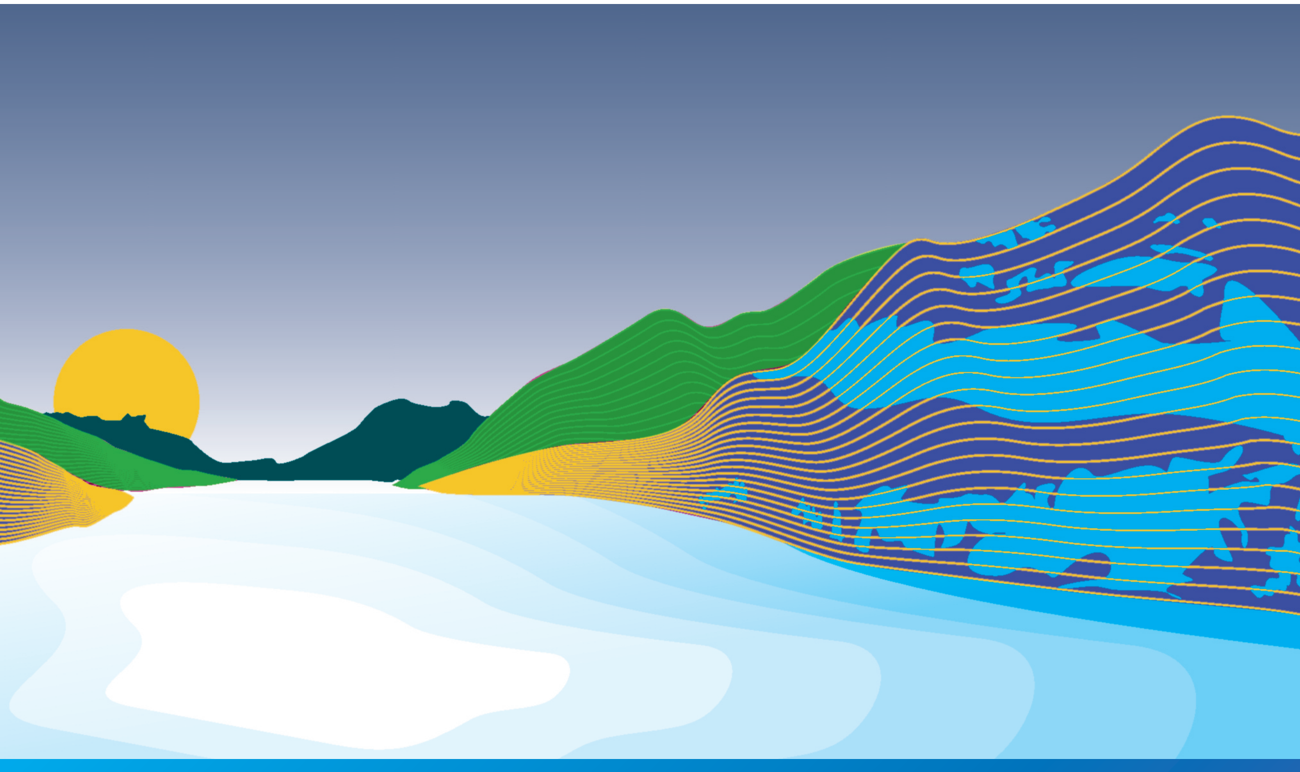

THE HANDBOOK FOR MANAGEMENT AND RESTORATION OF AQUATIC ECOSYSTEMS IN RIVER AND LAKE BASINS

March 2015

International Network of Basin Organizations
Global Water Partnership
ONEMA
Office national de l'eau et des milieux aquatiques
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The handbook can be downloaded from the following websites:

www.inbo-news.org

www.gwp.org

www.basins-management-publications.org

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FOREWORD

Freshwater resources are increasingly used, wasted and polluted, with the result that aquatic ecosystems are threatened and sometimes destroyed.

Aquatic ecosystems provide several services for producing, regulating and structuring. Wetlands improve water quality by trapping sediments, filtering pollutants and absorbing nutrients. They play also a key role in the control of floods and prevention of droughts. However, human action and activities often disturb the structure of the biotope, cause organic pollution and many of the world's rivers have become fragmented.

Many countries have introduced an integrated approach to water resources management (IWRM) into their policies. Hydrological, social, economic and environmental interdependences occur in the catchment areas of rivers, lakes and aquifers. This is therefore where integrated development and management of water resources and territories is likely to be the most successful.

The joint study of "green" and "grey" infrastructure constitutes a new paradigm, and Natural Water Retention Measures provide a wide range of benefits for flood control and ecosystem services. Combining the conservation of aquatic ecosystem services with IWRM is a very effective strategy for achieving water security and adapting to the effects of climate change.

To support this process, the International Network of Basin Organizations (INBO), the Global Water Partnership (GWP), ONEMA and the International Office for Water (IOWater) have worked together to publish this Handbook. This collective work provides relevant and practical information that can assist the improved management and restoration of aquatic ecosystems.

This Handbook addresses a large number of stakeholders involved both in restoration of ecosystems and integrated management of water resources, including practitioners and, more broadly, representatives of public authorities, water users, non-governmental stakeholders and anyone with an interest in these subjects. They all are invited to work together to meet the many current and future challenges.

This new work supplements the Handbook for Integrated Water Resources Management in Basins, published in March 2009 at the Fifth World Water Forum in Istanbul, and the Handbook for Integrated Water Resources Management in Transboundary Basins of Rivers, Lakes and Aquifers, published in March 2012 at the 6th World Water Forum in Marseille. Another handbook is being published simultaneously, in partnership with UNECE, on "Water and climate change adaptation in transboundary basins: Lessons learned and good practices".

We welcome your comments and contributions to this new handbook, which we consider to be a platform for sustainable development in its economic, social and environmental dimensions.

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ACRONYMS

ANEW	African Civil Society Network on Water and Sanitation
ASTEE	French national association of water technicians and engineers
AUSRIVAS	Australian River Assessment System
BRGM	The French geological survey
CATIE	Tropical Agricultural Research and Higher Education Center
CBD	Convention on Biological Diversity
CIPEL	Commission Internationale pour la Protection des Eaux du Léman
CIREF	Iberian Center for River Restoration
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of the Parties
DPSIR	Driving forces - Pressures - State - Impact - Responses
ECOWAS	Economic Community of West African States
ECRR	European Center for River Restoration
EIS	Environmental Impact Assessment
EU	European Union
FANCA	Freshwater Action Network - Central America
FAO	Food and Agriculture Organization
GWP	Global Water Partnership
IBWC	International Boundary and Water Commission (United States and Mexico)
ICOLD	International Commission on Large Dams
ICPDR	International Commission for the Protection of the Danube River
IFREMER	French Research Institute for Exploitation of the Sea
IHA	International Hydropower Association
IIED	International Institute for Environment and Development (UK)
IISD	International Institute for Sustainable Development
INBO	International Network of Basin Organizations
INERIS	National competence centre for Industrial Safety and Environmental Protection (France)
IOWater	International Office for Water
IPBES	Intergovernmental Platform on Biodiversity and Ecosystem Services
IRSTEA	National Research Institute of Science and Technology for Environment and Agriculture (France)
IUCN	International Union for the Conservation of Nature
IWRM	Integrated Water Resources Management
IWR	US Army Engineer Institute for Water Resources
LNE	Laboratoire national de métrologie et d'essais (France)
M-POWER	Mekong Program on Water, Environment and Resilience
NARBO	Network of Asian River Basin Organizations
NEPA	National Environmental Policy Act (United States)
NGO	Non-Governmental Organization
NRC	National Research Council (United States)
NWRM	Natural Water Retention Measures
ONEMA	National Agency for Water and Aquatic Environments (France)
PCoR	Proceeding Chain of Restoration
PES	Payment for Ecosystem Services
RBMP	River Basin Management Plan
TEEB	The Economics of Ecosystems and Biodiversity

UfM .Union for the Mediterranean
UK . . . . .United Kingdom
UNDP . . . . .United Nations Development Programme
UNEP . . . . .United Nations Environment Programme
UNESCO . . . . .United Nations Educational, Scientific and Cultural Organization
UNGA . . . . .United Nations General Assembly
USA . . . . .United States of America
WCED . . . . .World Commission on Environment and Development
WFD .Water Framework Directive (Europe)
WWF .World Wildlife Fund

1 Introduction

1.1. Context

The International Network of Basin Organizations (INBO) and the Global Water Partnership (GWP), associated with other partners, have already produced two handbooks: a Handbook for Integrated Water Resources Management in Basins, launched at the 5th World Water Forum in Istanbul in March 2009, and the Handbook for Integrated Water Resources Management in Transboundary Basins of Rivers, Lakes and Aquifers, published in March 2012 for the 6th World Water Forum in Marseille. Both have been highly popular throughout the world and continue to make a contribution. This new handbook follows the same format as previous editions, focusing on Integrated Water Resources Management (IWRM) for basins including managing ecosystems, with a sustainable development objective.

This handbook draws from real-life experiences, practical examples and expertise acquired in national and transboundary basins throughout the world. It is organized by theme and centred on the key issues linked to managing and restoring aquatic ecosystems. The work includes contributions from several authors who represent different approaches in this complex domain, including experts on IWRM and the environment.

1.2. How to use this Handbook

This handbook is aimed at practitioners involved in managing water resources and restoring ecosystems and, more broadly, anyone with an interest in these subjects. It includes:

- An overview of the key concepts, fundamental issues and approaches used in tackling these areas. The successive chapters look at how ecosystems work, ways of managing and restoring ecosystems, and the relevant governance and regulations;
- A specific chapter on ecosystems monitoring;
- A focus on the economic challenges and the funding issue;
- Examples of ecosystem management and practical advice in every chapter.

1.3. Key concepts and definitions

1.3.1. Ecosystems

An ecosystem, or ecological system, is a functional unit comprised of a given environment or biotope, and the organisms that live in it, known as the biocenosis. A biocenosis is a group of living organisms attracted to environmental factors. The group is characterized by a specific composition that determines their interdependence; it occupies a living space known as a biotope.

Biotope, or “living environment”, means all of the abiotic and biotic factors that characterize the environment in which a biocenosis lives. The word “habitat” is generally used to describe the living environment of one or several species. A habitat is different from an ecological niche, which could be all of the functional components plus all of the abiotic factors.

An ecosystem approach aims to balance the needs of human communities and ecosystems, and thus foster harmonious relationships at all levels. The basic concepts are:

- All of an ecosystem’s components (i.e. physical, chemical and biological) are interdependent;
- Ecosystems have a dynamic and complex nature that requires taking a flexible, adaptable approach;
- Scientific, social and financial concerns must be included.

1.3.2. Integrated Water Resources Management

The Global Water Partnership (GWP) defines Integrated Water Resources Management as a process that promotes the coordinated development and management of water, land and related resources in order to maximize economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

In its studies, GWP focuses on the following pillars for the harmonious implementation of IWRM:

- Enabling environment;
- Institutional framework;
- Management instruments.

The International Network of Basin Organizations (INBO) suggests taking an organized approach at the level of the hydrographic units that make up basins, i.e. water catchment areas for surface water, aquifers for groundwater, and joint management of surface and ground water based on the hydrographic basin's boundaries. At the INBO's General Assemblies in Morelia, Valencia, Salvador, Zapopan, Quebec, Martinique, Debrecen, Dakar and Fortaleza, it particularly recommended that agreements and strategies, programmes, financing and monitoring should all be devised at basin level.

2 Functions and benefits of aquatic ecosystems

KEY POINTS:

- An aquatic ecosystem in good condition can carry out diverse functions: production, regulation and organization.
- Ecosystem services are provisioning, regulatory, cultural and support services.
- Human action and activities often disturb the structure of the biotope, and cause organic pollution.

Aquatic ecosystems are numerous and diverse and they also provide several roles and functions, benefiting to mankind. This chapter briefly describes their composition and functioning, the ways to characterise them but also their functions to related services.

2.1 Role and functions of aquatic ecosystems (rivers, lakes & wetlands)

2.1.1 Varied ecosystems involving constant exchanges

Aquatic ecosystems are a subset of ecosystems (see definition in Introduction) in which water is a key component. A wide variety of aquatic ecosystems exist, and although they represent a low percentage of the Earth's surface, their roles and functions make them crucial.

We will focus here on inland surface water aquatic ecosystems. Three main types can be distinguished:

- Rivers, where water flows from source to mouth;
- Lakes, in the broad sense from small ponds to large lakes where water is stored according to the specific landscape and topography;
- Wetlands directly depending on aquatic ecosystems. The Ramsar Convention gives a wide definition of wetlands - "Areas of marshes, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is flowing or static, fresh, brackish or salty, including areas of marine water the depth of which at low tide does not exceed six metres." We focus here on inland wetlands.

More specifically, rivers, lakes and wetlands are complex systems that contain a richly diversity of living species that interact in varied ways by establishing relationships of cohabitation, competition, predation and parasitism. These species cannot survive on their own. To grow, they need energy and food, which they obtain from the outside environment comprising water, soil and atmosphere.

The composition of these populations therefore depends closely on the living conditions available to them, such as the water's current and depth, the temperature, oxygenation and chemical composition of the water, the nature of the beds, landform and vegetation of the catchment area, atmospheric conditions, etc. Conversely, the water's chemical composition is constantly modified by the living species present in the environment, especially the mineral and dissolved gas content.

Thus, biological species live in close interdependence and with their surrounding physical environment. The multiple exchanges of energy and matter constitute a delicate balance to maintain.

Box 1: World Wetlands Day

Each year, World Wetlands Day is celebrated on 2 February, to commemorate the signature of the Convention on Wetlands on 2 February 1971, in the Iranian town of Ramsar. The Ramsar Convention provides a framework for the preservation and rational use of wetlands and their resources. Wetlands management is an international issue and the Convention currently counts 160 member countries that recognize the value of a single international treaty devoted to one type of ecosystem.

On this day, governmental organizations, non-governmental organizations and citizens' groups are encouraged to initiate and take part in activities to raise public awareness of the value and benefits of wetlands in general, and the Ramsar Convention in particular. In recent years, this has involved a special theme or message defined by the Convention. The chosen theme for 2015 is "Wetlands for our Future".

More information:
http://www.worldwetlandsday.org/en

2.1.2 Identifying the parameters

Describing the status and diversity of aquatic ecosystems is based on structuring parameters that determine their functioning characteristics. Generally, water sciences distinguish four categories of parameters:

- Biological components;
- Hydromorphological components;
- Hydrological components (treated either separately from hydromorphology, or grouped together, as in the European Union);
- Chemical and physicochemical components.

For each of these categories, a wide set of parameters can be used and combined to determine the status of aquatic ecosystems. The parameters are qualitative or quantitative variables. In Europe for instance, with the adoption of the Water Framework Directive in 2000, they take the form of monitoring parameters that are combined to define the "ecological status" of the aquatic environment.

Box 2: European Water Framework Directive

The Water Framework Directive (WFD) is a European directive that defines a framework for a general EU Community policy on water. It requires achieving good water status by 2015. This water status is based on different parameters:

- **Biological** parameters - relating to the composition and abundance of aquatic flora and fauna;
- **Hydromorphological** parameters - the hydromorphological status of watercourses takes into account different factors - the hydrological regime (water flow, etc.), the ecological continuity (circulation capacity of aquatic species and sediment) and the morphological conditions (depth and width of the watercourse, structure of the bed or river banks, etc.);
- **Chemical and physico-chemical** parameters - the WFD makes a distinction between chemical parameters, i.e. the content of different polluting substances (priority and toxic substances), and physico-chemical parameters supporting the biology, such as the oxygen balance, water temperature, or nutrient concentrations.

In an undisturbed pristine water cycle, aquatic ecosystems are considered as having at least "good ecological status" or good quality, according to these criteria.

More information:
http://ec.europa.eu/environment/water/water-framework/index_en.html

Most aquatic ecosystems are disturbed by one or more driving forces, generally of human origin. These driving forces make use of the aquatic ecosystems and generate different types of pressure (pollution discharge, dam water storage, etc.) that can be identified by the above-mentioned parameters used to determine the state of the aquatic environment. These pressures generally have an impact on biological factors. The causal framework DPSIR / Driving forces - Pressures - State - Impact - Responses (adopted by the European Environment Agency) provides a suitable structure for analysis.

2.1.3 Ecosystem functions

The parameters are used to qualify and/or quantify the key functions of aquatic ecosystems. Ecosystem functions are defined as a subset of the interactions between biophysical structures, biodiversity and ecosystem processes.

An aquatic ecosystem in good condition can carry out diverse functions that can be grouped into several families:

- Production functions, which mostly concern the production of organic matter, the availability of non-renewable resources like water, and mineral substances;
- Regulation functions - the way ecosystems function contributes to stabilizing the variability of natural processes (climate, natural risks, etc.) and resource flows (soil water retention). They also play a role in eliminating the transformation of toxins (water self-purification);
- Organization (or structuring) functions - these contribute to defining the system’s self-organization rules. They involve the physical organization of systems (landscape structuring) and their biological organization (biodiversity).

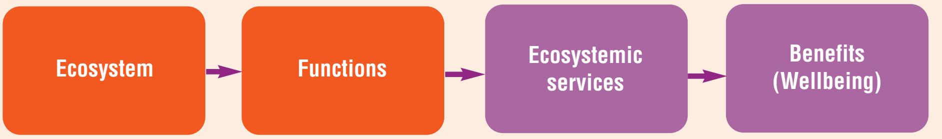
2.1.4 Ecosystem services

An aquatic ecosystem has multiple functions, which is highly important in a finite environment because it generates many benefits and services. These services are called ecosystem services and are usually defined as the benefits that humans derive from ecosystem functions. The sustainable functioning of these ecosystems should therefore be a target for water managers and many studies have shown that they are crucial to sustainable economic activity.

Each individual ecosystem forms the basis of functions that themselves generate services. Several alternative classifications of ecosystem services exist (The Economics of Ecosystems and Biodiversity, Millennium Assessment, Common International Classification of Ecosystem Services, as examples). They include three or four types of service (provisioning, regulatory, cultural and sometimes a fourth category of supporting services):

- Provisioning services include products resulting from ecosystems (food and water resources, diverse materials, fibres, genetic and biochemical resources, and other mineral resources);
- Regulatory services are the benefits resulting from the regulation of ecosystemic processes (i.e. climate regulation, hydrological regulation, water purification and treatment, regulation of natural risks and disease, erosion and sedimentation, pollution filtration);
- Cultural services include non-material benefits resulting from ecosystems (recreation and well-being services, religious and spiritual services, aesthetic value, education and cultural heritage);
- Supporting services comprise soil formation, the nutrient cycle and the water cycle.

Figure 1: Relationship between ecosystems, functions and services



Box 3: The Economics of Ecosystems and Biodiversity

The Economics of Ecosystems and Biodiversity (TEEB) is a global initiative that was launched by the G8 and five developing countries in 2007. It centres on the "economic benefits of biodiversity including the growing cost of biodiversity loss and ecosystem degradation. TEEB presents an approach that can help decision-makers recognize, demonstrate and capture the values of ecosystem services and biodiversity".

The TEEB study gathers experience, knowledge and expertise from around the world in the fields of science, economics and politics. Its aim is to guide decision-makers in establishing concrete political responses to the repercussions of the current deterioration of biodiversity and ecosystem services.

Several reports were published from 2008 to 2010 and the final results of the TEEB study were presented in October 2010 at the tenth Conference of the Parties (COP-10) of the Convention on Biological Diversity in Nagoya, Japan.

Source: http://www.teebweb.org/

Ecosystem services are established on different time and spatial scales. They can be apprehended at different levels, from local level (protection against natural risks, water sanitation, cultural functions) and national level (a country's water resources, national basins) to international level (transboundary basins, world water cycle, fight against climate change, etc.). They also vary over time: the water cycle takes place over the whole biosphere and over very long periods.

Box 4: Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES)

Following 6 years of negotiations, IPBES was set up in April 2012 to provide a platform of scientific information to aid local and international politicians making decisions on biodiversity conservation issues.

IPBES has several missions:

- Carry out assessments on biodiversity, ecosystemic services and their interactions on international, regional and sub-regional levels, as well as on thematic issues and new topics identified by science;
- Support the production and implementation of policies by identifying appropriate tools and methods and facilitating their access;
- Identify and accompany capacity-building requirements (training, dialogue, etc.) to improve the science-politics interface, especially in countries in the South;
- Facilitate a coordinated approach to producing new knowledge.

More information: http://www.ipbes.net/

2.2 Human activities and pollution sources

Human beings are key users of aquatic ecosystems and associated ecosystem services. This use may be conscious or not, and, depending on its intensity, may have little or no effect on the aquatic environment, or may generate significant effects, often known as dysfunctions. This chapter describes the main human activities that use aquatic ecosystems and the main dysfunctions, with a separate focus on pollution, split into the four categories of parameters identified in the previous chapter.

2.2.1 Biology: Modifications of the biocenosis - Invasive alien species

In aquatic ecosystems, all living species (i.e. the biocenosis) operate interdependently in a relatively balanced way via the food chain and the pyramid of productivity. This balance can be disturbed and broken by, for example, the disappearance of one or several species, or the introduction of invasive alien species.

The proliferation of invasive alien species threatens biodiversity and has an impact on human health. This is the case, for example, for plant species like water primrose, giant hogweed, Japanese knotweed and Myriophyllum spicatum, whether or not they are introduced intentionally. These invasive plants grow rapidly and supplant indigenous species; they develop excessively, reducing the concentration of oxygen, asphyxiating the natural aquatic environment and endangering fish and the development of other aquatic species.

Invasive alien plants can have consequences on human health. For example, the pollen of some plants (e.g. common ragweed) provokes allergies like rhinitis, conjunctivitis, asthma, hives and eczema. Invasive alien species can also have economic consequences, such as affecting agriculture, livestock production and fishing, or a negative impact on tourism and leisure activities (e.g. bathing, sailing).

Box 5: Evaluation of damages caused by invasive species in Europe

A European study for the first time evaluated the ecological damage and financial cost of invasive species in Europe (e.g. toxic algae, coypu, Canada geese, zebra mussel, etc.). The study was based on the European project Daisie (Delivering Alien Invasive Species Inventories for Europe) launched in 2005.

This programme led to an inventory of all alien species introduced onto the European continent since the discovery of America in 1492. Of the 10,000 species listed, 1,094 (11%) appear to have an ecological impact and 1,347 (13%) have an economic impact. Land vertebrates and invasive freshwater plants and animals appear to do the most damage to crops and forests in terms of cost, explained INRA. Thus, the invasive species that incur the greatest financial cost each year include single-celled toxic algae in Norway (8.2 million euro/year), water hyacinth in Spain (3.4 million euro/year) and the coypu in Italy (2.8 million euro/year). Land vertebrates like the coypu and the muskrat appear to have the highest combined ecological and financial impact, causing damage in over 50 European regions.

Scientists' objective in this study is to help prevent risks caused by the arrival on the continent of other potentially harmful alien species.

Reference: Front Ecol Environ 2009

Example 1: Invasive plants and neophytes in Lake Geneva

Japanese knotweed, summer lilac, cherry laurel and the black locust; these names have become familiar because they now appear in the vegetation around Lake Geneva. However, it was not always so.

These species are not indigenous; they were imported during recent centuries for trade, their ornamental qualities, or by accident, and have gone on to colonize natural environments. On the banks of Lake Geneva, some of these plants can be seen in gardens, but some are outside and have taken over unplanted areas or those previously occupied by indigenous vegetation. They can now be found in natural environments, like along watercourses, the lake or in forests, but also in urban environments, along roads or railways, or in rocks on the banks of Lake Geneva.

The Convention on Biological Diversity, which Switzerland and France have ratified, advocates preventing new introductions and requires monitoring or eradicating species already in place, which shows the benefit of the CIPEL for this problem and the need to act.

2.2.2. Hydromorphology: Mechanical action in ecosystems

Hydromorphological pressures on rivers and aquatic ecosystems are numerous, take several forms and can be originated from various human activities or water uses.

They comprise all physical alterations of water bodies modifying their shores, riparian/littoral zones, water level and flow (except water abstraction). Examples of such pressures are damming, embankment, channelization, non-natural water level fluctuations. Hydromorphological pressures are the consequence of human activities in the catchment area including hydropower production, flood defence structures, navigation, agriculture, land drainage, urban development, sand extraction and fisheries. Hydromorphological changes may also result from more than one activity (e.g. a multi-purpose dam for hydropower generation, water supply and flood protection).

Those mechanical actions, like dredging rivers and channelling banks with rocks or cement have an influence on the aquatic environment functioning, as they modify the equilibrium of river dynamics. It impacts water velocity, sediment transport and biological habitats, thus disturbing the structure of the biotope and consequently the organisms participating in the ecosystem.

Dredging a watercourse is generally a response to hydraulic considerations. For example, silting and clogging of the bed can cause floods so that the contractor is obliged to dredge. The primary cause is generally at a different level, i.e. urbanism, sediment erosion accelerated by deforestation, elimination of ditches, badly channelled drainage, etc.

A river may need to be dredged when navigation is hampered or made impossible by silt. Mechanical works on the watercourse may also be necessary when the bed is invaded by plants from the banks, aquatic plants have proliferated, the bed is clogged by diverse deposits (floating, blocking, etc.), or if the watercourse has shifted or the banks have collapsed.

Dragging rivers to extract gravel or sand can also perturb aquatic ecosystems.

Box 6: REFORM - Restoring rivers for effective catchment management

The overall aim of REFORM in Europe is to provide a framework for improving the success of hydromorphological restoration measures to reach targeted ecological status or river potential in a cost-effective manner. "Success" is defined as being hydromorphologically sustainable, ecologically effective, and exploiting full potential within the socio-economic setting. "Cost-effective" implies optimizing the ecosystem's health and the goods and services provided by natural, modified and restored rivers, floodplains and connected groundwater.

To achieve this aim, the REFORM consortium develops protocols and procedures to monitor the biological response to hymorphological change with greater precision, support the design of programmes of restoration and mitigation measures for the WFD, and improve the connection between restoration and socio-economic activities.

