Many services to society depend on the quality of aquatic environments

The main points:

- Societies depend on the good status of rivers in order to ensure their long-term development.
- The multiple roles of aquatic environments must be understood so that they can be managed in a sustainable manner.

The natural environment provides many services (also called *amenities*) to human societies, thus contributing to their development and well-being. The majority of the services provided depend on the conservation status of ecosystems. Indeed, the preservation of the functions and services that can be associated with these ecosystems is often dependent on them operating in good conditions.

The same applies to the services provided by river systems, i.e. all of the aquatic ecosystems (rivers, wetlands, river corridors, floodplains, side arms and alluvial groundwater) which form the aquatic environment and which are inextricably linked by the same river dynamics.

For further information about river dynamics, consult the information sheet: "Why restore? River dynamics at the origin of biodiversity and good ecological status"

The services provided by the environment are generally only noticed by the public authorities and civil society when they are in decline. For example, we only appreciate the value of the services provided by a river of good status when the water quality deteriorates and becomes incompatible with bathing or for use as a drinking water supply. This value is assessed by calculating the economic loss associated with a temporary or permanent ban on bathing or additional intervention costs concerning extra recurrent treatments that can become necessary.

That is why in recent years, numerous studies have been carried out in an attempt to estimate the economic value associated with the services provided by ecosystems. This evaluation is characterised by a great variety of methods developed by economists specialising in the environment. However, there are limits to these methods which make the data difficult to use outside the specific context of the study. The approach has nevertheless made it possible to clarify the different types of services that can be grouped into broad categories as an aid to general understanding.

Identifying and evaluating ecosystem services: a valuable approach

It is not always easy to perform an evaluation of the services provided by a waterbody, in particular due to the lack of a market valuation. What is important in the approach to economic assessment is not so much the values generally estimated within a specific context using a precise approach, but above all the following: all ecosystems, including the smallest ones, have a substantial economic value. One of the aims of this approach is to increase the knowledge of the services rendered by ecosystems and their operation and provide additional arguments in favour or preserving or indeed restoring natural

An international approach in favour of identifying and acknowledging the services provided by natural environments: *Millennium Ecosystem Assessment*

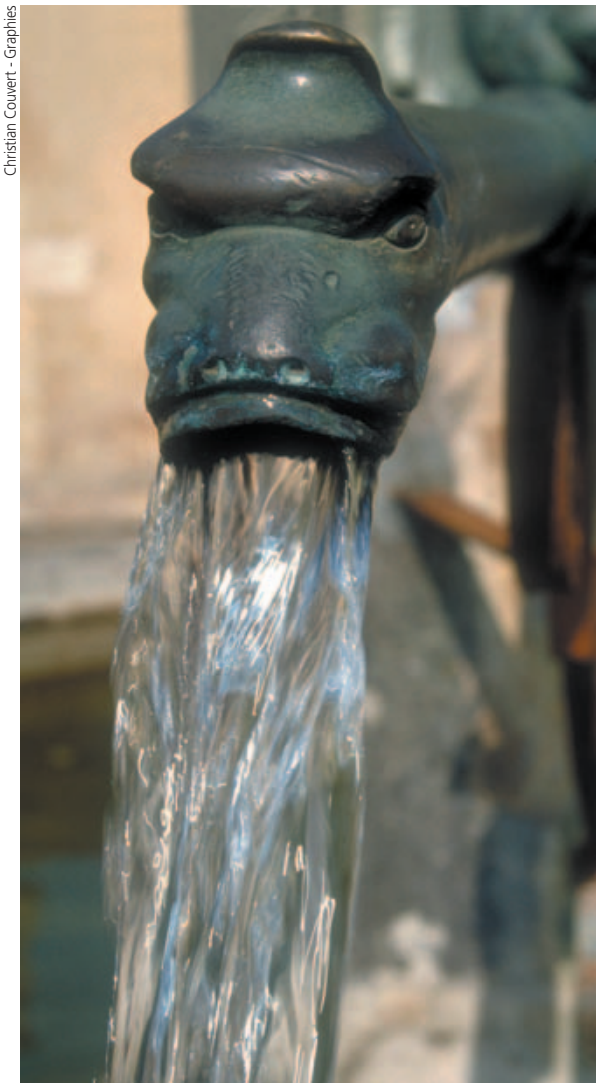
In 2005, in order to understand the nature of the services provided by ecosystems and to evaluate them in monetary terms, the United Nations' Environment Programme (UNEP) produced a report on the assessment of ecosystems for the millennium and identified 31 services, classified in four categories: supply, regulation, cultural services and self-maintenance. Numerous projects are underway in order to estimate the costs that would result from the loss of these services.

