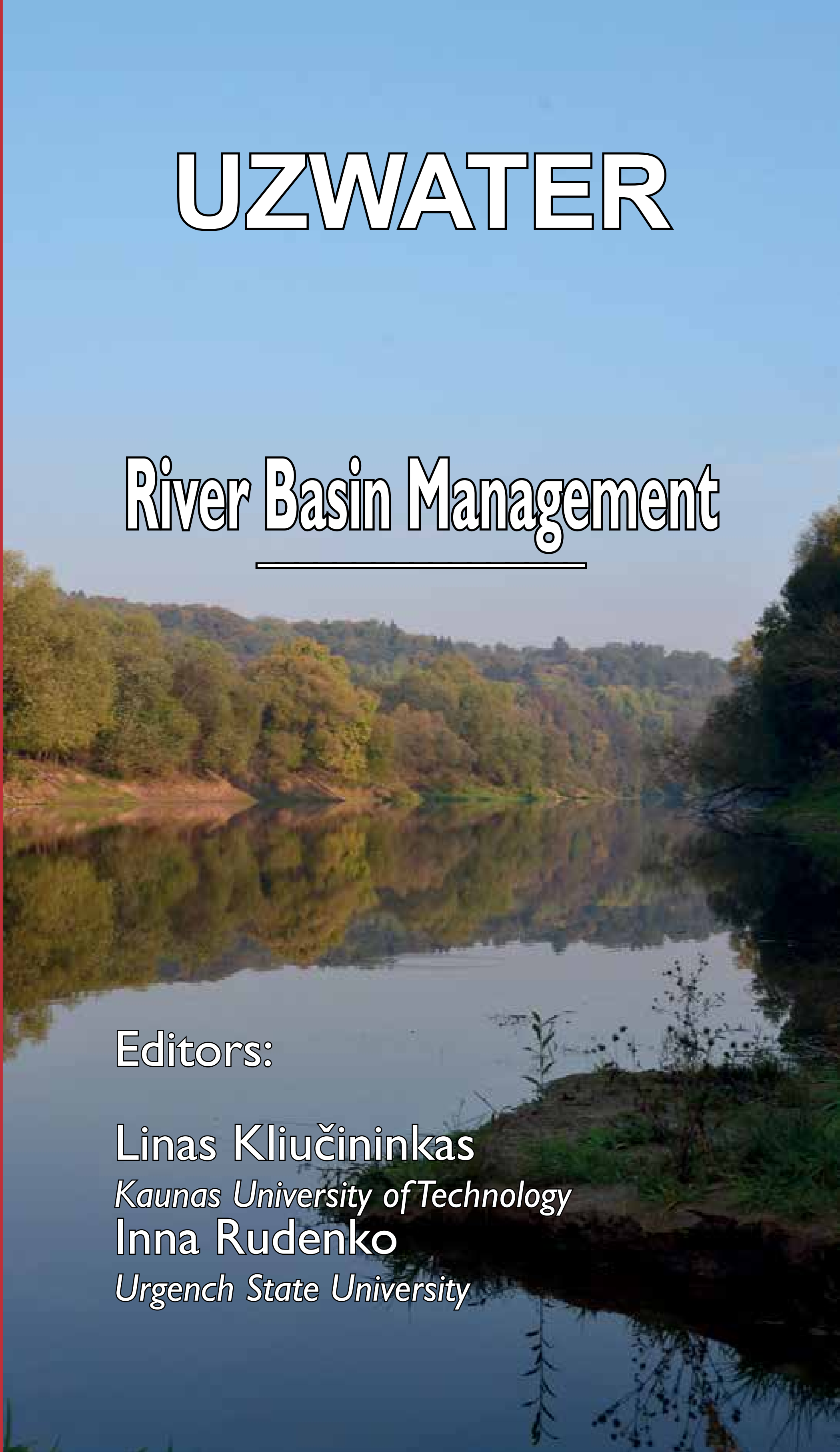

UZWATER

River Basin Management

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Kaunas University of Technology
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This compendium is produced for a master level course in the UZWATER project. It consists of some newly written material as well as previously published texts extracted from freely available books, reports and textbooks on the Internet, dominated by publications from the Baltic University Programme. The sources used for each chapter is listed at the end of the chapter.

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Acronyms and abbreviations

AWB Artificial water body
BHDs Birds and Habitats Directives
BOD Biochemical oxygen demand
CAP Common Agricultural Policy
EEA European Environmental Agency
EFTA European Free Trade Association
Eionet European Information and Observation Network
EQS Environmental Quality Standards
ETC/ICM European Topic Centre on Inland, Coastal and Marine Waters
ETC/BD European Topic Centre on Nature and Biodiversity
EU European Union
GEP Good ecological potential
GES Good ecological status
HMWB Heavily modified water body
IAS Invasive alien species
NGO Non-governmental organisation
NIS Non-indigenous species
NREAP National renewable energy action plan
NWRM Natural water retention measure
PAHs Polycyclic aromatic hydrocarbons
PP Public participation
RBD River basin district
RBMP River Basin Management Plan
REACH Registration, Evaluation, Authorisation and Restriction of Chemicals
SCI Site of Community Importance
SPA Special Protection Area
SWMI Significant Water Management Issue
TBT Tributyltin
UWWT Urban Waste Water Treatment (Directive)
WB Water body
WFD Water Framework Directive
WFD-CIS Water Framework Directive Common Implementation Strategy
WISE The Water Information System for Europe

Chapter 1
The Role of Basin Management Planning

River basin is the area of land from which all surface run-off flows through a sequence of streams, rivers and, possibly, lakes into the sea at a single river mouth, estuary or delta.
Source: http://glossary.eea.europa.eu/EEAGlossary/R/river_basin

Water resources provide the lifeblood of natural systems, societies and economies. People have lived near and on rivers, lakes, wetlands and deltas for many centuries. Most early civilizations emerged on the banks of some of the world's iconic rivers. Rivers provide a multitude of services such as water supply for farms and cities, waste disposal for factories and households, fisheries to provide food for communities, energy to drive economies, flood attenuation for downstream developments, cultural and recreational enjoyment for people, spiritual upliftment for believers and a habitat for many animals.

It is precisely because water resources provide so many functions that planning for their use is so complex. Unfortunately the demands on rivers increasingly exceed their natural capabilities, resulting in over-abstraction, pollution, alien infestation, floodplain alteration and habitat destruction. These failures are usually the consequence of poor decision-making, inadequate management and inappropriate planning. The multiple uses of and demands on a river basin mean that an integrated approach to managing river basins is required. Reconciling and coordinating competing demands relies on appropriate planning mechanisms, and basin planning can now be seen as the starting point of sustainable management of river basins and the associated social and economic systems.

Basin planning is the process of identifying the way in which a river and its limited natural resources may be used to meet competing demands, while maintaining river health. It includes the allocation of scarce water resources between different users and purposes, choosing between environmental objectives and competing human needs, and choosing between competing flood risk management requirements.

Examples of single-purpose water allocation, flood control and navigation rules go back centuries. However, with increasing development and population pressures, the complexity of many of the world's river basins has increased and many have experienced serious crises related to floods, deteriorating water quality, acute water shortage or degraded ecological health. This has often led to the political requirement to manage rivers more effectively, in order to pre-empt crises and resolve conflicts. The practice of river basin planning has therefore increased in significance over the past few decades, with an emphasis on more integrated approaches to management.

1.1 Emerging challenges in basin management planning

The evolution of basin planning over the last quarter of a century has therefore seen a profound shift in focus from a narrow, engineering-focused approach, to a more complex process incorporating environmental sustainability, demand management, institutional development and economic and social analysis and trade-offs.

Much of the development of these new approaches to basin planning has been implemented in the context of Integrated Water Resource Management (IWRM). However, the international experience with IWRM and its implementation has been mixed, and has led to a number of critiques. While the insights encapsulated in the early approaches to IWRM have clearly been important in a number of areas, there are now a number of issues emerging as central challenges for the development of basin planning as it seeks to move beyond the early IWRM concepts. Seven interrelated issues are identified here as being of particular significance. Taken together, these issues define the likely evolution of international approaches to basin planning in the years ahead.

There is no one blueprint for effective river basin planning, and the approach should be developed according to the specific basin challenges, priorities and conditions. This more pragmatic approach recognizes that while there are some common principles and approaches that can be adopted, river basin planning should build on and evolve out of existing historical and cultural experiences and approaches. In practice, the most appropriate approach to basin planning will respond to the local and national political, social and institutional context, the challenges faced by that basin, and the extent of development pressure and environmental stress within the basin.

A pragmatic approach needs to be adopted to institutional development. Much of the development of IWRM in both theory and practice was undertaken by practitioners rooted in the European context, where water management was conducted by a large number of well-resourced institutions, in basins with high levels of economic and infrastructure development and with effective legal and regulatory systems. This often led to the assumptions that basin planning required consideration of all interactions to reflect the interconnected nature of the system; a river basin organization was needed to coordinate this planning; the focus should be on demand-side management (rather than supply-side infrastructure); and that stakeholders must be engaged at all stages and levels of the process. As a consequence, the focus of river basin planning shifted strongly to the development of institutions and processes. However, while the development of management institutions is important in supporting improved basin planning, these institutions must be seen as an enabler of equitable, efficient and sustainable management of water resources, rather than as an end in themselves. In many cases, a tendency has emerged for planning to focus on the development of basin-scale institutions as the objective. As a consequence, the real objectives of basin planning initiatives may become lost. A more pragmatic interpretation of institutional development is now emerging, based on recognition of the need to simplify and focus management attention on key basin priorities, with basin plans developed in the context of the management resources, information and institutional capacity that are realistically available.

Strategic environmental planning is emerging as a critical area of focus. There is increasing acknowledgement of the need to progress beyond minimum-standards approaches to environmental and ecological planning, to techniques that seek to prioritize the key areas and processes in the river system that need to be protected and maintained. This is based on a greater recognition and better understanding of the reliance of human social and economic systems on the goods and services provided by natural and ecological water systems.

The issue of scale and scope has become increasingly fundamental. There is recognition that rather than a simplistic view of planning being undertaken at the basin scale, a more complex, multi-scale approach is required, with management undertaken at a series of scales including national, basin and sub-basin. This more complex, multi-scale approach has been driven by a number of tensions. These include tensions between basin boundaries and administrative boundaries. This means that governments conduct development planning according to administrative boundaries which do not align with basin planning boundaries. Basin planning exercises need to engage with a complex set of developmental, social, economic and environmental priorities across a range of issues. The social and economic 'footprint' of the basin also becomes an important consideration in a basin planning process, particularly where there are strong linkages between the basin and regional economic development activities located outside of the basin. At the same time, many basin planning processes attempt to address complex issues in heterogeneous basins. This complexity is increasingly being managed through the prioritization and nesting of thematic or geographic plans under the umbrella basin plan, rather than attempting grand comprehensive basin plans addressing all issues at a basin scale. While this challenge is complex between states in federal systems, it can become almost insurmountable on an international basis without strong cooperative arrangements.