The specific objectives of REFORM are:

1. To select WFD-compliant hydromorphological and biological indicators for cost-effective monitoring that characterize the consequences of physical degradation and restoration in rivers and their services;
2. To evaluate and improve practical tools and guidelines to design restoration and mitigation measures;
3. To review existing data and information on hydromorphological river degradation and restoration;
4. To develop a process-based, multi-scale hydromorphological framework on European rivers and floodplains and connected groundwater;
5. To understand how hydromorphological pressures interact with other pressures that may constrain successful restoration;
6. To assess the significance of scaling effects on the effectiveness of different adaptation, mitigation and restoration measures to improve the ecological status or potential of rivers, floodplains and connected groundwater;
7. To develop instruments to analyze risk and assess the benefits of successful river restoration, including resilience to climate change and the relationship with other socioeconomic activities;
8. To increase awareness of the benefits of river restoration, along with an appreciation of the need and the potential.

More information:
http://www.reformrivers.eu/home

Works that eliminate all or part of wetlands, e.g. blind channels to plant crops or afforestation (especially poplar planting), or that use landfill to create land for building, also have a direct impact on the way the aquatic ecosystem operates.

2.2.3. Hydrology: Abstraction, regulation

Many human activities abstract water from the aquatic environment to use for different purposes. Abstraction can be carried out directly in the aquatic environment, or a specific infrastructure can be created (dam, reservoir, diversion, etc.) that may change the water regime over the hydrological year (e.g. store water in winter for use in summer).

When abstraction is substantial in relation to the quantity of water available, and/or carried out at low water levels, it perturbs the water cycle, which can damage the balance of the ecosystem. Similarly, diverting a watercourse reduces the quantity of water available in the main riverbed and thus impacts the hydromorphology and the biocenosis components of the ecosystem. Changing the annual water curve (dam regulation for example) can have similar effects by modifying water flow dynamics and disturbing sediment movement. Reducing or blocking a river's continuity by creating a sill or dam can also impact the living community of aquatic ecosystems.

Numerous examples exist of dysfunction due to abstraction or diversions caused by human activity: the drying-up of the Aral Sea following massive withdrawals to irrigate cotton crops is a symptomatic case that has been the centre of much media attention. However, the reduction in the number of wetlands around the world illustrates the extent of this type of dysfunction, which can affect much smaller areas than the Aral Sea.

Watercourse diversions and many hydromorphological alterations that modify the water curve (channelization and meander cut-off) also come under this category, since the natural flows of the low-flow and high-flow channels are affected.

2.2.4 Chemical and physico-chemical: Organic pollution, eutrophication and micropollutants

Many human activities cause organic pollution. In addition to the discharge of domestic wastewater (untreated wastewater) or industrial wastewater that has not been treated adequately (e.g. from food and wood industries), agriculture can be a significant source of pollution, via livestock farming including silage production or manure / sludge spreading on land. This input of organic matter into the aquatic environment can use massive amounts of oxygen, with the potential to kill fish and disturb the aquatic ecosystem.

Depending on its content, organic pollution can also add high levels of nutrients to the aquatic ecosystem. The excessive use of fertiliser can have a similar effect via erosion or leaching.

Excess nutrients trigger the phenomenon of eutrophication. The exaggerated growth of aquatic plants with access to a significant mass of nutrients (phosphates and nitrates) results in a considerable reduction of dissolved oxygen and environmental asphyxia. This phenomenon can be natural in closed environments, like ponds, where plants produce nitrogen and phosphate compounds when they die and sink. However, the phenomenon of eutrophication through inputs of human origin creates disequilibrium in the ecosystem that is visible as "algal bloom", and causes the death of fish and putrefaction.

Human activities can also discharge micropollutants. Micropollutants are chemical substances found in low quantity that have a polluting effect on the aquatic environment. Three main groups are generally identified: organic, metallic and organometallic. They are generated by a number of human activities linked to extracting, transforming and using raw materials. It also can be generated through their end-of-life breakdown (waste). Depending on their physico-chemical and toxic characteristics, they have a varying impact on all or part of the ecosystem. People can then be exposed through environmental factors (especially air or skin contact), through food, or at work.

Other parameters can also have an impact on the functioning of ecosystems. For instance, discharges of hot water (e.g. from industry and nuclear power stations), when regular, modify the ecosystem by changing the structure of the biocenosis.

3 Including ecosystems in River/Lake Basin management plans

KEY POINTS:

- A basin management plan should include a strategy and measures relating to aquatic ecosystems.
- Ecosystems conservation and restoration should be analyzed in line with the social and economic dimensions.
- The basin's "ecology" dimension needs to be crossed with all of the objectives and themes covered by the plan.

Efficient basin management requires a multiannual management plan. This should be devised and implemented on the basis of a diagnosis of the basin's water resources and territory taking into account any probable changes.

Box 7: River Basin planning - Principles, procedures and approaches for strategic basin planning

This Asian Development Bank (together with GWP, UNESCO, WWF) publication gives advice on how to prepare a basin management plan. The authors list 10 basic rules to respect when devising a basin plan:

Rule 1: Fully understand the basin and how it functions;

Rule 2: Start preparing the plan even if your knowledge of the basin is not complete;

Rule 3: Rank the challenges and take an iterative approach in several phases to reach long-term targets;

Rule 4: Allow for adaptations to account for changing circumstances;

Rule 5: Accept the fact that drawing up a basin plan is intrinsically iterative and chaotic;

Rule 6: Draw up pertinent, consistent thematic plans;

Rule 7: Tackle problems at the appropriate level using local plans within the basin plan;

Rule 8: Involve stakeholders to strengthen institutional relations;

Rule 9: Constantly focus on the plan's implementation;

Rule 10: Select the method that best corresponds to the basin's requirements.

More information:
www.adb.org/publications/river-basin-planning-principles-procedures-and-approaches-strategic-basin-planning

3.1. Ecosystem considerations in basin planning processes

The planning process comprises the following steps:

❶ Carry out a basin characterization - a diagnosis, made not only in the sense of the hydrographic basin (including groundwater), but considering the basin as a territory involving interaction between the activities that develop there, the water resources and aquatic environment.
It is important that the diagnosis phase should be carried out in a participative way, in particular to ensure that environmental aspects are integrated right from the start of the process ("major issues").
Several methods and tools can be used for basin diagnosis; a special approach uses "Water footprints";

Box 8: Water footprints as a diagnosis tool

Evaluating the water footprint is a technique to connect the water situation and aquatic systems. The water footprint is the total volume of virtual water used to produce a product or service. It is an indicator based on the actual consumption of water at different stages of production by the consumer or producer. A distinction is made between:

- Blue water, which is the water withdrawn for domestic and agricultural use (surface or ground freshwater);
- Green water, which is rainwater stored in the soil (moisture + evaporation + transpiration);
- Grey water, which is water polluted by production processes.

Water footprints can be useful for:

- Assessing the extent of potential environmental impacts relating to water;
- Identifying possible solutions to reduce potential environmental impacts associated with products at different stages of their life cycle and with processes and organizations;
- Managing strategic risks related to water;
- Implementing effective, optimal water management at the level of products, processes and organizations;
- Informing decision-makers from industry and governmental and non-governmental organizations of their potential environmental impact on water (e.g. for strategic planning, establishing priorities, designing or re-designing a process or procedure, decisions concerning investing resources);
- Supplying consistent and reliable information, based on scientific proof, to present the results of the water footprint.

A water footprint evaluation carried out in line with international standards can either be an autonomous evaluation, assessing only impacts relating to water, or part of a life cycle assessment, in which all environmental impacts are taken into account.

❷ Based on the characterization and detailed diagnosis, the next phase involves defining the basic (ranked) objectives. Objectives relating to the preservation and restoration of aquatic ecosystems can feature via more general objectives;

❸ The next phase relates to developing strategies in the basin (strategies to reach objectives) and the actions or measures to carry out; it should obviously comprise action relating to aquatic ecosystems;

❹ The programme of measures or programme of action results from the previous stages. It should include an analysis of how the measures will be funded and indicators for evaluating the action.

Example 2: Danube River Basin Management Plan 2009 - 2015

The preparation of the Danube River Management Plan by the International Commission for the Protection of the Danube River (ICPDR) followed WFD recommendations in four distinct phases:

- **PHASE I:** Definition of districts of the basin and definition of the institutional framework and coordination mechanisms (19 different countries);
- **PHASE II:** Analyses of basin characteristics, pressures and impacts, and financial analysis; establishment of a register of protected zones;
- **PHASE III:** Development of surveillance networks and programmes;
- **PHASE IV:** Development of basin management plan including joint programme of measures.

The 2009 - 2015 management plan comprises several parts, with a strong focus on the challenges of protecting the basin's ecosystems:

1. The plan begins by identifying the significant pressures in the basin, both on river and lake waters and groundwater;
2. The plan then analyzes all of the protected zones in the basin;
3. A specific section presents the ecological and chemical status resulting from data supplied by networks measuring and monitoring surface waters and groundwater;
4. On this basis, the plan defines the environmental objectives in the basin. These are then broken down into joint programmes of measures involving riparian countries, by type of action. The plan stipulates actions involving the "whole basin" and those relating to national level.

The river basin management plan constitutes a general framework to inspire complementary national plans.

More information:
www.icpdr.com

Example 3: Basic guidelines - Rhone Mediterranean Corsica River Basin 2009 - 2015

The management plan ("SDAGE") for the Rhone Mediterranean Corsica river basin in France targeted 8 basic guidelines. Some of these are directly related to ecosystem issues:

- Prevention, i.e. foster prevention and intervention at source for greater effectiveness;
- Non-degradation, i.e. make the principle of non-degradation of aquatic environments a reality;
- Functional environments, i.e. preserve and develop the natural functions of river basins and aquatic environments.

Others are connected to environmental aspects:

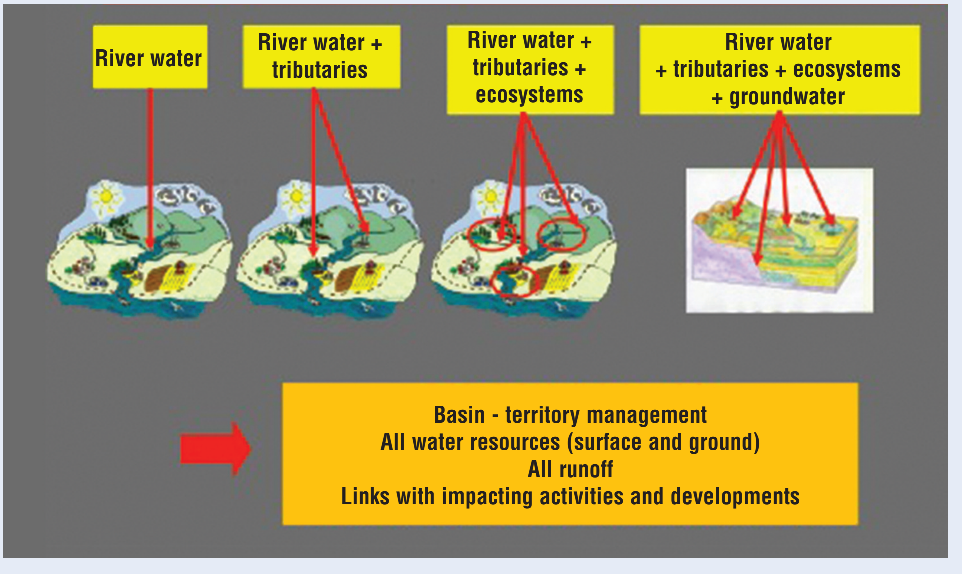
- Social and economic vision, i.e. include social and economic dimensions when implementing environmental objectives;
- Local management and territorial planning, i.e. organize stakeholder synergy to set up genuine territorial projects for sustainable development;
- Flood control, i.e. manage flood risks taking into account the natural function of waterways.

Example 4: Fundamental guidelines of the SDAGE (water development and management masterplan) for the Rhone Mediterranean Corsica River Basin, France

The Rhone Mediterranean Corsica River Basin Agency in France has produced a management plan for 2016 - 2021. To make it easier to identify priority action, important issues emerging from the basin characterization were crossed with the basic objectives.
While ecosystems are directly mentioned under basic objective 6 "Physical Restoration of Environments", significant issues relating to ecosystems also feature in several sections, i.e. toxic substances, pesticides, eutrophication, wetlands, species and biodiversity. Overall, ecosystems are dealt with in numerous sections, such as pollution control, physical restoration of environments, and non-degradation. This method ensures that the subject of aquatic ecosystems is present in all activities, and not just those centred on the environment.

Another important aspect in considering ecosystems in basin planning is the need to move from managing waterways in a basin towards managing the territory. The following diagram illustrates how the concept of basin management has evolved.

Figure 2: How water management has evolved. Scope of management

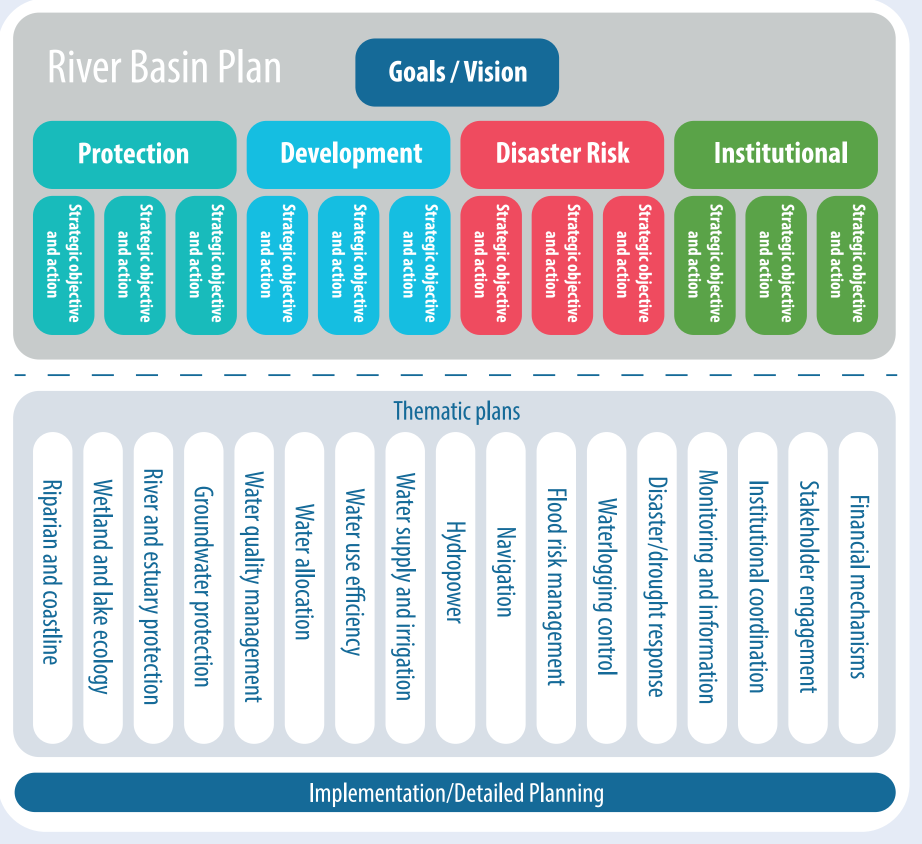


Source: INBO

3.2 Interface between basin management plan and the thematic plan

To include the management, conservation and restoration of aquatic ecosystems in basin management plans requires taking a cross-cutting approach. "Greening" a basin management plan by introducing a chapter on ecosystems is far from sufficient. The basin's "ecology" dimension needs to be crossed with all of the objectives and themes covered by the plan.

Figure 3: Interface between elements of the basin plan and supporting thematic plans



Source: INBO

To ensure that the basin management plan correctly deals with environmental aspects, several conditions must be met:

1. Understand the functioning of ecosystems, their challenges and the services they provide;
2. Incorporate the environmental objectives in the vision and objectives of the basin;
3. Pinpoint the ecological objectives in the basin;
4. Define objectives, priorities and different levels of protection for each part of the basin;
5. Set up standards or plans where necessary;
6. Support planning by financial planning (too often a weak part of planning documents) - including planning of water infrastructure financing, without ignoring to include ecosystems / natural infrastructure.

3.3 Barriers to implementation

It is important to be aware of obstacles to considering environmental aspects in river basin management plans. Firstly, the basin organization should have a clear mandate to deal with issues related to the environment.

A realistic plan regarding environmental issues is preferable to a plan that is too ambitious and unlikely to succeed. Even if the state of knowledge is still insufficient, it is preferable to start including ecosystems in a basin management plan rather than waiting for more exhaustive knowledge on the subject.

Technical barriers can result from the design of a plan, its complexity or over-ambitious targets that make it unrealistic. When stakeholders' responsibilities for implementing actions are not properly defined, difficulties can hinder implementation. It is indispensable to take into account increasingly uncertain future trends (e.g. climate change, global changes), which impact on ecosystems.

Communication is an important lever throughout the planning process. Information and communication aimed at the public and stakeholders should be carefully prepared, consistent and educational.

4. Management and restoration of aquatic ecosystems

KEY POINTS:

- Restoration is an integral part of sustainable water management and involves a wide range of stakeholders.
- Wetlands improve water quality by trapping sediments, filtering pollutants and absorbing nutrients.
- Environmental flow helps maintain downstream aquatic ecosystems.
- Human intervention has fragmented around 60% of the world's rivers.
- The joint study of green and grey infrastructures constitutes a new paradigm.
- Natural Water Retention Measures provide a wide range of benefits for flood control and ecosystem services.

4.1 Restoration practices

Restoration refers to a large variety of measures and practices, which can vary considerably in size and complexity. These are aimed at restoring the natural state and functioning of the river system, lake or wetland to enable its sustainable and multifunctional uses. River restoration is thus an integral part of sustainable water management, and is also becoming more and more important in integrated river basin management. The European Center for River Restoration has established a network for best practices of river restoration in Greater Europe. Lot of restoration measures are linked to flood risk management.

4.1.1 Restoration methods

A restoration project requires expertise and skill in various disciplines. The different steps can be summarized as: planning, designing, constructing and monitoring.

Careful planning of a restoration project, clear objectives and communication with all those involved greatly improve the chances of reaching its targets. There are several reasons for this: for example defining the aims of the project makes it easier to identify the specialists required, and setting clear and measurable objectives means that the project can be evaluated. Planning entails understanding people's needs and points of view, which is important since restoration of aquatic ecosystems involves a wide range of stakeholders from the public and private sectors, including policy makers, practitioners, scientists and non-government organizations, as well as any citizens groups that may be impacted. It also avoids inefficiency and gives project leaders an opportunity to explain what they are doing and the related costs. Various regulations usually apply to restoration projects. It is essential to make a list of all of the regulatory constraints to ensure that a project is successful.

Example 5: Restoring river continuity in France

In France, more than 80,000 structures - dams, locks, weirs and mills - have been listed on rivers and are potential obstacles to river continuity. The European Water Framework Directive (WFD), the French Water Act of December 2006, the French National Eel Management Plan, and the Grenelle 2009 law whose objective is to implement an ecological network (French “green and blue network”), all focus on improving and restoring biological continuity between major natural habitats and within aquatic environments. In practical terms, these regulatory texts increase collective efforts and action in France in favour of restoring river continuity over the next four years.

More information:
http://www.onema.fr/IMG/EV/publication/continuite-cours-eau-UK.pdf

Design work will help to identify the most appropriate restoration measures for the situation, and the projected costs of these measures. This step can also be a good point to determine a monitoring strategy, setting out its objectives, spatial extent, the period of monitoring, measurement protocol, and the stakeholders involved.

Pre- and post-project monitoring are required. Pre-project monitoring is based on the existing conditions report. Monitoring makes it possible to evaluate whether ecological targets have been reached and whether restoration techniques have been effective. Feedback from monitoring can lead to the implementation of other projects.

When constructing a restoration project, several considerations should be taken into account. The project is usually conducted so as to avoid or minimize impacts to the surrounding environment; erosion and sediment control, noise control, etc. All existing elements, such as roads, wildlife, streams or wetlands should also be considered when building a project. It is important to avoid disturbing historic features designated for protection and preferable to consider the landscape that the project will create. Lastly, communication and management skills are essential for an efficient project. Post-project monitoring can determine if the restoration was carried out according to the approved objectives.

Sharing lessons and experiences can be of maximum benefit, since it improves best practices and may influence future funding for similar schemes.

Example 6: RESTORE - A database to share case studies on river restoration

RESTORE RiverWiki is a tool for sharing best practices and lessons learned for policy makers, practitioners and researchers involved in river restoration. This interactive database comprises over 800 case studies from across Europe with examples of mitigation, restoration, enhancement and rehabilitation that illustrate the multiple benefits achievable through properly planned and executed projects. Registered users are free to add case studies. The database provides project data (including objectives, techniques and outcomes) as well as information on ecosystem benefits, stakeholder participation and costs.

http://restorerivers.eu/wiki/index.php?title=Main_Page

Example 7: Sharing river restoration examples in France

A brochure put together by ONEMA features more than 80 examples of river hydromorphology restoration undertaken over the past 20 years throughout France. These actions, which aim to preserve river hydromorphology or re-establish the hydromorphological processes of rivers, take three forms: remeandering, weir or dam removal, and river bank protection removal. The examples highlight the benefits of each project.

The first part of the publication provides basic information on the advantages of restoration, pointing out that river dynamics lie at the origin of biodiversity and good ecological conditions, and that aquatic environments have much to offer society.

More information:
http://www.onema.fr/IMG/EV/publication/plaquette-hydroGB.pdf
http://www.onema.fr/Hydromorphologie,510

4.1.2 Flood risk management

Rivers, floodplains, lakes and wetlands perform financially and environmentally valuable functions related to the regulation of river discharge. They play a particular role in floodwater retention and in the recharge and discharge of groundwater. Restoration measures can increase natural storage capacity and reduces flood risk by re-connecting brooks, streams and rivers to floodplains, former meanders and other natural storage areas, and enhancing the quality and capacity of wetlands.

Example 8: The Izumi River restoration

The Izumi River is a small river flowing through lowlands at the bottom of the valley in the plateaus west of Yokohama City, Japan.
Farmland and sloping woods line the riverbanks of the middle and lower streams, but the riverside area has undergone rapid urbanization because the area is close to the centre of Yokohama City. As a result, during the 1970s the river flooded easily, even when rainfall was low. To respond to this, steel-sheet-pile revetments were constructed and the riverbed was deeply excavated, which made the river inaccessible.

In 1987, Yokohama City drew up a plan to use the land abutting the Izumi and improve the river, in line with other projects for developing parks and conserving green space. It also planned workshops for elementary school children living in the river basin. Various waterfront bases were established. For example, at the “Waterfront of Higashiyama” the river width was increased, and the shapes of flow channels and riverbanks were rearranged to suit surrounding geographical features. The sloping woods on the left bank of the river were also improved as part of the development of river space. The result is a green area that is attractive to citizens.

Source: Guideline for restoration by eco-compatible approach in river basin of Asia - ver.2
http://www.a-rr.net/index.html

4.1.3 Hydropower and dams

Dams and weirs built to generate electricity and for other operations (irrigation, flood control, water supply, etc.) can constitute a serious threat to functioning river systems. Among other impacts, they affect the transportation of natural sediment, resulting in the retention of sediment upstream from dams and consequently the loss of sediment downstream. Works of this kind have a significant effect on ecological continuity by preventing fish from migrating upstream to access spawning areas and downstream. Mortality rates of fish can be significant when they pass through hydraulic turbines during their downstream migration. Discharge modification, changes in water quality in the lakes created, and temperature can also deteriorate habitats and impact species.

To reduce the impact of dams, several options are possible. The creation of fish passes or ladders can facilitate the movement of a range of targeted fish species. Implementing good practices in managing structures can also limit the impact on the environment and species. Examples are: stopping turbines during downstream migration to limit fish mortality; sediment flushing or sediment removal by mechanical dam management procedures; installing screens at inlets and fish-friendly turbines in order to reduce mortality of fish moving downstream; and implementing an environmental minimum flow to sustain freshwater ecosystems.

Specific dam operating rules could also be implemented such as artificial floods that can also help preserve downstream wetlands, or sediment flushing techniques that could limit siltation rates in the dam and sediment material deficits downstream.

Example 9: Practical solutions to improve fish passage for an endangered migratory fish - The eel

The European eel was until recently an abundant species in most European freshwaters, but its numbers have fallen sharply since the 1970s and 1980s. The causes of the rapid decline, which now threatens the very existence of the species, are clear for the most part and include fishing, poor quality of water and habitats, fragmentation of rivers by weirs and dams, and death in hydroelectric turbines. To meet the restocking goals set by the European Union, France has initiated a management plan addressing each of the factors responsible for the decline of the species.
Concerning river obstacles and turbines, the Ecology ministry launched a Research & Development programme bringing together a number of partners, including ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie), Onema and five hydroelectric companies (namely Compagnie nationale du Rhône, EDF, France Hydro Electricité, GDF Suez and Société hydroélectrique du Midi).
The programme, managed by a steering committee comprising the partners mentioned above and under the responsibility of the Ministry for Ecology, targeted a number of operational goals that resulted in the development and testing of technical solutions designed for rapid implementation in the field: How can the upstream migration of eels be encouraged, from the initial tide gates in estuaries up to and beyond the high dams located upstream? How can the conditions for downstream migration be improved at each installation? Finally, how can the cumulative impact of a series of installations along a river be calculated in order to adapt the management of hydroelectric turbines?
All programme results were presented in November 2011 at the feedback symposium, which brought together researchers, water managers, associations and hydroelectric companies.

More information:
http://www.onema.fr/IMG/EV/meetings/management-plan-to-save-the-eel.pdf

4.1.4 Preservation of biodiversity and habitats

Aquatic ecosystems including wetlands provide habitats for many plants and a space for animals to feed, rest and reproduce. Rivers carry sediments that transform riverbeds and contribute to the creation of habitats. However, humans have modified the structure and aquatic fauna habitat of many rivers in the world by constructing dams, weirs and watermills in order to produce electricity, facilitate navigation and irrigate.

River restoration contributes to biodiversity by restoring ecosystems, habitats and ecological continuity. Physical restoration works include re-meandering (bringing back the curves of a natural river if they are still identifiable or creating a new meandering course), creating green-natural river banks where banks were previously encased in concrete, or returning a watercourse to its original bed to reconnect it with its associated groundwater.

Fish passes, however, only allow a range of selected fish species to pass obstacles such as sluices or dams (see paragraph above) situated in the river. Therefore, to restore both the fish habitat when the dam or weir has damaged the impounded reach, and the river's continuity (sediment transport, passage of aquatic fauna), it is often preferable to remove such obstacles so as to restore the river dynamics.

