System Analysis

The content of the Building with Nature guidelines was moved to EcoShape.org
Click the link above if you are not automatically redirected within 10 seconds.

System Analysis

Type: Method

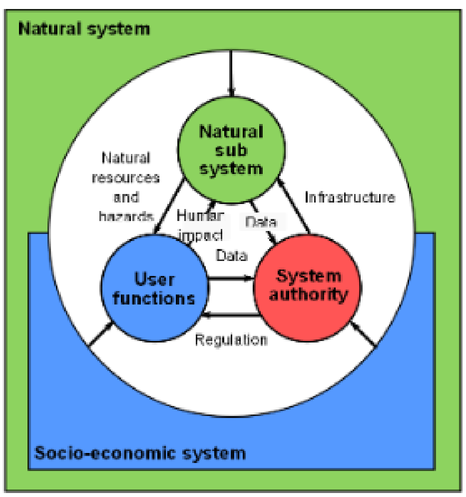
Project Phase: Initiation, Planning and Design

Purpose: Understanding systems functioning by analysing the interactions between/ within its natural and socio-economic subsystems

Requirement: Multidisciplinary team

Relevant Software: none

About



The natural system is the starting-point of any Building with Nature project. In order to develop solutions, the general scope and structure of the system need to be defined. To understand the physical, functional and regulatory aspects that are involved, a consistent systems approach is required.The Systems Analysis tool provides guidance to be able to apply this approach within the Building with Nature context, providing the theoretical background behind system analysis. For a more applied description of a system the Ecomindmap or the stakeholder analysis tool can be used. By definition any system analysis deals with elements and relationships between those elements. The action of the whole can only be understood by knowledge of the interactions of all the parts. The work of systems analysis is to select a system or subsystem to be analysed, define its boundary, identify the components and to develop models that describe the interaction of these components. It starts by insisting on a clear understanding of exactly what the problem is and the goal that should dominate the solution and lead to the criteria for evaluating alternative avenues.

>> Read more

Subsystems

5 Basic steps towards Building with Nature

Related Building solutions

Governance assessment and scoping

Habitat requirements for corals

Habitat requirements for seagrass

Innovative contracting for BwN

Creating hanging and floating structures

Related Projects

Area development for sustainability - Wieringerrandmeer, NL

Coral Protection - Puerto Caucedo Dredging, DO

Knowledge - Ecosystem services

Knowledge - Sediment and ecology in delta lakes

Sand nourishment - Hondsbossche Dunes, NL

Sustainable development - Perkpolder ferry port, NL

Related Tools

Frame of Reference for specialist and end-user interaction

Identification of ecological and socio-economic components - EcoMindmap

The figure shows a typical system diagram for projects in a BwN context (Van der Weide, 1993, Van der Weide and Van Koningsveld, 2003). At the highest level of abstraction, the system is controlled by two main elements: the natural system and the socio-economic system. The former includes all components of the abiotic and biotic environment and the latter includes the users, and the required physical and social infrastructure. The natural subsystem is the field of natural sciences whereas social sciences are required to describe the anthropogenic subsystem. The interactions between the two subsystems and their respective structure and internal processes are depicted in the diagram as well. The interactions between the natural and socio-economic subsystems can be categorised into:

1. Environmental services, the positive services provided by the natural system to society. This includes resource use, the use of space and renewable or non-renewable natural resources for social and economic activities
2. Natural hazards, the negative impact of nature on the man-made environment
3. Positive ecological effects as a result of BwN solutions
4. Environmental impacts, the negative impact of social and economic activities on the functions of nature, i.e. the production of renewable resources and the regulation of vital processes

Natural system **Socio-economic system**	Positive: Negative:	1. Environmental services 2. Natural hazards
Socio-economic system **Natural system**	Positive: Negative:	3. **BwN solutions** 4. Environmental impacts

The socio-economic subsystem can be divided into a functional (user functions) and regulatory part (system authority). The user functions represent the entire set of human interests in terms of use which is or may be made of the natural resources. The regulatory subsystem contains mechanisms and instruments to control interactions between the natural and socio-economic subsystem. Legislation and institutional arrangements are examples of instruments; the involvement of all stakeholders in the decision making process, as a means to create public support, is an example of a mechanism.