Infrastructure development remains important in many contexts. The early application of IWRM was primarily undertaken in Europe, with the focus on managing water resources through environmental protection, allocation and demand management interventions, with water resources infrastructure development being viewed as no longer appropriate or desirable. The more recent interpretation of integrated basin planning in many developing countries recognizes the importance of infrastructure development in order to support economic and social development, while ensuring that this development does not result in unacceptable environmental and social consequences. This requires a shift from either a European approach focused on environmental restoration or the traditional infrastructure development approach, to a more nuanced approach that combines elements of both.

Both national and river basin water resources planning exercises need to engage actively with national, provincial and local development policies and strategies. This is required both to ensure that basin planning supports national, provincial and local development priorities, and that development planning is aligned with the opportunities and constraints related to water. The significance of this issue is highlighted by the private sector's increasing engagement with water policy, strategy and institutions. This follows the recognition by the private sector that inadequate water management and scarcity pose direct risks to their operations or supply chains. The ability of water planners to engage effectively with economic, development and planning ministries remains an international challenge.

The uncertainty and variability around climate change has emerged as a challenge to conventional river basin planning, leading to calls for adaptive management and scenario planning. This is particularly relevant for the longer-term (20+ year) aspects of basin planning. It becomes increasingly important to assess the degree of flexibility and robustness that current interventions may have under different futures, as well as the possible future options that an intervention may restrict. A major shift that water resource planners need to make is from deterministic or stochastic analysis of variability under assumptions of stationary hydrology based on historic data, to the assessment of uncertainty under non-stationary conditions. Uncertainties around changes to climate are exacerbated by rapid changes in energy, agriculture and industrial development. This is particularly the case in those parts of the world where climate predictions cannot even reliably indicate the direction of change in precipitation.

1.2 Components of a River Basin Management Plan

Basin plans (and their sub-strategies) tend to be built around the management of four broad areas: protection, development, disaster risk and institutional aspects. Not all of these systems may be adopted in all basin plans, depending on the nature of the specific challenges and priorities in the basin.

Protection and conservation system

This area of planning is focused on the hydro-ecological system of the water resources and natural assets, particularly around the protection of the aquatic ecosystem health, water resource functioning in providing goods and services, fitness for use of quality for abstraction or instream activities. Specific plans and issues may include:

- environmental flow/regulation
- river coastline and riparian zone protection, utilization and rehabilitation
- water quality management
- wetland, lake and estuary protection
- fisheries management
- catchment protection and soil conservation.

Water use and development system

This area of planning is focused on the water resources infrastructure and water use systems, particularly around the abstraction, storage or regulation of the basin water resources for economic production or social development. Specific plans and issues may include:

- water allocation
- water use authorization, control and enforcement
- water conservation and demand management (efficiency)
- water resources supply infrastructure
- water resources demand management
- agricultural or urban supply and distribution schemes
- hydropower infrastructure
- navigation.

Figure 1.1. Generic structure of a river basin plan. (Source: UNESCO river basin planning. pdf)

Disaster risk management system
This area of planning is focused on the impacts of extreme or unplanned events, particularly around the mitigation and management of public safety and property risks associated with flooding and unexpected disasters. Specific plans and issues may include:
- flood mapping
- flood risk management
- waterlogging and drainage control
- extreme drought event management
- pollution incidents.

Institutional management system
This includes the plans that provide the supporting cooperative arrangements and requirements for implementing the water management related strategies:
- institutional development and capacity building
- stakeholder engagement, awareness and communication
- information and monitoring
- economic instruments.

Basin planning needs both to set high-level goals, and to provide the more detailed objectives and implementation plans that enable these goals to be turned into action. Water management in a basin is not typically set out in a single document, but instead through a series of strategies and plans. The basin plan provides the synthesis that sets out the overall objectives and ensures coherence across basin management. These different parts may be progressively developed over time and may be revised at different times, following the concept that basin planning is an ongoing, iterative and adaptive process.

Basin plans from different countries tend to have a number of core elements, even though these may be structured in different ways to reflect the varying hydrological, economic and institutional contexts (see Figure 1.1.). The key elements are:
- A basin description is usually included within a basin plan to provide information on the past, current and future situation (hydro-ecological, socio-economic and legal-institutional).
- The intent of the basin plan is provided by the basin vision, which encapsulates the vision statements, principles and goals outlining the desired future state for the basin to achieve broader social, economic and environmental priorities.

- The basin strategy outlines the way in the basin vision will be delivered through time-based objectives and strategic actions, and thus provides a synthesis of all the plans that have been or will be developed to manage the basin.
- These higher-level strategic objectives and actions are usually expanded upon in an implementation plan which provides a coherent set of priority actions, milestones, responsibilities and possibly resources to roll out the basin plan, together with an indication of the required institutional arrangements, financing possibilities, monitoring systems and review process to implement the plan.

Chapter 1 sources:

G. Pegram, Y. Li, T. Le. Quesne, R. Speed, J. Li, and F. Shen. 2013. River basin planning: Principles, procedures and approaches for strategic basin planning. Paris, UNESCO.

A Handbook for Integrated Water Resources Management in Basins. 2009. Global Water Partnership http://www.unwater.org/downloads/GWP-INBOHandbookForIWRMinBasins.pdf

Chapter 2
The European Union Water Framework Directive

2.1 Introduction to Water Framework Directive

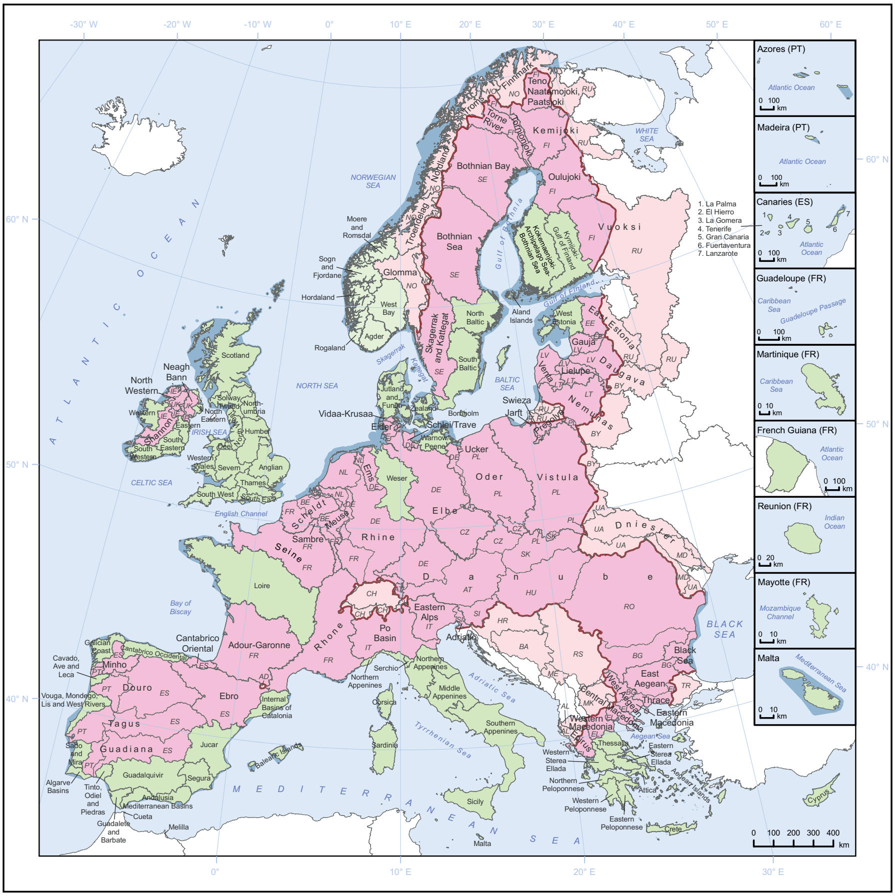
Historically, European Union (EU) water policy has largely developed through a series of five Environmental Action Programmes extending over the period 1973-2000. These Action Programmes identified a number of priority issues for reducing water pollution and improving water quality, and resulted in a large number of directives all dealing with quite specific issues, such as bathing water quality or dangerous substances. However, at the end of the 1990's it was clear that the many directives had resulted in a fragmented and sometimes conflicting approach for EU water policy. Based on this recognition, it was decided to develop a new more integrated approach to water management. On 23 October 2000, the "Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy" or, in short, the EU Water Framework Directive (or even shorter the WFD) was finally adopted. The WFD replaces many of the earlier directives and takes a more holistic approach to water management by, among other things, setting the overall objective to achieve "good water status" for all waters by 2015.

EU Member States should aim to achieve good status in all bodies of surface water and groundwater by 2015 unless there are grounds for derogation then achievement of good status may be extended to 2021 or by 2027 at the latest. Good status means that certain standards have been met for the ecology, chemistry, morphology and quantity of waters. In general terms 'good status' means that water only shows slight change from what would normally be expected under undisturbed conditions.

The Water Framework Directive establishes a legal framework to protect and restore clean water in sufficient quantity across Europe. It introduces a number of generally agreed principle and concepts into a binding regulatory instrument. In particular, it provides for:

- Sustainable approach to manage an essential resource: It not only considers water as a valuable ecosystem, it also recognises the economy and human health depending on it.
- Holistic ecosystem protection: It ensures that the fresh and coastal water environment is to be protected in its entirety, meaning all rivers, lakes, transitional (estuaries), coastal and ground waters are covered.
- Ambitious objectives, flexible means: The achievement of "good status" by 2015 will ensure satisfying human needs, ecosystem functioning and biodiversity protection. These objectives are concrete, comparable and ambitious. At the same time, the Directive provides flexibility in achieving them in the most cost effective way and introduces a possibility for priority setting in the planning.
- Integration of planning: The planning process for the establishment of river basin management plans needs to be coordinated to ultimately achieve the WFD objectives.
- The right geographical scale: the natural area for water management is the river basin (catchment area). Since it cuts across administrative boundaries, water management requires close cooperation between all administrations and institutions involved. This is particularly challenging for transboundary and international rivers.
- Polluter pays principle: The introduction of water pricing policies with the element of cost recovery and the cost-effectiveness provisions are milestones in application of economic instruments for the benefit of the environment.
- Participatory processes: WFD ensures the active participation of all businesses, farmers and other stakeholders, environment NGOs and local communities in river basin management activities.
- Better regulation and streamlining: The WFD and its related directives (Groundwater Daughter Directive (2006/118/EC); Floods Directive COM (2006)15) repeal 12 directives from the 1970s and 1980s which created a well-intended but fragmented and burdensome regulatory system. The WFD creates synergies, increases protection and streamlines efforts.