Example 10: Largest dam removal in the United States

Elwha River Restoration is a project that aims to restore the Elwha River's ecosystem by removing the lower Elwha Dam and the higher Glines Canyon Dam that were built on the river for hydropower.
The removal of these dams began in late 2011.
Today, both dams are gone, Elwha River flows freely from its headwaters in the Olympic Mountains to the Strait of Juan de Fuca, sediment once trapped behind the dams is rebuilding the river and nearshore habitats, vegetation is being restored, and salmon and trout are naturally migrating past the former dam sites for the first time in over 100 years.
Glines Canyon Dam, which once towered 64 metres tall, is the largest dam to have been removed in US history. Numerous people and groups have worked for decades to restore the Elwha River (lawyers, scientists, associations, tribes, etc.).
More than 1,100 dams have been removed nationwide, with positive impacts on river water, fish and wildlife, public safety, recreation, and local economies.

Source (image): seattletimes.com
More information : http://www.nps.gov/olym/naturescience/elwha-ecosystem-restoration.htm

Lakes and wetlands are of main importance for biodiversity. They support a large number of species: birds, mammals, amphibians, reptiles, plants, etc. and can be a stopover for migratory birds to rest or feed. Many species rely on the regular flooding cycles of wetlands to reproduce. Wetlands are important for freshwater fish, and many of these species require shallow wetlands to breed. The restoration of lakes and wetlands thus helps increase biodiversity and improve connectivity between habitats.

4.1.5 Improvement of water quality

Good functioning aquatic ecosystems can play a role also in sustaining or improving water quality, for example thanks to self-purification process along rivers.

Wetlands also improve water quality by trapping sediments, filtering pollutants and absorbing nutrients. Wetlands are even sometimes used for wastewater treatment. The restoration of wetlands contributes to maintaining these services and is also a basis for achieving a healthy environment.

Example 11: The Tancat de la Pipa

Júcar River Basin Authority

One of the most valuable wetlands in the Mediterranean region is the Albufera Natural Park wetlands in Valencia, which is included in the RAMSAR List of Wetlands of International Importance. This wetland, which has immense ecological value, is located south of the city and covers 21,000 hectares.

For centuries, Albufera Natural Park has seen its wetlands transformed by successive generations of inhabitants benefitting from the natural resources in the area (salt, wood, game and fish).
In the 18th century, it was changed from a salt marsh to a fresh water system used for rice crops, but still with a stable ecological balance.

In the 1970s, however, the strong urban, agricultural and industrial growth of Valencia and its surrounding villages significantly impacted on the lagoon's water quality. This was due, on one hand, to a constant flow of untreated urban and industrial wastewater inflows and, on the other hand, nutrient-loaded runoff from crop fields.

Thus, the crystal clear waters filled with aquatic flora and fauna became cloudy as a result of the large amounts of pollution in the form of organic matter discharged directly into the natural environment. This drastically increased the concentrations of dissolved nutrients favouring a very high growth of phytoplankton, which resulted in the water's hyper-eutrophication.
Since the 1980s, significant investments have been made in water treatment and sanitation; nevertheless, the Albufera's water is still eutrophic.

The decision was therefore made to develop the construction of an artificial wetland to form the 40-hectare "Tancat de la Pipa". The implementation of this project responds to a need to quantify and experiment with the wetland's environmental needs in order to reverse the current situation. The site is the result of an ecologic restoration project that involved transforming rice fields into different, typical wetland habitats. The Júcar River Basin Authority (Confederación Hidrográfica del Júcar) is the owner of the land and main contractor of the restoration works, together with the Regional Ministry for Infrastructures, Land and Environment.

So far, the benefits of this project have been:

- Improved water quality. The water ecosystems established in Tancat de la Pipa, which comprise artificial wetlands with surface flow and lagoons, have shown a great capacity to reduce suspended solids, total phosphorous, total nitrogen and phytoplankton in the water;
- Increased biodiversity. Water quality is key to constituting a well-balanced trophic chain in wetland ecosystems. Submerged water plants have reappeared in the lagoons thanks to the water inflow from green filters, providing shelter, nutritional value and oxygen, which are vital to many living things. Some species have, once again and in a natural way, found in Tancat a suitable spot to live and breed after a long absence from the Natural Park;
- Higher demand for visits and social participation. Since it officially opened to the public in 2009, more than 20,000 people have visited Tancat de la Pipa and participated in numerous activities on the site. Guided visits and training and volunteering programmes have been organized. The Public Use Plan of Tancat de la Pipa aims at proving the importance of preserving the huge patrimony of Albufera Natural Park to all sectors of the population.

In order to optimize the site's management, in 2011 the Júcar River Basin Authority signed land custody agreements with the NGOs Acció Ecologista-Agró and SEO/BirdLife, which directly run Tancat de la Pipa under the Júcar River Basin Authority's supervision.

More information:
www.tancatdelapipa.net

4.1.6 Land use management

The different forms of land use, such as agriculture or forestry, can alter the functioning of aquatic ecosystems, and the quality of waters.

Land application of fertilizers near streams, lakes or wetlands can for example, directly pollute water through runoff or projection. Small agricultural streams are important since they join together and create rivers, and also provide habitats for plant and animal species. Their pollution thus has an impact on rivers. Pollution in lakes and wetlands can also lead to a loss of biodiversity.

Agricultural activities can cause sedimentation problems: wind and water move soil, exposed without vegetation, from the watershed into the water body. These sediments reduce the amount of sunlight available to aquatic plants and cover fish-spawning habitats, and food supplies interfere with filter feeding organisms.

In both cases, buffer strips can provide a physical barrier that helps restrict the flow of pollutants and sediments and prevents them from being washed into the aquatic ecosystem.

Forestry operations can also be accomplished without harming the ecology and morphology of rivers or wetlands. If water crossings cannot be avoided, appropriate technical solutions exist to reduce the impact of machines or cars crossing forest streams, for example building culverts, arches or bridges.

4.2. Green infrastructures and environmental impacts

4.2.1 Green infrastructures

Critical services provided by nature equate to most functions of traditional infrastructure. Wetlands and lakes, upland forests and aquifers provide water storage, wetlands filter water, rivers provide conveyance and transportation, floodplains and wetlands lower flood peaks downstream, while mangroves, coral reefs and barrier islands protect coasts against storms and inundation.

With the term infrastructure defined as “the stock of facilities, services and installations needed for the functioning of a society”, nature is part of the infrastructure portfolio of every country and economy. Nature is thus a “green infrastructure” or “natural infrastructure”, based on its capacity to complement or augment the services provided by traditional engineered (or “grey”) infrastructure. According to the European Commission, green infrastructure addresses the spatial structure of natural and semi-natural areas, but also other environmental features which enable citizens to benefit from its multiple services.

Box 9: Investing in green infrastructure in Europe will bring multiple returns to nature, society and people

Europe's landscape is dramatically modified every day by the fragmentation, modification and intensification of land use as a result of a persistent human development. Degraded ecosystems tend to be less species-rich and are unable to offer the same range of services as healthy ecosystems.

In May 2013, the European Commission adopted a new strategy for encouraging the use of green infrastructure, and for ensuring that the enhancement of natural processes becomes a systematic part of spatial planning. Green infrastructure is often cheaper and more durable than conventional civil engineering alternatives. In addition to health and environmental benefits, green infrastructure brings multiple social benefits: it creates jobs and makes cities more appealing places in which to live and work.

The strategy focuses on:

- Promoting green infrastructure in the main policy areas, such as agriculture, forestry, nature, water, marine and fisheries, regional and cohesion policy, climate change mitigation and adaptation, transport, energy, disaster prevention and land use;
- Improving research and data, strengthening the knowledge base and promoting innovative technologies that support green infrastructure;
- Improving access to finance for green infrastructure projects;
- Supporting EU-level Green Infrastructure projects.

By the end of 2017, the European Commission will review progress on developing Green Infrastructure and publish a report on the lessons learnt together with recommendations for future action.

More information:
http://ec.europa.eu/environment/nature/ecosystems/index_en.htm

The multiple ecosystem services provided by natural infrastructure multiply the benefits received. In this sense, a natural infrastructure that functions well enables built infrastructures to perform better thus increasing returns on investment. It also provides job opportunities and is a key solution for climate change and disaster risk reduction.

The costs and benefits of ecosystem services need to be valued for dams, storage, irrigation and drainage investment. Leaving natural systems out of the planning processes can be very costly. Also, there is a need to include ecosystem valuation in water investment decisions, to ensure that the returns on investment for river basin management are clear and quantified, to inform better decision making. Valuation of ecosystem services can help supply the tools to make better economic decisions about threats to the environment.

4.2.2 Environmental flows

Developed and developing countries are increasingly adopting environmental flow provision, including volumes and timings, to maintain downstream aquatic ecosystems and provide services to dependent communities. The causes of changes in river flow can be broader than just the abstraction of water or a regulation of flow due to infrastructures (large dam, water transfer or diversion); upstream land-use changes due to forestry, agriculture, and urbanization can also significantly affect flows. The impacts of environmental (or ecological) flow can extend beyond surface water to groundwater, estuaries, and coastal areas.

Example 12: Water for the environment in Australia

The world's driest inhabited continent, Australia, suffers from water scarcity issues due to highly variable rainfall patterns and prolonged droughts. This is problematic for Australia's largest river catchment, the Murray-Darling Basin. Known as 'the nation's food bowl', the Basin covers more than one million square kilometres, and has been developed to secure vital social and economic outcomes.

To address river management and environmental health issues, the first Murray-Darling Basin Plan was passed into law in 2012. It provides for the integrated and sustainable management of water resources across the entire Murray-Darling Basin. As part of this plan, 25% of water currently used for human activity will be secured to support the ecological health of the basin's rivers. This water is being acquired from irrigators through direct purchase of entitlements and by making existing infrastructure and on-farm water use more efficient. It is being held by a dedicated environmental water holder and used to augment river flow patterns - to restore ecologically important components of the flow regime and thereby improve environmental outcomes.

Above: Little Rushy Swamp during a 2013 environmental watering event
Inset: Ibis breeding in Barmah-Millewa Forest (Photos: Keith Ward)

The Murray-Darling Basin contains the largest river red gum forest on the planet - The Barmah-Millewa Forest. Home to over 550 native plants and 270 animal species, this Ramsar-listed area is one of the few preserved freshwater floodplain systems along the River Murray, and contains many sites of significance to Aboriginal people.

River regulation has reduced extensive flooding in the Barmah-Millewa forest from once every two years to once every four years. Combined with an extended drought from 1999 to 2009, lack of water resulted in extreme stress in the forest ecosystem, with many native species of flora and fauna under strain or dying.

To support the health of this river red gum ecosystem, environmental water is being used across Barmah-Millewa Forest in many ways:

- During drought, environmental water is used to protect vital habitat refuges. This boosts small-scale breeding and fosters the survival of native species;
- During periods of above-average inflow, environmental water is released to supplement naturally high river flows. This creates larger flooding events and, as natural flows recede, environmental water is used to maintain water levels across the forest for longer periods.

This supports successful breeding of large numbers of water birds, increases fish and turtle populations, and improves the health of vegetation. Flows returning from the forest support ecological outcomes in downstream reaches of the river.

When flooded, 54 water bird species have been recorded breeding in this forest, including 25 species of colonial nesting water birds - sometimes in their tens of thousands.

More information on video: http://youtu.be/cOg5xHqUDOQ

According to the World Bank, lessons in assessing and implementing environmental flows are:

1. Environmental flows must be included in water resources policy;
2. Environmental outcomes need to be linked closely to social and economic outcomes;
3. Environmental flow assessments should be conducted for all components of the hydrological cycle (not only low flow but also managed flood releases, which maintain wetlands);
4. IWRM basin plans provide benchmarks for water allocations during project assessments;
5. Active monitoring is needed to enforce flow allocation decisions and undertake adaptive management;
6. Engineering improvements usually have to be combined with reoperations to provide the volume of water needed for major ecosystem restoration;
7. Economic studies can support arguments for downstream water allocations.

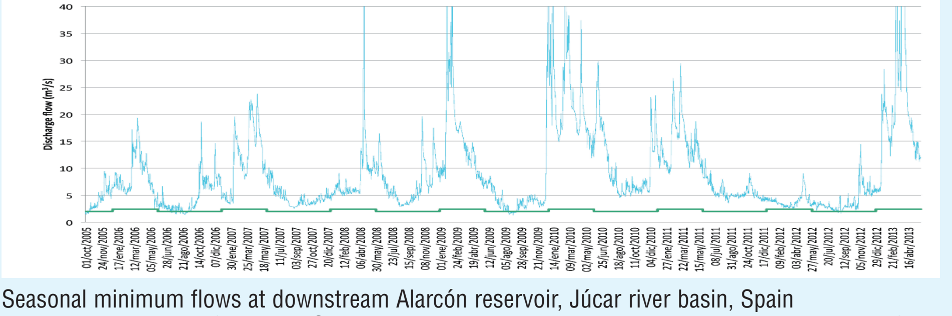
Example 13: Ecological flow regimes in Spain

The ecological flow concept was developed in Spain as a response to the degradation of water ecosystems due to an overexploitation of river flows. Ecological flows are essential to achieve sustainable water resources management that respects the water environment. Nevertheless, there is a risk that establishing ecological flows could increase water-related conflicts, particularly in water scarce regions.

In Spain, the Water Act establishes that hydrological basin plans determine environmental flows, understood to be flows that maintain at a minimum the fish life that would naturally inhabit the river, as well as its riverbank vegetation. A fundamental feature of the Spanish basin plans is water resources allocation for the different water demands, which makes ecological flows compatible with satisfying demands.

The Hydrological Planning Instruction considers the following with regard to the environmental flow regime:

1. Ecological flow regime;
2. Ecological flows for hydrological altered water bodies;
3. Ecological flow regime during prolonged droughts;
4. Water requirements of lakes and wetlands;
5. Repercussion of the environmental flow regime on water uses;
6. Participation process for implementing the ecological flow regimes;
7. Ecological flow regime follow-up.



Seasonal minimum flows at downstream Alarcón reservoir, Júcar river basin, Spain

Integrating ecological flows into Spanish water management will be a challenge over the next few years, particularly since Spanish legislation does not consider these flows as an environmental demand that might not be satisfied in specific circumstances, but as an environmental restriction to water use.

Source: Júcar River Basin Authority and Technical University of Valencia

4.2.3 Environmental impacts and the new paradigm

The nature of the impacts of large dams on ecosystems is generally well known and many guidelines exist regarding Environmental Impact assessments: the International Commission on Large Dams (ICOLD), International Hydropower Association (IHA), World Bank, Economic Community of West African States (ECOWAS), etc. According to the World Commission on Dams, human intervention (dams, inter-basin transfers, and water withdrawals or irrigation) has fragmented around 60% of the world's rivers.

Until recently, efforts to mitigate the ecosystem impacts of large dams have met with limited success. More specifically:

- It is not possible to mitigate many of the impacts of reservoir creation on terrestrial ecosystems and biodiversity;
- The use of fish passes to mitigate the blockage of migratory fish has had little success;
- Good mitigation results from a good information base, early co-operation between stakeholders, and regular monitoring and feedback on the effectiveness of mitigation measures;
- Environmental flow requirements are increasingly used to reduce the impacts of changed streamflow regimes on aquatic, floodplain and coastal ecosystems downstream;
- Avoidance or minimization of ecosystem impacts can be achieved through legislative or policy measures that set aside particular river segments or basins, or through effective site selection.

Example 14: Guidelines for the development of water infrastructures in West Africa

The Water Resources Coordination Centre of the Economic Community of West African States (ECOWAS) has been developing a Dialogue on large infrastructure projects in the water sector since 2008. The dialogue includes discussions with civil society stakeholders, especially representatives of local communities and resource users.

A panel of experts made recommendations for best practices for the development of sustainable hydraulic infrastructures in West Africa. On this basis, a regional directive on hydraulic infrastructures is being produced by ECOWAS.

Guideline recommendations are the following:

- Affirm the critical role of river basin organizations in developing and implementing transboundary projects;
- Involve affected populations as project stakeholders, partners and beneficiaries;
- Ensure that all stakeholders involved in project development play their respective roles;
- Assess and optimize the profitability of large water infrastructure in West Africa;
- Capitalize and share existing experiences within the framework of ECOWAS;
- Adopt a regional framework of reference for the environmental and social assessment of transboundary projects and delivery of their associated plans.

More information: www.dialoguebarrages.net

Social and environmental safeguards for large dam projects are inherently dynamic tools. A recent review by IIED made the following recommendations:

- Agencies seeking to measure the degree of compliance of individual projects should increasingly adopt the IHA Hydropower Sustainability Assessment Protocol;
- Better consider assessments in different contexts and geographical areas, ensuring that feedback is incorporated into the protocol provisions, methods and approaches of the certified assessors;

- Implement processes to develop regional or basin-level standards on environmental and social impacts, irrespective of the funding stream;
- Review the effectiveness of the current European Union Linking Directive's voluntary template and process. Monitor the outcomes of a subset of projects funded under the Directive's carbon credit programme;
- Seek legal clarification of a donor government's precise commitments to 'respect' or 'refer to' various types of standards or guidelines and harmonize such interpretation between government departments;
- Consider smaller projects in context and effectively assess their cumulative social and environmental implications.

Box 10: Hydropower Sustainability Assessment Protocol

The Hydropower Sustainability Assessment Protocol is the result of an intensive review that ran from 2008 to 2010 made by the Hydropower Sustainability Assessment Forum. The Protocol was launched in May 2011 at the International Hydropower Association world congress.
The Hydropower Sustainability Assessment Protocol is a tool that promotes and improves the sustainable use of hydropower. The Protocol can be used at any stage of hydropower development, anywhere in the world.

The table below shows the topics addressed during an assessment: More information:

Cross-cutting			
Climate Change	Human Rights	Gender	Livelihood
Environmental			
Downstream Flow Regimes	Erosion and Sedimentation	Water Quality	Bidiversity and Invasive Species
Social			
Resettlement	Indigienous Peoples	Public Health	Culture Heritage
Technical			
Siting and Design	Hydrological Resource	Infrastructure Safety	Asset Reliability And Efficiency
Economic/Financial			
Financial Viability	Economic Viability	Project Benefits	Procurement

More information:
www.hydrosustainability.org

Natural infrastructure can be integrated into the financing and investment of grey infrastructure. The result is a mixed portfolio of engineered and natural infrastructure in a river basin in which one complements the other, with more optimal results in terms of cost-effectiveness, risk and sustainable development. This kind of mix is best suited to meeting multiple development objectives, such as hydropower generation, agricultural water supply, fisheries production, biodiversity conservation and climate resilience. The natural infrastructure can thus be positioned effectively as a building block for the future green economy.

The joint study of green and grey infrastructures constitutes a new paradigm. Previous approaches centred on studying the impact of grey infrastructures (traditional facilities like dams, water transfers, hydroelectric power stations, irrigated perimeters) on green infrastructures (aquatic ecosystems, wetlands, etc.). This new approach studies both types of infrastructure together rather than separately. The sub-basin in question is perceived as a whole in which human activities and the natural environment are inseparable and should thus operate harmoniously for the long term.

4.3. Natural Water Retention Measures, cross-cutting objectives and results

4.3.1 Introduction

The past decades have seen a series of devastating flood and drought events in Europe, South East Asia, Australia (see boxes below) and many other regions in the world. In response, many projects and studies on flood protection and mitigation have been carried out. These projects have clearly shown that grey infrastructure solutions alone cannot provide 100% protection and, as stated by the British Environment Agency, "working with natural processes is becoming increasingly accepted", above all in "flood and coastal erosion risk management policy."

Several flood mitigation strategies have thus introduced a mix of Natural Water Retention Measures (NWRM) with other approaches including hard-engineering works. The result is increasing recognition that Green Infrastructures and particularly NWRM provide a wide range of benefits not only for flood control but for the provision of a set of Ecosystem Services.

4.3.2 What is NWRM?

NWRM is a new term that covers a complex notion whose key aspects are:

- First of all, NWRM are "measures" or specific means to tackle the problems identified and improve the situation in a river basin;
- Secondly, the central part of the expression is the term "water retention"; this covers a wide set of mechanisms the effect of which are to increase the capture of water by aquifers, soil, and aquatic and water-dependent ecosystems. This retention also includes a set of important co-benefits for ecosystems that can be even more important than the water retention itself;
- Finally "natural" refers to a particular set of means used to pursue the aim of water retention that use or mimic nature to regulate the flow and transport of water so as to smooth peaks and moderate extreme events (floods, droughts, desertification, salt water intrusion).

On this basis and following intense debate, experts gathered in the WFD Common Implementation Strategy Working Group on Programme of Measures developed a European definition for NWRM.

Box 11: NWRM European platform

In 2012, the European Commission published the "Blueprint to Safeguard Europe's Water Resources". One of its proposals for action is to maximize use of Natural Water Retention Measures. In 2013, as a response to this proposal, the European Commission launched a major project to structure and share knowledge on Natural Water Retention Measures (NWRM). The objective was to set up a network of experts and develop a European web-based platform to structure and share knowledge on NWRM. The objective is that water stakeholders should make more systematic use of these measures in their programmes of measures. NWRM support Green Infrastructure and are therefore a key instrument in the greening of EU policies.
In parallel to this platform, a dedicated group of Member State representatives developed guidelines on NWRM and established a detailed definition:
"Natural Water Retention Measures are multi-functional measures that aim to protect water resources and address water-related challenges by restoring or maintaining ecosystems as well as natural features and characteristics of water bodies using natural means and processes. The main focus of applying NWRM is to enhance the retention capacity of aquifers, soil, and aquatic and water dependent ecosystems with a view to improve their ecological status. Appropriate application of NWRM supports green infrastructure, improves the quantitative status of water bodies as such, and reduces the vulnerability to floods and droughts. It positively affects the chemical and ecological status of water bodies by restoring natural functioning of ecosystems and the services they provide. The restored ecosystems contribute both to climate change adaptation and mitigation."
This definition clearly defines NWRM, their appropriate targets, and the aspects of the hydrological cycle and the broader environment that they should impact.

http://nwrm.eu/

Many projects and organizations already implement NWRM to a certain extent, and some have been doing so for years or even centuries. Several national organizations established in countries already familiar with the use of natural techniques for solving environmental issues have identified measures similar to NWRM in terms of functionality. Other terminologies used for NWRM, or measures similar to NWRM are:

- In 2006, the DTI Global Watch Mission reported that urban storm water NWRMs were known as Best Management Practices and/or Low Impact Developments in the US, and as Sustainable Drainage Systems in the UK;
- The Environment Agency of England and Wales and Newcastle University implemented "runoff attenuation features" on farms in 2011;
- In 2013, the Scottish Environment Protection Agency identified a set of measures similar to NWRM under the name "Natural Flood Management";
- The French national association of water technicians and engineers (ASTEE), in collaboration with ONEMA and the French Ministry of the Environment, published a document in December 2013 referring to "ecological engineering applied to aquatic environment";
- In 2014, Manning-Jones and Southgate used the term Catchment Riparian Intervention Measures;
- Other terms are used elsewhere, such as Water Sensitive Urban Design in Australia and much of the Far East.

4.3.3 Applying NWRM

As shown above, the NWRM concept embraces a complex reality extending beyond floods and droughts and the water retention function.

Overall, NWRM are implemented to restore aquatic ecosystems. They therefore embrace a wide set of measures, many of which have been used in the past, but not addressed with a multi-functional approach. For example, agriculture measures have been developed to improve land yield or water management as a key production factor; urban measures have aimed at managing runoff to avoid flooding in lower-lying city areas and other urban disturbances.

NWRM are space-related measures closely related to land use. The correct implementation of NWRM involves taking account of several key principles:

- Limit the conversion of land use with high water retention (forests, grasslands, wetlands, etc.) to land use with low water retention (cropland, etc.) because different land uses have different water retention capacities;
- Avoid limiting the natural hydraulic functioning of waterways (building, barriers, etc.);
- Manage land so as to maintain landscape diversity, maximum return of organic matter to the soil and green cover, and minimize soil sealing, in particular in urban areas;
- Promote the development of a wide-ranging set of techniques for retaining water in the landscape, like permeable pavements, sustainable drainage systems, etc., which slow down the response to heavy rainfall events and provide many benefits.

Based on these principles, a set of possible NWRM can be identified for four main land uses: agriculture, forestry, urban area and aquatic environment. Most measures can be applied in more than one land use space but will primarily employ techniques known in the key land use for which they are identified.

Box 12: Set of Natural Water Retention Measures

Agriculture area		Urban area		Aquatic environment		Forest area	
A1	Meadows and Pastures	**U1**	Green roofs	**N1**	Basins and ponds	**E1**	Forest riparian buffers
A2	Buffer strips and hedges	**U2**	Rainwater harvesting	**N2**	Wetland restoration and management	**E2**	Maintenance of forest cover in headwater areas
A3	Crop rotation	**U3**	Rainwater harvesting	**N3**	Floodplain restoration and management	**E3**	Afforestation of reservoir catchments
A4	Strip cropping along contours	**U4**	Swales	**N4**	Re-meandering	**E4**	Targeted planting for "catching" precipitation
A5	Intercropping	**U5**	Channels and rills	**N5**	Stream bed re-naturalization	**E5**	Land use conversion
A6	No till agriculture	**U6**	Filter strips	**N6**	Restoration and reconnection of seasonal streams	**E6**	Continuous cover forestry
A7	Low till agriculture	**U7**	Soakaways	**N7**	Reconnection of oxbow lakes and similar features	**E7**	"Water sensitive" driving
A8	Green cover	**U8**	Infiltration trenches	**N8**	Riverbed material renaturalization	**E8**	Appropriate design of roads and stream crossings
A9	Early sowing	**U9**	Rain gardens	**N9**	Removal of dams and other longitudinal barriers	**E9**	Sediment capture ponds
A10	Early sowing	**U10**	Detention basins	**N10**	Natural bank stabilisation	**E10**	Coarse woody debris
A11	Controlled traffic farming	**U11**	Retention ponds	**N11**	Elimination of riverbank protection	**E11**	Urban forest parks
A12	Reduced stocking density	**U12**	Infiltration basins	**N12**	Lake restoration	**E12**	Trees in urban areas
A13	Mulching			**N13**	Restoration of natural infiltration to groundwater	**E13**	Peak flow control structures
				N14	Re-naturalisation of polder areas	**E14**	Overland flow areas

(Source: www.nwrm.eu)

NWRM are said to take either passive or active forms. Passive techniques (e.g. pulse flows, changes in watershed land use, creation of buffer strips, etc.) rely on natural recovery processes and "allow the river to do the work" (Regulated Rivers: Research & Management; 1996), and thus their effects take a long time. Active techniques are used when longer recovery times are inconsistent with meeting management or environmental policy goals. Often, active restoration measures attempt to mimic the form of analogous natural structures/features based on local knowledge.