Cross border effects

The systems approach can be applied to different spatial scales. In their books “Limits to Growth” and “Beyond the Limits”, Meadows et al. (1972, 1992) apply a systems approach to the whole world. In practice, however, the system only represents a part of the world. In order to account for the interaction with the environment outside the system, cross border effects have to be included in the system description.

BwN interest

A well-defined system diagram is a useful tool in problem analysis and problem solving. A system analysis for BwN projects should focus on the interaction between various systems. Ecosystem knowledge is especially important for identifying essential supporting services and related natural processes. (e.g. transport, carrying and restoration capacities.) Combining these opportunities that a certain system environment may offer could benefit the project as a whole. Identifying potential win-wins with other projects is another characteristic of a BwN system analysis. Many BwN projects use material that may become available as part of another project. Dredging shipping lanes and harbours generates dredging sludge that may be used for nature restoration purposes or the creation of green defences. Long-term strategies may incorporate a steady stream of dredging sludge, using an incremental development approach. One of the first steps in the EDD-approach is to widen the project scope and make it greener. A proper system analysis in the initiation phase of the project will help to widen the scope. In subsequent project phases the system analysis will still help to identify potential opportunities in combining services and functions.

How to Use

Setting up a well-defined analysis of the system relevant for the project at hand requires input from a variety of expertise’s. Collaboration between different disciplines should provide with a coherent approach addressing all the key components of a project (natural, social and regulatory). Users of this tool need no special knowledge except their own specific field of expertise.

Including natural value in decision-making - Nature Index

Stakeholder analysis

>> Read more

Phased plan process

Building with Nature designs depend on the environment in which they are planned. Different environments provide different eco-system services, which in turn provide different opportunities for BwN. Systems analysis is a tool to obtain knowledge about the ecosystem in which the BwN project will be developed. This knowledge is necessary to identify:

- long-term processes that determine ecosystem sustainability: transport, building, carrying and restoration capacities;
- ecosystem services;
- opportunities for restoration or enhancement of ecological processes and win-win solutions.

For BwN the link between environment, project and society is mainly made in terms of ecosystem services. In principle every ecosystem service can act as a target variable for the design and may help to make it more cost-effective, more multifunctional and more acceptable to stakeholders. Systems analysis required for BwN projects identifies the links between ecosystem services. Seasonal dynamics, incidents and trends are especially critical if they have an influence on essential supporting services. Often there is a lack of data, which limits the possibilities to do the necessary analysis. In that case reference studies and data should be used.

Ecosystem capacities

An important part of systems analysis is to identify key driving factors, their links to ecosystem processes and services and their capacities. Carrying capacities can be relevant on different system levels. The overall sand balance of the Mississippi Delta will for example determine the long-term sustainability of maintaining the present extension of wetlands and coastlines. Carrying and other capacities of the natural environment are important design variables for a BwN project. It determines limits of what can be done using natural processes. Sometimes a project can become much more cost-effective if its implementation is attuned to natural process capacities. Often, the short-term deadlines require costly engineering interventions. An eco-engineer needs to know the natural process capacities, which include:

1. **Transport and building capacities**
   Set limits to the use of natural driving forces in project design, for example:
   - the (building) capacity of natural dune formation: the net dune growth depends on the beach width and orientation and wind conditions. For coastal protection projects it is important to know whether natural dune formation is fast enough in order to counterbalance sea level rise. The case of the Delfland coast shows that this is in fact the case. It is possible to build a long-term defence strategy purely on natural dune formation, provided that the conditions for dune formation are optimized;
   - the (building) capacity of salt marshes: the growth of salt marshes depends mainly on silt concentrations, tidal activity and wave exposure. Salt marshes may grow with rising sea levels and may therefore provide a lasting service in the attenuation of waves and therefore to coastal protection. A BwN project may use this ability and ensure that the appropriate conditions that make this possible are met;
   - the (transport) capacity of long shore currents: this capacity determines the deployment of sand along the coast in case a mega nourishment is used. The faster the deployment, the longer the coastal section that will be provided with sand.
2. **Carrying and restoration capacities**
   Determine the possible effects on ecosystems and limits to specific ecosystem services, for example:
   - the (carrying) capacity of bottom dwelling communities in case of sand nourishment. In the case of foreshore nourishment, already a thin blanket of sand may kill most benthic organisms present. Bottom dwelling communities are however adjusted to occasional re-suspension and burial during storms. So in some areas dredging material is spread in a way that it simulates storm conditions and hence has limited effects on the environment;
   - the (carrying) capacity of shellfish beds to withstand waves. Shell fish beds are mostly found on locations with limited wave energy. This may mainly be related to the abilities of juveniles to settle and maintain specific morphological positions. In one of the BwN projects, the growth of a shell fish bed was kick started using a biodegradable artificial structure. In this case it is important to know whether a fully grown shellfish bed will be able to maintain its position; and
   - the (carrying) capacity of a coral reef to withstand temporary exposure to higher turbidity levels and sediment concentrations. This is a critical factor for the design of dredging activities in a sensitive area with corals. The lower limit to the environment sets the upper limit for the dredge plumes.