According to the same logic, and using a similar approach, the Water and Biodiversity Directorate (DEB – Direction de l'eau et de la diversité) of the French Ministry for Ecology is currently studying how to assess the status of French terrestrial, aquatic and marine ecosystems. This "MEA France" study has been conceived in the spirit of the *Millennium Ecosystem Assessment*.

environments, thus facilitating the undertakings of mainly public but also private project holders, by progressively obtaining support for ecology from society in general.

Numerous studies have shown that ecological restoration facilitates the recovery of ecosystem services and allows for an increase of 44% in biodiversity and 25% in ecosystem services [1]. From a social point of view, the improvement of ecosystem services also acts as a driving force for the economy by stimulating "green" employment. From an economic point of view, there is a need to show its contribution in terms of benefits or costs that can be avoided. On these grounds, the preservation and restoration of the functions of aquatic environments also acts as a stimulus for sustainable development, based on these three cornerstones: ecology, economy and social factors.

Christian Couvert - Graphies



Spring water: the most vital of resources provided by aquatic environments.

1 - Rey-Benayas J.M., Newton A.C., Diaz A., Bullock J. (2009). "Enhancement of Biodiversity and Ecosystem Services by Ecological Restoration: A Meta-Analysis." F Science 325(5944): 1121 - 1124.

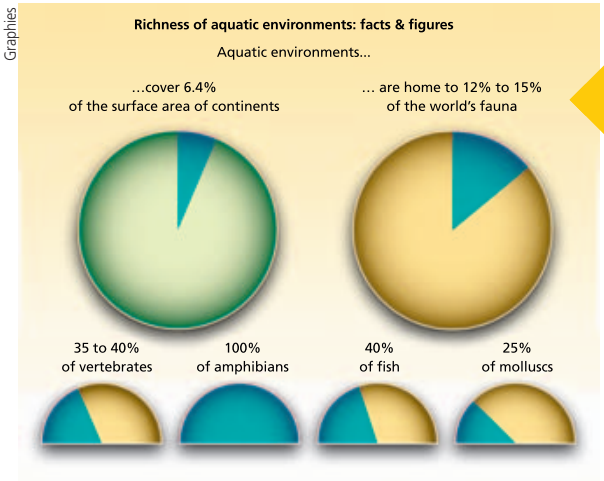
Supply services

In general, ecosystems provide numerous resources and products such as food products, fibres (wood, cotton, wool, silk, fish, sea products, etc.), fuels, natural medicines (algae, roots, non-woody products), pharmaceutical products and ornamental resources. The most vital of these is, of course, the supply of fresh water by aquatic environments.

The abundance and diversity of products originating from the river system are highly dependent on the quality of its constituent environments. A river system consisting of heterogeneous habitats (riparian vegetation, wetlands, shelters under riverbanks, stone blocks, woody debris, side arms, etc.), favours the presence and abundance of diversified fauna and flora, which will find all of the resources and areas required for the completion of their life cycle in their environment. These environments are characterised by their richness and productivity with regard to biodiversity and the size of the biomass that characterises them.