Example 15: The Clarence Floodplain Project (Australia)

The 'Clarence Floodplain Project' was established in 1997 with the aim of improving the environmental management of the Clarence Valley Council's flood mitigation infrastructure and addressing some of the past impacts of flood mitigation on floodplain ecosystems.

Flood mitigation works have been carried out for over a century on the Clarence River, particularly in the 1960s and 1970s. Over the years many extensive drainage systems and hundreds of floodgates and other grey structures have been constructed. Their purpose is to provide protection from floods in both urban and rural areas. Better drainage has also increased agricultural productivity on the floodplain.

Flood mitigation has had some adverse impacts on coastal floodplains. A combination of drainage and blockage of natural creek systems has often led to poor water quality, fish kills, and reduced habitat for fish and other aquatic species. In some areas over-drainage has resulted in acid problems in waterways, and the loss or drying out of some natural wetland areas.

A team of dedicated staff at Clarence Valley Council have been working on the project for 13 years. During this period, more than 80 individual environmental restoration projects have been carried out to restore the health of the estuary, including the revival of 73 floodplain watercourses and 24 wetlands.

The benefits of the CFP on the environment include improved water quality due to increased tidal exchange, improved access to habitat and breeding areas for aquatic species, fewer fish kills, reduced acid discharges from acid sulphate areas, re-inundation of previously drained wetlands, improved water bird habitat, increased grazing productivity, and improved riparian vegetation. The project has had an economic benefit on the fishing, tourism and cattle industries. Social benefits include a reduction in community conflict and an increased involvement of a wide cross section of the community in on-ground resource management.

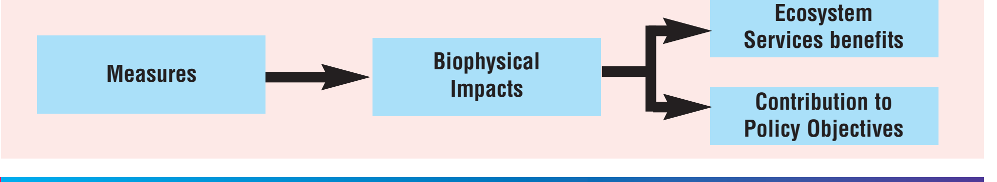
More information :

http://www.clarence.nsw.gov.au/cp_themes/metro/page.asp?p=DOC-LLW-02-05-64

Due to the broad range of possible NWRM, selection criteria need to be identified in relation to local problems. NWRM are multi-functional by definition and a good starting point is to pinpoint the biophysical impacts because these biophysical impacts represent important selection criteria due to the positive consequences on the biophysical environment. This positive impact on the environmental structure and functions result from well-designed and properly implemented measures (i.e. that modify water balances in order to make nature work better).

Evidence of biophysical impacts is crucial to achieving benefits and policy objectives, as illustrated in the following figure, and therefore an essential selection criterion.

Figure 4: Biophysical impacts



For the purposes of NWRM, biophysical impacts are of two types:

- The mechanisms by which measures retain water (slowing, storing or reducing runoff);
- The biophysical impacts that result from water retention (reducing pollution, creating habitats, soil conservation or climate alteration).

EU legislation in particular requires taking an integrated approach. NWRM provide multiple functions and should be used as part of a systemic approach to managing runoff, reducing flood risk and increasing water adsorption. They need to be planned and targeted as part of future catchment management. NWRM have key advantages and can be solutions to favour and combine with other measures in a wide set of possible measures.

Example 16: Integrated ecosystem management in Upper Yangtze River Basin (China)

Description

The Yangtze River is the largest river in China, with a total length of 6,300 km and a drainage area of 1.8 million km². Over 400 million people live in the Yangtze River basin. The river has significant impacts on the environment of the East China Sea. The Chinese government incurs significant costs due to floods and ecological degradation in the Yangtze River basin. The response has been to create Ecosystem Function Conservation Areas (EFCAs) to increase water retention capacity and reduce sediment loads, and also provide benefits for biodiversity, carbon sequestration and sustainable land management.

Action taken

Efforts have been made to establish two demonstration sites to increase water retention capacity and reduce sediment loads, coordinate sector programs, protect biodiversity, and increase carbon gains in an integrated manner. A system of EFCAs with multiple environmental benefits has been set up in the upper basin of the Yangtze River. In each demonstration site province, a committee with representation from major stakeholders presided by the provincial government coordinates all project activities. Based on the results of the demonstration activities, the Chinese government is expected to replicate the project results throughout the Yangtze upper river basin in the future. A monitoring and early warning information system has been established on the two sites: Baoxing, Sichuan and Laojunshan, Yunnan.

Lessons learned

The project took advantage of positive natural and political conditions to speed up implementation. To sustain the integrated management of the Yangtze River Basin watershed areas and conserve biodiversity, the Chinese Ministry of Environmental Protection needs to mainstream Integrated Ecosystem Management in the implementation of National Biodiversity Strategies and Action Plans (NBSAP).

The project is a high priority for the Chinese government. Nature conservation in the upper Yangtze River Basin region has never received as much attention and support as it does today, with planned investment of USD 9.29 billion over the next five years. These resources, targeting rehabilitation and restoration measures, will be sector-based and coordinated by the appropriate ministries.

More information:

http://www.gwp.org/en/ToolBox/CASE-STUDIES/Asia/China-Integrated-ecosystem-management-in-Upper-Yangtze-River-Basin-406/

In comparison to standard structural measures, NWRM tend to involve less engineered construction and greater reliance on ecosystem functions and services, instead of a purely artificial system (green roof instead of tile roof). While NWRM do not exclude physical constructions (e.g. urban NWRM), they tend to limit them to the strict minimum to allow for the development of an ecosystem and associated Ecosystem Services.

A programme of measures on a river basin should aim at shifting from grey to green. In other words, it should apply a no-deterioration principle and target the enhancement of natural functions of the ecosystem previously lost by the implementation of grey infrastructure (for instance, before a city expanded, the soil was less impervious and water could infiltrate, be stored for plant use and not contribute as much to flooding; the programme should thus aim at increasing the permeability of soil and use of water for plants in the urban area, or alternatively in the surroundings, so as to reduce the water balance and high flows or runoff peaks in the basin).

Restoring an undisturbed environment, or re-establishing the key functions of such an undisturbed environment, helps provide more resilience to changes like climate change, incidents, etc. This can be done by implementing structural or non-structural measures.

Example 17: Green roofs in Vienna

Description of the project
The lack of useable land in big cities such as Vienna and ongoing soil sealing obliges authorities and citizens to find new solutions. Since 2003, the city of Vienna has financially supported the creation of green roofs with a budget of €8-25 per m² and a maximum subsidy of €2,200. By 2010, 16.000 m² of roofs had been transformed for an investment of €150,000.

Selection of the NWRM
Soil sealing has the effect of increasing the amount of rainwater to deal with. This water has to be treated in sewage water plants and pipe systems have to be adapted. Storm floods can result in critical water levels. Green roofs absorb up to 50% of rain water and retain peak flows for a certain time, which means they contribute to reducing flood risk and improving purification standards in sewage water treatment plants

Lessons learned
Green roofs provide significant benefits, such as climate regulation, water retention and "island habitats" for plants and animals. These advantages should be communicated more extensively to the public. Green roofs are only slightly more expensive than traditional flat roofs. These costs are often compensated by the longer lifespan of the roof and energy savings.

More information: www.nwrm.eu/case-study/green-roofs-vienna-austria

Box 13: Structural and non-structural measures

Structural measure: “Any physical construction to reduce or avoid possible impacts of hazards, or application of engineering techniques to achieve hazard-resistance and resilience in structures or systems”. Common structural measures for disaster risk reduction include dams, flood levies, ocean wave barriers, earthquake-resistant constructions and evacuation shelters. However, these all come under grey infrastructure measures. Green infrastructure structural measures could include those that either recreate pristine conditions (e.g. re-meandering, which is recreating meanders that primarily existed), or that mimic key functions of this pristine situation (e.g. creating a wetland, not necessarily where it primarily existed but elsewhere in the river basin to replace a wetland that previously existed).

Non-structural measure: “Any measure not involving physical construction that uses knowledge, practice or agreement to reduce risks and impacts, in particular through policies and laws, public awareness raising, training and education”. Common non-structural measures include building codes, land use planning laws and their enforcement, research and assessment, information resources, and public awareness programmes. In other words, measures that favour changes of practice in favour of enhancing key functions previously assured by the pristine conditions mentioned before.

UN/ISDR - UN Office for DRR, 2009

Some NWRM are simply structural measures (e.g. re-meandering or natural bank stabilization), whereas others can be non-structural (e.g. meadows and pastures are based on providing funds to farmers who preserve their fields), and others combine both types. NWRM are a way of merging these two different approaches.

Box 14: EU Twinning projects on the Flood Directive

IOWater supported the Turkish Directorate General of Water Management of the Ministry of Forestry and Water Affairs and Croatian Waters in two recent EU Twinning projects, targeting capacity building for Flood Directive implementation.

The experience illustrated the importance of **participative preparation in a Flood Risk Management Plan.** This thematic planning process **created the conditions for opening the scope of flood risk management measures** to non-structural and green infrastructure projects with positive effects on both flood risk reduction and ecosystems.

The objective of the European Flood Directive is to reduce the adverse consequences of flood events by setting out a framework to assess and manage flood risk. The requirements of the Flood Directive are:

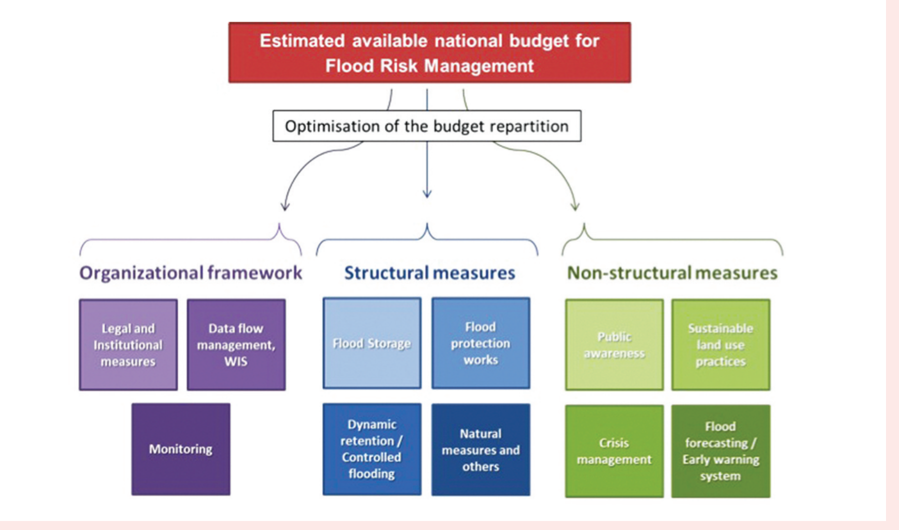
- Perform a Preliminary Flood Risk Assessment (assessment of significant past floods and possible future floods) and determine areas with significant flood risk;
- Prepare Flood Hazard and Risk Maps: map out the flood area, depth and, if appropriate, flow velocity, and the assets (cultural heritage sites, economic activities, environment, etc.) and humans at risk in these areas;
- Prepare Flood Risk Management Plans (including the objectives to reduce the flood risk and the measures to reach these objectives).

The Flood Directive also promotes public access to this information and active stakeholder participation in the planning process.

The twinning projects, which included support to develop a Flood Risk Management Plan in pilot basins, provided capacity building and guidance in:

- Prioritizing, at national or large basin scale, the area to be mapped including large-scale modelling techniques;
- Developing flood hazard and flood risk mapping, which are crucial to future project definition, including an exploration of the different possible measures;
- Producing an economic analysis to assess the best options including cost and long-term benefits;
- Devising a stakeholder involvement strategy to facilitate decision-making.

Figure 5: Economic scoping of the programme of measures in a Flood Risk Management Plan



These projects provided an opportunity to transfer know-how and develop synergies between the River Basin Management Plans under preparation. They resulted in a more global vision of the Water Framework Directive and the thematic plans, in particular Flood Risk Management Plans, which open up the scope of solutions to multipurpose measures by integrating the objectives of both plans.

5 Governance and regulation

KEY POINTS:

- The current water crisis affecting ecosystem services is mainly a crisis of governance.
- Participation from indigenous peoples and local communities can result in their customary law systems being integrated into statutory legal frameworks.
- Combining the conservation of aquatic ecosystem services with IWRM is a very effective strategy for achieving water security and combating climate change.
- Improving the governance of aquatic ecosystems involves reforms that go beyond the water sector.

5.1 Example of European legislation and policies as driving forces for ecosystem protection and restoration

Restoration of ecosystems is a very complex management process requiring multi-and intra-disciplinary interventions. From an administrative and legal point of view, ecosystem restoration is usually included in the environmental agenda together with other policies and activities dealing with nature conservation/protection. Gradually, ecosystems restoration has been integrated into policies and management of natural resources (e.g. water), adaptation to climate change and the prevention of natural and man-made disasters.

To fully understand the role of European Union (EU) Directives and policy, which were initiated in the early 1970s to drive environmental interventions in EU Member States, it is important to emphasize some of their specific characteristics, which are unique in international law. First, and perhaps most important, EU Legislation is obligatory, and failure of Member States to apply this legislation may lead to sanctions and considerable penalties. EU Directives are also widely used as "guidelines" or "blueprints" for a number of accession, candidate and European Neighbourhood countries; it is also noteworthy that newly introduced legislation is often accompanied by demonstrative actions and economic incentives/support mechanisms.

Furthermore, EU legislation is drafted using a very wide consultative process involving civil society. Civil society can also monitor non-implementation of this legislation and has the right to file complaints at all levels, including appeals to the Commission and Ombudsman regarding insufficient or improper enforcement. Finally, an important critical characteristic is the continuity of policy making and coordination within the EU, as well as with global and regional initiatives on relevant issues. This concerted approach provides a constant driving force, despite weaknesses that occasionally include a drop in intensity and focus. As a conclusion, it is possible to say that most if not all ecosystem restoration and protection measures in EU Member States (and definitely in those with less environmental awareness or fewer ecological traditions) are linked to EU legislation and policy frameworks that also incorporate, to a large extent, the overall International environmental legislation.

In the 1970s, the international community began to realize the value of ecosystems and biodiversity and started taking actions that, directly and indirectly, led to the conservation of natural and semi-natural areas and biodiversity. As a result, several international environmental treaties were signed and ratified, including the 1971 Convention on

Wetlands of International Importance (the Ramsar Convention), the 1973 Convention on International Trade in Endangered Species of Wild Fauna and Flora (known as CITES), the 1979 Convention on the Conservation of Migratory Species of Wild Animals (known as the Bonn Convention) and the 1979 Convention on the Conservation of European Wildlife and Natural Habitats (the Bern Convention).

In 1987, the United Nations World Commission on Environment and Development (WCED) published their "Our Common Future" report, (Brundtland Report), which, by introducing the concept of "sustainable development" aims to reconcile economic development and environmental/ecosystem conservation. This report strongly influenced the Earth Summit in Rio de Janeiro (1992), and set the stage for a new level of environmental awareness and legislation, including on the protection of ecosystems all over the world. One of Rio's main achievements was the adoption of "Agenda 21" and the "Rio Declaration". Furthermore, important legally binding agreements were opened for signature, including the Convention on Biological Diversity, the Framework Convention on Climate Change and the United Nations Convention intended to Combat Desertification. Regarding biodiversity, the Rio Summit signalled the world's recognition of the need to preserve biodiversity and the political significance of the concept of biodiversity.

In response to the above, the EU's landmark policies and legislation on nature-conservation and ecosystem protection/restoration include article 130 of the Treaty on European Union (Maastricht 1992) which calls for prudent and rational utilization of natural resources; the 1979 Directive on the Conservation of Wild Birds (Directive 79/409/EEC), as codified and amended by Directive 2009/147/EC (the Birds Directive); the 1992 Directive on the Conservation of Natural Habitats and of Wild Fauna and Flora, (Directive 92/43/EEC / the Habitats Directive), and the 1998 European Biodiversity Strategy.

Box 15: Projects in Europe

The EU Directives were catalytic for the initiation of a large number of projects, many of which also cover other objectives of EU policy. For instance, the bittern (Botaurus stellaris) recovery project in the United Kingdom, led by the RSPB and English Nature, aims to create and rehabilitate reedbeds (Phragmites australis) in order to increase the number of booming males from their 1994 level of 16 to a target of 100 by 2020. In the UK, the high loss of reedbed habitat due to agricultural drainage (10%-40% from 1945 to 1990: Bibby et al., 1989) has led to intensive reedbed creation efforts over the last 20 years.

Example 18: Doñana restoration programmes

The Doñana restoration programmes have been promoted largely thanks to EU legislation and support. Doñana in southern Spain is one of the largest and best-known wetlands in Europe. Intensive tourism and agricultural developments over the last 40 years have resulted in the dehydration of internationally important ecosystems through drainage, channelization, dyke construction, artificial drains and over-abstraction of groundwater. In 1998, a catastrophic toxic spill occurred at the Los Frailes mine near Aznalcollar. A burst tailings lagoon at the mine site resulted in 5 million m^3 of toxic sludge and waste water flooding down the Guadiamar river and over farmland in the floodplain, including areas inside the Doñana national Park. Two major projects aim to remediate the area of the Guadiamar River and floodplain that was directly affected by the mining disaster and restore an eco-corridor from the mountainous upper catchment running through Doñana to the coast, and water flows to the marshlands in the National Park.

Box 16: Natura 2000 and biodiversity objective projects

The EU Directives on Habitats and Birds require that "compensatory measures" should be taken when a Natura 2000 site (designated in the directive) is damaged, for reasons of overriding public interest. This was the case in South Wales, where a major freshwater wetland area was rehabilitated to compensate the destruction of part of the Severn Estuary Natura 2000 site caused by a tidal barrage (Madgwick and Jones, 2002).
Natura 2000 biodiversity objectives are at the heart of many projects throughout Europe, such as large-scale wetland restoration (feedbed, carr and wet meadow management) in the Norfolk Broads (UK), and the very large and ambitious project to restore Lake Homborga, Sweden, in the extended wetland and lake area of Hornborgasjon (4124 ha). The Swedish project succeeded in restoring the lake and large areas of secondary flooded grasslands, increasing them from 50 ha to approximately 600 ha and in the UK the project continued a long term tradition of lake restoration techniques. Some large-scale restoration projects have been inspired by biodiversity objectives, while obviously fulfilling several other objectives. Finland's lake restoration programme has been implemented on more than 1 000 lakes and included many (innovating) techniques.

Example 19: United Kingdom lowland heathland projects

In the UK, lowland heathland has shrunk by 80% since 1800. "Tomorrow's Heathland Heritage" is a major ten-year, 41 million euro project set up to reverse the decline of lowland heathland in the UK with the aim of reaching the national Biodiversity Action Plan target of 58,000 ha. A significant amount of restoration has been carried out on former arable land. The Royal Society for the Protection of Birds has restored 152 ha of heathland on farmland at its Minsmere nature reserve in eastern England. A large part of the former cruise missile base at Greenham Common, southern England, which was decommissioned after the end of the cold war, is also being restored to lowland heathland.

It is noteworthy that until the end of the 1990s, EU nature conservation policy focused mainly on terrestrial ecosystems. In 2000, a policy was defined on the aquatic environment, and the EU Water Framework Directive (2000/60/EU) mentions wetlands restoration. Finally, in 2008, Directive 2008/56/EU introduced a framework for action related to marine environmental policy (known as the Marine Strategy Framework Directive).

Example 20: The Skjern River restoration project

The Skjern River restoration project (Denmark) gives (quantitative) insight into the effectiveness of nutrient retention and removal by restored wetlands. The approach incorporates changes in land use into a program of measures for achieving the ecological objectives of the WFD for water bodies. It shows that floodplain wetland restoration has clear benefits in terms of water quality improvement and enhancement of ecological quality elements (e.g. fish); moreover it demonstrated that WFD objectives can be integrated into flood protection and socio-economic functions.

In June 2001, the EU Heads of State and Government at the EU summit in Gothenburg, Sweden, decided that, "biodiversity decline should be halted with the aim of reaching this objective by 2010". One year later, in 2002, the sixth Conference of the Parties (COP) of the Convention on Biological Diversity established the 2010 Biodiversity Target, which was subsequently endorsed by the United Nations General Assembly at the 2005 World Summit, highlighting the political significance attached to biodiversity issues.

One important tool in promoting the relevant EU policies and legislation was, and still is, the EU Life - Nature financial instrument, which has been an important catalyst and source of funding for a large number of pilot/experimental and more traditional nature restoration and rehabilitation projects benefiting European priority habitats, notably Natura 2000 sites.

In 2010, the European Commission assessed the implementation of the EU Biodiversity Action Plan and reported to the European Council and Parliament. The report concluded that, despite the significant progress made, the overall goal of halting biodiversity loss in the EU by the end of 2010 had not been achieved, nor had the global target. Europe’s ecosystem services were judged to be of mixed status or degraded, while the global situation is even more alarming, particularly as pressure on biodiversity continues to intensify. Such pressures include land-use changes, pollution, spread of invasive alien species and climate change. The findings of this 2010 assessment are meant to provide valuable information to ensure the successful delivery of the 2020 target at EU and global levels.

In May 2011, the European Commission adopted a new strategy establishing the framework for EU action intended to meet the 2020 biodiversity headline target set by EU leaders in March 2010. Through this strategy, the EU adopted a vision for 2050, the so-called “EU 2050 vision”, and a more immediate goal for 2020. According to this vision, by 2050, European Union biodiversity and the ecosystem services it provides - its natural capital - must have been protected, valued and appropriately restored for biodiversity’s intrinsic value and for their essential contribution to human wellbeing and economic prosperity, thus ensuring that catastrophic changes caused by the loss of biodiversity will have been avoided.

The EU 2020 headline target aims at stepping up the EU’s contribution to averting global biodiversity loss, while halting the loss of biodiversity and the degradation of ecosystem services in all EU Member States by 2020, and restoring them as far as possible, combining them with (rural) development.

Example 21: Restoration of the Danube Delta

Successful projects based on the combination of ecosystem restoration/integration with rural development as suggested by the Biodiversity Strategy to 2020 have already been carried out in various parts of Europe. One of the most successful was the restoration of the Danube Delta (Romania/Ukraine). The strategic breaching of the dykes on the Babina (2200 ha) and Cernovca (1580 ha) polder islands resulted, after only five years, in almost total replacement of terrestrial vegetation by reedbeds and aquatic vegetation, including for example the species Nymphoides peltata and Potamogeton. The diversity of birds on Babina Island increased from 34 to 72 species and characteristic invertebrates reappeared within two years of the recolonization of the reed stands and aquatic habitats. Fifteen fishermen can now make their living as a result of the polder restoration.

As mentioned above, ecosystem protection and restoration in EU policies and legislation are also linked to climate change and a series of other issues emerging from global evidence, thinking and developments. A long series of international conferences on climate change followed Rio’92. Since these meetings, negotiations on how to deal with climate change have advanced, and several agreements have been reached, including a second Kyoto Protocol commitment period until 2017. References were also made to adaptation options, including ecosystem restoration.

EU policy on climate-change adaptation was officially launched in 2007, when the Green Paper on Adapting to Climate Change was published. In this policy, the Commission identifies four pillars of action, i.e. early action in the EU, provided that sufficient knowledge has been acquired; integrating adaptation into EU external relations; improving knowledge where there are gaps; and involving all stakeholders in the preparation of adaptation strategies.

As a result of international conventions and the aforementioned relevant EU legislation, numerous EU Member States undertake activities directly linked to ecosystem restoration, many of which are supported by LIFE funding.

Example 22: Flood plain restoration measures

In the Netherlands, wide-scale flood plain restoration measures are in the pipeline to accommodate the expected increase in flood volume in the Rhine, Meuse and Scheldt rivers. The “Committee on Water Management in the 21st Century” claims that safety can only be guaranteed by giving rivers more space. A policy decision to create 7,000 ha of “new nature” along the Rhine and Meuse dates back to 1993. The Delta Plan for the Major Rivers is to be implemented in 2015 at a cost of around 1.05 billion euro. This will result in 3,000-4,000 ha of restored river floodplains, approximately half of the original target.

The rising need for coastal flood defences also provides a major opportunity to restore coastal marshes that were previously reclaimed from the sea. This is partly justified to take account of the estimated losses of intertidal habitats for conservation reasons. However, the economic argument is also strong, as it is now widely recognized by coastal engineers that the presence of saltmarsh on the seaward side of sea walls dramatically reduces the cost of constructing and maintaining these walls.

New opportunities for ecosystem restoration have emerged through the Climate Sub Programme, Integrated Projects, and Prioritized Action Framework Projects, which have improved habitat connectivity and ecosystem heterogeneity, combining them with climate change adaptation measures.

Another interesting aspect of EU legislation derives from the EU’s involvement as a contracting party to regional conventions, such as the Convention for the Protection of the Mediterranean Sea Against Pollution (Barcelona Convention, 1976), under UNEP’s umbrella, which was amended in 1995 and renamed as the Convention for the Protection of the Marine Environment and the Coastal Region of the Mediterranean. Although the initial focus of the Barcelona Convention was marine pollution control, over the years its mandate has widened to include integrated coastal zone planning and management, as well biodiversity conservation. In 2005, the parties of the Barcelona Convention adopted the Mediterranean Strategy for Sustainable Development

Based on the pre-existing Oslo (1974) and Paris (1978) Conventions, in 1992 their 14 signatory parties, Switzerland and the Commission of the European Communities adopted the Convention for the Protection of the Marine Environment of the North-East Atlantic (the OSPAR Convention), which entered into force in 1998. Its Annex V contains provisions with regard to the Protection and Conservation of Ecosystems and Biodiversity of the Marine area, which is now one of the four main issues covered by the Convention, in addition to its traditional ones: hazardous substances, radioactive substances, eutrophication.