Ecosystem services

Ecosystem services can be divided into four main categories:

1. **Provisioning services**
   The most obvious, since they generate tangible and marketable products. Nevertheless, production services also depend upon supporting services that can only be identified on the basis of more in-depth understanding of population dynamics and ecosystem relations. Spawning and nursery areas are a good example with regard to fisheries. But ecosystem relations can be very complex. A notable example is the flounder. It spawns in the North Sea, to the south of the Netherlands, and larvae reach the nursery areas along the coast by freely floating with tidal currents. Critical to their transport is a slight landward undercurrent that is driven by salinity gradients present because of the inflow of fresh river water from the Rhine. A land reclamation project may adversely influence this undercurrent. Therefore, in preparation of the expansion of the Port of Rotterdam, the flounder was subject to extensive environmental impact studies.
2. **Regulating services**
   Often not readily identified, since they do not, in economic terms, deliver a marketable product. The service they provide can however be very critical, such as maintaining water quality or a wide beach that is essential to beach recreation or coastal safety. Without this regulation services costs would be necessary to deliver similar services, but with man-made installations, such as a waste water treatment plant or structures, such as a dike.
3. **Cultural services**
   Especially important for the public acceptance of a project, although they may have a concrete economic impact. These services depend upon supporting services as well. The formation of attractive beaches may determine beach front property prices, but requires an on-going long shore transport of sand. If this transport is blocked, erosion would be the result with the ultimate risk of property damage.
4. **Supporting services**
   Necessary for the production of all other ecosystem services. Some examples include biomass production, production of atmospheric oxygen, soil formation and retention, nutrient cycling, water cycling, and provisioning of habitat. Supporting services depend upon basic hydraulic and morphological processes. Supporting services are the major drivers and design parameters in most BwN projects. This is due to the fact that most interventions have an influence on hydraulic and morphological processes. In practice nearly every provisioning, regulating and cultural service is linked to processes that start in a web of interrelated supporting services. The focus is not only on fish communities, but also on their spawning, nursery and feeding areas. The vitality of mangrove forests also depends upon sedimentation processes and soil forming processes. And these areas depend upon hydrological and morphological processes. The interaction between abiotic processes and organisms merits special attention. Understanding this relation will help to identify the conditions needed to steer and stimulate colonisation, primary production and so on. It will also help to identify the way in which organisms can actively be used to steer desired morphological or soil forming processes. Pilots are conducted within BwN using shell fish. But smaller organisms, such as algae, may also play an important role in the sedimentation processes that occur on mudflats.

BwN opportunities

The steps mentioned above help to identify impacts and dependencies. The DPSIR tool is an approach that primarily focuses on impacts. But project dependencies are also very important. A project takes place in an environment that is the result of on-going processes and related ecosystem services. An impact analysis focuses on the impact of a project on this environment and vice versa. But there may be other on-going developments that influence the underlying matrix of supporting services. Examples are long-term developments in sand balances, that may be altered due to interventions in adjacent coastal areas or upstream rivers, that block sediment transport. So a comprehensive system analysis goes beyond the mere interaction of the project and its environment, but looks also into overall and general trends.