Implementation of the Directive is to be achieved through the river basin management (RBM) planning process, which requires the preparation, implementation and review of a river basin management plan (RBMP) every six years for each river basin district (RBD), identified. This requires an approach to river basin planning and management that takes into consideration all relevant factors into account and considers them together. There are five main elements of the process:



National and International River Basin Districts

- International River Basin Districts
  Compiled from data reported to WISE by EU Member States
- Approximate extent of International River Basin Districts outside of the EU
  Compiled from data reported to WISE by AD, CH, LI MC and NO, supplemented with CCM2 Seaoutlets and ICPDR data
- EU27 extent
- National River Basin Districts
  Compiled from data reported to WISE by EU Member States
- National River Basin Districts outside of the EU
  Compiled from data reported to WISE by NO
- Coastal waters
- Country borders

Map produced by WRc plc on behalf of the European Commission©, DG Environment, 2012

Footnotes

1) The boundaries of the National River Basin Districts are displayed using version 1.5 of the Water Information System for Europe (WISE) River Basin Districts dataset available from the European Environment Agency:
http://www.eea.europa.eu/data-and-maps/data/wise-river-basin-districts-rbds-1.
This dataset is based on data reported to WISE by EU Member States, Andorra, Switzerland, Liechtenstein, Monaco and Norway.

2) The boundary of the Mayotte RBD (France) is displayed using the country border dataset.

3) The boundaries of the International River Basin Districts are derived from the WISE River Basin Districts dataset.

4) Country border data was provided by Eurostat and is derived from EGM at a scale of 1:3 million.

5) The international river catchments outside of the EU are displayed using data from a number of sources:
- Data reported to WISE by Andorra, Switzerland, Liechtenstein, Monaco and Norway.
- Seaoutlets data from the Catchment Characterisation Modelling (CCM2) database developed by the Joint Research Centre to show the approximate extent of international catchments in Belarus, Moldova, Russia, Ukraine, Macedonia, Albania and Turkey.
- Data provided by the International Commission for the Protection of the Danube River to show the extent of the Danube International River Basin District in the Balkans.

6) Coastal waters are defined in the Water Framework Directive as extending 1 nautical mile from the coastline. Some Member States included a larger part of their coastal waters within their River Basin District boundaries.

Figure 2.1. Map of national and international River Basin Districs (RBDs) 2012. (Source: http://ec.europa.eu/environment/water/water-framework/facts_figures/pdf/River%20Basin%20Districts-2012.pdf)

Table 2.1. The key milestones of Water Framework Directive. Note: The key milestones of the Directive 2007/60/EC on the Assessment and Management of Flood could be fount at http://ec.europa.eu/environment/water/flood_risk/timetable.htm

Year	Issue	Reference
2000	Directive entered into force	Art. 25
2003	Transposition in national legislation Identification of River Basin Districts and Authorities	Art. 23 Art. 3
2004	Characterisation of river basin: pressures, impacts and economic analysis	Art. 5
2006	Establishment of monitoring network Start public consultations (at the latest)	Art.8 Art. 14
2008	Present draft river basin management plan	Art. 13
2009	Finalise river basin management plan including programme of measures	Art. 13 & 11
2010	Introduce pricing policies	Art. 9
2012	Make operational programmes of measures	Art.11
2015	Meet environmental objectives First management cycle ends Second river basin management plan & first flood risk management plan	Art. 4
2021	Second management cycle ends	Art. 4 & 13
2027	Third management cycle ends, final deadline for meeting objectives	Art.4 & 13

- Governance and public participation;
- Characterization of the river basin district and the pressures and impacts on the water environment;
- Environmental monitoring based on river basin characterization;
- Setting of environmental objectives; and
- Design and implementation of a programme of measures to achieve environmental objectives.

2.2 River basin planning process

To meet the overall objective of the directive, one of the first key steps countries need to take is to identify river basins, assign them to River Basin Districts (RBDs) and appoint competent authorities to manage the districts. A RBD may be made up of either one single river basin or a combination of several small river basins, together with associated groundwater and coastal waters. These are based largely on surface water catchments, together with the boundaries of associated groundwater and coastal water bodies (see Figure 2.1.).

Based on the RBD as spatial management unit, a characterisation in terms of pressures, impacts and economics of water uses shall be done, and a programme of measures for achieving the objectives of the directive drawn up. This will finally lead to the production and publishing of a River Basin Management Plan (RBMP) for each district.

If a river basin extends across international boundaries, the directive specifically requires it to be assigned to an international RBD. The directive further specifies that countries shall ensure cooperation for producing one single RBMP for an international RBD falling within the territories of the EU; however, somewhat confusingly, the directive at the same time indicates that if not produced, plans must be set up for the part of the basin falling within each country's own territory. If the basin extends beyond the territories of the EU, the directive encourages Member States to establish cooperation with non-Member States and, thus, manage the water resource on a basin level The Water Framework Directive (WFD) prescribes that management activities should aim to achieve the goals of the directive within geographical areas or river basin districts (RBDs).

Other river basins are contained completely within a country and they are known as National RBDs. River basin districts are defined as the area of land and sea, made up of one or more neighbouring river basins together with their associated ground waters and coastal waters, as the main unit for management of river basins. Coastal waters are defined as one nautical mile from the coastline and extending, where appropriate, up to the outer limit of transitional waters. Coastal waters are included in RBDs, but this is not consistently reported by Member States. Transitional waters are defined as bodies of surface water in the vicinity of river mouths which are partly saline in character because of their proximity to coastal waters but which are substantially influenced by freshwater flows. For more information about European waters, please visit the WISE portal (http://water.europa.eu).

The implementation of the WFD has resulted in the establishment of 110 river basin districts (RBDs) across the EU. Since 40 river basin districts are international, there are more than 170 national or national parts of international river basin districts. The international river basin districts cover more than 60% of the territory of the EU making the international coordination aspects one of the most significant and important issue and challenge for the WFD implementation.

Only rivers arising deep inside the continent are relatively large. Many central European countries are drained by only a few river catchments. For example, the Vistula (Wisla) and Oder drain more than 95% of Poland and the Danube drains most of Austria, Hungary, Romania, Serbia, Slovak Republic and Slovenia. France, Germany and Spain are drained by relative few large rivers and these countries have several large RBDs.

Countries with long coastlines, for example, the United Kingdom, Ireland, Norway, Sweden, Denmark, Italy and Greece, are usually characterised as having large numbers of relatively small river catchments and short rivers; the three to four largest of which drain only 15% to 35% of their area. In these countries, a number of river catchments have been merged to form river basin districts.

The Water Framework Directive sets out clear deadlines for each of the requirements, which adds up to an ambitious overall timetable.

For each river basin district, a river basin planning process must be set up. The first milestone of this planning process (analysis, monitoring, objective-setting and consideration of measures to maintain or improve water status) is the initial river basin management plan. The river basin management plan should:

- record the current status of water bodies within the river basin district;
- set out the measures planned to meet the objectives;
- act as the main reporting mechanism to the Commission and the public.

The whole process of river basin management planning includes the preparation of programmes of measures at basin level for achieving the environmental objectives of the Water Framework Directive cost-effectively (see Fig. 2.2.). The planning, implementation and evaluation of the programme of measures is an

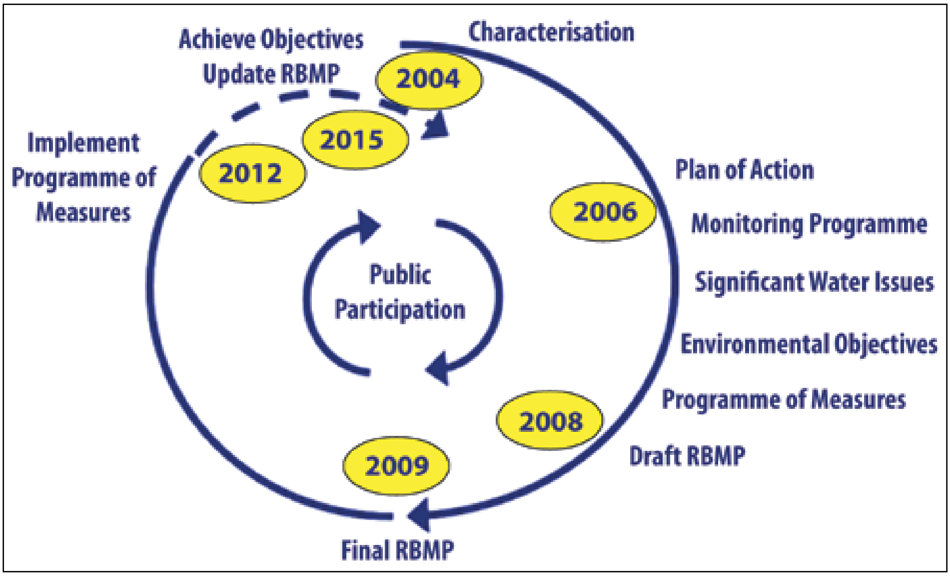


Figure 2.2. The river basin planning process (http://www.eea.europa.eu/)

iterative process that will probably include the river basin management plan of the first (2009), second (2015) or further cycles (2021, 2027).

Basic measures include control of pollution at source through the setting of emission limit values as well as through the setting of environmental quality standards. The use of economic instruments, such as water pricing, is part of the basic measures. Here, in particular, the 'polluter pays' principle should be taken into account. The directive aims to ensure that pricing policies improve the sustainable use of water resources.

2.3 Methodology

2.3.1 Basics for classification of ecological status and potential

The WFD defines "good ecological status" in terms a healthy ecosystem based upon classification of the biological elements (phytoplankton, phytobenthos, benthic fauna and fish) and supporting hydromorphological, physico-chemical quality elements and non-priority pollutants. Biological elements are especially important, since they reflect the quality of water and disturbance of environment over longer period of time. The ecological status is reported for each water body. Water bodies are classified by assessment systems developed for the different water categories (river, lake, transitional and coastal waters) and the different natural type characteristics within each water category.

WFD has different requirements for natural waters and for artificial or heavily modified waters. *Artificial water bodies* (AWB) are those, created by human activity (e.g. an artificial lagoon in the area where there was naturally no water before). *Heavily modified water bodies* (HMWB) are waters, where significant human induced physical alterations have changed of their hydro-geomorphological character to the extent that habitats are negatively affected (e.g. large harbours, hydropower reservoirs, major reductions of natural river flow, etc.). For natural water bodies the ecological status is standard for classification, while for heavily modified and artificial water bodies the ecological potential should be determined. Member States will need to meet the *good ecological potential* (GEP) criterion for ecosystems of HMWBs and AWBs rather than good ecological status as for natural water bodies. The objective of GEP is similar to good status but takes into account the constraints imposed by social and/or economic uses.

The ecological status classification scheme includes five status classes: high, good, moderate, poor and bad. *High status* is defined as the biological, chemical and morphological conditions associated with no or very low human pressure. This is also called the reference conditions as it is the best status achievable - the

Table 2.2. Description of ecological quality statuses and their colour codes for rivers, lakes, transitional waters and coastal waters

	Description of Ecological Status
High (blue)	There are no, or only very minor, anthropogenic alterations to the values of the physic-chemical and hydrological quality elements for the surface water body type from those normally associated with that type under undisturbed conditions.
Good (green)	The values of the biological quality elements show low levels of distortion resulting from human activity but deviate only slightly from those normally associated with the surface water body type under undisturbed conditions.
Moderate (yellow)	The value of the biological quality elements deviate moderately from those normally associated with the surface water body type under undisturbed conditions. The values show moderate signs of distortion resulting from human activity and are significantly more disturbed than under conditions of good status.
Poor (orange)	Waters showing evidence of major alterations to the values of the biological quality elements for the surface water body type and in which the relevant biological communities deviate substantially from those normally associated with the surface water body type under undisturbed conditions.
Bad (red)	Waters showing evidence of severe alterations to the values of the biological quality elements for the surface water body type and in large proportions of the relevant biological communities normally associated with the surface water body type under undisturbed conditions are absent.

benchmark. These *reference conditions* are type-specific, so they are different for different types of rivers, lakes or coastal waters in order to take into account the broad variation of ecological conditions in Europe.

