. The nature quality effects in this alternative are both permanent and temporary. The tidal flat area (ecotope 1) still reduces permanently, since the nourished volume is relatively small. In addition, the nourishment activity has two temporary negative effects on the tidal flat area. Firstly, burial by sand causes a temporary loss of species (Holzhauer & van der Werf, 2009). After completion, species recolonise the sand layer within a period of about 3-5 years. This recolonisation rate depends on the thickness and characteristics of the sand layer, the physical distance to the surviving ecosystem and the migration characteristics of surviving fellow species. Secondly, sand transport away from the nourishment may disturb the wading birds and mammals (seals) in the surrounding tidal flat area. The actual disturbance also depends on the timing of the activity.

The shallow water area (ecotope 2) increases when tidal flats become submerged. As this will not be the case for nourished areas, this effect will be smaller than in the autonomous development. The nourishment therefore has a temporary negative effect on the shallow water area. Depending on how the nourishment is realised, the activity results in more or less suspended matter in the water column directly adjacent to the nourished area. The resulting turbidity may temporarily affect benthos and fish, and if much of this sand is deposited it may also harm filter feeders (mussels, oysters).

The deep water area (ecotope 5) will not increase or decrease significantly. The sand extraction does have a more or less permanent negative effect on the borrow area. The benthos in the borrow area is probably destroyed completely and, depending on the depth of the sand pit, will take time to recover or will not recover at all. In addition, dredging may have a temporary negative effect via the turbid plume it creates. Depending on the intensity and the duration of the ensuing stress, this may affect benthos and fish (see also the tool Species Response Curves for Seagrass).

Scenario 3: Tidal flat alternative: nourishment of all tidal flats

In the tidal flat alternative, the aim is to maintain the current tidal flat area (10.000 hectare) and its quality. To maintain the current area, 8.500 hectare tidal flat is nourished. The other 1.500 hectare does not erode since these flats are located in sheltered areas. The tidal flats are nourished one by one. Nourishing the whole area at one time is both unfeasible (in terms of amount of sand required) and undesirable (in terms of environmental damage). For this case study example, the maximum area affected by a single nourishment is set at 10%. Furthermore, after a number of years the nourished areas have to be re-nourished for maintenance. The ratio tidal flat/ shallow water in this alternative remains the same as in the current situation. The negative side-effects of nourishment and sand mining are similar to those described for the shore alternative.

1c) Define components and system relations for each ecotope

First, the biotic players in the plan area will be identified. Note that their interrelations are not necessarily predator-prey related, but can also be non-food relations such as vegetation providing shelter for fish to grow up. In the biotic domain, the most important players are:

- filter feeders that affect and are affected by turbidity and are an important food source to birds;
- vegetation, which is both legally protected (Zostera spec. and Chara spec.) and important as food source, habitat for fish and water quality filter;
- fish, which are an important food source for birds and seal, and feed on filter feeders and vegetation;
- birds, highly diverse, most of which are legally protected and feed on filter feeders, vegetation and fish.
- predators, mainly seal (legally protected), which feed on fish and are at the top of the local food chain.

The second step is to define the most important abiotic influences. These can be either natural or human-induced. The focus of this step is to identify the abiotic parameters that will change over time. The Eastern Scheldt estuary system can roughly be defined as dynamic, brackish and semi-terrestrial. The driving processes are:

- tide: not as strong as before the storm-surge barrier, but still present. Tidal fluctuation influences water depth and morphology;
- water depth: influenced by tidal fluctuation and morphology, affects vegetation, birds and filter feeders;
- salinity: has decreased since the construction of the storm-surge barrier, and is not influenced by any of the above;
- turbidity: mainly due to suspended particles, influenced by water depth and morphology; affects filter feeders, vegetation and fish.

1d) Define the time period of the analysis

The Dutch government considers nourishment as the policy line for the coming decades. Other alternatives, such as adaptation of the Delta works, come in view in 2100 at the earliest. Nourishing requires regular maintenance and therefore is a continual activity with long-term effects. Therefore it was decided to start the analysis in 2010, at the start of the shoal nourishment case study, and take a time frame until 2100.

1e) Quantify the ecotope areas per alternative over the time period

The table below presents the areas of different ecotopes per scenarios over time.