Two aspects are noteworthy here as they concern the EU’s involvement in regional conventions. First, although UN conventions are known to have no obligatory enforcement/sanctions provisions, the fact that the EU is a contracting party introduces the provisions of the convention into Community law and therefore makes them compulsory for EU Member States. Second, in the framework of either regional or neighbourhood policies, the EU supports pilot, demonstration and other programmes, many of which directly or indirectly address ecosystem protection and restoration projects that frequently also extend to non-EU Neighbourhood countries, and thus also act as a driving force beyond EU borders.

Example 23: Lake Bizerte Charter

Under the H2020 programme, which aims to "depollute the Mediterranean by 2020", the Tunisian Government suggested that a management project should focus on the whole of Bizerte Lake (lagoon), which generates significant indirect pollution in the Mediterranean Sea. After a thorough study and public consultation, the Bizerte Charter (2012) was signed by all relevant ministries and stakeholders. Administrative arrangements were made and a contract worth several million euros was signed for the first series of interventions. The project has been granted Union for the Mediterranean (UfM) labelling to increase visibility and attract further funding.

More information:
http://www.h2020.net/resources/training-materials/finish/192/1712.html.

5.2 Example of other regulations

International water allocation treaties routinely deal with the duty of upstream states to maintain minimum flows for the benefit of downstream states, usually for power generation and consumptive uses. However, most major river treaties ignore the impact of upstream development and diversions on the river's maritime delta.

There is no specific duty to protect aquatic ecosystems in customary international law. The best that one can say is that modern formulations of customary international law recognize the need for such a duty. The duty can be derived from the international environmental law of state responsibility for transboundary harm. The duty not to cause harm has been limited to air and water pollution; however, ecosystem risk can be encompassed by the foundation principle that states have a duty not to allow state agencies and private parties subject to the state's regulatory jurisdiction to use their territories in a manner that causes substantial harm to other states and their nationals.

There are several examples of aquatic ecosystems regulations:

- Environmental Impact assessment - countries have it and Espoo convention exists at international level;
- Convention on Biological Diversity - most countries transposed it into national legislation;
- Ramsar Convention - again, most countries transposed it into their legislation.

Another major regulation is the 1997 United Nations Convention on the Non-Navigable Use of Waters, which entered into force in 2014; this convention does not control treaty allocations because it is subordinated to pre-existing treaties and other agreements. Nonetheless, the Convention can inform the evolution of new duties by recognizing that the core right to an equitable and reasonable share of a river includes environmental uses of a river. From 2012-2014, Mexico and the United States developed a programme to restore the stressed Colorado River Delta in Mexico.

Box 17: Protection of the Colorado Delta in Mexico

Mexico's Colorado River Delta is one of the world's many stressed deltaic aquatic ecosystems (The Delta Regional Alliance). The Colorado originates in the United States Rocky Mountains, enters Mexico at the Arizona-California border, and drains into the Gulf of California. The 1922 Interstate Compact involving seven federal United States, and the 1944 Mexico-United States Water Treaty (Treaty), allow users in both nations to divert the entire average flow upstream from its mouth, thus cutting off both the necessary seasonal sediment deposits and water flows to sustain the Delta. Until 2012, the two nations had no treaty obligation to supply any flows to the Delta; remnant marshes survived precariously on wet year surplus "pulses" and upstream agricultural return flows. For years, both Mexico and the United States took the position that the degradation of the Delta was a non-remedial consequence of the Treaty. This position was consistent with both the Treaty and customary international water law, which does not recognize a nation's right to the pre-dam flow of a river. However, after a two-decade campaign by NGOs to protect the Delta, in 2012 the two countries de facto amended the Treaty to provide a modest experimental Delta flow maintenance regime.

Minute 319 sets three important, broadly defined precedents. First, it is a de facto implementation of the ecosystem conservation mandates of the United Nations Convention on the Uses of Non-Navigable Waters (Convention) and other recent attempts to incorporate such a duty into customary international water law. Second, Minute 319 is also recognition of the emerging duty of riparian nations to cooperate in the long-term management of shared rivers. Third, the agreement would never have occurred without the efforts of NGOs. Environmental NGOs in both Mexico and the United States urged the two nations to address the Delta's problems. More importantly, they helped provide the financing to acquire the necessary wet water for the flows on an over-allocated river system.

Minute 319 is a de facto amendment to the Mexico-United States Water Treaty. The Treaty is more flexible than other treaties because the parties can amend it through "interpretive" minutes negotiated through the International Boundary and Water Commission (IBWC).

United States water users in both the lower and upper basins benefit from the Minute and face no risk of curtailment. The upstream benefits partially derive from the benefits that Mexico gained from the Minute: Mexico obtained a major advantage because Minute 319 opens Lake Mead to Mexican storage for the first time, between Arizona and Nevada.

The first of three planned pulse flows was a success:
As provided in Minute 319 of the US-Mexico Water Treaty of 1944, a pulse flow of approximately 130 million cubic meters was released into the riparian corridor of the Colorado River Delta from Morelos Dam at the US-Mexico border. The water was delivered over an eight-week period that began in March 2014. Peak flows were released early in this period to simulate a spring flood. Some pulse flow water was released into the riparian corridor via Mexicali Valley irrigation canals.

The monitoring programme established by Minute 319 assembled baseline information on the hydrology and biology of the riparian corridor and deployed binational, multi-agency teams of scientists during and after the pulse flow. Ground-based and remotely sensed data were collected to evaluate the ecosystem response to the pulse flow.

5.3 Governance of aquatic ecosystems

The current water crisis affecting ecosystem services is mainly a crisis of governance. The concept of governance has evolved in the last two decades. In 1997, the United Nations Development Programme (UNDP) defined governance as, "The exercise of economic, political and administrative authority to manage a country's affairs at all levels. It comprises the mechanisms, processes and institutions, through which citizens and groups articulate their interests, exercise their legal rights, meet their obligations and mediate their differences".

According to GWP, water governance refers to, "The range of political, social, economic and administrative systems that are in place to develop and manage water resources, and the delivery of water services, at different levels of society".

The Tropical Agricultural Research and Higher Education Centre (CATIE) defines governance as:

- "A result of the creation of networks and partnerships which involves different actors whose interaction is crucial for facing the key challenges;
- A change in the exercise of the public administration power prone to the coordination and organization of a deliberative space based on trust, participation and social control."

Thus, governance of ecosystem services can be defined as "The interaction of laws and other norms, institutions, and processes through which a society exercises powers and responsibilities to make and implement decisions affecting ecosystem services" (IUCN). Therefore, governance is relevant for the global system, which depends on aquatic ecosystems for the provisions, regulation and cultural services people obtain from them. Good governance is closely tied up with sustainable development, ecosystem conservation and the capacity for facing climate change uncertainties and risks. In actual fact, it is a very broad and inclusive concept.

Figure 6: Good governance

Source: http://www.pacific-iwrm.org/

5.3.1. Framework for the governance of aquatic ecosystems

Aquatic ecosystem governance is broader than water governance. An ecosystem dimension must be integrated into the framework for aquatic ecosystem governance, which results from the synergy between water governance and ecosystem governance. Its targets are healthy aquatic ecosystems for a water-secure world. A healthy aquatic ecosystem is an aquatic environment that sustains its ecological structure, processes, functions, and resilience within its range of natural variability.

Figure 7: Governance of aquatic ecosystems

Source: http://www.waterforlife.alberta.ca/01055.html

Institutional dimension

Significant, coordinated efforts are required to strengthen aquatic ecosystem governance and ensure the conservation of ecosystem services, upon which sustainable development depends. Along with non-governmental organizations, academics, businesses and international institutions, this process mainly involves governments, which have to turn around a traditional, fragmented sectoral approach and adopt an integrated, multi-sectoral attitude.

At national level, in the environmental sector institutions were initially created as separate entities, such as ministries of natural resources, mining, agriculture, cattle breeding, and forestry, but it is now common for these ministries to have overlapping responsibilities. A process of consolidation, rationalization, and coordination has recently started up in many countries (IUCN).

Example 24: Institutional coordination and policy development, Chilika Lake, India

Chilika Lake, a unique assemblage of marine, brackish and fresh water eco-systems with estuarine characteristics, was facing a critical ecological situation in the early 1990s. The government of Orissa created the Chilika Development Authority (CDA) as a macro initiative in 1992. Prior to the authority's constitution, responsibility for the lake came under a number of departments belonging to different ministries, without any coordination or dialogue.
To overcome this deficiency, the CDA was created as an umbrella organization with the mission of promoting conditions conducive to sustainable management of the lagoon and its drainage basin, and based on sound scientific principles through a participatory process.

More information:
http://www.chilika.com/
http://wldb.ilec.or.jp/ILBMTrainingMaterials/resources/Chilika.pdf

A crucial factor in the governance of ecosystem services is the interplay of governmental, inter-governmental and non-governmental institutions, the private sector and civil society based on rules established by statutory and customary law (IUCN). Although in many cases it is difficult to create dialogue between customary and modern institutions, a participative strategy including women facilitates the process and strengthens the institutionality.

Democratic and participatory governance based on the will of the people is crucial to assure a safe process of sustainable aquatic ecosystem management. This process requires, "The meaningful involvement and active participation of regional, national and sub-national legislatures and judiciaries, and all Major Groups: women, children and youth, indigenous peoples, NGOs, local authorities, workers and trade unions, business and industry, the scientific and technological community, and farmers, as well as other stakeholders, including local communities, volunteer groups and foundations, migrants, families as well as older persons and persons with disabilities" (The Future we Want).

The IUCN and the Convention on Biological Diversity (CBD) distinguish four broad governance types:

- Governance by government (at various levels and possibly combining various institutions);
- Governance by various rightsholders and stakeholders together (shared governance);
- Governance by private individuals and organizations;
- Governance by indigenous peoples and/or local communities.

Example 25: Local-scale aquatic ecosystem governance in Vietnam

In 2005, the largest aquatic ecosystem in Southeast Asia - Tam Giang-Cau Hai lagoon - was in biological, social and economic disarray. Illegally constructed ponds and unregulated fishing had led to overfishing and depletion as well as water and food insecurity for 300,000 people around the lagoon.
Through the FAO Integrated Management of Lagoon Activities (IMOLA) project, 26 fishery associations were set up and 9 existing ones were improved, facilitating the establishment of a representative body that works with government authorities to manage human activities and the lagoon environment. Working together to develop aquaculture management plans, people have become aware of the interrelationships within the ecosystem and improved their fishing, income and welfare.

More information:
http://www.fao.org/docrep/018/i2940e/i2940e24.pdf

Legal dimension

Integration of customary law

The experience of many countries has shown that interactive and meaningful participation from indigenous peoples and local communities can result in their customary law systems, including on ecosystems and water governance, being integrated into statutory legal frameworks.

The resilience of customary governance regimes on water resources has led water law practitioners and researchers to concede that they should be taken into account when preparing modern legislation on water resource governance or integrating customary law into civil law (Pastaza, Ramsar river wetland complex).

Example 26: Pastaza, largest river wetland complex and Ramsar site, integrating statutory and customary law

Located in the Pastaza River Wetland Complex, Peru (the largest Ramsar Site in the entire Amazon), the Rimachi Lake extends over 790 km² alongside the habitat of 30,000 indigenous people (mainly Kandoshi). At the end of the 1990s, the lake was strongly affected by overfishing and climate change. The Peruvian government granted a concession to the Kandoshi communities to manage the lake. Their first step was to get rid of the fishery belonging to the Ministry of Fishing; thereafter they banned fishing for two years. Consequently, the Rimachi has recovered its fish population and currently, with the help of WWF, the Kandoshi people are protecting their aquatic resources and organizing their own fishing activities. Resulting from close cooperation between indigenous and public authorities, the first indigenous fishing plan has been approved by the Peruvian Government.

More information:
http://peru.panda.org/en/our_work/in_peru/freshwater/freshwater/pastaza/
https://rsis.ramsar.org/RISapp/files/RISrep/PE1174RISformer2002_EN.pdf

General environment and ecosystems laws

Due to their complex and closely interrelated components, environmental laws facilitate the creation of working groups on integrated implementation of water legislation including integrated aquatic ecosystem management.

Sectoral environmental laws (e.g. water laws, forest laws, protected areas laws, and biodiversity laws) usually focus on specific ecosystems and their services. Even if ecosystem services are not explicitly mentioned, these laws are the most relevant for governing ecosystem services.

Environmental Dimension

A sound understanding of the environmental dimension is crucial to strengthening the governance of aquatic ecosystems and water. This involves considering the three dimensions of the watershed (subterranean, superficial and atmospheric) as well as its ecosystem services (water availability, food productivity, climate regulation, regulation of carbon dioxide and methane, flood control, nutrient recycling, natural water purification, other natural processes and cultural benefits). The key governance decisions for an aquatic ecosystem are those that most directly relate to biodiversity, natural resources and people.

Economic Dimension

The economic dimension includes all traditional economic instruments, such as taxes, fees and regulations, as well as new instruments, such as payments for ecosystem services (PES), i.e.

1. a voluntary transaction in which;
2. a well-defined environmental service (ES), or a form of land use likely to secure that service;
3. is bought by at least one ES buyer;
4. from a minimum of one ES provider;
5. if, and only if, the provider continues to supply that service (conditionality).

Example 27: Payment for watershed services in France

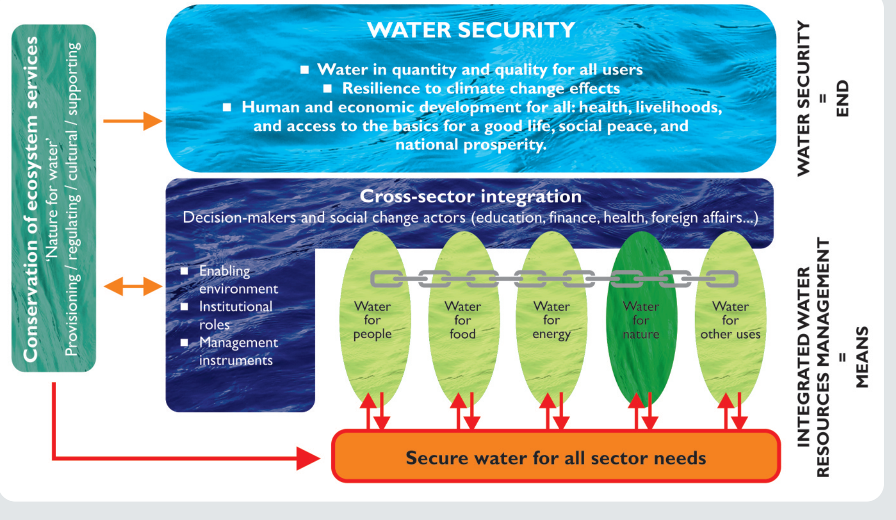
In the Rhine-Meuse Watershed, the company Perrier-Vittel granted an allowance of around €200/hectare/year to upstream farmers for not using pesticides. Although this cost seems high, it is in fact far lower than the cost of water decontamination and the damage to the company's image.

More information:
http://www.worldwatch.org/files/pdf/State%20of%20the%20World%202008.pdf

5.3.2. Strategic instruments for effective aquatic ecosystem governance

Combining the conservation of aquatic ecosystem services with Integrated Water Resources Management is a very effective strategy for achieving water security and combating climate change and growing uncertainty. Through conservation actions and programmes, ecosystem services contribute to economic welfare in two ways, i.e. by generating income and wellbeing. In the face of complex challenges, it is important to identify the key instruments that strengthen the four dimensions of governance.

Figure 8: Water security



Source: GWP Programmatic Approach on Water security and Ecosystems, July 2014

These instruments are the following:

- Direct regulation to control the overuse of land and development within catchments and flood plains; the quantity and timing of private water abstractions; and the quantity, quality and timing of waste discharges into the water environment;

- Protected areas; IUCN has defined six categories of protected area, ranging from strict prevention of human interference to the sustainable use of natural resources (strict nature reserve, wilderness area, national park, natural monument or feature, habitat/species management area, protected landscape/seascape, protected area with sustainable use of natural resources);

- Aquatic ecosystem inventories and monitoring facilitate dialogue, continuous awareness and stakeholder participation. Databases and inventories must be built with care, choosing methods for sampling designs, sampling, and sample handling and processing. Inventories can provide information on the temporal and geographic scale of the aquatic ecosystems, the services they provide, their characteristics and their economic value;

- Indicators of governance of aquatic ecosystems. Principles on Water Governance and OECD Indicators on Water Governance can be implemented to engage decision-makers at all levels, within and outside the water sector, to enhance better governance in the water sector, pave the way to an implementation Toolkit to monitor and support countries, and facilitate benchmarking;

- Capacity building to promote communication, to encourage participation and strengthen governance. In the context of IWRM, this represents the sum of efforts to nurture, enhance and use the skills and capabilities of people and institutions at all levels, so that they can work towards the broader goal. Capacity is needed at two levels: capacity to plan and develop IWRM programmes, and operational capacity. Capacity in institutions is needed to plan, regulate, provide services and allocate resources. The GWP Toolbox is a very efficient way to achieve this. The ecosystem structure and function is a pillar of water integrity. Capacity building strengthens integrated knowledge, which is, "Essential to guide management and policies for the wise, and hence sustainable use of surface inland waters and their connection with groundwater and coastal zones" (UNESCO-IHE);

- Creation of networks, such as the OECD Initiative on Water Governance, launched in March 2013; Global Water Partnership - GWP; Canada Water Network Inc.; Freshwater Action Network - Central America - FANCA; International Network of Basin Organizations - INBO; Network of Asian River Basin Organizations - NARBO; Mekong Program on Water, Environment and Resilience (M-POWER), African Civil Society Network on Water and Sanitation (ANEW), among others. All of these networks increase understanding of regional water governance and economic development issues and facilitate collective action in water governance and aquatic ecosystem governance.

Box 18: Ecosystem Management - From Concept to Local-scale Implementation

UNEP and IISD, in association with other partners, have developed an Ecosystem Management training workshop. Its objectives are to provide participants with ready-to-use tools, skills and ideas related to water management that they can take back and implement in their own catchment. The target audience preferably has an engineering or natural-resource background, and experience with IWRM.

Workshops are aimed at people responsible for managing a catchment area, often focusing on water in that catchment. Participants learn from experiences and materials that foster IWRM, develop lessons and ideas into an integrated, ecosystem approach, and identify and solve problems. A special focus is put on gender roles, which are critical when addressing natural resource issues, especially water.

The five-day workshop follows an evolving timetable:

1. A common starting point - Starting here (An initial conceptual framework), Complementarities between IWRM and Environmental Management, The structure and function of ecosystems;
2. Thinking like an ecosystem - Field trip, A conceptual framework for understanding an ecosystem's state and impact, State of ecosystem services and functioning;
3. Thinking and acting like a manager - Understanding current conditions, Beginning the cycle of strategic, adaptive management, Human activities are central to ecosystem management, Incentives and tools for local-scale management;
4. Managing our ecosystems - Valuing ecosystem services, Trade-offs and goals for ecosystem management, Selecting tools for local application, Monitoring and evaluation);
5. Putting it all to work - Field trip (return to the same catchment, applying conceptual model to local conditions, demonstrating good management practices), Completing the cycle of strategic adaptive management.

5.3.3. Principles of effective aquatic ecosystem governance

"Good governance addresses the allocation of management of resources to respond to collective problems; it is characterized by the principles of participation, transparency, accountability, rule of law, effectiveness, equity and strategic vision. It is a complex yet important universal concept" (UNDP). GWP emphasizes the need for ethical values (openness, transparency, inclusiveness, communication, equity, accountability, effectiveness and responsiveness).

Many governance reforms fail because of:

- Lack of implementation. Countries must intensify actions and political commitment towards the implementation of existing policies, plans and legislation for ecosystems and water;
- Lack of continuity of government authorities;
- Deficiency of research, weakness of both the public-academic nexus and the private-public one;
- Increasing levels of corruption and general lack of trust and willingness.

The aquatic environment is at the heart of Integrated Water Resources Management and the governance on which it depends. That is why improving the governance of aquatic ecosystems and water is a considerable challenge that necessarily involves reforms that go beyond the water sector. Water stakeholders at all levels have a responsibility to assist reform by making efforts to work towards it.

5.4. Main difficulties encountered in implementing restoration measures/projects

Aquatic ecosystems continue to be impacted by population growth, urbanization, industrial development and the construction of numerous waterworks and other huge infrastructures, which result in polluted surface waters, reduced aquatic organisms and wildlife, ruptured connectivity, and other stresses due to changes in sedimentation, turbidity and flows. At the same time, changes in lifestyles and eating habits in recent years require more water consumption per capita. Freshwater withdrawals have tripled over the last 50 years. Demand for freshwater is increasing by 64 billion cubic metres a year and aquatic ecosystems produce fewer services than in the past. Restoration is a key strategy for assuring sustainability. In some regions (Europe, North America) the need for aquatic ecosystem restoration is now well established, but in most developing regions, it is still a utopian dream.

"Restoration of freshwater habitats is essential to maintain ecosystem services, especially food and drinking water supply" (Millennium Ecosystem Assessment). Physical, ecological and hydromorphological restoration is an urgent matter.

In addition, it is increasingly recognized that aquatic ecosystem restoration depends on a combination of scientific, technological, social, economic and political efforts as well as ecological, physical, spatial and management measures and practices.

5.4.1. The multiple dimensions of aquatic ecosystem restoration are difficult to understand

The very first step is to recognize the two interdependent components that form the ecosystem of a river or lake: riverine and riparian. All waterworks, whatever their size, have an impact on the water; they affect its quality, quantity, flows, the dynamics of its banks and bed, change the silt loads, flood pulse, connectivity with the aquifer, erosion dynamics, and create accumulative damages. Thus, the main difficulties result from the huge complexity of aquatic ecosystems, the impossibility of restoring colossal impacts such as large dams (except in the US, where 1,185 dams have been removed to date), the lack of antecedents and consequently models, as well as the low level of political and social willingness to restore aquatic ecosystems. Another difficulty is the lack of concept clarification in norms, rules and policies.

Box 19: Importance of ecosystem concept clarification

In the United States, the Water Resources Development Act of 1986 and 1990 uses terms such as environmental improvement and environmental enhancement, as well as restoration, to describe new missions and authorities for the US Army Corps of Engineers. Surprisingly, these terms are not adequately defined because they do not emphasize biological, physical, and chemical processes of aquatic ecosystems despite the fact that this emphasis was almost certainly the intent of the Water Resources Development Act (The Journal of Social, Political and Economic Studies, spring 2006).

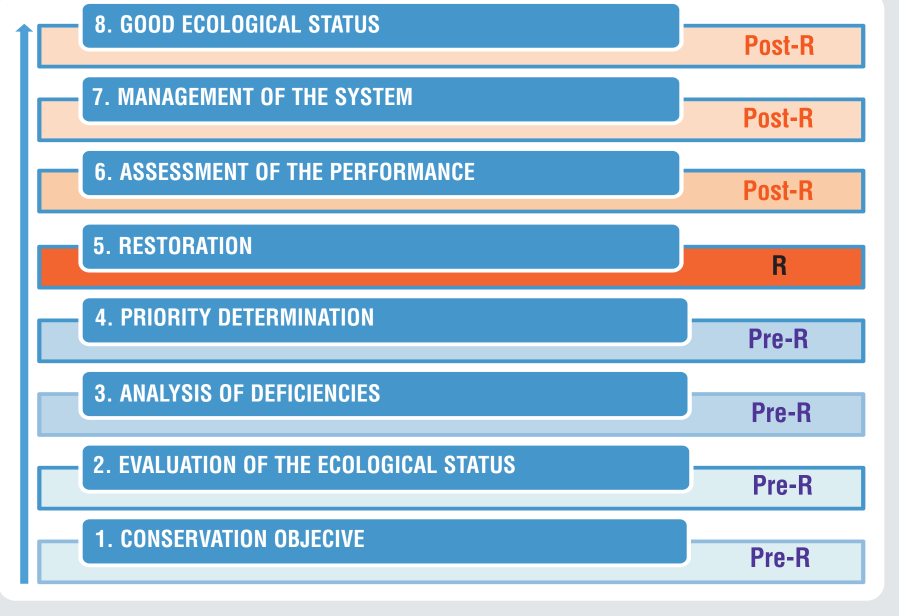
Restoration is, "The return of an ecosystem to a close approximation of its condition prior to disturbance. In restoration, ecological damage to the resource is repaired. Both the structure and functions of the ecosystem are recreated" (National Research Council, 1992).

For the Iberian Centre for River Restoration (CIREF), the restoration process is characterized by functionality, dynamics and natural variability, complexity, diversity and natural resistance. Therefore, effective restoration returns the river to its original condition, and has little to do with current social requirements, such as immediate security, recreation areas (river parks, riparian domestication), urbanization, etc. CIREF insists on the difficult social acceptation encountered in restoration projects that have failed because of the many natural and social barriers and the need for long-term support.

5.4.2. Difficulties encountered in the "Proceeding Chain of Restoration"

Building the proceeding chain of restoration (PCoR) is the first and most crucial step. Each step of the PCoR is complex yet essential to ensure the success of the whole process. Frequently, when national, regional or local authorities decide to start a restoration process, they only look at the deficiencies, i.e. usually water pollution and landscapes. As a result, the PCoR starts off in a weak position, with no restoration objective and no consideration of the benefits of the aquatic ecosystem. Instead, the focus is on improving the quality of water, usually to respond to an increasing demand for water for domestic and agricultural use.

Figure 9: The Proceeding Chain of Restoration



(Adapted from Pander and Geist, 2013)

The Proceeding Chain of Restoration is a step-by-step approach that systematically structures the complex procedure of restoration, from pre-restoration proceedings, restoration measures and actions, to post-restoration proceedings.

A long-term monitoring programme lies at the heart of Post-Restoration Proceedings, but can be considered at any level. This type of programme is a valuable tool to determine the success of restoration projects. With over three decades of experience, the National Research Council (NRC) and the US Army Engineer Institute for Water Resources (IWR) recommend monitoring during each phase of a restoration project.