The Directive requires that the overall ecological status of a water body be determined by the results for the biological or physicochemical quality element with the worst class determined by any of the biological quality elements. This is called the "one out - all out" principle.

At "good" ecological status, none of the biological quality elements can be more than slightly altered from their reference conditions. At "moderate" status, one or more of the biological elements may be moderately altered. At poor status, the alterations to one or more biological quality elements are major and, at bad status, there are severe alterations such that a large proportion of the reference biological community is absent.

The class boundaries for the biological classification tools are expressed as *ecological quality ratios* (EQRs). EQRs are a means of expressing class boundaries on a common scale from zero to one. The boundary EQR values represent particular degrees of deviation from the corresponding reference values. High status is represented by values relatively close to one (i.e. little or no deviation) and bad status by values relatively close to zero (i.e. substantial deviation). These ratios represent the relationship between the values of the biological parameters

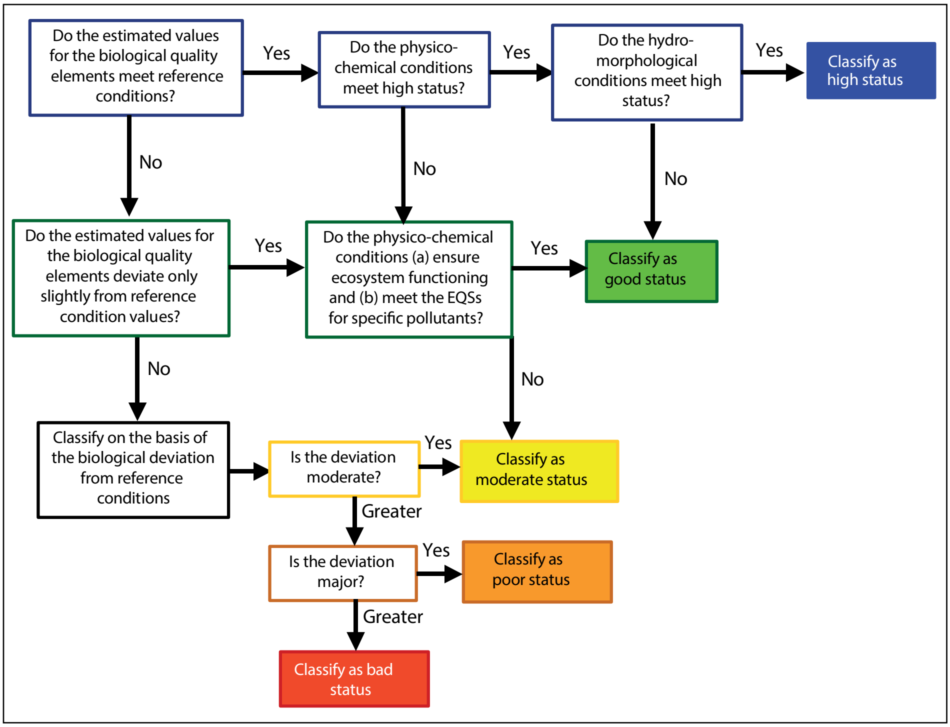


Figure 2.3. Classification of ecological status (from WFD CIS Guidance on classification)

observed for a given body of surface water and the values for these parameters in the reference conditions applicable to that body. Therefore the standard methods of analysis have to be employed and the results expressed as EQRs.

The idea of ecological quality ratios evolved as a response to the likelihood that different interpretations will be laced on the results of assessment, leading ultimately to differing interpretations will be laced on the results of assessment, leading ultimately to different levels of ecological quality being classified as the same.

In order to assess if the surface water falls within the appropriate category of 'good water status' Member states have to carry out sufficient monitoring of all the characteristics. Appropriate monitoring networks as well as comparable sampling and analysis techniques for the ecological and chemical status and the volume or rate of flow relevant to other parameters have to be established. Additionally, estimates of the level of confidence and precision of the monitoring results are to be provided in the Programme of Measures. Basing on the information gathered each water body will be assigned one of the five ecological status classes.

WFD requires that standard methods are used for the monitoring of quality elements, and that the good status class boundaries for each biological quality element are *intercalibrated* across member states sharing similar types of water bodies. The aim of the intercalibration has been to ensure that the good status class boundaries given by each country's biological methods are consistent. Further information on the intercalibration process and results are given in the text box below.

2.3.2 Results of classification of status and Biological Quality elements

Due to delays in the development of national classification systems in many member states, only a few biological quality elements could be used for assessing ecological status of water bodies for the first river basin management plans. The assessment systems available at the time of delivering the RBMPs were mainly for benthic invertebrates in rivers and coastal waters, for diatoms in rivers and for phytoplankton chlorophyll a in lakes. Most of the assessment systems are relevant mainly to assess impacts of pollution pressures causing nutrient and organic enrichment, whereas hydromorphological pressures causing altered habitats have mainly been assessed in rivers using fish as indicator of ecological status. For transitional waters, there were almost no assessment systems available in time to be used in the first RBMPs. There were also large differences in the level of

Classification of ecological status

The national classification systems for assessing ecological status for all the required *biological quality elements (BQEs) have been intercalibrated according to WFD requirements*. Through the intercalibration process, the national classification systems has been adjusted to ensure that the good status boundaries are set at the same distance from reference conditions for each biological quality element in all member states sharing the same type of water bodies. The first phase of intercalibration was completed by the end of 2007. Due to delays in the development of the national systems in many member states the results from this first phase do not cover all the biological classification tools required and provide only partial results for others. The delays were most severe for transitional waters, which were not even included in the first phase of the intercalibration process, but there were also major gaps for coastal waters, as well as for lakes. For rivers, most member states had developed assessment systems for at least two BQEs (macroinvertebrates and diatom phytobenthos) in time for the first phase of the intercalibration. This means that the comparability across member states of the ecological status reported in these first RBMPs are best for rivers, less good for lakes and coastal waters and not known for transitional waters. For more information on the first Official Decision of the Intercalibration exercise and the Technical Annexes to this Decision for Rivers, Lakes and Coastal Waters, see:
Source: http://eurlex.europa.eu/LexUriServ/LexUriServ.do?uri=
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development of assessment methods across Europe, with the most serious gaps found in the Mediterranean and Eastern Continental / Black Sea regions.

An additional weakness in the national systems used for ecological status assessment of water bodies in the first RBMPs is that the class boundaries for the supporting quality elements (e.g. nutrients, organic matter etc.) in many cases are not well linked to the class boundaries for the biological quality elements. For ecological potential of heavily modified and artificial water bodies, the assessment systems applied have either been the same as those for ecological status (for example in terms of phytoplankton chlorophyll in Mediterranean reservoirs or fish in Alpine rivers), or been based on expert judgement considering possible measures that could be used to improve the ecological potential.

For rivers, the most commonly used quality elements are macroinvertebrates and fish, as well as the supporting quality elements for hydromorphology, for general physico-chemical and for non-priority specific pollutants. The proportion of classified water bodies is much larger than the proportion of monitored water bodies illustrating the practice of grouping and/or expert judgement for classifying non-monitored water bodies. This grouping is justified by the very large number of river water bodies. The phytobenthos (mainly diatoms) are monitored in less than 10% of all water bodies, used for classification of less than 20%, while macroinvertebrates are monitored in more than 20%, and classified in more than 40% of all river water bodies. This is surprising, considering the high sensitivity of phytobenthos to nutrient enrichment, but probably reflects the traditional use of macroinvertebrates to assess organic enrichment (saprobic indices) in rivers.

For lakes, phytoplankton is the most commonly used biological quality element. In many cases, the phytoplankton classification is based only on chlorophyll a, which was the only part of this quality element that was fully developed for classification by most member states for the first RBMPs. Also for lakes, the supporting quality elements, especially the general physico-chemical ones, are most commonly monitored and used for classification. As for rivers, the classification of lakes is based on grouping and/or expert judgement for the majority of the classified water bodies; less than 20% of the water bodies are monitored for one or more quality elements, while close to 80% is classified for general physico-chemical quality elements.

For coastal waters, phytoplankton and macroinvertebrates are the most commonly used biological quality elements and is monitored in ca. 30% of all water bodies, and classified in more than half of all coastal water bodies. The supporting quality elements are also monitored and classified in almost the same proportions as the biological quality elements. As for lakes, the use of phyto-

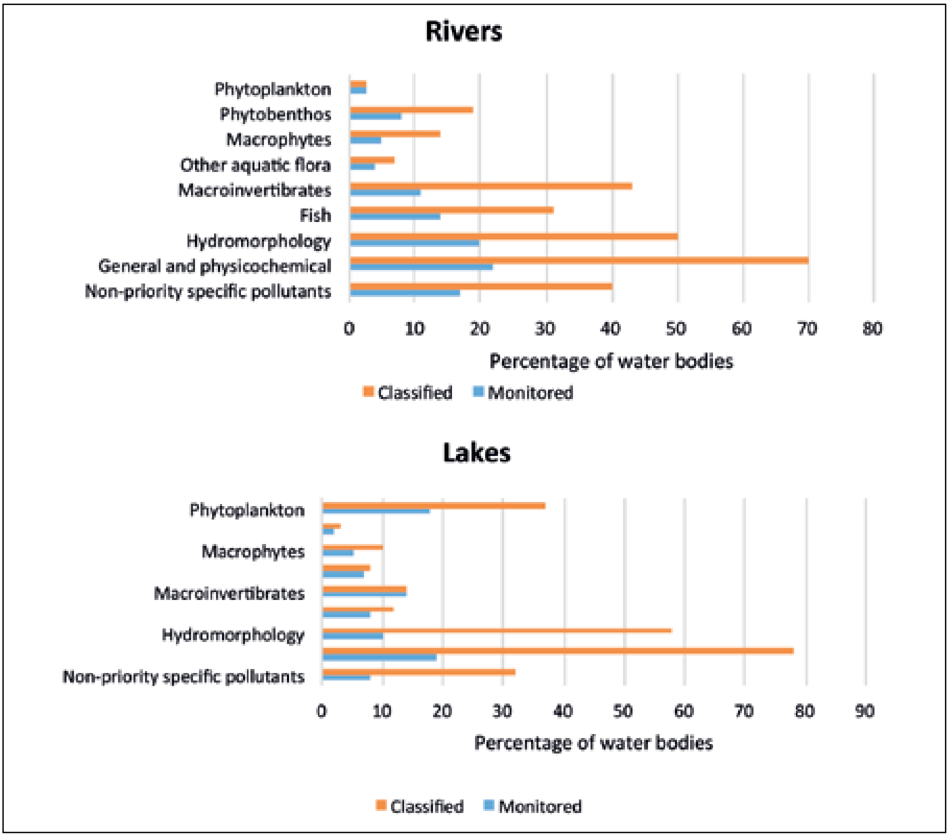

Figure 2.4. European overview of the different quality elements reported by Member States to be used for monitoring and classification of rivers and lakes. Notes: The percentage is calculated against the total number of classified water bodies, i.e. total number of water bodies reported where quality elements were identified are for rivers: 75763, for lakes: 13849. "Monitored" means water bodies with at least one monitoring station for that particular quality element.

plankton is probably dominated by chlorophyll a measurements, while the use of macroinvertebrates reflects the traditional use of this biological quality element to assess organic enrichment (and secondary impacts of nutrient enrichment) in soft-bottom sediments.