Ecotope areas for the reference situation (autonomous development) and design alternatives in 2010 and in 2100.

ecotope	area (ha in 2010)	autonomous development (ha in 2100)	shore alternative (ha in 2100)	tidal flat alternative (ha in 2100)
1. tidal flats a. tidal flat b. suppleted tidal flat	**10.000** 10.000 0	**1.500** 1.500 0	**2.000 ***** 2.000 0	**10.000** 10.000 0
2. shallow water c. shallow water d. sea grass e. mussel bed	**8.000 *** 7.629 21[1] 350*	**16.500** 15.779 21 350	**16.000** 15.279 21 350	**8.000** 7629 21 350
3. deep water a. deep water b. sand gaining	**850** 850 0	**850** 850 0	**850** 825 25	**850** 0 850**
Total	**18.850**	**18.850**	**18.850**	**18.850**

[1] year 2001-2006, source: STOWA 2007-32

Starting points in completing the accompanying excel spreadsheet are in general:

- submerged tidal flats become shallow water;
- the recovery time of a nourished tidal flat is 5 years, thereafter the area is completely recovered and becomes a tidal flat again in the spreadsheet.

Specific starting points for the shore alternative are:

- the nourishment of 500 hectare tidal flat takes place in 2015 and is repeated in 2060. This area does not submerge in the period 2015-2100;
- a sand borrow pit of 25 hectare is dug in 2015 and deepened in 2060.

Specific starting points for the tidal flat alternative are:

- a maximum of 10% (1000 hectare) of the tidal flat area is affected by one nourishment. The 8500 hectare of tidal flats at risk are nourished in two rounds, where already submerged area is treated first. After the recovery time of 5 years, a new area of 1000 hectare is nourished. In the period 2015-2100, every hectare is visited twice. After the second nourishment the area remains intertidal until 2100;
- a sand borrow pit of 50 hectare is dug for every nourishment round.

Step 2: Assessing change in ecotope quality

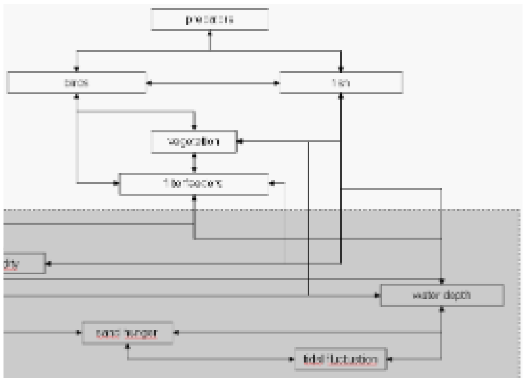
2a) Determine quality indicators

In this part of the analysis, the quality change of the ecosystem over time will be analysed for each alternative. After the ecosystem is defined (see step 1), first the abiotic parameters will be discussed, followed by their influence on each of the species groups. Subsequently, the method for determining a quality index will be explained. In step 1 the main species groups in the ecosystem of the plan area were identified (see figure on the right).

Abiotic parameters

The abiotic parameters can be defined to an arbitrary degree of complexity, but for the purpose of this qualitative analysis it is convenient to only define parameters that will change over time or between alternatives. In the Eastern Scheldt example, the following parameters are defined:

- turbidity;
- substrate type;
- light penetration;
- water depth;
- drought duration.



Biotic relations

The most important biotic components are:

- benthos;
- vegetation;
- fish;
- birds.

Step 3 Determining the weighting factors

For the shoal nourishment project the local weighting factors are derived from the Water Framework Directive, meaning that both the target situation and the current situation are taken from the WFD. In this table the relative areas of the ecotopes in the Eastern Scheldt are presented for the target and current situation.

Weighting factors for the Eastern Scheldt estuary.

ecotope	target situation	current situation (%)	weighing factor
tidal flat	33,0%	17,8%	0,05
shallow water	40,2%	37,8%	0,03
sea grass	7,0%	0,14%	1,31
(lithoral) mussel bed	1,8%	0,00%	2,62
total	82,0%	55,8%	4

This example of the Eastern Scheldt shows that the weighting factor can vary widely. A hectare of sea grass can be worth 27 times more points than a tidal flat. This is not surprising as sea grass is almost extinct, while it should cover about 7% of the area. Damaging the last remaining hectares of sea grass should be attributed a high negative value, whilst measures to develop sea grass meadows get a high positive value.

The example of the Eastern Scheldt estuary also points out is that it is difficult to calculate the weighting factor for ecotopes that have completely disappeared - for instance the littoral mussel beds. This ecotope should cover about 1,8% of the area, but in the current situation no area of mussel beds is left. If the percentage is zero, no weighing factor can be calculated (the formula is dividing by 0). A pragmatic solution is to work with a minimum of 1% of the target situation - resulting in the presented weighing factor. It also raises the discussion whether the target situation is realistic. Perhaps the littoral mussel bed should not be part of the list if reintroduction of the ecotope is necessary.

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>> Read more

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