Practical Applications

1. Building with Nature Environment Pages
2. Integrated Coastal Management

>> Read more

Practical Applications

Example: BwN environment pages.

Physical processes can be highly variable, both in time and in space at a wide range of scales (from individual particle movement to global, sea level rise). Organisms living in a certain environment are adapted to this dynamic environment and reflect the complex biophysical interactions. Human interventions (for example shore nourishment) will change the environment and may generate anomalous habitat conditions. When designing such an intervention, it is therefore essential to consider the biophysical interactions involved and the different scales at which they take place. Building with Nature takes these processes into account and tries to make use of them wherever possible. In the BwN environment pages, the principal processes are being discussed, distinguishing smaller and larger scale processes. Ecosystem knowledge and a thorough description of the system environment is crucial for identifying essential supporting services and related natural processes (e.g. transport, carrying and restoration capacities) (see Identification of ecological and socio-economic components - EcoMindmap). Key driving factors and their link to ecosystem services are important points of focus in a design based on the BwN-principle and can lead to potential opportunities for BwN.

The System Analysis method is used in this elaboration of the environment at hand and provides an overview of EDD experiences and opportunities for several environments i.e. sandy shores, Coastal seas, Delta lakes, Tropical shelf seas and shores and Estuaries. Systems analysis required for BwN projects identifies the links between ecosystem services and their supporting services. It identifies the latter as design parameters. Seasonal dynamics, incidents and trends are especially critical if they have an influence on essential supporting services. Often there is a lack of data, which limits the possibilities to do the necessary analysis. In that case reference studies and data should be used. For BwN the link between environment, project and society is mainly made in terms of ecosystem services. In principle every ecosystem service can act as a target variable for the design and may help to make it more cost-effective, more multifunctional and more acceptable to stakeholders.

Building with Nature designs depend on the environment in which they are planned. Different environments provide different eco-system services, which in turn provides different opportunities for BwN. Systems Analysis is a tool to obtain knowledge about the ecosystem in which the BwN project will be developed. System Analysis aims to clearly define:

- long-term processes that determine ecosystem sustainability: transport, building, carrying and restoration capacities;
- ecosystem services;
- opportunities for restoration or enhancement of ecological processes and win-win solutions.

External example, Integrated Coastal Management

Integrated coastal management is a multidisciplinary and dynamic process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. Integrated coastal management (ICM) can be seen as the link between the system components taking into account both the vertical integration between different levels of government and horizontal integration of different sectors. Equally important, however is the role of ICM in the decision making process and the involvement of the stakeholders in this process as a means to create public support.

For ICM, system analysis is a useful method to model the complex natural and socio-economic processes. Once properly validated, such a system analysis model can be used to quantify the effect of changing external conditions (scenario's) and internal response strategies. The actual solution of ICM problems is extremely complex and involves a great number of aspects. Dealing with those aspects in a responsible, balanced and sustainable manner requires the gathering and processing of vast amounts of information. Reduction is commonly applied by scientists and researchers as a means to solve such complex problems. In this approach problems are decomposed in separate problem areas, for which subsequently solutions are sought which together solve the problem.

Although the identification of problems usually follows the analysis of the system and therefore of data collection, in reality data collection is often driven by key issues/problems. This cannot exclude the possibility of enriching the analysis, at a later stage, adjusting the relevant boundaries of the area concerned. After all the whole process is cyclical. ICM uses the informed participation and cooperation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. ICM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics.

References

>> Read more

- Meadows, D. H.; Meadows, D. L.; Randers, J. & Behrens III, W. W., 1972. The limits to growth. Potomac Associates, New York.
- Meadows, D. H.; Meadows, D. L.; Randers, J. & Behrens III, W. W., 1992. Beyond the limits. Earth Scan Publications.
- Van der Weide, J., 1993. A Systems View of Integrated Coastal Management. *Ocean & Coastal Management* **21**: pp. 129-148
- Van der Weide, J. and M. van Koningsveld, 2001. Enabeling Mechanisms. Progress report of the Balkan Workshop. *Nato Science Publications* - Progress report of the Balkan Workshop, NATO Science Series - Series IV - Earth and Environmental Sciences, **12**: pp. 203-220

Back to Top