2.3.3 Basis for classification of chemical status of surface waters and groundwater

Chemical status is assessed by compliance with environmental standards for chemicals that are listed in the WFD (Annex X) and the Environmental Quality Standards (EQS) Directive 2008/105/EC. These chemicals include priority substances, priority hazardous substances and eight other pollutants carried over from the Dangerous Substances Daughter Directives. Chemical statuses are recorded as good or fail to achieve good status.

Surface Water

The WFD reporting guidance proposed that Member States grouped the reporting of priority substances into four categories; heavy metals, pesticides, industrial pollutants and other pollutants. The latter category included a mix of individual chemical types including polycyclic aromatic hydrocarbons (PAHs) and tributyltin compounds. Inconsistency in reporting was apparent between Member States, however, with some reporting a mix of pollutant groups and individual pollutants, whilst others reported either individual pollutants or groups only. Moreover, different matrices (i.e. water column, sediment and biota) have sometimes been used to assess the risk of particular chemicals across different Member States, meaning that the results arising are not always directly comparable.

Groundwater

Reporting with respect to WFD groundwater chemical status required a grouping into three categories; nitrate, certain pesticides and the Annex II pollutants covering arsenic, cadmium, lead, mercury, ammonium, chlorides, sulphates, trichloroethylene and tetrachloroethylene. Inconsistency in reporting was apparent between Member States, however, with some reporting a mix of pollutant groups and individual pollutants, whilst others reported either individual pollutants or groups only. Moreover, the definition of pollutants and their associated threshold values (as required under the Groundwater Directive) vary markedly between Member States.

2.3.4 Pressures and impact analysis

The WFD defines "good ecological and chemical status" in terms of low levels of chemical pollution as well as a healthy ecosystem. To achieve good ecological status, Member States will have to address the factors affecting water eco-systems. Pollution is one, and the morphological changes such as dams built on rivers is another one. The extraction of water for irrigation or industrial uses can also harm ecosystems if it reduces water levels in rivers or lakes below a critical point.

The status of a water body is greatly influenced by the characteristics of its catchment area (Figure 2.5.). The climatic conditions, for example rain, bedrock geology and soil type, all influence the water flow. In addition, soil type affects the mineral content of the water. Similarly, human activity affects surface water

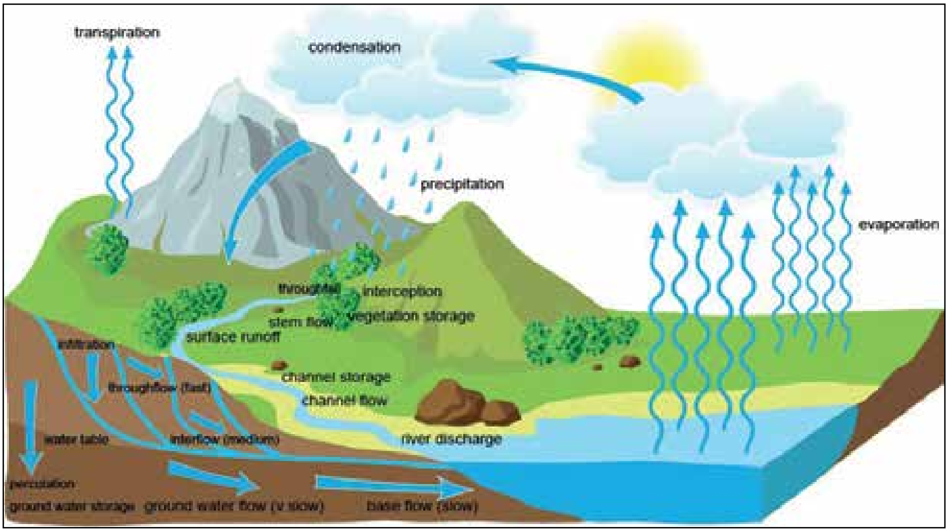

Figure 2.5. River Basin Hydrological Cycle (http://www.alevelgeography.com/)

and groundwater through afforestation, urbanisation, land drainage, pollutant discharge, morphological changes and flow regulation.

The WFD requires that Member States collect and maintain information on the type and magnitude of significant pressures to which water bodies are liable to be subject. The common understanding of a 'significant pressure' is that it is any pressure that on its own, or in combination with other pressures, may lead to a failure to achieve one of the WFD objectives of achieving good status. Annex II of the Directive provides lists of some of the different types of pressures that may be significant.

Published in 2005, the WFD Article 5: Characterisation and impacts analyses reports were the first step in identifying pressures and impacts in the river basin management planning process. This pressure and impact analysis reviewed the impact of human activity on surface waters and on groundwater and identified those water bodies that are at risk of failing to meet the WFDs environmental objectives.

"At risk" means that: the pressure and impact assessment shows that there is a likelihood that a water body will fail to meet the WFD´s environmental objectives by 2015 unless appropriate management action will be taken. "At risk" does not necessarily mean that the water bodies are already suffering poor status, but it does highlight areas where appropriate management measures should be applied to ensure that good status is maintained or to ensure it is achieved in the future.

The first identification of pressures and impact (Article 5) was the basis for the overview of *Significant Water Management Issues* (SWMI) that was reported in 2007 and was the basis for establishing the first RBMPs. The identification of significant pressure and impact were further developed in the RBMPs.

2.3.5 Significant pressures and impacts

Several factors contribute to surface water bodies being at risk. These include point sources - for example pollution from urban areas and industries as well as diffuse sources such as agriculture. In addition, the influence of water extraction and of morphological changes are important pressures. Changes in habitats can result from the physical disturbance through damming, channelisation and dredging of rivers, construction of reservoirs, sand and gravel extraction in coastal waters, bottom trawling by fishing vessels etc. Below is described the main pressures and impacts affecting Europe's surface waters.

One major pressure is *pollution*. Pollution is harmful to aquatic plants and animals, and may threaten drinking water and water supplies. Pollution can be anything from hazardous substances to a nutrient, which can result in excessive plant growth or even silt that can smother fish spawning beds. Pollution comes from one of two types of source:

- *point sources*, e.g. pipes discharging effluents from urban wastewater treatment plants, industrial sites, or mines; and
- *diffuse sources*, e.g. land use activities such as farming, forestry and urban areas.

During the last decades, significant progress has been made in reducing the point source pollution: improved wastewater treatment, reduced volume of industrial effluents, and reduced or banned phosphate content in detergents as well as reduced atmospheric emissions. Over the last 30 years the urban and industrial wastewater treatment has progressively improved and in many parts of Europe a large proportion of the pollutants are today removed. However, pollution caused by inadequately treated wastewater is still in some areas an important source of river pollution and an important source for transitional and coastal waters. Main impacts related to point source pollution are organic pollution, nutrient enrichment and contamination by hazardous substances. Severe organic pollution may lead to rapid de-oxygenation of water, a high concentration of ammonia and the disappearance of fish and aquatic invertebrates.

Diffuse water pollution is a serious problem in many parts of Europe. Diffuse sources of pollution include run-off from farmland, run-off from roads or scattered dwellings. Diffuse pollution is closely linked to land use (e.g. the applica-

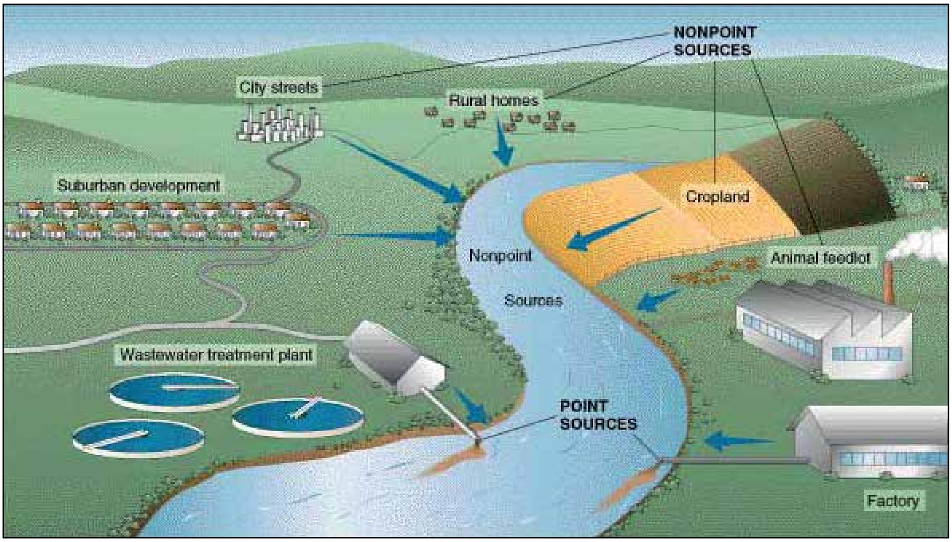

Figure 2.6. Point and diffuse sources of pollution (http://apesnature.homestead.com/)

tion of fertiliser or pesticides to farmland; livestock manure; use of chemicals and leakage from old waste storage and polluted industrial sites). Diffuse pollution is also linked to air emissions, for example acid rain or deposition of nitrogen, impacts of traffic emissions or other air transported pollutants.

Some of the main impacts related to diffuse pollution are high levels of nutrients in rivers, lakes, estuaries and coastal waters, which can cause eutrophication; nitrate and pesticide contamination of groundwater; hazardous chemicals leaking into rivers, lakes and groundwater from industrial sites; and air pollution causing acid rain, deposition of nitrogen on sensitive waters and deposition of hazardous chemicals (e.g. mercury and PAHs).

During the last centuries European mining for coal, metal ores, and other minerals have affected water bodies. Many thousands of mines have been abandoned and now discharge mine-water containing acid water, heavy metals and other pollutants into water bodies. Other mines are still filling up with groundwater or have heavy regulation of water level affecting the surrounding groundwater aquifers or surface waters. Abandoned mines in several areas of Europe are today a significant pollution pressure. For example, eight of the twelve River Basin Districts in the UK have identified abandoned mines as a significant problem. Nine per cent of rivers in England and Wales, and 2% in Scotland are at risk of failing to meet their WFD targets of good chemical and ecological status because of abandoned mines. These rivers cause some of the biggest discharges of metals such as cadmium, iron, copper, and zinc to rivers and the seas around Britain.