Box 20: Main difficulties characterizing the different phases of a proceeding chain of restoration

Pre-restoration Proceedings				**Restoration Proceedings**	**Post-restoration proceedings**		
Planning				Measures and actions	Monitoring		Good ecological status
Conservation objective	Evaluation of ecological status	Analysis of deficiencies	Priority determination		Performance assessment	Management of the system	
Difficulty building the project's vision integrating physical, ecological, hydromorphological, social, cultural, economic, legal and political aspects.	Lack of historic data, technical and interdisciplinary studies. Baseline studies do not supply enough information to define existing conditions and conditions without the Project.	Build the analysis of deficiencies around the problem, and not the vision, to resolve politically natural impacts and social requirements.	Determine priorities according to the political agenda and the budget and not according to the vision, and the results of the previous phases. Baseline studies do not identify required actions to restore the system.	Difficulties may be multiple: legal, political, social but also technical. The less attention paid to the different phases in the Pre-R, the more difficulties will occur in the restoration proceedings. Weak governance and conflicts.	Lack of useful and accessible monitoring information available to all interested parties. Performance criteria have not been developed.	Weak Monitoring system does not help to build an efficient management strategy. Lack of professional expertise and budget for assuring continuity.	Lack of budget for disseminating results. The appropriate level of effort has not been determined. There is no concise and informative way to report the results of the monitoring.
Deficient capacity building for multi-scale and multi-time analysis							
Absence of monitoring from the first phase of the restoration project and throughout.							
Lack of consideration for one major determinant: scale of action, sections affected by the project, and impacts downstream, upstream, in the aquifer and in the atmosphere (water cycle).							

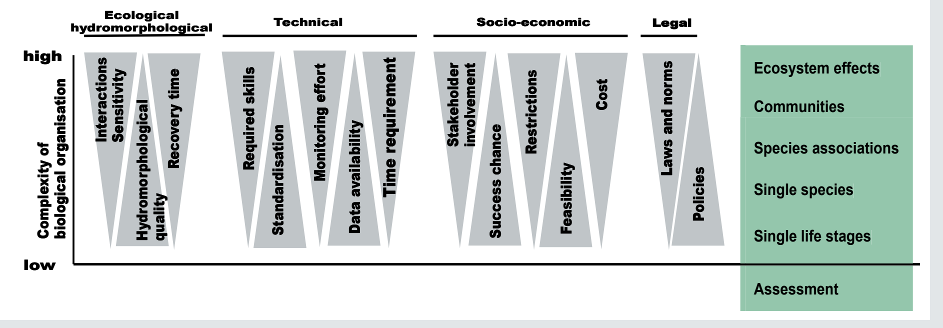
Negative impacts are common in restoration projects when technical teams are incomplete or do not have the sufficient capacity to:

- Analyze the structure and functions of the riparian corridor and riverine system;
- Analyze legal, social and cultural questions that are potentially relevant to the project;
- Coordinate public and private participation; integrate local and indigenous knowledge;
- Analyze the economic and financial aspects of the restoration.

5.4.3. Types of difficulty

Ecological/hydromorphological, technical, socio-economic and legal difficulties affect aquatic ecosystem restoration. The extent of their impact depends on the complexity of the restoration's biological organization. The respective assessment scales for restoration targets of increasing biological complexity are highlighted in green (and difficulties as grey triangles) in the figure below.

Figure 10: types of difficulty (Adapted from Pander and Geist, 2013)



Box 21: Common difficulties affecting aquatic ecosystem restoration projects

Ecological /Hydromorphological	
Interactions/ Sensitivity	Difficulty to define ecosystem services and their underlying ecological functions and carry out sensitive analysis to understand the effect of interactions. The connection between ecological succession and ecological restoration is not established.
Hydromorphological quality	Difficulty in obtaining quantitative data on flows, floods and sediments, including riverine and riparian spaces to restore the river system.
Recovery time	Under-estimated recovery time due to lack of studies, data and models.
Technical	
Required skills	Absence of technological innovations. Lack of transdisciplinary teams and academics involved in the restoration projects.
Standardization	EEach ecosystem is the result of a sequence of climatic and biological events unlikely to be repeated precisely. Lack of data and studies make it difficult to build a model that shows the direct and indirect connections between the ecosystem's physical, chemical, and biological components.

cont'd ■■■

Box 21: Common difficulties affecting aquatic ecosystem restoration projects (Continued)	
Monitoring efforts	Problems in monitoring programmes frequently occur during a programme's development and implementation phases. Too few parameters may provide insufficient information to evaluate performance or information that is difficult to interpret. Much of the information generated by monitoring programmes ends up filed away or so closely guarded that it is unavailable to others.
Data availability	Most of the restoration cases studies revealed a lack of reference studies of the natural situation in the past. It is quite difficult to identify and quantify the cumulated anthropic and natural impact. The many barriers within the educational system hinder interaction between disciplines, which is required to restore complex multivariate systems such as aquatic ecosystems.
Time requirement	Political stakeholders often consider time as the duration of their electoral mandate. Restoration projects are always designed for the long term.
Socio-economic	
Stakeholder involvement	Common problems include: lack of governance and interactive participation, exclusion of traditional knowledge, social inertia and administrative conflicts, lack of political and social willingness. Gaps may exist between social and political decisions, scientific research and proposals.
Potential success	Poor and limited Proceeding Chain of Restoration, lack of check-list. Lack of common goals and explicit directives.
Restrictions	Regulations established in Land Use Plans, Ecological-Economic Zoning, the existing infrastructure or other social rules that are incompatible with natural systems.
Feasibility	A feasibility study does not have the capacity to evaluate and analyze the potential of the proposed project due to deficient baseline studies and monitoring. New administrative costs impact the project.
Cost	Lack of financial instruments. According to NRC (1992), restoration projects can cost millions of dollars to implement, which is one of the reasons for failure. Restoration costs often exceed the forecasted budget. When a new administration comes to power, it may not be aware of former commitments.
Legal	
Policies	Lack of policies and integrated policies together with weak governance.
Laws	Lack of norms, rules and agreements to facilitate the processes of restoration and rehabilitation.

Although significant progress has been made in aquatic ecosystem restoration, projects are usually based on ecology, ecological processes and ecological integrity. Few scientific studies and projects integrate river ecology, hydromorphology and governance into a holistic and necessary approach.

Example 28: Designing ambitious projects for river restoration - Analysis based on European experiences integrating human and social sciences

The Water Framework Directive makes the physical restoration of aquatic environments an essential component of public water-management policies. However, initial feedback indicates that technical excellence alone is not sufficient to guarantee the effective implementation of river-restoration projects. To help solve this problem, ONEMA has produced a comprehensive framework describing the potential tools within an overall strategy designed to accompany stakeholders keen to launch a successful hydromorphological-restoration project. It specifically looks at which conditions determine the technical and political legitimacy of project promoters. The approach tackles how to ensure the social and territorial relevance of a project and demonstrate its technical and economic compatibility with the local social-economic context.

More information:
http://www.onema.fr/IMG/EV/publication/CERCEAU-FLYER.pdf
http://www.onema.fr/IMG/EV/cat7a-thematic-issues.html#restauration

Box 22: Tidal restoration projects and permit obstacles in the USA - Issue: Permit obstacles impede restoration efforts

The Nisqually National Wildlife Refuge tidal restoration project is the largest ongoing estuary restoration project in the Pacific Northwest and has been identified as a key priority for recovering Chinook salmon in the Nisqually watershed. Involving several years of planning and design, the project is supported by extensive scientific analyses, hydrologic modelling, an NEPA review (an Environmental Impact Assessment was completed), public participation, support and funding from national partners and the Nisqually Indian Tribe.

The permit process was difficult, with the risk of delaying the entire construction project. The longest delays involved obtaining the wetland/regulatory permits required by the US Army Corps of Engineers, compounded by the inefficiency of confusing and redundant state permits, including Washington State Department of Ecology (water quality certification and coastal zone management act concurrence) and Washington Department of Fish and Wildlife (hydraulics permit). Permit processing delays affect the timeframe of achieving landscape restoration projects with commensurate resource benefits.

It is critical to consider a more streamlined process for restoration projects of this magnitude, particularly when all other required environmental compliance is complete. Delays have resulted from the need to obtain additional permits to address adaptive management design modifications. Adaptive management of project design is an essential part of comprehensively planned restoration, but delays have also resulted from changes subject to the permit process and present an obstacle to implementing restoration projects.

Action: Consider streamlined processes for Federal Clean Water Act permits and applicable State permits for restoration projects of this magnitude.

More information:
http://www.americasenergycoast.org/USFW-ConflictingPolicyReport.pdf

6 Monitoring aquatic ecosystems

KEY POINTS:

- The different methods for monitoring watercourses and bodies are used to assess the state, characterize the pressures on the ecosystems, verify the efficiency of action, and inform the public.
- It is important to devise methods and protocols to ensure that results are reliable and comparable in time and space.
- The state of a watercourse or water body is characterized by its biological, physico-chemical, chemical and hydromorphological qualities.
- Monitoring after restoration is important to characterize how the environment is evolving, assess the restoration's efficiency, and determine any adjustments or additional action.

Why monitor?

To protect aquatic ecosystems, it is crucial to know them well. The different methods for monitoring watercourses and bodies are used to:

- Assess the state of the water and ecosystems, and determine whether processes are compromised by natural or human-induced environmental perturbations;
- Identify, characterize and if possible quantify the pressures on the ecosystems (withdrawals, discharge, local and diffuse pollution sources);
- Improve overall understanding of the aquatic ecosystem with the aim of directing management policies and the necessary action to preserve it;
- Verify the efficiency of action undertaken in relation to defined targets, and conformity with implementation of water legislation;
- Inform the public and promote implementation action.

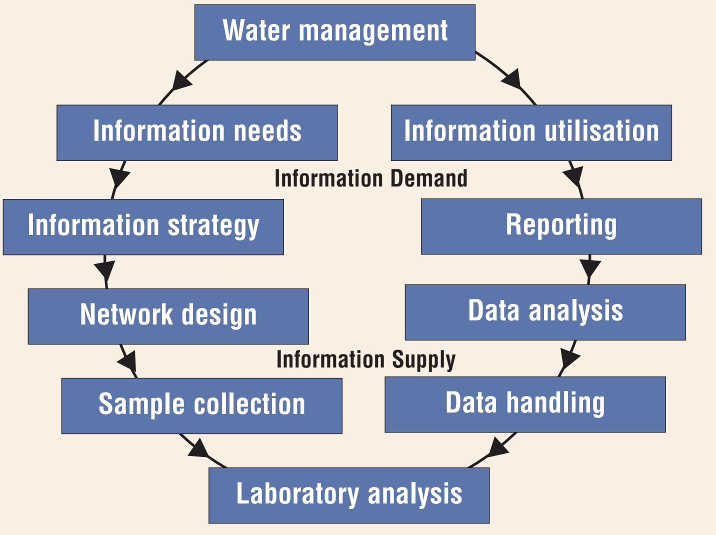
6.1. Monitoring ecosystem functions

What does monitoring entail?

Monitoring corresponds to a set of data collected using different methods (e.g. surveys, information on withdrawals and discharge, monitoring of the state of waters and ecosystems). The state of waters and ecosystems is monitored using a sampling plan organized in space (i.e. location and number of measurement and sampling points) and time (frequency and duration of measurement campaigns). However, the monitoring organization chain is not restricted to measurements; it involves several stages:

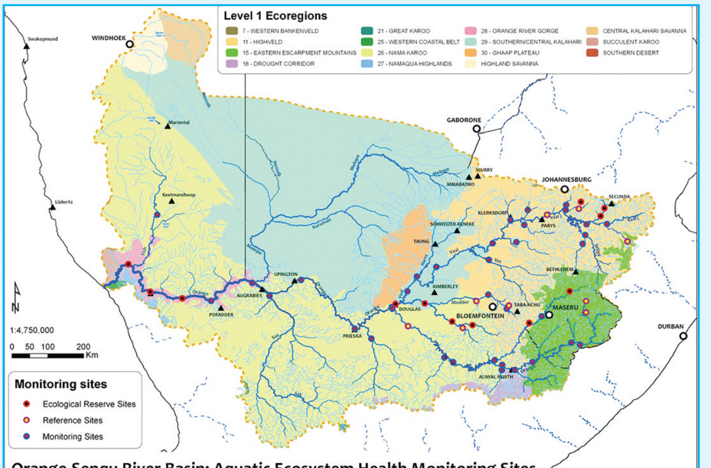
- Defining the objectives of the monitoring programme - choosing which watercourses or water bodies to survey, the sampling points, items to follow (matrices and parameters), the frequency and duration of campaigns, sampling and measurement protocols (recognized and replicable standards), etc.;
- Choosing operators (samplers, analysis laboratories, validators, etc.) and securing funds;
- Collecting samples;
- Analyzing;
- Collecting and storing data;
- Processing data and making use of the results;
- Communicating data, results and information.

Figure 11: Monitoring Cycle



Source: Rijkswaterstaat
INBO 2013 - Workshop on Monitoring 13 November 2013

Example 29: The OSAEH (Orange-Senqu Aquatic Ecosystem Health) Monitoring Programme



Orange-Senqu River Basin: Aquatic Ecosystem Health Monitoring Sites

The Orange-Senqu River Commission (ORASECOM) promotes the equitable and sustainable development of the resources of this river, whose basin extends into four countries: Botswana, Lesotho, Namibia, and South Africa, covering an area of 1,000,000 km².

As part of its activities, ORASECOM established the Orange-Senqu Aquatic Ecosystem Health (OSAEH) monitoring programme whose objectives are to:

1. Measure, assess and report on the ecological state of the aquatic ecosystems of the Orange-Senqu River System;
2. Detect and report on spatial and temporal trends in the ecological state of aquatic ecosystems, centring more on the ecosystem's response and less on the drivers of change;
3. Identify and report on emerging problems regarding the ecological state of aquatic ecosystems;
4. Provide information to support recommendations for more detailed investigative monitoring where problems emerge.

Monitoring surveys enter into two categories:

1. Routine Monitoring - this is monitoring conducted at the prescribed frequency to build up a reliable database of the condition at each site and identify any trends or changes in this condition. Routine monitoring is either annual or five yearly;
2. Investigative Monitoring - this is monitoring that responds to the identification of "hot spots" at any of the Routine Monitoring sites. This monitoring cannot be planned but should respond to the specific features of the situation in hand in order to establish the cause of the problems.

Monitoring must be regular, always visiting the same sites, whose location should not be changed without sufficient motivation. As a result, a record of the ecosystem's health can be built up over time, making the monitoring programme increasingly robust.

http://www.orasecom.org/_system/writable/DMSStorage/661Manual%20for%20the%20Aquatic%20Ecosystem%20Health%20Programme.pdf

To ensure that results are reliable and comparable in time and space, it is important to devise methods and protocols for sampling and withdrawals along with robust, standardized measures.

Example 30: AQUAREF, French reference laboratory for monitoring aquatic environments

In France, five public bodies (BRGM, IFREMER, INERIS, IRSTEA, LNE) make their skills and research capacities available to a national reference laboratory for monitoring aquatic environments called AQUAREF. This laboratory was established in 2007 with the objective of providing tools and methods to improve the quality of monitoring data on chemical and physico-chemical parameters along with biological quality elements for surface waters (continental or coastal) and groundwater.

AQUAREF's main three missions are:

1. Establish rules for measurement, sampling and analysis processes in order to standardize and ensure the quality of monitoring data;
2. Devise solutions to anticipate monitoring (identify emerging risks and develop tools for monitoring in the future);
3. Represent France in groups of European technical experts.

AQUAREF's work on "chemical" aspects relates to improving the methods for sampling and analyzing chemical substances in water, sediment and aquatic organisms. The aim is to improve standardization of sampling techniques, analytical methods for meeting regulatory requirements for chemical substances concerned by monitoring, reference methods for analyzing emerging substances that are not yet subject to regulation, and alternative methods to standard sampling techniques.
In terms of hydrobiology, AQUAREF's work centres on identifying methodological requirements, programming and developing protocols and assisting operators in their undertakings, by producing technical guidelines and providing vocational training, producing texts likely to be standardized, and assisting authorities in French and European standardization.

More information at:
http://www.aquaref.fr/

What needs monitoring?

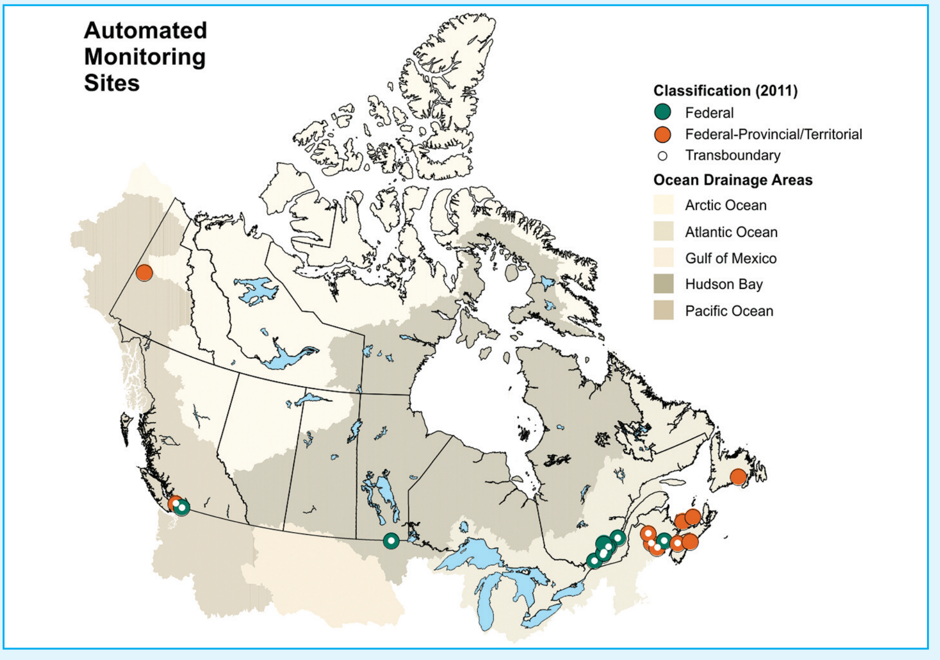
An aquatic environment's functioning involves all of its compartments, i.e. water, flora, fauna, and habitats. Thus the state of a watercourse or water body is characterized by its biological quality as well as elements of physico-chemical, chemical and hydromorphological quality. To identify the main alterations, their causes and the action required, a diagnosis of the environment should centre on the state of all of these components and measure any differences with the reference conditions.

Chemical and physico-chemical quality elements

Physico-chemical analyses (temperature, oxygen, salinity, suspended matter, etc.) and chemical analyses (micropollutants like heavy metals, pesticides, hydrocarbons, etc.) provide information on water quality.

Example 31: Automated Water Quality Monitoring Sites

In Canada, the Automated Water Quality Monitoring Network works in partnership with provinces and territories, and federal departments. Most stations monitor hourly for temperature, dissolved oxygen, pH, specific conductance and turbidity. Surveillance objectives aim to detect spills and react accordingly, identify specific events and trends in water quality, especially at transboundary sites in support of the International Joint Commission (with United States), and report on the status of aquatic ecosystems of interest to the federal government.



In 2011, the Canadian territory comprised 20 automated water quality monitoring sites. Two transboundary sites exist in British Columbia: one federal and one federal-provincial. Manitoba features one transboundary federal site. Five transboundary federal sites and two federal sites are located in Quebec. New Brunswick numbers four transboundary federal-provincial sites, and three federal-provincial sites can be found on Prince Edward Island. Nova Scotia counts one federal-provincial site and one transboundary federal-provincial site. One federal-territorial site is located in Yukon.

More information:
http://www.ec.gc.ca/eaudouce-freshwater/default.asp?lang=En&n=50947E1B-1

Biological quality elements

Biological analyses (populations of fish, invertebrates, aquatic plants, microscopic plankton, etc.) are used to detect chemical and/or physical deterioration of the environment that has resulted in a change in the population's composition. These analyses provide information on the modification of water quality over longer periods of physico-chemical and chemical analyses.

Species low down in the food chain, such as benthic invertebrates (aquatic insects and algae) provide early warnings regarding contaminants and other environmental stress factors.

Note, however, that the introduction of invasive species can also alter the composition of the population, which may not necessarily indicate chemical or physical modification/deterioration of the environment. That's why, in Europe with the introduction of the Water Framework Directive for example, the biological quality elements described by biological indicators shall describe the ecological status as compared to reference conditions (population under no or slight anthropogenic pressures).

Example 32: AUSRIVAS - A biomonitoring system for rivers

AUSRIVAS (Australian River Assessment System) is a rapid prediction system used to assess the biological health of Australian rivers. AUSRIVAS was developed under the National River Health Program by the Federal Government in 1994, in response to growing concern in Australia about maintaining ecological values.
Predictive models are a crucial feature of AUSRIVAS and are based on the British RIVPACS models (River InVertebrate Prediction And Classification System). These models predict the aquatic macroinvertebrate fauna expected to occur at a site in the absence of environmental stress, such as pollution or habitat degradation, to which the fauna collected at a site can be compared. Thus, AUSRIVAS produces a biological assessment that can be used to indicate the overall ecological health of the site. Macroinvertabrate predictive models have been developed for each state and territory for the main habitat types found in Australian river systems, including riffle, edge, pool and bed habitats.

Each state/territory possesses models constructed from single season data in addition to models with data combined from several seasons. The AUSRIVAS predictive system and associated sampling methods offer a number of advantages over traditional assessment techniques. The sampling methods are rapid and standardized within each state/territory, results can be turned around fast, and the outputs from the AUSRIVAS models are tailored for a range of users including community groups, managers and ecologists.

More information:
http://ausrivas.ewater.com.au/

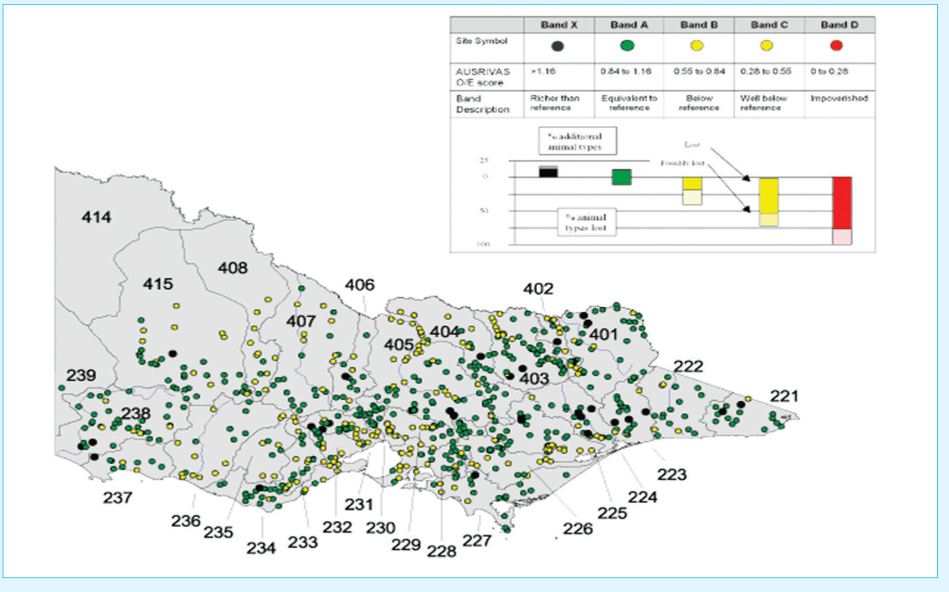


Figure: Summary of AusRivAS bioassessment results for all river sites surveyed in Victoria
Source: Co-operative Research Centre for Freshwater Ecology 2001, data supplied by relevant state authority http://www.environment.gov.au/node/21908

Hydromorphological quality elements

A study of the physical environment can highlight the hydromorphological characteristics of the river (hydrological regime, ecological continuity, morphology), along with anthropogenic pressures and hydromorphological dysfunctions.

Example 33: Water Framework Directive and hydromorphology - Challenges and implications in Romania

To successfully implement the Water Framework Directive (WFD) and achieve its objective of good ecological status / potential of all water bodies requires the identification, assessment and control of all major anthropogenic pressures on water bodies, including pressures on the physical structure of rivers. Across Europe, it is thus crucial to develop a set of hydromorphological indicators at different spatial and temporal scales powerful enough to capture changes in the ecological state of water bodies (rivers) and assist decision makers in identifying priority actions.

According to the Romanian National River Basin Management Plan (2009), of a total of 3,399 water bodies, 1,241 (i.e. 36% of all water bodies) risk failing to achieve environmental objectives by 2015. Almost half of these water bodies at risk show significant hydromorphological alterations (15% of all identified water bodies are heavily modified). Considering the hydromorphological alterations identified in Romanian rivers, it is crucial for the implementation of the Water Framework Directive to develop a set of hydromorphological indicators.

A study has thus been set up at the National Institute of Hydrology and Water Management to develop a methodology for establishing a set of hydromorphological indicators for Romanian rivers. This innovative methodology takes into account the strengths, limitations and gaps of existing European and non-European methods and integrates all of the hydromorphological elements required by the WFD for an ecological status assessment.

The methodology is intended to represent a scientific basis for the national water monitoring system and water status assessment. In addition, the methodology should be a tool to support the decision-making process in order to improve water quality in Romania.