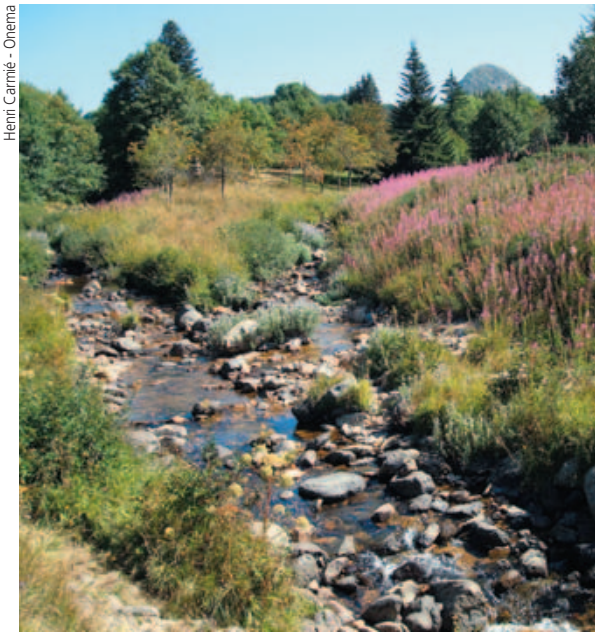
On the other hand, in a system which is altered or whose operation is downgraded (e.g. a straightened river, homogeneous habitats, lack of riparian vegetation, etc.), we observe a global change in the structure of the system: disrupted food web, risk of accelerated eutrophication, increased competition between species, imbalanced structuring of animal and plant populations and confinement of species. The impacts of the artificialisation of aquatic environments (e.g. canalisation), are very serious and continuous, while fish biomasses are frequently reduced by 80% or more. There is no biological recovery for as long as the physical alteration lasts [2].

Graphies



2 - Wasson J-G., Malavoi J-R., Maridet L., Souchon Y., Paulin L. (1995). "Impacts écologiques de la chenalisation des rivières" : 152.

Henri Carmié - Onema



Rich and productive environments are characterised by their biodiversity.

On a global level, as well as tropical forests, aquatic environments are the most productive environments[3]. If their status is good, they are capable of supporting important economic activities and, above all, meeting the essential needs of populations in terms of food and drinking water: fishing products, exploitation of resources that have not undergone too many additional treatments, etc. The restoration of river dynamics, aquatic habitats, the floodplain and/or the modification of certain agricultural practices in the catchment area help to increase the quality of products and/or improve the natural productivity of the environments.

An example

Restoration of pike spawning grounds on the Charente

The restoration of 12 hectares of pike spawning grounds on the River Charente by the fishing federation of the Charente département has recreated carrying capacities and favourable conditions for the natural reproduction of pike. The effectiveness of this measure has been demonstrated by the fishery catch records established in 1995, which show that the fish population is more abundant. Prior to the works, eleven hours of fishing were required to capture a grass pike, in comparison with just six hours today. The fishermen are satisfied and the local managers no longer need to restock the area due to the restoration of natural reproduction.

Source: Milot F. "La restauration des frayères à brochet - Le cas des marais d'Ambérac" Colloquium: "Les bons comptes des zones humides", February 2009.

3 - Barnaud. G., Fustec. E (2007). "Conserver les zones humides : pourquoi ? comment ? " : 295
4 - Namour, P. (1999). "Auto-épuration des rejets organiques domestiques. Nature de la matière organique résiduaire et son effet en rivière". LYON 1, Université Claude Bernard : 164

Regulation services

The operation of hydrosystems helps to regulate different processes, such as the climate or natural risks. The storage of precipitation in floodplains, the recharging of aquifers, the support for rivers during low-flow periods provided by wetlands and water purification are the most commonly observed regulation services at the level of the river system.