Aquaculture has grown substantially in a number of European countries over recent years such as Atlantic salmon in Scotland, Norway and Ireland, seabass and seabream in the Mediterranean and mussel farming in Ireland, Spain and France. In particular, marine aquaculture of finfish has become more intensive over the last 25 years resulting and can generate considerable amounts of effluent, such as waste feed and faeces, medications and pesticides, which can have undesirable impacts on the environment.

The *abstraction* of too much water from rivers, lakes or groundwater is harmful to the environment and can compromise the water resources needed by other water users. Water abstraction may reduce the amount of water available to dilute discharges and therefore makes pollution worse. In extreme cases, rivers and reservoirs can dry up or salt water can be drawn into groundwater. Transfers of water from one catchment to another and flow-controlling structures, such as dams may also have major influences on water flows.

Hydrological alterations refer to pressures resulting from water abstraction and water storage affecting the flow regime such as change in daily flow (hydropeaking) and seasonal flow. In addition, river stretches may dry up and water levels of lakes and reservoirs may be heavily regulated. The flow regime of a water body may be significantly altered downstream of an impoundment or an abstraction, and the biology may impacted. Alterations to the flow regime degrade aquatic ecosystems through modification of physical habitat and of erosion and sediment supply rates.

Land reclamation, shoreline reinforcement or physical barriers (such as flood defences, barrages and sluices) can affect all categories of surface waters. Weirs, dams and barrages can alter water and sediment movements, and may impede the passage of migratory fish such as salmon. Using water for transport and recreation often requires physical alteration to habitats and affects the flow of water. Activities such as maintenance and aggregate dredging and commercial fishing using towed bottom-fishing gear can also damage physical habitats.

Biological pressures related to *Invasive Alien Species* (IAS) have been identified as a significant pressure in several of the RBMPs. IAS are non-native plants or animals which compete with, and may even over-run, our natural aquatic plants and animals. Introduction of IAS may alter both species composition and the numbers of different species in surface waters. Escaped farmed salmon for instance, represents a serious risk to wild salmon stocks.

It is increasingly being recognised that *climate change* will have a significant impact on the aquatic environment in Europe (EEA 2008; CEC 2009; IPCC, 2007, 2008). Climate change is projected to lead to major changes in yearly and seasonal precipitation and water flow, flooding and coastal erosion risks, water quality, and the distribution of species and ecosystems. Models indicate that at a general level the south of Europe will show a significant drying trend and the north of Europe one of wetting. There are many indications that water bodies, which are already under stress from human activities, are highly susceptible to climate change impacts and that climate change may hinder attempts to prevent deterioration and/or restore some water bodies to good status. Although climate change is not explicitly included in the text of the WFD, the step-wise and cyclical approach of the river basin management planning process makes it well suited to adaptively manage climate change impacts.

2.4 Europe is far from meeting water policy objectives and having healthy aquatic ecosystems

In 2012, the 'Blueprint to Safeguard Europe's Water Resources' stressed that a key element of meeting the standard of good status is ensuring that there is no over-exploitation of water resources. In 2010, EU Member States released 160 River Basin Management Plans aimed at protecting and improving the water environment. The plans covered the period 2009–2015, with the second set of River Basin Management Plans covering the period 2016–2021 due for finalisation in 2015. Over the last few years, European countries that are not EU Member States have developed similar river basin activities to those introduced by the Water Framework Directive.

In 2009, 43% of surface water bodies were in good or high ecological status, and the Water Framework Directive objective of reaching good ecological status by 2015 is only likely to be met by 53% of surface water bodies (Fig. 2.7.). This constitutes a modest improvement and is far from meeting policy objectives. Rivers and transitional waters are on average in a worse condition than lakes and coastal waters. Concerns about the ecological status of surface water bodies are most pronounced for central and north-western Europe in areas with intensive agricultural practices and high population densities. The status of coastal and transitional waters, in the Black Sea and greater North Sea regions is also of concern.

Pollution from diffuse sources affects most surface water bodies. Agriculture is a particularly large source of diffuse pollution, causing nutrient enrichment from fertiliser run-off. Agricultural pesticides have also been widely detected in surface and groundwater bodies. Hydromorphological pressures (changes to the physical shape of water bodies) also affect many surface water bodies. Hydromorphological pressures alter habitats and are mainly the result of hydropower, navigation, agriculture, flood protection, and urban development.

Chemical status is another cause for concern. Around 10% of rivers and lakes are in poor chemical status, with polycyclic aromatic hydrocarbons a widespread cause of poor status in rivers, and heavy metals a significant contributor to poor status in rivers and lakes. Around 25% of groundwater has poor status, with nitrate being the primary cause. Notably, the chemical status of 40% of Europe's surface waters remains unknown.

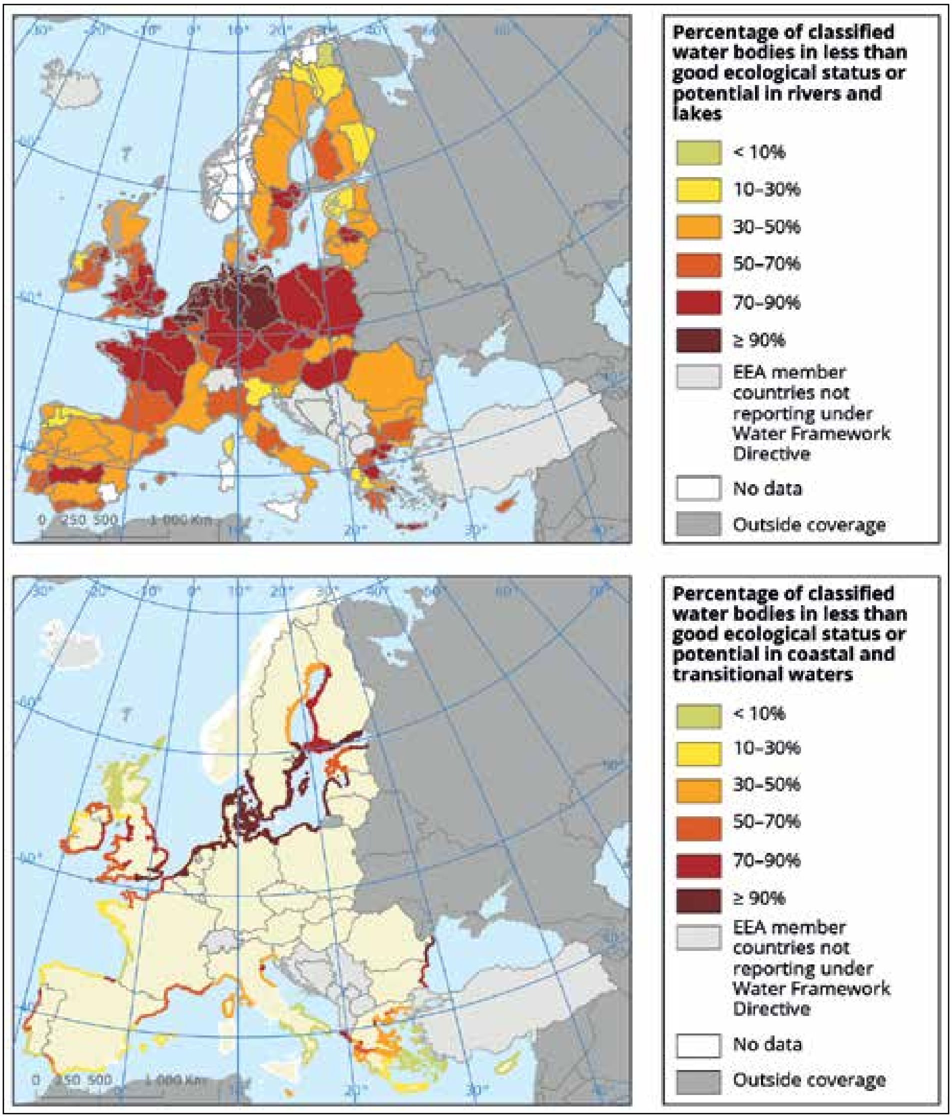

Figure 2.7. Percentage of good ecological status or potential of classified rivers and lakes (top) and coastal and transitional waters (bottom) in Water Framework Directive river basin districts (EEA, 2012).

River basin management activities in cooperating countries outside the EU

Norway and Iceland have activities for implementing the EU Water Framework Directive, and in Switzerland and Turkey, there are water policies comparable to the Water Framework Directive regarding water protection and management.

In these countries outside the EU, a large proportion of waters are affected by similar pressures as those identified by the EU River Basin Management Plans. Many of the West Balkan river basins are heavily affected by hydromorphological alterations and pollution from municipal, industrial, and agrochemical sources. This pollution is a major threat to freshwater ecosystems. In Switzerland there are significant deficits in the ecological status of surface waters, particularly in the intensively used lowland areas (Swiss Plateau) with recent assessments showing that 38% of medium and large river sites have insufficient macroinvertebrate quality and that roughly half of the total river length (below 1 200 m above sea level) is in a modified, non-natural, artificial or covered state.

Source: EEA, 2012.

While there is relative clarity about the types of pressures encountered in river basins, there is less clarity on how these will be addressed and how measures will contribute to achieving environmental objectives. The next cycle of River Basin Management Plans (2016–2021) will need to improve this situation. In addition, improving efficiency of water use and adapting to climate change are major challenges for water management. Restoring freshwater ecosystems and floodplain rehabilitation as part of green infrastructure will help address these challenges. These actions will also deliver multiple benefits by using natural water retention methods to improve ecosystem quality, reduce floods and reduce water scarcity.

Achieving healthy aquatic ecosystems requires taking a systemic view, as the state of aquatic ecosystems is closely connected to how we manage land and water resources, and to pressures from sectors such as agriculture, energy and transport. There are ample opportunities to improve water management to achieve policy objectives. These include stringent implementation of existing water policy, and integration of water policy objectives into other areas such as the Common Agricultural Policy, EU Cohesion and Structural Funds, and sectoral policies. Over the last few years, European countries that are not EU Member States have developed similar river basin activities to those introduced by the Water Framework Directive.

Chapter 2 sources:

Directive 2000/60/EC of the European Parliament and of the Council establishing a framework for the Community action in the field of water policy.

Mostert, E. 2003. Conflict and Co-operation in the Management of International Freshwater Resources: A Global Review. Paris, UNESCO.

Impacts of Europe’s changing climate - indicator-based assessment. 2008. EEA. Copenhagen.

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Chapter 3
The European Union Water Framework Directive and Sectorial Issues

3.1 Hydropower

Hydropower has been identified as one of the main drivers to hydro-morphological alterations, loss of connectivity and to alter water and reduced sediment flow. Pressures related to hydropower may be one of the reasons for many water bodies not to achieve good ecological status by 2015 or the subsequent RBMP cycles.

In the context of the EU Directive on the promotion of the use of energy from renewable sources 2009/28/EC (EC, 2009), hydropower is an important measure for increasing the share of renewable electricity but, depending on its management, hydropower can impact water bodies and adjacent wetlands.

