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ECOSYSTEM SERVICES, A USEFUL CONCEPT FOR THE RESTORATION OF ESTUARIES?

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ABSTRACT

The Schelde estuary was subjected to major human impacts leading to major environmental problems such as pollution, habitat loss, but also increasing water levels leading to higher risks of inundations. In this paper we describe how an approach using the ecosystems service concept was applied as a basis for restoration of the estuary.

Keywords: Estuarine restoration; ecosystem services, Schelde estuary

1. INTRODUCTION

The Schelde estuary with a length of 160 km, a surface of more than 350 km^2 and a tidal amplitude of up to 5.5 m on average, was subjected to major human impacts over the past centuries (Meire et al., 2005). Starting already more than 1000 years ago, land reclamation is responsible for an enormous reduction in tidal areas, reducing the estuary to its present size and shape. As shipping became more and more important and especially ship sizes increased, important dredging works further changed the morphology of the estuary. Since the beginning of the 20th century, pollution coming from the catchment and the industry along the estuary lead to a dramatic decrease in water quality with large parts of the estuary being anoxic for most of the year (Meire et al. 2005).

Environmental legislation led to a reduction in emissions and by now water quality improved and no anoxic periods occur anymore. Also measures for habitat restoration are undertaken. Although there are some clear objectives formulated (eg water quality standards, conservation objectives, safety levels, depth of the fairway,..) there is a clear lack of more integrated objectives. Indeed there is a close relation between tidal characteristics and estuarine morphology and between morphology, tidal characteristics and water quality. Restoration of tidal areas might impact both tidal characteristics as well as water quality and ecological functioning. However these aspects are not or rarely taken into account in current policy frameworks and no integrated objectives for estuaries are formulated.

In this paper we explore the concept of ecosystem services and describe how it was used in the restoration of the Schelde estuary. The concept of ecosystems services, the direct and indirect benefits people derive from ecosystems, proved to be a very useful and unifying concept that allows to put forward more integrated objectives and come to more integrated projects.

2. ECOSYSTEM SERVICES

A crucial element is the Ecosystems services (ES) delivered by the biophysical system. ES are simply defined as “the benefits humans derive from nature” (MA 2005). They can be grouped in four major categories: provisioning services include food (fish, game, fruit,…), water (drinking, irrigation, cooling), raw materials (fiber, timber,…), genetic, medicinal and ornamental resources; regulating services as air quality regulation, climate regulation, moderation of extreme events (storms, floods,..), regulation of water flow, waste treatment (water purification), erosion prevention, maintenance of soil fertility, pollination and biological control; habitat services being the maintenance of life cycles of species and maintenance of genetic diversity and finally the cultural services being recreation, aesthetic and spiritual experience, information for cognitive development (TEEB, 2010). The large loss of biodiversity in the last decades resulted in a serious reduction of the ES delivered to men by the remaining ecosystems. This was for the first time clearly shown in the Millennium Ecosystem Assessment, a document prepared by more than 1360 experts from all over the world under the coordination of UNEP (MA, 2005). Crucially important is that in the millennium ecosystem assessment it is clearly shown that there is a tight link between the ES and the constituents of human wellbeing such as security, basic material for good life, health, etc. Indeed, we are to a very large part dependent on these ecosystem services. The importance of these losses of ES, not only in terms of biodiversity loss, but also in economic loss became clear since the very influential paper of Costanza and coworkers in Nature in 1997 (Costanza et al. 1997) where for the first time the economic value of the earth’s ecosystems was calculated and proved to be as large as three times the gross global product. Some of this value comes from direct use values (the prices we pay for marketed ES) but the largest part is due to the indirect use values. This is the price we have to pay to compensate a loss of ecosystem services (the loss of a floodplain might result in flooding of inhabited areas, the cost for infrastructure to protect this area against flooding can be seen as the economic value of the lost flood plain). The concept of ES allows to link on the one hand the ecological aspects and on the other hand the economic aspects and as such might become a crucial element for restoration and sustainable development. Not surprisingly the concept of ES was taken up very quickly by different environmental organizations like IUCN, but also by large bodies like the World Bank, UN and several governments. In Europe the TEEB (The Economics of Ecosystems and biodiversity) study forms a milestone in the development and the application of the concept (TEEB, 2010). It is very likely that it will be taken up in environmental legislation in the near future and that it can become a crucial concept in IWRM (Integrated Water Resources Management). Not taking these into consideration might lead to unprecedented poverty and environmental problems as the biophysical system is the basis for the human society.