Improvement of the physico-chemical quality of water: the self-purifying capacity of the river and its alluvial plain

Continental, coastal and marine hydrosystems perform water purification functions. They can assimilate and detoxify compounds which are harmful to organisms via certain processes which operate in the soils or sub-soils.

Studies have shown that the diversity of a river's morphological characteristics increases its self-purifying capacity [4]. The self-purifying capacity of rivers is dependent on parameters such as the flow rate, current velocity, temperature and geomorphology. As a general rule, the more diversified the interactions between the surface water and the hyporheic zone (bottom of the river), the greater the purification capacity. Consequently, organic matter is broken down more quickly when it is blocked by small woody debris or stone blocks and in the presence of alternating riffles and glides.

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In rivers with little artificialisation, the purifying capacity is maintained, as exchanges remain possible between surface waters and the hyporheic zone.

Contribution of alluvial plain to the purifying capacity

• The purifying capacity for surface flows of 6-metre wide vegetated strips amounts to an inter-annual mean of 70%. A 12 to 18-metre grass buffer strip offers a purification capacity of 84 to 91%[a].

• In less than 30 metres, an alluvial forest is capable of eliminating up to 80% of the nitrate content in surface flows[b].

• Root systems can significantly reduce the nutrient salt content, such as nitrates and phosphates added by the agricultural sector. The combined actions of root absorption by plants and denitrification by micro-organisms can, in certain conditions, eliminate more than 99% of nitrates[c].

For further information about the effects of vegetated and wooded strips: CSPNB (2008). "L'arbre, la rivière et l'homme", MEDAT / D4E: 64.[d]

For further information about buffer zones: CORPEN (2008). "Les zones tampons, un moyens de préserver les milieux aquatiques", MEDAD / MAP. 20.[e]

a - Agence de l'eau Loire Bretagne, 1997.
b - Lefeuvre, Wetlands colloquium, October 1994.
c - Décamps – MATE.
d – Can be downloaded from the following address: http://www.ecologie.gouv.fr/L-arbre-la-riviere-et-l-homme.html
e - Can be downloaded from the following addresses:
- brochure: http://www.ecologie.gouv.fr/IMG/pdf/zones_tampons_20_pages_a5-2.pdf
- slide show: http://www.ecologie.gouv.fr/IMG/pdf/diaporama_ZT_def-2.pdf

For example, on the River Rhine, it has been shown that self-purification is more intense when the hydrosystem is diversified and has "little artificialisation". Conversely, when the river is degraded (for example incised), the purification capacity for certain parameters diminishes[5], hence the benefit of a river with good "hydromorphological" status, and thus a good operating status.

Wetlands, in addition to the vegetated or wooded zones along rivers, also called "buffer zones", also participate in the proper operation of river purification processes. They help to trap pollutants and fine particles *(see box above).*

The relatively unaltered morphology of rivers, the vegetation of riverbanks and the functional dynamics with the floodplain thus contribute to reducing the pollution of aquatic environments.

These observations consolidate the need to restore good operating conditions to the hydrosystem in order to re-establish rivers of high physico-chemical quality, avoiding the hyper-eutrophication phenomena characterised by the development of algae and higher plant species, on the one hand, and the need to use additional, costly treatments for drinking water supplies, on the other.

The Ministry for Ecology has estimated that the damage relating to water pollution in France amounts to three billion euros per year[6]. For an area of wetlands covering 89 sites worldwide, it has been estimated that the purification function could represent an economic value of approximately €251 ha/year[7]. The preservation of the water quality of rivers could represent significant savings in terms of investments in water purification and/or reducing water pollution.

This was the case for the city of New York which, in 1996, decided to implement an ecological restoration programme in the drinking water catchment area rather than establish a water treatment system. Both scenarios were priced and compared and the chosen solution led to savings of more than six billion dollars, thus raising awareness of the importance of the services rendered by ecosystems[8].

Regulation of water flow rates: water retention capacity of floodplains.