It is important to ensure that existing and forthcoming EU policies to promote hydropower ensure coherence with the Water Framework Directive/other EU environmental legislation and clearly consider the ecological impacts on the affected water bodies and the adjacent wetlands.

In 2008 hydropower provided 16% of electricity in Europe and hydropower currently provides more than 70% of all renewable electricity, more than 85% of which is produced by large hydropower plants. The share of hydropower in electricity production is generally high in the northern and Alpine countries.

The total number of hydropower stations in the EU-27 amounts to about 23,000. There are about 10 times more small (P < 10 MW) than large hydropower plants (P > 10 MW). However, the electricity generation of small hydropower only amounts to 13% of the total generation of all hydropower stations. Today large hydropower plants account for 87% of the hydropower generation with only 9% of the stations.

In absolute numbers, Germany has most hydropower plants more than 7,700 of which 7,300 are small plants. Austria, France, Italy and Sweden all have more than 2,000 hydropower plants. The highest numbers of large hydropower plants (> 10 MW) are found in Norway (333): Italy (304); France (281) and Sweden (206).

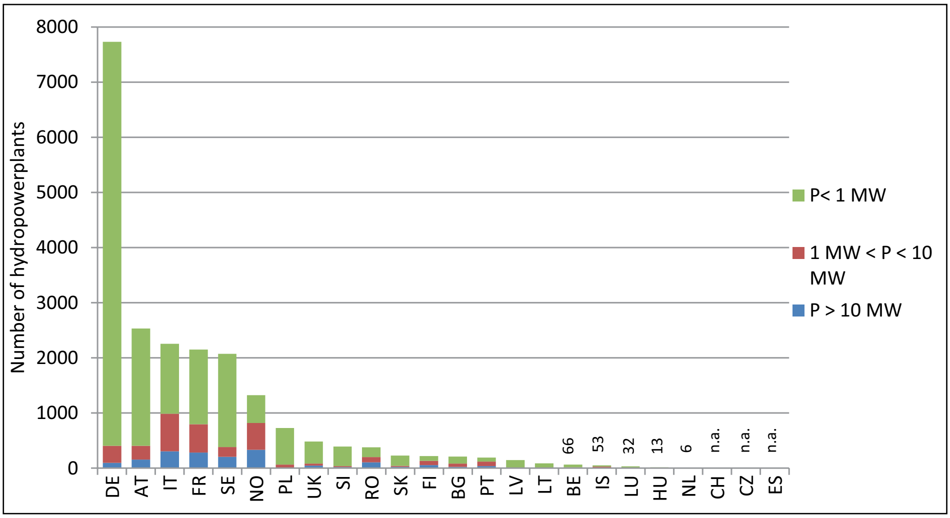


Figure 3.1. Total number of existing hydropower plants for different plant size (Kampa et al. 2011). Note: 1) Data was not available for CH, CZ and ES. In CH, there are 556 plants > 300 kW and ca. 1000 plants < 300 kW. In the CZ, a different range is followed: P<0.5 MW, 0.5 MW<P<10 MW, P>10 MW (other data is not available).

Three types of power stations can be found:

- *Hydropower stations with storage reservoir*. A storage reservoir offers the opportunity to store energy and to meet e.g. the peak electricity demands. Such reservoirs can comprise daily, seasonal or yearly storage. Many of the large HP stations operate with a reservoir.
- *Run-of-the-river stations*. This type of installation uses the natural flow of a water course in order to generate electricity. There is no intention to store water and to use it later on. This type is most common for small hydropower stations but can also be found with large stations.
- *Pumped storage hydropower plants*. Pumped hydropower stations utilize two reservoirs located at different altitudes. Water can be pumped from the lower into the upper reservoir and can be released, if needed, to the lower reservoir producing energy on ts way through the turbines. In times of high demand e.g. during peak hours electricity is produced to satisfy the demand. When there is a surplus of electricity in the system, water can be pumped to the upper reservoir.

The different types of hydropower plants have different effects on the ecosystems and hydromorphology. Generally the hydropower plants with storage reservoirs

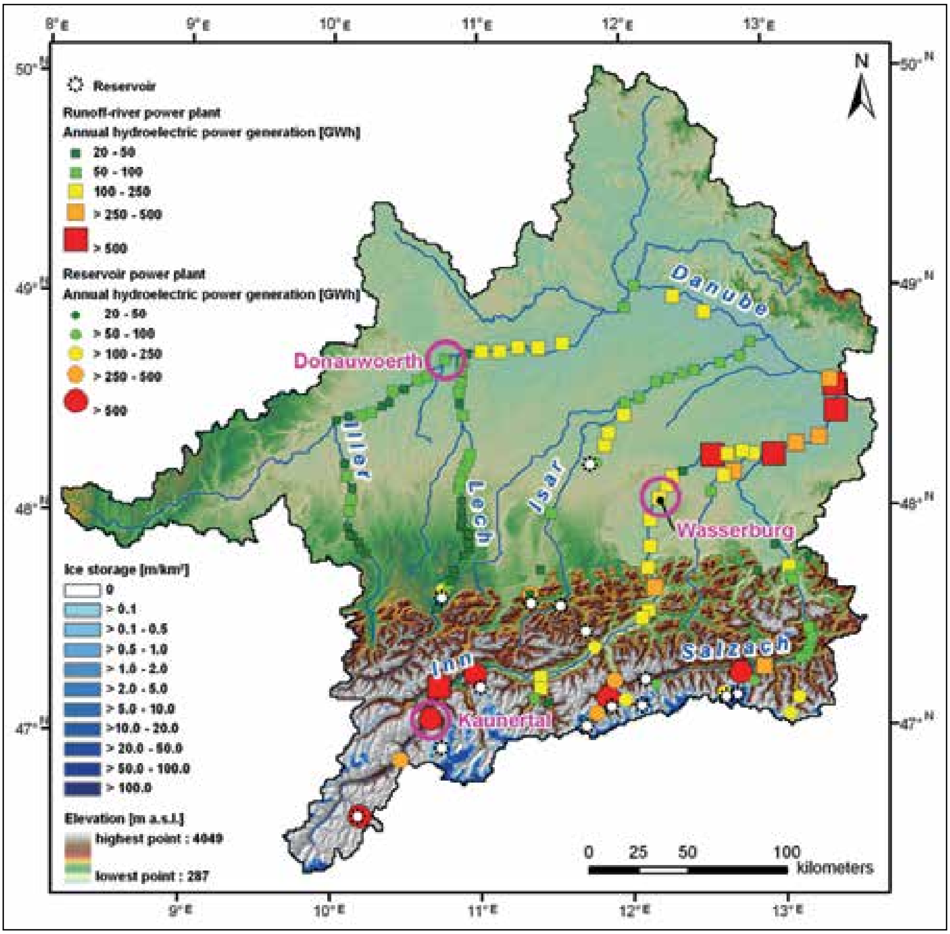


Figure 3.2. Hydropower in the upper Danube watershed. In the mountainous Upper Danube watershed (77,000 km²) covering parts of Germany and Austria there are in the alpine headwaters 20 big reservoir hydropower plants (annual hydropower generation of more than 250 GWh) and there are 120 relative smaller run-of-the-river stations hydropower plants (annual hydropower generation of 20 to 500 GWh) mainly situated on the river Danube and its larger tributaries Iller, Lech, Isar, Inn and Salzach. (Source: Koch et al. 2011).

generate more severe impacts on the river system including loss of connectivity, change in water flow regime and reduced sediment flow. There are unfortunately no European overview of the number of hydropower plants by types and their location. Generally the reservoir type hydropower plants are found in the mountainous areas with steep relief, while the larger run-of-the-river stations are found on the main course of larger rivers and their tributaries. Smaller hydropow-

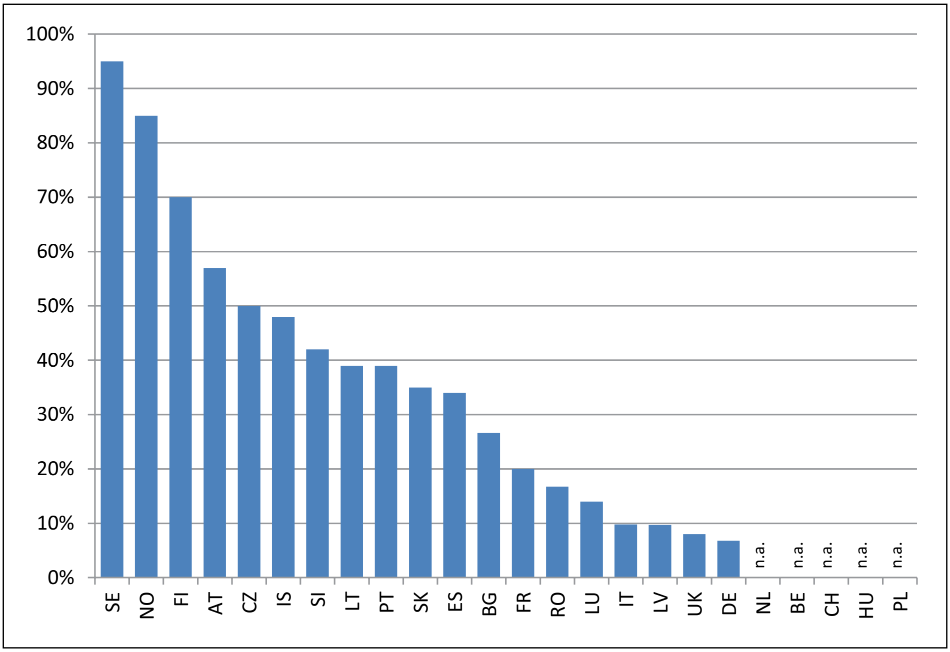


Figure 3.3. Percentage of HMWB designated as such due to hydropower use in relation to total HMWB (%). Note: 1) Percentages were reported in the WFD and Hydropower questionnaires of European States. 2) Data was not available for CH, BE, HU, PL. 3) The mean is calculated based on the percentages provided in the European States questionnaire.

er plants are often found on relative smaller rivers and with limited storage, but often acting as migrating barriers. However, compared to the impacts generated per electricity production the impacts by many small hydropower plants may be comparable to or larger than one large hydropower plant.

The effects of hydropower production are taken up in most of the RBMPs. The plans generally provide an overview of the plants and their location. River basins with hydropower schemes generally have several water bodies designated as heavily modified such as lakes and reservoirs that have their water levels regulated due to operation of the hydropower scheme e.g. storage of water during summer and hydropower production during winter; or river section that are affected by dams and/or changed flow regime.

Most countries have relevant legislation on national level (in a few, also on regional level) to ensure minimum ecological flow and upstream continuity via fish passes at hydropower plants.

For downstream continuity and hydro peaking mitigation, fewer countries have legislative requirements to ensure environmental improvement in this re-

The state of small hydropower in the Alps

In 2010 several hundred applications for new small hydropower stations have been reported across the whole Alpine area (with considerable difference of numbers between countries), thus potentially adding to the high number of facilities already in place. This boom has been triggered in particular by the financial incentives and support schemes in place in all countries of the Alps. It presents a particular challenge for competent authorities in handling the huge amount of applications and deciding on authorisations for new facilities, due to variety of aspects to be taken into account (energy generation, CO_2 emission reduction, ecological impact etc.).