3. APPLYING THE ECOSYSTEM SERVICE CONCEPT IN RESTORATION: THE CASE OF THE SCHELDE ESTUARY

Taking into account the whole concept of ES was also the base of the integrated management of the Schelde estuary. As a result of the human interventions in the estuary, most ES delivered by the system are seriously deteriorated resulting in major problems, such as increased risk of flooding, collapse of fisheries, increased erosion, reduced sink function for nutrients and pollutants leading to higher loads going to the coastal sea. The loss of ES was either compensated by very expensive management measures or simply “suffered” (eg the complete loss of recreational and professional fisheries in large parts of the estuary). Insight in the concept of ES resulted in a very fundamental change in the vision of the classical managers and led to the understanding of having a common problem for both economic and ecological management and the need to manage the whole of the estuary as one system based on integrated solutions. An integrated strategy requires the understanding of the ES and their quantification. If we take the tidal marshes as an example, they are important for storage of flood water, sedimentation and as sink or source for nutrients among many other ES (Van Damme et al., 2009). For example silica is a very important element because it is essential for the growth of diatoms that form the basis of the food chain and are the most important group of phytoplankton responsible for most of the primary production. Dissolved silica, taken up by diatoms, is incorporated in biological structures: Biogenic silica. This form cannot be used by diatoms anymore. It enters at high tide with the floodwater in the tidal marshes and is there transformed back into dissolved silica, the form that can be used again by diatoms, and exported at low water to the estuary (Struyf et al. 2005). This recycling of Silica was shown to be very important to sustain the primary production in the summer months. The next crucial step is to determine our objectives. Here it is of utmost importance to move from classical environmental objectives such as basic water quality standards or protection of biodiversity or classical economic objectives such as a fairway of 13 m deep to more integrated objectives including the crucial elements of the system and taking both ecological and economic elements into consideration. In the long term vision made for the Schelde estuary objectives were formulated for accessibility, safety and naturalness of the system. These must be made more precise and can be formulated as: ‘which and how much services the ecosystem must deliver?’ This means a functional approach. This can be seen as determining the carrying capacity not only for species (the classical ecological approach) but also for ES. For example, One can determine a volume of water that should be stored on marshes to control water levels in case of a storm surge or the amount of primary production needed to sustain the nursery function or the productivity in the coastal sea. It can be determined as the retention of nutrients which is needed in the estuary to prevent eutrophication in the coastal sea or how much we want to reduce the increase of the high water level, etc. These objectives, must then be translated into a surface of the habitats (and of a population size of species) delivering these ES. If the goal is to recycle X tons of biogenic to dissolved Silica and we know that mashes transform Y $g.m^{-2}$ the surface needed can be calculated, being X/Y. This exercise can be done for the different ES and will result in a surface of different habitats needed. Of course each habitat delivers several ES which allows us to have many win-win situations and innovative measures can be worked out.

To reach the required safety level for protection against flooding in the Flemish part of the Schelde estuary, it was calculated, using an advanced hydrodynamic model, that 1800 ha of flood control areas (FCA) are needed along the Scheldt estuary to reach the required safety against floodings (Broeckx et al. 2011). Flood control areas are low laying polders near the river, surrounded by dikes. The dike near the estuary is lower than the ring dike to allow overtopping of the dike at high water during storm tides. At low tide, the water is flowing back to the estuary through big sluices in the dike. Similarly, it was calculated that even when the water quality of all tributaries meets the WFD standards, still an additional 1300 ha of marshes and 500 ha of tidal flats in the estuary are needed to avoid Si limitation, reduce N loads, provide enough benthic biomass for migrating and wintering waterbirds etc. On top of that about 4000 ha of non tidal wetlands are required as habitat for rare species, to buffer peak discharges etc (Adriaensens et al. 2005).