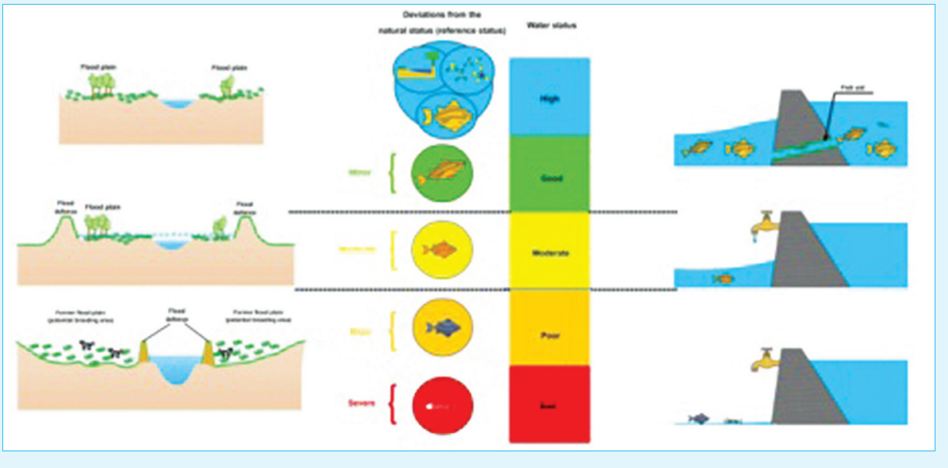


Figure: Hydromorphological alterations and ecological water status (adapted from Peter Pollard, Scottish Environment Protection Agency)

6.2 Monitoring after restoration measures

The completion of restoration works is often considered as the final stage of a project, but in fact it is only the beginning of the next phase, i.e. monitoring. Monitoring can generally only be carried out correctly if values are known before setting up the measure. This therefore means devising a restoration strategy early on including measurements of the parameter categories that the planned action is aiming to improve. It is important to monitor sites to characterize how the environment evolves following the interventions, assess the efficiency of the action carried out, and determine whether any adjustments or additional action are necessary.

This monitoring also helps to improve knowledge on restoration/ecology interactions, reinforce or revise the operations' financing policy, and improve future implementation of the operations. In addition, it may be beneficial to evaluate the socio-economic repercussions of activities impacted by the project. Lastly, monitoring generates feedback that managers of aquatic environments can refer to when establishing new projects.

Post-action monitoring should be based on identical measures (sites, elements, protocols, etc.) before and after restoration, so that the evolution can be characterized, and should be carried out after a minimum time period corresponding to the environment's response time. Depending on the local context, some actions can have unexpected impacts (e.g. water retention, self-purification). It is important to consider the potential effects of actions carried out and possibly adjust the monitoring in line with observed or suspected impacts that were not anticipated or for which monitoring data was not collected during the initial phase.

Progress on the restoration programme's effects can be assessed using a scorecard (cf. Chapter "Natural Water retention measures, cross-cutting objectives and results").

Example 34: PRAGMO - Guidance document on suitable monitoring for river and floodplain restoration projects (UK)

PRAGMO is a guidance document that aims to provide a set of pragmatic guidelines to help a range of people, from government agencies to community action groups, determine the level of monitoring required for establishing monitoring protocols as part of a river restoration project.

Given the wide range of organizations, knowledge and abilities, the guidance document includes monitoring strategies suitable for different groups. The steps outlined are intended to support technical staff working for competent authorities, consultancies and academic institutions as well as organizations with limited funds, which may need to demonstrate success to trustees and funders. As a 'living' document, the techniques and methods will be updated over time.

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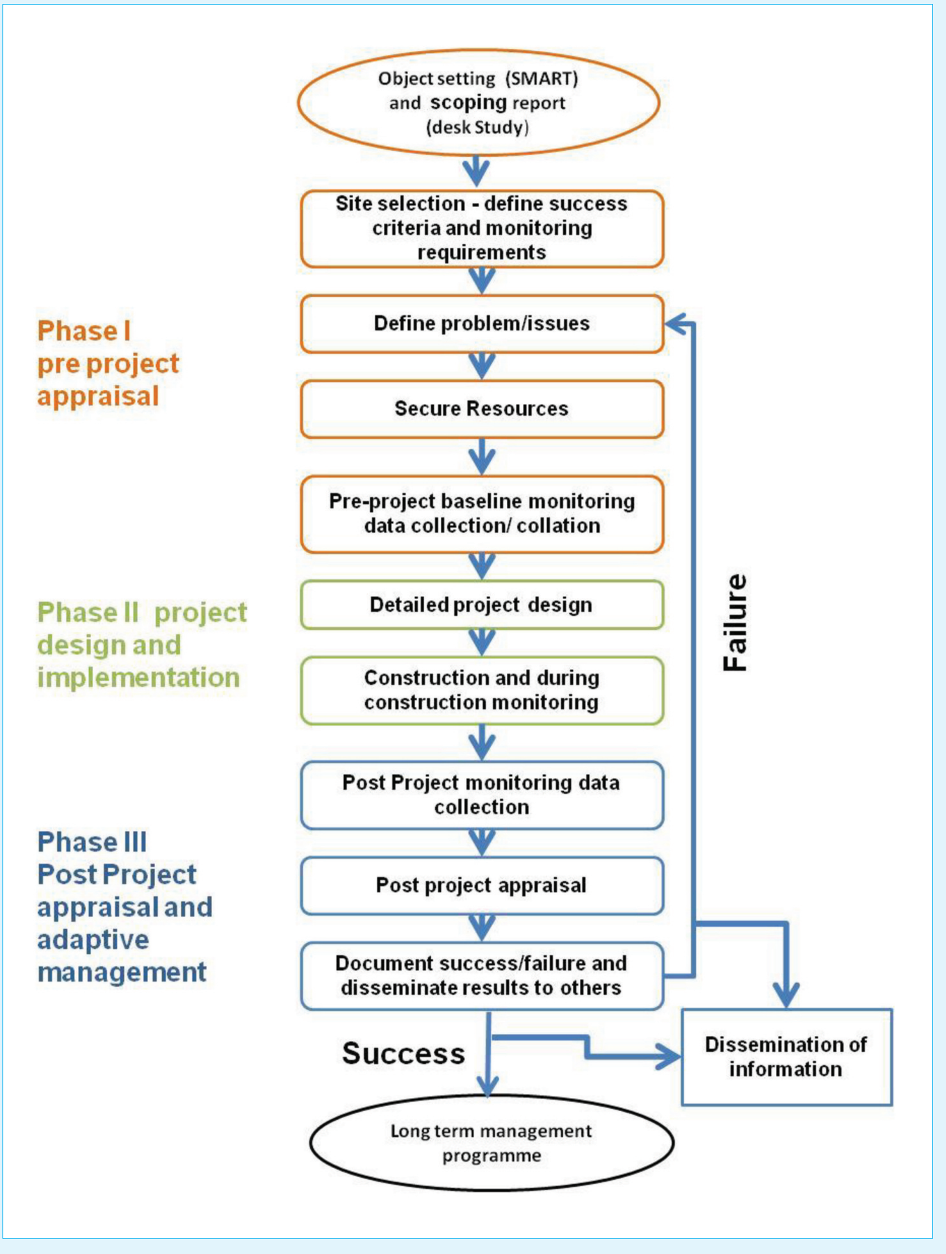

Figure: Flow Diagram of the Restoration Process (adapted from Bruce-Burgess, 2004)
More information:
http://www.therrc.co.uk/rrc_pragmo.php

Box 23: REFORM - REstoring rivers FOR effective catchment Management - Evaluation of hydromorphological restoration

An increasing number of rivers have been restored over the past few decades, but only a few of these projects have been monitored, with the result that knowledge on the effect of river restoration on biota is limited. Nevertheless, the monitoring results of several projects are available in peer-reviewed scientific literature and have been compiled in recent research projects. Some narrative reviews have already been published, but a comprehensive quantitative meta-analysis summarizing the findings of these existing studies is lacking.

The overall aim of REFORM (REstoring rivers FOR effective catchment Management in Europe) is to provide a framework for improving the success of hydromorphological restoration measures, in a cost-effective manner, targeting the ecological status or potential of rivers.
The objective of one of the studies was to evaluate the effect of hydromorphological restoration on biota based on these existing data. The specific objectives were to quantify restorations' success, identify the catchment, river reach, and project characteristics that influence (i.e. constrain or enhance) the effect of restoration, and derive recommendations for river management.

Overall, the evaluation of hydromorphological restoration based on existing monitoring data led to some interesting conclusions relating to river management. However, monitoring data are still scarce. The following would lead to more robust, practical, relevant, and quantitative results (e.g. thresholds) and be of benefit to river management: (I) original monitoring data, (II) full before-after-control-impact monitoring designs, (III) a higher number of monitored projects, (IV) availability of long-term monitoring data sets to investigate the influence of projects' duration. Another strong recommendation is more intensive exchange and collaboration between river science and river management in planning monitoring programmes.

More information:
http://www.reformrivers.eu/results/effects-of-river-restoration

Example 35: Monitoring the migration of the European eel (Anguilla Anguilla): a non-intrusive sonar method

The European Commission has established legislation (Regulation No.1100/2007), which requires all member states with natural A. anguilla habitats to produce Eel Management Plans. The goal of these plans is to allow at least 40% of the silver eel (adult life-stage) biomass that would have occurred prior to anthropogenic influences to escape to the sea.

To demonstrate the level of compliance with this target figure and ensure the conservation of the species involves collecting accurate and reliable datasets on Anguilla anguilla escapement. The aim of this study was to evaluate the potential of high-frequency multi-beam sonar for collecting such data and to examine the usefulness of this non-intrusive approach for the conservation of elusive aquatic species such as A. anguilla.
The research was carried out in the period July-November 2009 on the River Huntspill (Somerset, UK), using high-frequency multi-beam sonar firing across the complete channel cross-section.

The data and information gleaned from this type of research improves understanding of the behaviour and population dynamics of A. Anguilla. This study demonstrated that high-frequency multi-beam sonar is capable of continuous monitoring and can capture, in a non-intrusive manner, discrete events when A. Anguilla migration occurs. This technology is capable of monitoring in turbid and relatively deep water environments (to a depth of 300 m) during nocturnal hours, the specific types of habitat through which A. anguilla typically migrate during escapement.

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LOCATION

Location of the River Huntspill, Somerset (UK), with a plan view and cross-section view of the sluice gates and position of the Didson unit and beam position. Arrows in the cross-section and plan views denote the direction of flow. Adapted from Bilotta et al., *(2011).*

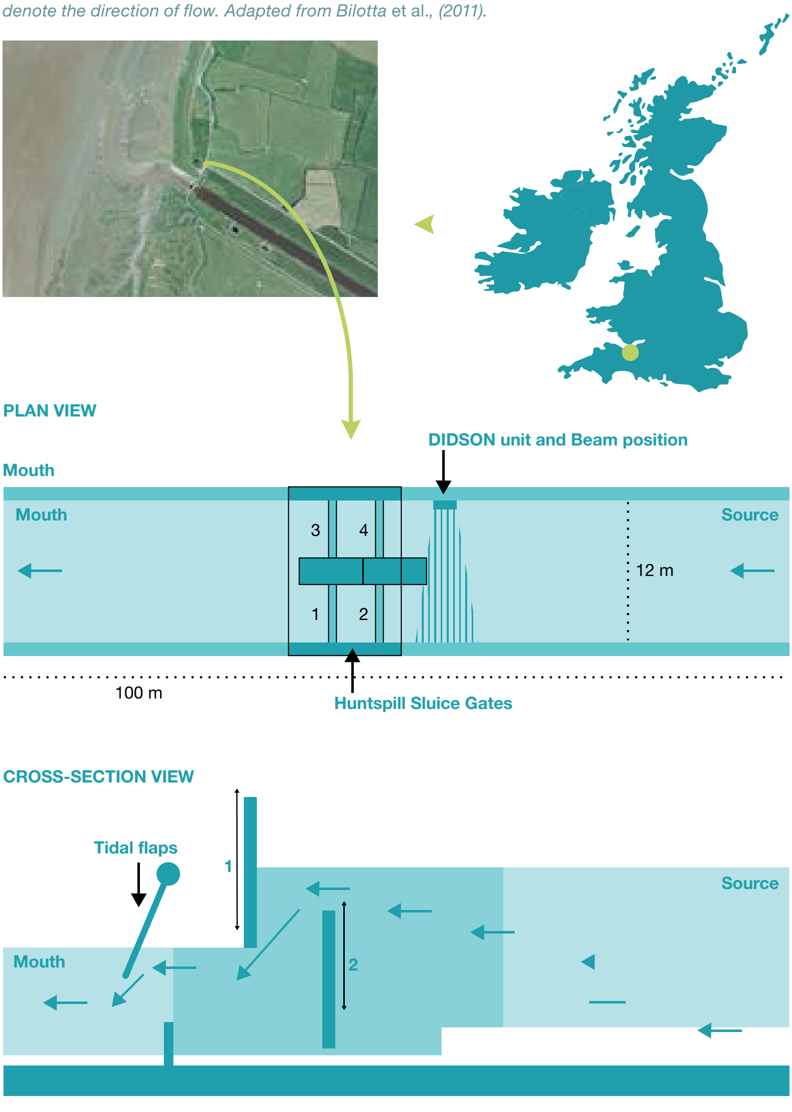


Figure: Migration of the European Anguilla (from Bilotta, Sibley, Hateley and Don, School of Environment and Technology / University of Brighton and Environment Agency) http://www.fromseatosource.com/?page=DOWNLOAD

Example 36: River restoration monitoring and outcomes on the Val des Choues, in Burgundy, France

Monitoring:

The restoration of the Val des Choues was preceded by a scientific monitoring process whose purpose was to determine the evolution of the site's physical and biological characteristics. An initial assessment upstream and downstream of the ponds was carried out in 2005 prior to the drying-out process. Following the works, inventories were made of the invertebrate, fish and amphibian populations and the environment was mapped and described in order to measure the speed and dynamics of the environment's recolonization and observe the morphological development of the watercourse. Regular photographic monitoring provided supplementary visual information.

Outcome of the project and outlook:

Initial results of the scientific monitoring have been very promising: the winter flow rates have allowed the stream to re-establish its bed along almost the entire length of the restored watercourse, which follows a slightly sinuous course in a main shallow bank channel (banks only 10 to 20 cm deep). The response is better than expected, with fast development of the bed in favour of biogenic habitats related to the presence of woody debris. However, coarse alluvia (small pebbles, gravel and sand) remain scarce and the bottom of the bed is still muddy.

The draining of the first three ponds in June led to an explosion of vegetation growth. In less than three months, the dried-out former ponds were recolonized by natural vegetation - mainly white willow and brown galingale - thus stabilizing the sediment.

More information:

http://www.onema.fr/IMG/EV/publication/rex_r2_valchoues_vbatGB.pdf

7 Economic and financial aspects

KEY POINTS:

- Aquatic ecosystems and the services they provide are inestimable, but economic evaluation of ecosystems can make it easier to rank challenges and choices.
- An ecosystem's natural value comprises the ecosystem's support structure, the value of the stock of "products" and of the value of the "natural infrastructure".
- The total economic value of ecosystems is generally broken down into the usage values of services provided and the non-usage values associated with the ecosystem.
- Willingness to pay (or willingness to do without the advantages supplied by the ecosystem) is based on the following question: How much are users ready to pay to ensure that the aquatic ecosystem is not subject to degradation?
- Payments for Ecosystem Services work on the principle of a contractual payment to stakeholders, on the condition that they maintain or restore ecosystem services.
- Funding for environmental action can come from the basin's budget as part of a basin management plan, or from outside the basin.

7.1 Economic value of aquatic ecosystems

Ensuring the maintenance and restoration of aquatic ecosystems and the services they provide involves making choices based on a combination of environmental, social and economic reasoning. Consequently, an economic analysis of aquatic ecosystems is necessary. Numerous documents produced during the last ten years have shown the significance of the economic value of ecosystems, in particular in terms of the losses incurred by their degradation.

Some sources (Wageningen, 2008) estimates the loss of ecosystem services in the world in 2010 at almost 12,000 billion euro, or about 6% of the global gross domestic product.

Box 24: Loss of ecosystem services

	Value of loss of ecosystem services in billion EUR per year in 2010	
	Amount	% GDP
Natural zones	- 12,703	6.50
Barren natural zones	- 6	
Managed forests	+ 1,691	0.87
Extensive farming	- 819	0.42
Intensive farming	+ 736	0.38
Wood biofuel	+348	0.18
Cultivated pasture	- 1181	0.60
Total World	- 11,933	6.10

The 2007 study, “The Economy of Ecosystems and biodiversity” (TEEB), evaluates the value of annual losses of ecosystem services at 50 billion euro. This evaluation relates to all ecosystem services and therefore extends far beyond aquatic ecosystems.

7.1.1 Why make an economic evaluation of aquatic ecosystems?

Aquatic ecosystems and the services they provide are theoretically and objectively inestimable. Since they have no “price” (in the economic sense of the term), in the past their value was often left out of economic calculations, both in terms of heritage and services rendered.

The result was often bad decisions, leading to inappropriate allocation of resources (e.g. increased withdrawals in water courses) and the disappearance of services provided by ecosystems (e.g. flow regulation effect of a wetland), with negative impacts on the wellbeing of the inhabitants concerned, at least for a relatively long period.

The economic evaluation of ecosystems does not necessarily target making the “best” decisions, but rather improving decision-making. Thus, by giving a monetary value to an aquatic ecosystem, we make the hypothesis that its “natural capital” will be introduced into economic calculations connected to projects and that we will use the most realistic figure possible for all phenomena of degradation and overexploitation of an environment and its resources. In addition, this evaluation can make it easier to rank challenges and choices in a sustainable development framework.

Ultimately, economic evaluations of ecosystems provide reliable information in figures to help make private, collective and individual decisions.

7.1.2 What is the economic value of an aquatic ecosystem?

An ecosystem’s natural value can be introduced into the assets in the accounting balance in the same way as for example the value of property or land; it also gives the value of losing the ecosystem good or the value of replacing it. An ecosystem’s natural value comprises three parts.

❶ The value of the ecosystem’s support structure

This might be the monetary value of the terrain on which a wetland operates, or the value of a natural body of water (land and water reserve), or the length of a watercourse (river bed and water), each of which constitutes the basis of the aquatic environment in question. The value of the ecosystem’s support structure can generally be easily understood through the surrounding land market. Nevertheless, it is important to be aware that the value resulting from market references can vary significantly depending on the potential interest: a hectare of wetland has little monetary value for a farmer or urban planner because of the prior investment required to make it useable for crops or urbanization (drainage or filling in of the wetland, possibly surplus infrastructure costs).

❷ The value of the stock of “products” or “matter” connected to the ecosystem that can be commoditized

A pond can contain significant quantities of fish that, from an economic point of view, constitute a stock of living working capital. Similarly, peatland possesses a stock of matter (peat) that has an economic value on a market. The subsoil of a riverbed can contain aggregate or sand that could be extracted and sold. The value of this “stock of matter” is harder to determine, both in terms of quantity (e.g. study of the terrain to quantify the mass of peat, its quality, etc.; electric fishing to quantify and qualify the stock of fish) and price. Nevertheless, in a great number of cases, a market exists and can be used to identify reference prices, which then need to be adapted to the particular context.

❸ The value of the actual ecosystem, i.e. the value of the “natural infrastructure”

The natural infrastructure provides environmental services (cf. Chapter Management and restoration of aquatic ecosystems) via the elements that make up the ecosystem’s biocenosis.

For example, a wetland, by facilitating the breakdown of organic matter and nitrogen and phosphate-based matter, has a self-purification power comparable to a water treatment plant. These services can be assimilated to infrastructures comprising the service provided (i.e. treatment of polluted water, reduction of pollution) and the unit required (i.e. treatment plant, drinking water production unit). Natural economic analysis considers the latter. It involves looking for elements that can be used to give a monetary value to this natural infrastructure, although the task is not easy for some elements, like flora and fauna biodiversity.

Another distinction in the economic value of ecosystems is to consider what is or could be the object of a market transaction and thus "marketable", and what is "non marketable" because it cannot be traded on a market. The marketable category could include goods, like the capital represented by a pond, or part of a river with all of its components (water, biology, etc.) that, depending on the context, could be the object of an exchange. It could also involve ecosystem services like water supply, peat production, etc.

Non-marketable ecosystems and ecosystem services are typically connected to biodiversity in general, in the knowledge that some parts of biodiversity might become marketable, e.g. medicinal plants. The separation between marketable and non-marketable ecological goods is nevertheless difficult to define, especially given that something that is not marketable today could become marketable in the future.

Example 37: The OECD's vision of the value of ecosystems

The OECD manual (2002) portrays a fairly global vision of the value of ecosystems broken down into three sections:

1. Instrumental value, derived from an objective function, like seeking human wellbeing; the ranking of wellbeing situations is based on preferences, as are the instrumental values of ecosystems;
2. Aesthetic values, based on preferences; the "beauty" of landscapes, their diversity or certain elements of biodiversity (including farm-forest biodiversity) make up aesthetic values;
3. Moral values, which are clearly not instrumental; these convey the idea that an ecosystem has intrinsic or inherent values.

7.1.3 Evaluation method for aquatic ecosystems

Several conditions are required to make an economic evaluation of aquatic ecosystems:

- Possess sufficient, extrapolative knowledge about the state and evolution of the ecosystems;
- Identify the different types of value that the ecosystem might comprise, and identify those that can be translated into monetary value;
- Define clear methods to measure (and update) these values.

The first important issue is to determine the pertinent area to evaluate. This might be, for instance, the degraded surface of wetland or watercourse length, or the disturbed habitats.

One way of doing this is to start by evaluating the environmental services provided by the ecosystem. For example, a quantification of the purification effect of a wetland (physical quantity) can be used to work out the average investment value required for the same level of purification. These data can then be employed to determine the equivalent investment that would give the same type of result (substitution or compensation investment value).

Another method is to apply these environmental service values on a timescale (at least 50 to 100 years) and take the ecosystem's value to be the sum of the annual values of the services provided by the ecosystem.

Generally though, analysis of ecosystem services tends to employ usage values, which do not constitute an ecosystem's total value, even when extended to include future or conditional uses. This is because ecosystems comprise entities that have not yet been identified, but might be in the future.

Prior to making an economic evaluation, it is indispensable to carry out a precise and thorough study of the ecosystem and its functioning and identify the different services that it supplies. These services should then be quantified: purification rate, quantity of aquifer recharge, quantity returned in dry periods, quantity of water stored in excess precipitation periods, etc. At basin scale, these elements can be used to rank ecosystems, based on technical data and information supplied by experts and interviews with users.

Example 38: Protocol suggested in the Bessin and Cotentin Regional Natural Park (France) project

The suggested protocol included ecology-focused activities:

- Identify the types of wetlands present in the study zone considered, their surface area and current conservation state. The information needed at this stage is usually well documented;
- Identify the complete list of services provided by the different types of wetlands present, combining data, technical reports and accounts of local experts;
- Characterize each of the services provided by analyzing the operation of wetlands, uses and their relationships.

Although it is theoretically possible to attribute a set of services to wetlands, in practice current knowledge on how they function is limited and this investigation work proves difficult. The indicators used to quantify the services provided are chosen according to their ability to provide information on the role of wetlands and their ability to be used. In practice, the state of knowledge rarely results in a precise quantification of the services provided by a particular wetland: quantification thus makes use of the characteristics of the site studied to extrapolate results and data available from other sites with similar characteristics. Whatever the information and methods used, any uncertainty regarding the values obtained is systematically stipulated.

Analyses on the NRP site illustrate the particular difficulties encountered in quantifying the water purification service associated with wetlands. The geochemical quantification of the purifying service is challenging and few pertinent sites exist on the scale of the study site.

Social and cultural dimensions are also crucial when making economic evaluations of ecosystem services, as shown for example in the use of joint analysis to understand individual preferences. Involving sociologists specialized in cultural and natural heritage issues could reinforce preparatory analyses for economic evaluations, resulting in a more detailed and robust understanding of these dimensions.

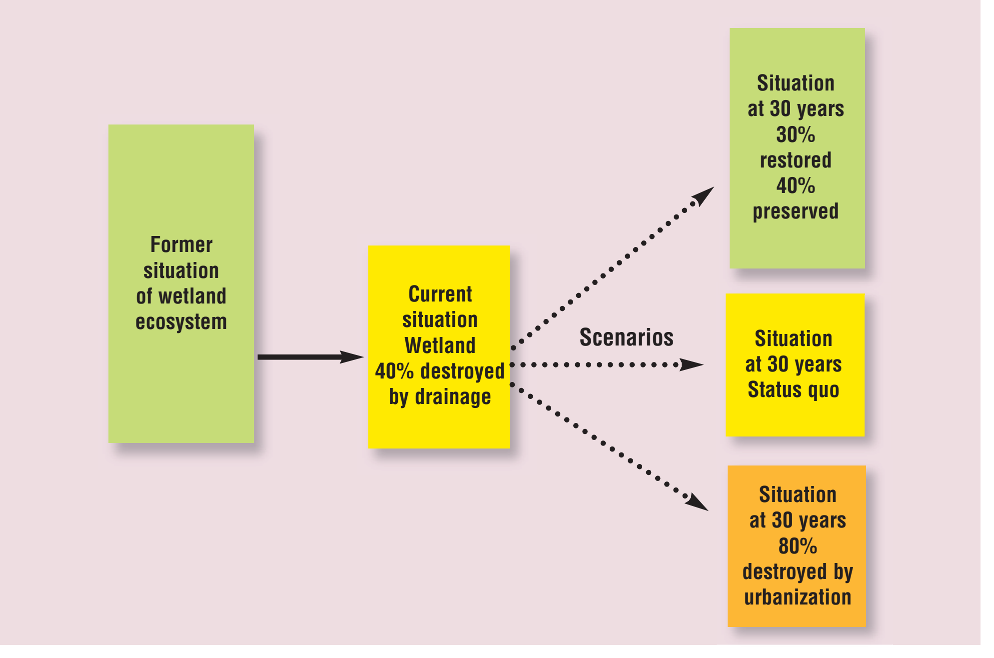
7.1.4 Monetary evaluation of the restoration of aquatic ecosystems

Two options are possible for the monetary analysis of ecosystems:

1. The "macro" option, which is used to set situation targets for ecosystems (conservation and restoration); this general objective, e.g. for a country or basin, is translated by the overall cost of restoration / conservation, which is then compared to the real or provisional results; this thus becomes a cost-efficiency analysis;
2. The "micro" option centres on an identified object, and is used to determine whether or not restoration would be beneficial; in this case, the cost of restoration is compared with the gains obtained through restoration (gain of service rendered), making it a cost-advantage analysis.

The principle of an evaluation carried out in a cost/advantage analysis is to compare choices by looking at their advantages and disadvantages in economic terms. This involves creating scenarios that integrate hypotheses on the evolution of ecosystems interacting with human activities. These scenarios depend on knowledge of the dynamics of ecosystems affected by human activity, and hypotheses of the evolution of human activities in the basin (population, economy, etc.). They can also integrate conservation targets.