The river system regulates the water regime (flood storage and water level support during the low-flow period). It especially influences the distribution of water over time, the magnitude of runoff and the supply of aquifers and rivers.

Floodplains (or flood expansion fields) allow for the storage of water in period of significant flooding and its slow and continuous restitution to the river in drier periods. They thus influence the propagation of the flood by reducing the flood water velocity. The storage of water in floodplains thus reduces the risk of potentially damaging flooding downstream, but also contributes to water purification by alluvial wetlands and the recharging of aquifers. The damage caused by flooding in France amounts to an

The contribution made by certain parts of the river system to flood regulation

• Certain wetlands can store up to 15,000 m³ of water per hectare[a].

• A study performed on 89 sites has estimated that the flood regulation service in wetlands may represent a benefit or an avoided cost of €404/ha per year[b].

• The vegetation in the floodplain plays a key role in slowing down floodwater by reducing the velocity of the current.

a - Bureau de la Convention de Ramsar, 2001
b - Schhuyt and Brander. 2004. "The economic values of the world's wetlands, living waters". Conserving the source of life, WWF International. Gland

5 - Barnaud. G., Fustec. E (2007). "Conserver les zones humides: pourquoi ? comment ?": 295
6 - According to the French Ministry for Ecology and Sustainable Development.
7 - Schhuyt et Brander (2004). "The economic values of the world's wetlands, living waters. Conserving the source of life", WWF International. Gland.
8 - CSPNB, (2007). La biodiversité à travers des exemples. MEDAD/D4E : 104

David Monnier – Onema

Regulation of the water regime by the storage of floodwaters in the floodplain of the river.

average of 265 million euros per year [9]. The preservation and restoration of river dynamics, which carry out the "maintenance" of aquatic environments in aquatic corridors, help to reduce the risk of harmful flooding in sensitive areas through the storage of water in floodplains.

The preservation and restoration of mobility areas and, beyond that, floodwater retention areas within which high-quality aquatic environments can develop, help to save money by reducing the amount and intensity of the damage caused by severe flooding.

On the River Charente, the modification of land uses, due to artificialisation, urbanisation and, above all, the reduction of meadows, has led to increased flooding in urban areas, the acceleration of runoff and the artificialisation of rivers. For the towns of Cognac and Saintes, the cost of the damage caused by the three floods suffered in eighteen years amounts to €10 M and €4M respectively. With the vegetation coverage that existed in the past, the costs would have been much less [10].

Cultural services

Ecosystems play an essential role in social and cultural life. As places of relaxation and recreation, interaction and rest, well-being and regeneration, offering changes of scenery, sources of inspiration and beauty, the embodiment of a personal or collective identity and the repositories of regions and certain traditions... aquatic areas play many roles within human society. Due to their tangible and intangible properties, aquatic ecosystems contribute to the quality of life and culture, which are not commercial values but they are still very real and determining factors in choices relating to human life and society. All of these non-commercial cultural services [11] are essential for human communities.

The perception of the landscape is therefore very important to local residents. People are more sensitive to the environment of the river: presence of trees, shade, birds, etc. than to the characteristics of the river itself. The river and its ecological corridor contribute to the attractiveness and quality of the river landscape.

Certain studies carried out in France show that local populations attach value to the functions of attractiveness, landscape and preservation of the terrestrial and aquatic biodiversity associated with the sites. Sometimes, these studies provide estimates of how much money the visitors to these sites would agree to pay in order to preserve or indeed improve the quality and accessibility of these sites. For the Orne estuary, for example, the local population would be willing to pay between €20 and €67 (2004 value) in order to contribute to "financing estuary maintenance and protection works" and between €2.50 and €5 per visit for the right to benefit from the pleasures afforded by this area [12]. Another approach involving transport costs also shows the importance attached by residents and visitors to the existence and protection of the Orne estuary.