The advantages of defining the Conservation Objectives in such a comprehensive and systemic manner are huge. It does not only put the emphasis on protecting and restoring species and habitats, but to a very large extent it also emphasizes the fundamental problems of the system (such as increasing tidal energy) that negatively affect both the ecology and economy of the system. The ES-approach is also an opportunity to link the various environmental legislations (Bird and

Habitat-, Water Framework-, flood directive etc.). This enables a truly integrated approach and makes it much easier to negotiate with all of the different stakeholders.

This approach led also to the development of entirely new concepts such as flood control areas with a restricted controlled tide. A pilot project, the Lippenbroek, was realized in 2006 and since then monitored in detail. During storm tides, water overtops the dike and is stored in the polder having a reducing effect on high water levels, increasing safety. During normal tides a limited amount of water enters the polder through sluices resulting in a much reduced tidal amplitude. However this is enough to allow the major ecological processes like nutrient retention to work very well in that area. In this way several objectives are integrated.

4. LIPPENBROEK: A PILOT STUDY

To derive the surfaces mentioned it is important to combine several services in one habitat. Indeed biodiversity development as well as flood storage and biogeochemical processes, could be combined in the same habitat. This requires new concepts, an example is a flood control area (FCA) with a controlled reduced tide (CRT). For safety reasons FCAs are necessary, however they are flooded only occasionally (once or twice a year on average) during storm surges. It is however, perfectly possible to introduce a tidal regime in a FCA by using culverts in the dike. This is done in such a way that the tidal system allows the development of a marsh system but at the same time the storage capacity of the area for flood water is retained. The tidal amplitude in the FCA is controlled and reduced. This innovative concept of introducing a CRT into a FCA has been implemented in the pilot project “Lippenbroek”, the world’s first FCA-CRT (Cox et al. 2006; Maris et al. 2007). Operational for six years, the Lippenbroek clearly delivers some important ecosystem functions as predicted. Oxygen poor estuarine water that enters the CRT is enriched up to 80 % saturation or more at the outflow. Nutrients are removed, e.g. the total dissolved nitrogen and phosphorus concentrations are reduced during one tidal cycle. The area is a hotspot for primary production and serves as a nursery and feeding ground for fish. This concept is now applied in large parts of the flood control area of Bazel, Kruibeke, Rupelmonde. This area of over 600 ha is essential for flood control. The original plan, dating back to 1976, aimed only at safety and in the 1990 the plan was adapted to accommodate different ES in a true integrated way. A cost benefit analysis, taking into account the ES, clearly proved the overall economic benefits of the integrated plan versus sectorial plans. (Liekens et al., 2009)

5. CONCLUSIONS

Optimization of ecosystem services proved to be a promising approach and should be at the heart of estuarine management. In the case of the Schelde estuary, it was the key factor to convince politicians and decision makers to take ecological restoration seriously and understand the benefits of an integrated approach. However, much more work is needed to identify and quantify ecosystem services and relate these to human well-being and economic parameters. Furthermore, if we want to use the ES approach as a strategy to also protect biodiversity, a better understanding of the relation between functional and structural biodiversity is crucial.

A successful restoration plan should be based on a comparison between the quantified losses and the desired levels of services. This in turn must be translated into the surface and quality of each habitat needed to deliver the required amount of service. Modelling is an indispensable tool and field experiments are crucial to increase our understanding of the system.

The Millennium Ecosystem Assessment can be seen as a milestone and stimulated a lot of new research, the field of ES science is developing exponentially. Although many examples of integrated projects, proofs of concept, already exist, still a major effort is needed to really implement the ES and integrated approach not only in policy documents but in the field. As water is the crucial link between all ecosystems from source to the coastal sea, the water framework directive should apply the ES approach as a cornerstone of integrated water resources management.

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