Figure 12: Example of monetary evaluation scenarios



References can of course be used, but global-scale references are currently insufficient both in terms of the economic value of ecosystem capital and the economic value of ecosystem services. Existing data are highly dispersed and they should be updated to reflect a more precise study of the question. As years go by, methods are improving and the calculated economic value of ecosystems is increasing.

A thorough economic analysis should establish the total economic value of ecosystems that are generally broken down into:

- The usage values of services provided by the ecosystem, which include the benefits for inhabitants and the use of assets (natural capital) and practices associated with this natural capital, but not resulting in their consumption;
- The non-usage values associated with the ecosystem, i.e. advantages obtained by others.

For a project, this total value corresponds to the total environmental costs of the project.

The limits of economic calculations are mainly due to uncertainty arising from:

- The difficulty of characterizing and precisely quantifying services;
- The imperfection of the methods used;
- The imprecision of the unit values used;
- Uncertainty regarding the extrapolation factor of unit values (population concerned, volumes withdrawn, etc.).

7.1.5 Updating values

Data need to be updated because an ecosystem's value is established over a very long period. To consider the long term, an updating rate should be used that is identical to that used for other aspects of the economic calculation (e.g. 4% today, diminishing after 30 years). Until 2050, we can consider an average 1% increase in the relative prices of ecosystems compared to manufactured goods (this can be higher in case of irreplaceable losses). Thus, the annual service value is multiplied by 40 to obtain a total updated value.

Example 39: Millennium Ecosystem Assessment

The Millennium Ecosystem Assessment presents an ecosystem service classification divided into four types:

1. "Self-cleaning services", or assistance services, which are not directly used by humans but that condition the smooth functioning of ecosystems (e.g. recycling of nutriments);
2. "Supply services", or withdrawal services, which result in usable goods (e.g. fresh water withdrawals);
3. "Regulation services", i.e. the capacity to modify, in a way favourable to humans, phenomena like climate, the occurrence and extent of extreme events or different aspects of the water cycle (floods, low water, physico-chemical quality);
4. "Cultural services", i.e. the use of ecosystems for recreational, aesthetic or spiritual purposes.

When establishing the value of an ecosystem, it is worth trying to identify the content of these four types of possible services.

http://www.millenniumassessment.org/en/index.html

Useful references include "The Economics of Ecosystems and Biodiversity" (TEEB, 2009), itself used in the revision of the United Nations national accounts system, with an underlying or stated objective of greening taxation, by introducing eco-eligibility criteria into public subsidies to limit their negative impacts on biodiversity.

7.1.6 Willingness to pay

Beyond an economic analysis of ecosystems in terms of capital value and service value, many cases also require associating users' willingness to pay, or willingness to do without the advantages supplied by the ecosystem.

This principle is based on the following question: How much are users ready to pay in a defined time unit (per day, per year, etc.) to ensure that the aquatic ecosystem is not subject to degradation, or for its restoration? In other words, would users accept compensation for the degradation of aquatic ecosystems and if so, what amount? This question can have several kinds of response, depending on whether the compensation would be "in kind" (cf. mitigation banks), or an equivalent final service through different means, or whether inhabitants' wellbeing would be maintained by replacing the services of destroyed ecosystems with other sources of satisfaction.

Similarly, in a project that impacts an aquatic ecosystem, the question is: How much are users ready to lose by doing without certain advantages provided by the aquatic ecosystem? This approach has the advantage of putting a monetary figure on a set of elements that are otherwise extremely subjective and qualitative.

Example 40: Bessin and Cotentin Regional Natural Park (RNP)

The methodology employed involves three stages:

- Understand the functioning and dynamics of wetlands on the RNP site;
- Individually estimating the monetary value of ecosystem goods and services on the study site by applying different economic evaluation methods. In particular, a joint analysis has been developed to identify the non-usage value associated with wetlands and their biodiversity;
- Estimate the total economic value of wetlands on the RNP site by making a reasoned aggregation of the individual economic values obtained by each service and put into perspective the results obtained. This third stage also provides keys to understanding the reliability of the transfer of values and identifying the conditions necessary for using the values.

The information and knowledge employed in these three stages were obtained from:

1. A literature review;
2. Interviews with key stakeholders on the RNP site;
3. Focus groups with inhabitants involved in the site;
4. A workshop for pooling and validating the results at the half-way stage.

7.1.7 Monetization of services provided by wetlands

Different methods have been used to translate the goods and services of wetlands into monetary values:

1. Methods that determine the value of a wetland (or more often of one of its functions) from the costs that would be involved if it disappeared or if its functioning were altered, using either the costs avoided method, the substitute cost method, or the replacement costs method. These methods have been used for services like water purification, flood control, and climate regulation (especially carbon storage in peatland);
2. The benefit transfer method, which uses results from similar studies to estimate the value of the wetland concerned, has occasionally been used to evaluate the education and research service;
3. Methods that identify the value of a wetland (or one of its functions) using a fictive substitute market (joint analysis method or experimental choices) consider the most diverse range of values (usage and non-usage).

Example 41: Study of marshland in France

In 2009, The Ministry of Ecology and the General Commission on Sustainable Development in France commissioned a study of three wetland sites located in the Seine-Normandy River basin: La Bassée, covering 24,000 ha of which 13,000 ha are wetlands, the Oise Valley with 11,000 ha of which 8,000 ha are wetlands, and the Bessin and Cotentin Regional Natural Park (Normandy), covering 148,000 ha of which 49,000 ha of wetlands. The study was an opportunity to test the methodology and provide a first series of figures relating to the total economic values of wetlands and users' willingness to pay.

In this example, the Total Economic Value calculated for wetlands ranges from 117 to 218 million euro per year, based on hypotheses made relating to a hectare of wetland, with an average value of 2,400 to 4,400 euro.

The willingness to pay was also evaluated for non-usage values using a survey of 800 people centred on the following three services:

- Aesthetic value and recreational value, characterized by the attributes "access to site" and "landscape";
- Water-purification service, characterized by the attribute "water quality";
- Biodiversity, characterized by the attribute "animals and plants", relating to the number of species and size of their population.

Value attributed to NRP	
Service	**Willingness to pay (euro/person/year)**
Biodiversity	9 euros
Water purification	15 euros
Landscape and access to site	15 euros
Total	**39 euros**

The study highlighted some issues that merit being taken further:

1. The issue of the "monetization factor" by which the unit value of the service provided is multiplied to obtain the monetization value of each ecosystem service of the zone evaluated;
2. The results expressed in value per service and per hectare according to the type of wetland concerned;
3. The services for which the value is difficult to obtain, e.g. market impacts on tourism and health, scientific value and cultural value.

7.2 Payment for Ecosystem Services

Ecosystem services are services supplied by ecosystems that benefit the population. The Millennium Ecosystem Assessment established a general framework in 2005 to help understand the issue of ecosystem services.

Ecosystem services, supplied “free” by nature, depend on the vitality and durability of aquatic ecosystems. However, multiple pressures can either reduce the services provided (e.g. the filled-in floodplain of a river no longer plays its role as a flood expansion area and therefore no longer provides a service of combating flooding), or lead to the disappearance of a service because the ecosystem has been destroyed (e.g. a dried-up wetland that no longer soaks up or purifies).

To combat this harmful evolution, two types of action are possible:

1. Coercive action through regulation (e.g. legal protection of a biotope that prohibits all human activity of exploitation or urbanism, or an obligation on all users to maintain the environmental flow of a river to ensure aquatic life at low water levels);
2. Negotiated or contractual action, between users / beneficiaries and environment stakeholders.

The concept of Payments for Ecosystem Services (PES) comes under the latter category and thus supplements obligatory action without taking its place. The mechanism works on the principle of a contractual payment to stakeholders, on the condition that they maintain or restore one or several previously identified ecosystem services.

Box 25: Payments for ecosystem services in figures

1. According to UNEP (Ecosystem Marketplace), in 2010, the annual value of all services provided by ecosystems (e.g. water, food, biodiversity) was estimated between USD 21,000 to USD 72,000 billion;

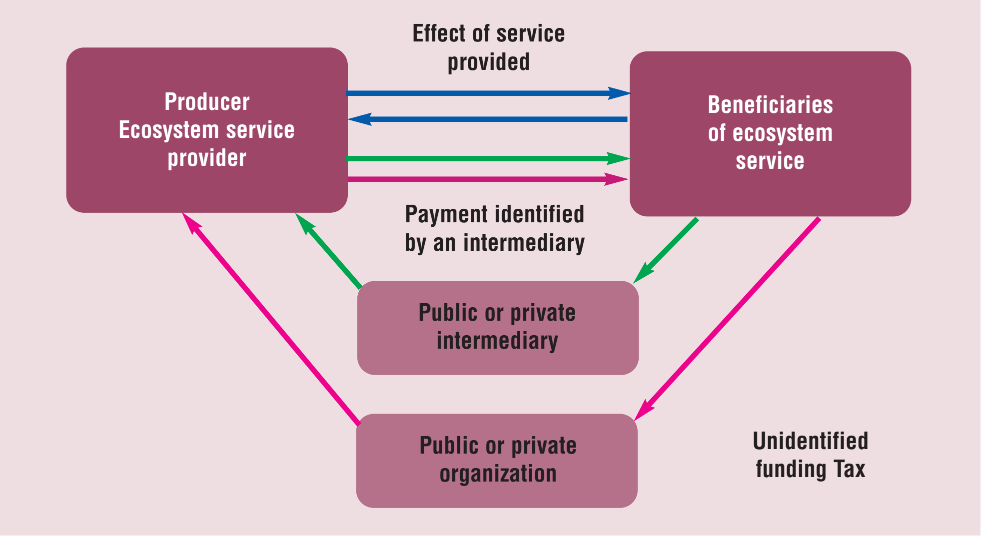
2. In 2011, the value of annual payments totalled USD 8.2 billion and concerned 205 active programmes and 76 in preparation. The managed surface area to produce these services at water catchment level was 117 million hectares, of which 116 were in China.

These figures show both the advantage of Payments for Ecosystem Services and the moderate action: 117 million ha compared to 12 million ha cleared a year, or 5 billion ha of farmland in the world, of which 1.4 billion ha are arable land.

When implementing PES, the emphasis is on negotiations between service beneficiaries and service suppliers or producers. This negotiation takes the form of a contract by which beneficiaries agree to remunerate / pay the supplier, which agrees to maintain or improve the ecosystem service(s) through its acts.

The voluntary aspect is often highlighted when implementing this instrument; nevertheless, real life and practical experience often show that PES comprises a paid service side (incentive payment) based on a voluntary process, and a finance-collection side based on a sovereign, obligatory process (e.g. tax). Thus for example an obligatory “polluter pays” tax compels farmers to reduce pollution from fertilizers, while at the same time, financial aid per hectare of grass strip planted along a water way encourages voluntary action.

Figure 13: Overview of PES implementation



The operational implementation of PES comprises three main issues:

❶ Environmental effectiveness involves evaluating the impact of changes in individual practices on the production of a given service. This makes it possible to target suppliers of ecosystem services that require priority compensation to increase the programme's environmental effectiveness. In practice, payments are often made in a standardized manner relating to surface area or length and efforts made by providers, but not in relation to results;

❷ The cost effectiveness of PES is connected to the question of the additionality of the supply of a service in relation to a status quo scenario. In other words, does the PES add value or, on the contrary, would the paid stakeholders have carried out the activities concerned without payment, voluntarily or otherwise?

❸ Equity occurs in as much as, in principle, PES remunerates people who are not ready to change their practices voluntarily, and who are not obliged to do so by regulations. However, at the same time, some stakeholders would be ready to spontaneously change their practices without waiting for compensation. The use of standard payments achieves greater equity between provider stakeholders.

PES has two main limitations:

- The windfall effect, i.e. the fact that stakeholders take advantage of an opportunity to receive payment for acting as they did in the past;
- Payment of a service to stop or modify an activity that is actually illegal.

In economic terms, for an operation to work, the Payment for Ecosystem Services must be higher than the cost of opportunity or service production by the supplier (or loss of earnings).

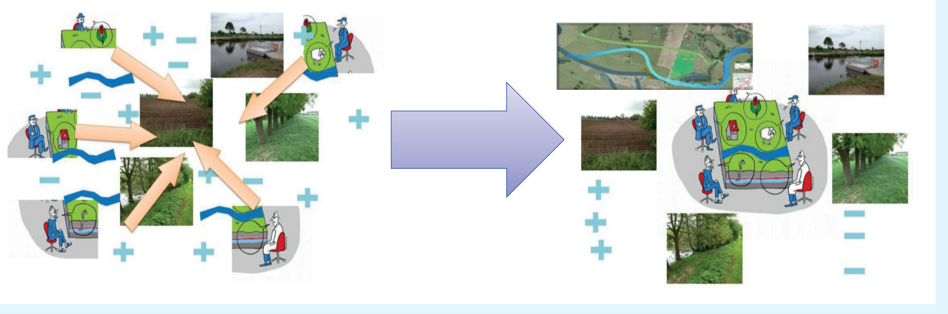
Two aspects should be studied and considered concerning the value of environmental services:

- On one side, the value of the ecosystem service should be brought to a specific territory (e.g. basin or sub-basin scale), before establishing overall targets for this service and devising management and monitoring instruments at this level ("macro" vision);

- On the other side, the costs of projects and local action should internalize their impacts on ecosystems, so that they are included in the socio-economic evaluation of their profitability. This supposes reference values to be integrated into evaluations for pollution and "microeconomic" water withdrawals.

Example 42: The Vecht is invaluable, or is it …? - Generating funds with help of Payment for Ecosystem Services in the transboundary Vecht region

A river basin ecosystem such as the Vecht Valley includes characteristics and processes that can be used by society and thus provide society with services. Changes in the ecosystem generate costs and benefits for different stakeholders.
This project explored whether a PES scheme is a useful approach to support the implementation of river restoration measures at a local water management level. In addition to an ongoing planning process for transboundary floodplain restoration, a down-to-earth, participatory research process was set up, establishing a single local stakeholder group to identify costs and benefits, and simulate a negotiation for additional funds.



Some conclusions:

- Floodplain restoration generates several significant costs and benefits that go beyond the interests of water management;
- Central costs and benefits e.g. for nature protection and tourism, influence each other so that they are affected by the measure's detailed design and framework;
- During the discussions, transboundary differences were less relevant than the differences between stakeholders. However, different institutional settings resulted in a different assessment of the measure's impact;
- The simulated PES negotiation process generated some additional funds, e.g. to add touristic features to the area. However, it did not raise the sum required by the simulation to enable implementation of the measure.

Stakeholders commented that:

- In terms of tourism, the measure is too small and the benefits too uncertain to bring support;
- In terms of nature protection, generating additional funds to support tourist activities is not warranted as they might harm nature;
- For municipalities, the amount of funds offered also depends on the expected engagement of other stakeholders;
- Agriculture anticipates incurring costs and asks for compensation.

More information:
http://www.interessen-im-fluss.de/en/projekts_/vecht_pes/

Example 43: Payment project for environmental services in the Tinkisso Basin (Guinea)

Upstream in the Tinkisso Basin, one of the main tributaries of the Niger River in the Republic of Guinea, the degradation of ecosystems impacts on the wellbeing of inhabitants and increases their vulnerability to climate change. In particular, the degradation of the catchment area has resulted in excess silt at a small dam and reduced its electricity production.
The project aims to study the conditions for restoring the dam with the aim of re-establishing electricity production for the benefit of the region's inhabitants and economy. The objective is to promote integrated management of the basin by taking an ecosystem approach to reduce the impact of climate change and increase the benefits for communities living up- and downstream from the dam. The project is centred on a financial incentive approach to benefit communities responsible for restoring and conserving environmental services in upstream basins. The project should produce the following results:

- The definition, with stakeholders, of the technical, environmental and socio-economic conditions to restore the dam's reservoir;
- The definition of objectives and appropriate sustainable management tools to ensure the maintenance of environmental services;
- The participation of dam user groups, members of the operating company, and technical service agents in the decision-making process for managing the dam and the basin's ecosystems.

More information at:

https://www.iucn.org/fr/propos/union/secretariat/bureaux/paco/programmes/prezoh/premi/premi_projets/premi_repase/

Example 44: Resource protection for Vittel water (France)

The methodology employed involves three stages:

For 20 years, Agrivair, a subsidiary of Vittel SA in France, has been involved in a strategy to protect water resources in the basin containing Vittel mineral water. This company provides technical and financial support to operators that have signed contracts to protect the resource. The method involves collaboration with stakeholders in the basin, especially farmers, and voluntary participation;

At the end of the 1980s, the water springs were at risk of qualitative impairment, mainly due to farming practices likely to increase the nitrate content in soils harbouring groundwater. Following a research period, scientists recommended stopping the use of phytosanitary products on the entire impluvium, rotating crops and composting animal droppings;

To fulfil its mission, Agrivair employed a concerted protection policy that led to guaranteed "zero pesticide" management of almost 10,000 hectares and 11 towns.
Farmers were accompanied through research, experiments and stakeholder participation;

The territory of Vittel is an example of beneficial interrelations between human activities and the ecosystem. The ecological transition of the impluvium has reached a level of maturity that means that Agrivair can now invest in new projects that closely connect the territory's economic and ecological development;

For farmers, the principle was to set up technical specifications aimed at "zero phytosanitary products" while guaranteeing modern, durable, profitable agriculture. A dialogue was put in place between the farmers concerned and researchers to implement the new farming model, while finding solutions for farmers' main problems;

In 20 years, 26 farms have adopted the new system, and 95% of farmland is now protected on the basin containing the natural mineral spring. The work carried out received support from public authorities and the French Water Agency.

The following guidelines can be useful in developing PES:

1. Identify the functions fulfilled by the ecosystem and then identify the services provided by this ecosystem;
2. Analyze the ecosystem services in the context of the basin by determining those that appear the most pertinent and identifying priorities;
3. Carry out a technical quantification of the ecosystem services chosen;
4. Make an economic evaluation of the ecosystem services, either using references already employed, or by establishing financial data based on information existing in the basin;
5. Work out the unit costs to protect and restore the services;
6. Evaluate if necessary the willingness to pay of the population concerned;
7. Look for compromises between costs and willingness to pay, and establish the PES.

7.3 Funding of environmental actions

Funding of environmental action in basins takes two main forms:

1. Funding from within the basin. Using basin-scale “polluter pays” and “withdrawer pays” principles is a way of collecting a tax or levy paid by water users to feed into the basin’s budget. This budget can be used by the basin organization to implement measures decided as part of a multi-annual basin management plan. The condition is that actions that benefit the basin’s aquatic ecosystems should be written into the management plan;

2. Funding from outside the basin. Funding from the State, local authorities or inter-state bodies (e.g. European Union, Regional Economic Commission) is also a significant source of finance for developing conservation and restoration action on aquatic ecosystems in basins. This is the case of the European Union, which provides funding for these actions (as part of the Common Agricultural Policy and the European Agricultural Fund for Rural Development, EAFRD), supplementing State and local government grants.

Example 45 : Setting up a water tax system in Bulgaria

Bulgaria has made lot of positive changes to its water policy over the last 20 years. In particular, the implementation of the European Water Framework Directive (WFD) has led to the creation of four River Basin authorities (River Basin Directorates).

These River Basin Directorates are responsible for implementing the WFD and in particular developing a River Basin Management Plan (RBMP) and Programmes of Measures. Bulgaria's current water tax system could still be expanded and revised. Based on the French experience, the water fee system could have the following characteristics:

Simple: the main structure of the system (calculation formula) should remain clear and understandable (although the formula includes coefficients than could be detailed) Progressive: one of the main challenges is making the economic sector accept to pay water taxes. A good strategy is to create a progressive system starting with a fairly moderate level of taxes;

Fair: the way that taxes are calculated should be equal within each economic sector and the level of tax should reflect the use of water or the pollution emitted and its evolution;

Incentivizing: the system should be designed so that the tax provides an incentive to use water rationally and decrease water pollution; taxes should not only collect revenue, they should also act as a powerful driver to change behaviour;

Cost-efficient: the cost of managing the water tax system should remain limited, in particular compared to the revenues generated by the taxes.

The different fees should be voted at national level with a minimum and maximum for each category of fee and devised at River Basin Level by the Basin Committee. Several threshold values per parameter are also needed at national level. These values determine the payment threshold of pollution per parameter.

The total amount of fees collected by the Basin agency should feed into the basin's budget and be used to develop and implement the programme of measures linked to the basin management plan.

8 Conclusion

Freshwater resources, which are limited and random, are increasingly used, wasted and polluted, with the result that aquatic ecosystems are threatened and sometimes destroyed. In a context of global changes, improved governance that respects the environment is one of the main keys to sustainable development and poverty alleviation.

Integrated Water Resources Management of rivers and lakes should be organized at basin level. Greater recognition should be given to the role and services provided by aquatic ecosystems because they function as "green or natural infrastructures", ensuring many services, such as flow regulation and water self-purification.

More integrated basin management is necessary to implement measures such as the restoration and maintenance of water ecosystems by natural means, or Natural Water Retention Measures, which improve water status and flood management. Links and exchanges between sectors must be enhanced to better integrate different policies, communicate on the benefits of approaches to restore rivers, mobilize partners from other sectors, and exchange on the work and tools available in different countries to facilitate river restoration measures.

Local communities should also increase their involvement in ecosystem restoration projects. Access to monitoring results and knowledge of water and aquatic environments should be extended to reach a broad section of the public. The keys to successful water policy include sound knowledge and easy access to data and information on the status and evolution of water resources, ecosystems and their uses.

Websites

Central and Eastern Europe Network of Basin Organizations
ceenbo.mobius.ro

Iberian Center for River Restoration
http://www.cirefluvial.com/en/

eaufrance
www.eaufrance.fr/ressources/documents

Global Water Partnership
www.gwp.org

GWP ToolBox
www.gwptoolbox.org

International Network of Basin Organizations
www.inbonews.org

International Office for Water
www.oieau.fr/anglais/index.htm

Latin American Network of Basin Organizations
www.ana.gov.br/relob/?lang=es
www.rebob.org.br

Mediterranean Network of Basin Organizations
www.remoc.org

Network of Asian River Basin Organizations
www.narbo.jp

OECD
http://www.oecd.org

Onema
www.onema.fr/Preserver-et-restaurer-l-hydromorphologie-et-la-continuite-des-cours-d-eau

The Future we Want
http://www.un.org/en/sustainablefuture/

Tropical Agricultural Research and Higher Education Center
http://www.catie.ac.cr/en/

UNEP
http://www.unep.org

UNESCO-IHE
http://www.unesco-ihe.org

Water for Life
http://www.waterforlife.alberta.ca/

References

European Commission; 2012; Blueprint to Safeguard Europe's Water Resources

European Commission; 2013; Building a Green Infrastructure for Europe

GWP - INBO; 2009; A Handbook for Integrated Water Resources Management in Basins

GWP TEC. TEC Background 7; February, 2003; Effective Water Governance

IIED; 2014; Watered down? A review of social and environmental safeguards for large dam projects

INBO / GWP / UNESCO / UNECE / GEF; March 2012; The Handbook for IWRM in transboundary basins of rivers, lakes and aquifers

IUCN; 2011; Governance of Ecosystem Services

Millenium Ecosystem Assessment; 2005; Ecosystems and human well-being

Onema, 2011. Evaluer les services écologiques des milieux aquatiques : enjeux scientifiques, politiques et opérationnels

Onema, 2011. La restauration des cours d'eau : Retours d'expérience sur l'hydromorphologie

Onema, 2014. Designing ambitious projects for river restoration

Regulated Rivers: Research & Management, 12; 1996; A general protocol for restoration of regulated rivers

TEEB; 2007; The Economics of Ecosystems and Biodiversity

UNGA; May 21, 1997; Convention of the Law of the Non-Navigable Uses of International Watercourses

The World Bank; 2009; Environmental Flows in Water Resources Policies, Plans, and Projects. Findings and Recommendations

Wageningen; 2008; The cost of policy inaction: the case of not meeting the 2010 target

World Commission on Dams; 2000; Dams and development. A new framework for decision-making

Further reading

Front Ecol Environ; 2009; How well do we understand the impacts of alien species on ecosystem services? A pan-European, cross-taxa assessment

INBO; 13-15 August 2013; 9th General Assembly of the International Network of Basin Organizations. Fortaleza - Brazil

INBO; 20-23 January 2010; 8th General Assembly of the International Network of Basin Organizations. Dakar - Senegal

INBO; 7-9 June 2007; 7th General Assembly of the International Network of Basin Organizations. Debrecen - Hungary

INBO; 24-28 January 2004; 6th General Assembly of the International Network of Basin Organizations. La Martinique - French West Indies

INBO; 28-30 May 2002; 5th General Assembly of the International Network of Basin Organizations. Quebec Province of Quebec (Canada)

INBO; 30 Sept.-4 Oct. 2000; 4th General Assembly of the International Network of Basin Organizations. Krakow - Poland

INBO; 1-4 December 1998; 3rd General Assembly of the International Network of Basin Organizations. San Salvador de Bahia - Brazil

INBO; 2-4 October 1997; 2nd General Assembly of the International Network of Basin Organizations. Valencia - Spain

INBO; 27-29 March 1996; 1st General Assembly of the International Network of Basin Organizations. Morelia - Mexico

International Hydropower Association; November 2010; Hydropower Sustainability Assessment Protocol

OECD (2002), Manuel d'évaluation de la biodiversité. Guide à l'intention des décideurs

UNEP-INBO; November 2014; First International Environment Forum for Basin Organizations - Towards Sustainable Freshwater Governance. Nairobi, Kenya

Water Resources Coordination Centre; October 2012; Guidelines for the development of water infrastructure in West Africa

Integrated Water Resources Management (IWRM) should be organized to correspond to the scale of river, lake and aquifer basins.

Today, significant progress is required to move from theory to practice and take concrete action to preserve and restore aquatic ecosystems, which are playing a key role as green infrastructures to regulate flow regimes and improve water quality.

To facilitate this process, the International Network of Basin Organizations (INBO), the Global Water Partnership (GWP), the International Office for Water (IOWater) and ONEMA have joined forces to write this handbook. This document aims to provide practical advice on how to improve management of aquatic ecosystems, based on examples of achievements in various national or transboundary basins.

This handbook is addressed to managers of river and lake basins, water professionals and representatives of public authorities, as well as non-governmental stakeholders involved in basin management and ecosystem restoration.

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