"The Schelde: managing a heavily impacted river"

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General introduction: The Schelde and its catchment

Both the catchment and the river Schelde itself (total length 350 km) are very small compared to most other European river basins. Nevertheless the river crosses three countries (F, B, Nl) and the basin is divided over 5 riparian regions (Table 1) since Belgium is a federal country.

France	Wallonia (B)	Brussels (B)	Flanders (B)	The Netherlands	Total
6.680	3.787	162	9.375	1.859	21.863
31%	17%	1%	43%	8%	100%

Table 1: Surface (km^2) of the Schelde basin in the 5 riparian regions.

It is characterized by a very high population density (477 inhabitants/km^2) that results in many different pressures on the system. Remarkable is that 160 km of the river is under tidal influence. Hence, the Schelde estuary is one of the largest in Europe and also one of the very few with a complete gradient from fresh to salt water tidal areas (ICBS-CIPE, 1994). For a more detailed description see Meire et al. (1991), papers in Meire and

Vincx (1993), Heip and Herman (1995) and Ysebaert et al. (1993,1998).

Impact of human activities

The impact of human activities is analysed according the different structures and relations in the ecosystem (Fig. 1).

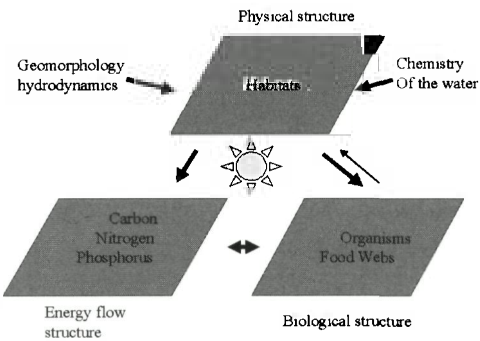

Figure 1. Different components of the ecosystem: the physical structure and the structural and functional biodiversity (after Buis & Meire 2002)

Habitat loss was very common in the past century. Along the estuary about 15 % of all intertidal areas were reclaimed for industrial and agricultural purposes during the last 100 years (Van den Bergh et al. 1999). Also throughout the entire basin, valuable habitat is lost mostly to urbanisation. Of the remaining habitats much is degraded due to human uses. More than 15 million cubic meters are dredged yearly to maintain the fairway to the harbour of Antwerp. This has an important impact on the geomorphology of the estuary. However all the dredging for nautical or hydraulic reasons throughout the basin and especially in the small rivers and brooks have a tremendous impact as often everything is removed from bank to bank.

The habitat structure is also to a large extent the result of the hydrodynamics. Both the sea and the runoff from the basin influence the estuary. At the mouth of the estuary sealevel rose by some 30 cm last century. This together with the dredging and embankments caused the tidal amplitude to increase by more than 1 meter near Antwerp in 100 years. Several characteristics of the tide changed significantly also affecting the morphology. On the other hand the total amount of fresh water reaching the head of the estuary decreased significantly as about 60% of the discharge of the river is diverted to canals in France and Flanders. This of course has an important impact on the salt intrusion in the estuary. Within the basin, human impacts resulted in general in much higher peak discharges and a shorter lag time between the peak of the rainfall and the discharge peak in the river. This together with an increased urbanisation of former floodplains results in more frequent floodings of houses and more economic damage during each flood.

The aquatic system is also under permanent stress caused by a high load of urban, industrial and agricultural waste water. Although recently large investments were made in water purification plants, up to 45% and 25% of the loads from nitrogen and phosporous are coming from non point sources (ICBS 1994), hence the problem of eutrofication is likely to become very important. Now we see already massive growth of macrophytes in the Nete catchment (Bal 2001). As these macrophytes increase strongly the roughness of the river they have an important impact on water levels. Hence removing these plants becomes an important management activity throughout the basin often resulting in serious loss of biodiversity.

Both habitat structure and waterquality determine the biodiversity of the system (Fig. 1). In large parts of the estuary, the Schelde and its tributaries, biological communities are very impoverished. The impact of water quality on biota is well known but more and more it is obvious that also habitat structure itself impacts biodiversity. Indeed species richness is well corellated with habitat area, largers habitats having more species. On top of this, the loss of connectivity between habitats also negatively affects species diversity.
Notwithstanding these problems, investments in water purification plants result in improving waterquality, especially concerning the oxygen status of the rivers. In respons e.g. fish communities in the brackish part of the estuary are recovering (Maes et al. 1998) and waterbird populations increased (Ysebaert et al. 2000)

The third pilar in our approach (Fig. 1) is the functional biodiversity. Different ecosystem functions such as:

- the regulation of biological processes (productivity ...)
- the regulation of hydrological processes (prevention of flooding, water storage,...)
- the regulation of biogeochemical processes (storage and (re)-cycling of nutrients, water purification,...)
- the regulation of geomorphological processes (control of erosion, retention of sediments,....)

have been identified by de Groot (1992) and Costanza et al. (1997). The impacts on the system as described briefly above, result in a decrease of these ecological functions. Soetaert and Herman (1995) showed that the removal of nitrogen in the Schelde estuary by biogeochemical processes decreased, leading to higher loads reaching the coastal sea. The loss of retention capacity for water in the basin results in higher peak discharges. This in turn results in the flushing out of phytoplankton reducing the primary productivity (Muylaert 1999).