Other economic approaches estimate the value placed by the population of visitors to natural sites or participants in activities in these areas according to all of the costs which directly or indirectly relate to their activities: time spent, travel and accommodation costs, equipment and operating costs, etc. Consequently, in the United States, sport fishing attracts more than 45 million people who devote 24 billion dollars to it each year [13]. Another example of the same type can be seen in the Loire-Brittany [14] basin, with the economic importance of recreational fishing reflecting the economic

An example

Restoration of the Vistre and the adjacent wetlands (Gard)

The restoration of the River Vistre has allowed for the re-establishment of wetlands which are directly associated with the river. The improvements made now allow for the storage of more than 40,000 m³ of water in the four hectares. The impact for the residents living downstream has been noticeable because they state that "in periods of flooding, the water level remains the same but the water no longer has the destructive power that it had before the improvements".

Also read one of the restoration examples of the collection, on the remeandering of the Vistre.

9 - Data from the French Ministry for Ecology and Sustainable Development.

10 - Agence de l'eau Adour-Garonne. (2009). "Évaluation économique des zones humides". Summary. Eco What ACTéon: 10.

11 - There are no economic or market transactions that can be used as references for the monetary evaluation of these services. However, certain assessment methods can be used to reveal these non-commercial values.

12 - Scherrer S. et al (2003). "Evaluation économique des aménités récréatives d'une zone humide du littoral : le cas de l'estuaire de l'Orne". Study series no. 03-E. Paris. French Ministry for Ecology and Sustainable Development – Economic Analysis and Environmental Assessment Department.

13 - Barnaud. G., Fustec. E (2007). "Conserve les zones humides : pourquoi ? comment ?" : 295

14 - Agence de l'eau Loire-Bretagne (2004) "État des lieux du bassin Loire-Bretagne"

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Fly-fishing (Haute-Loire).

Michel Bramard - Onema

Canoes passing through Ornans (Doubs).

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Bathers jumping into the river (Creuse).

Leisure activities associated with living rivers.

spinoffs of the fishermen's activities (expenditure on equipment, licence, accommodation, etc.) amounting to 110 million euros per year in 2004.

These economic approaches in the environmental field can offer additional arguments in favour of the restoration of aquatic environments. Their ecological and functional restoration does not conflict with the practice of recreational activities. On the contrary, the greater diversity of the river allows for the diversification of fishing activities and the practice of sporting activities, canoeing, and hiking, for example. The restoration of aquatic environments can add value to the landscape, which can be enhanced by creating access points for pedestrians and cyclists, and by creating hiking paths or interpretive trails that allow for the discovery of the natural and historic heritage of the region.

Self-maintenance services

Self-maintenance services correspond to the functions that are essential to the performance of all other ecosystem services. They differ from supply, regulation and cultural services by the fact that their effects on people are often indirect and extend over a very long period of time and include soil formation, the nutrient cycle, the renewal of habitats for animal species, primary production, photosynthesis and the water cycle.

In reality, the capacities of aquatic environments to provide these fundamental services are often impaired due to hydromorphological alterations which damage the river dynamics and prevent the hydrosystem from operating efficiently.

The preservation of the good ecological status of rivers and the restoration of conditions that are favourable to the establishment of good ecological status for degraded rivers (in particular, good hydromorphological conditions allowing for the efficient operation of the river system) are a key issue for our society in many ways.

An example

Removal of the Kernansquillec dam in the Côtes d'Armor

The rehabilitation project for the site, which was devised in conjunction with the local authorities, led to the creation of a nature and historic heritage trail, with a permanent exhibition established in a former arch of the dam, which describes the socio-economic history of the structure and its role in the industrial catchment area. The trail, which is known as one of the most beautiful hiking trails in Brittany, allows visitors to discover the alluvial meadows, which are classified as a Natura 2000 site and are maintained by a local farmer's cattle herd.

For further information, read the restoration example of the collection devoted to the removal of the Kernansquillec dam.