Towards an integrated management

To achieve sustainability, the ecosystem functions should be restored to a level where the ecosystem reaches the carrying capacity needed for current and future anthropogenic demands. A very simple paradigm as starting point is given in Fig. 2. The watershed is a system. Human impacts have an impact that results in increased losses from the system. More water is lost from the system due a reduced retention. This causes inundations downstreams, water shortage in drier periods, losses of sediments due to erosion because of higher current velocities etc. More nutrients are lost due to a higher input and less internal recycling.

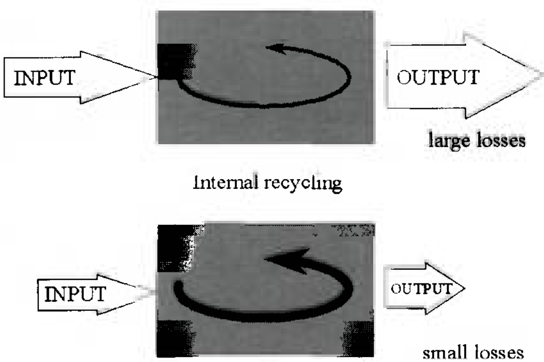

Figure 2. A system approach of a watershed. Management should reduce input, enhance internal recycling to reduce the losses from the basins.

Sediments are transported downstream were sedimentation increases, resulting in problems for both hydraulics and navigation etc. Finally biota are lost resulting in reduced self purification, less productivity…

An integrated approach should therefore aim at reducing the input to the system (e.g. of pollutants) and highly increase the internal recycling possibilities of the system. This means to a large extend restoration of crucial habitats like wetlands. Indeed their capacity for water retention, water storage, water purification etc. is very high.

River-estuary-sea continuüm

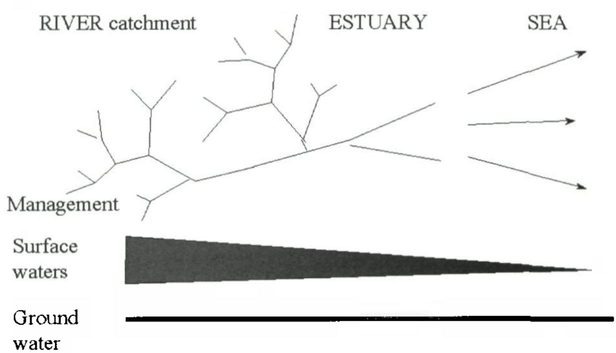

Figure 3. River-estuary-sea continuüm indicating the importance of managing surface waters as far upstream as possible.

This should be done within the whole catchment as it forms one continuum from source to mouth (Fig. 3). The possibility to manage the surface waters (both quality and quantity) is much easier upstream than downstream. The estuary is the last opportunity to manage the waters before reaching the coastal sea. Once here it is not possible anymore to manage neither water quantity nor quality. The groundwater compartment is very difficult to manage throughout the basin. Therefore, increasing the carrying capacity of the watersystem to accommodate the different human uses should start with the restoration of ecological functions within the river basin. This will result in an increase of goods and services to be delivered by the ecosystem of watersystem towards the socio-economic system (Fig. 4). Ecological engineering will be of major importance to create and restore the necessary habitats along the whole river continuum. Classical engineering will be crucial in reducing the input to the system and enhancing recycling of water within the water chain. Legislation, policy and organisation of all services concerned will be necessary to achieve sustainable development within this catchments (see Meire & Coenen this volume). As however the continuity of our human society entirely depends on the goods and services delivered by the watersystem there is no other option.

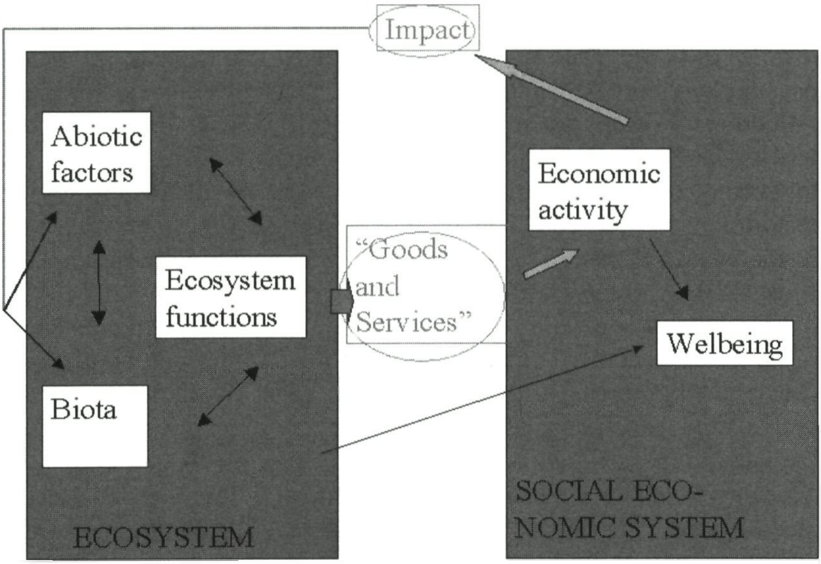

Figure 4. Relation between the ecosystem and the socio-economic system indication the crucial role of the ecosystem goods and services to be delivered by the ecosystem.

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