Despite its clear benefits, hydropower generation can also have substantial negative impacts on the aquatic ecology, natural scenery and ecosystems which are not always perceived by the wider public. This is not only the case for large dams, reservoirs and related hydropower facilities but also for small and very small hydropower stations, indeed the high number of such facilities already in place in the Alps, have a cumulative effect which is already impacting on a considerable number of river stretches

From the collected data on hydropower plants it is evident that the larger plants contribute by far the major share of total electricity production from hydropower, i.e. over 95% of the total production comes from facilities with greater than 1MW power output. Plants with a capacity of less than 1 MW constitute around 75% of all HP plants within the Alpine area but contribute less than 5% to the total electricity production.

The decision on new facilities is still mostly determined for sites individually (with exception that in some countries projects within National Parks, Nature2000-Sites, etc. are subjected to specific rules). Environmental legislation has developed significantly in recent decades. Residual water (or environmental minimum flows) as well as fish passes are now seen as basic provisions of new hydropower plants. However, many old facilities do not meet modern environmental standards. For instance, older hydropower facilities may not provide sufficient residual water or be equipped with fish-passes, hence causing a fragmentation of river stretches and habitats. In such cases, adaptations to the facilities may be required in order to meet environmental objectives.

However in some countries, once a water licence or authorisation has been granted, this legal right can only be varied during the set period of the licence or authorisation (between 30 to 90 years) if it is economically bearable for the owner or for reasons of higher public interests and against compensation. Furthermore, some water rights from the past do not have a license or authorisation period at all, i.e. the right is for an unlimited time period.

Source: Alpine Convention 2011 (reduced text of draft provided by Alpine Convention Nov. 2011).

spect. Requirements for measures are rather defined in individual cases (e.g. as a condition of authorisation) and, in some countries, there is generally no relevant legislative means.

For mitigating the disruption of sediment/bed load transport, several countries have no relevant legislative means. Only a few countries have national legislation and, in several countries, mitigation measures are defined in individual cases.

Member States should avoid taking action that could further jeopardize the achievement of the objectives of the WFD, notably the general objective of good

The EU's Danube Strategy

The EU's Danube Strategy was launched in April 2011. It involves 9 EU countries (Germany, Austria, Hungary, Czech Republic, Slovakia, Slovenia, Bulgaria, Romania and Croatia) and 5 non-EU countries (Serbia, Bosnia and Herzegovina, Montenegro, Ukraine and Moldova). Designed to coordinate EU policies across the Region, it is based on the idea that common challenges – whether environmental, economic or security related – are best tackled collectively. By involving EU neighboring countries at an equal level, the Danube Strategy also brings the Western Balkans, Moldova and the regions of the Ukraine closer to the Union.

The recent Commission report on governance of the EU's Macro-Regional Strategies (for the Baltic Sea Region and for the Danube Region) found that the Strategies are bringing concrete results on the ground. However, obstacles do remain with regard to impact, results and sustainability. Particular improvement is needed concerning political leadership and decision-making, as well as a clearer organization of work and definition of roles and responsibilities.

ecological status of water bodies. The further use and development of hydropower should consider the environmental objectives of the WFD. The requirements for new hydropower include amongst others that there are no significantly better environmental options, that the benefits of the new infrastructure outweigh the benefits of achieving the WFD environmental objectives and that all practicable mitigation measures are taken to address the adverse impact of the status of the water body.

At the same time, the Renewable Energy Directive (2009/28/EC) sets legally binding national targets for electricity and transport from renewable sources (not specifically for hydropower), adding up to a share of 20% of gross final consumption of energy in the EU as a whole. By June 2010, each EU Member State had to adopt a national renewable energy action plan (NREAP) setting out its national targets for the share of energy from renewable sources consumed in transport, electricity, heating and cooling in 2020 and describing the way and the extent to which different renewable sources (wind, hydropower, etc.) will contribute to the achievement of targets. In several European Member States, an increase in hydropower generation is needed for the achievement of these targets by increasing efficiency in hydropower generation at existing sites but also by building new hydropower plants.

The European States intend to achieve the objectives set for the contribution of hydropower to the 2020 renewable energy targets via construction of new hydropower plants, refurbishment or modernization and maintenance:

3.2 Navigation

European countries depend on maritime transport. Nearly 90% of the EU's external trade and more than 40% of its internal trade goes by sea. Almost 2 billion tons of freight are now handled in more than 1200 EU ports each year, and volumes are continuing to increase1. As a result, recent years have seen a number of applications and approvals for major seaport developments. Many such developments have been required in order to accommodate the significant global increase in containerised transport, and further increases in such cargoes are anticipated. In addition to rationalised or new cargo handling and transhipment facilities, new container vessels require deeper access channels to certain ports. Update of the Danube Regional Strategy aspects of increasing inland water transport by 20% by 2020 is presented below.

WFD potentially have significant implications for navigation, both for ongoing port activities such as dredging and disposal, and for new development proposals. The Program of Measures established by the RBMPs could potentially affect ports, navigation and dredging in a number of ways. For example, measures could require the modification of existing structures such as training walls or breakwaters to mitigate their effects. Measures affecting activities or operations are also possible - for example, the introduction of technical or temporal constraints on dredging and disposal activities to meet ecological targets. Potential impacts associated with modifications can include:

- the physical removal of habitats or species;
- changes of physical processes (erosion, accretion and sediment transport);
- barriers to movement of species or the loss of connectivity between habitat sites (e.g. due to impoundment or reclamation).

Invasive species have become a major concern in the Danube

The Joint Danube Survey in 2007 found killer shrimps, *Dikerogammarus villosus*, at 93 % of the sites sampled along the river, Asian clams at 90 % and carpets of weeds at 69 %. Killer shrimps can adapt to a wide range of habitats and cause significant ecological disruption such as species reduction. The water hyacinth (*Eichhornia crassipes*) is considered one of the worst aquatic weeds in the world.

Over the past two centuries, the connection of the Rhine with other river catchments through an extensive network of inland waterways has allowed macro-invertebrate species from different bio-geographical regions to invade the river. A total of 45 such species have been recorded. Transport by shipping and dispersal by man-made waterways are the most important dispersal vectors.

Inland waterway transport plays also an important role in Europe today, and shifting more freight transport to water is considered a significant option to improve Europe's transport system as a whole and to deal with constantly growing freight flows. Inland navigation is seen as an environmentally friendly transport mode with compared to other inland transport modes a relative low CO_2 emission.

More than 37,000 kilometres of inland waterways connect hundreds of cities and industrial regions. Some 20 out of 27 Member States have inland waterways, 12 of which have an interconnected waterway networks.

Navigation activities and/or navigation infrastructure works are typically associated with a range of hydromorphological alterations with potential adverse ecological consequences. Deepening including channel maintenance, dredging, removal or replacement of material is a major activity. Dredging, in turn, is of vital importance to many of the EU's ports, harbours and waterways - providing and maintaining adequate water depths and hence safe navigational access. Channel works such as channelisation and straightening, training walls or breakwaters often are needed. Bank reinforcement, bank fixation, and embankments (training wall, breakwater, groynes etc.) often have been constructed. Some developments may also involve land claim and/or impoundment, as well as inland waterways as corridors for spreading invasive species.

The extensive networks of inland waterways in parts of Europe have allowed species from different bio-geographical regions to mix, altering communities, affecting the food webs and introducing new constraints to the recovery of the native biodiversity.

3.3 Flood risk management

Millions of European citizens are threatened by flooding events from rivers, estuaries and the sea. Over the past ten years Europe has suffered more than 175 major floods, causing deaths, the displacement of people and significant economic losses. Although many flood defence measures were implemented in the European river basins and coastlines during the last century, the ongoing urban developments and changes in land use, as well as the social and economic development have increased the potential for flood damages. This significant increase of the flood risk is furthermore due to climate change and extreme weather events e.g. heavy rainfalls.

The EU Floods Directive (2007/60/EC) aims to reduce and manage the risks of floods to human health, the environment, cultural heritage and economic activity. The Directive requires Member States to assess what rivers and coast lines

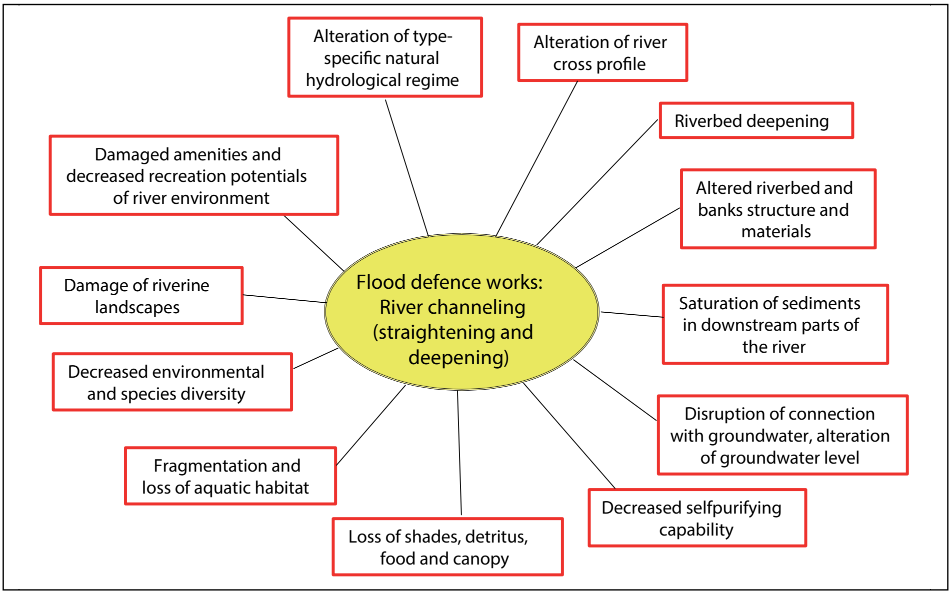


Figure 3.4. Illustrative range of possible ecological alterations and impacts typically associated with flood defence works – river corridor channelling (straightening and deepening)

are at risk from flooding, to map the possible extent of flooding and the assets and humans at risk in such areas, and to take adequate and coordinated measures to reduce the risks. All EU Member States have to develop such flood hazard and risk maps by 2013. Using hazard maps, this planning aims to limit increases in potential damage, to avoid aggravating it in risk areas, and even to reduce it in the longer term. European countries outside the EU generally have similar legislation. The implementation of the Water Framework Directive means a chance for many European countries to combine those measures to reach a Good Ecological Status (GES) with rehabilitation measures.

For centuries, hard infrastructure, including bank enforcements and dykes, navigation including canals, locks, dredging and bank reinforcement, water storage reservoirs and dams, and drainage through straightening rivers and pumping canals, has been used for flood defences. All these activities are typically associated with a range of hydro-morphological alterations and adverse ecological effects. In many countries, activities in relation to the WFD and flood risk planning have been an impetus for changing the way we manage flooding to enhance the environment and protect people from the damage.

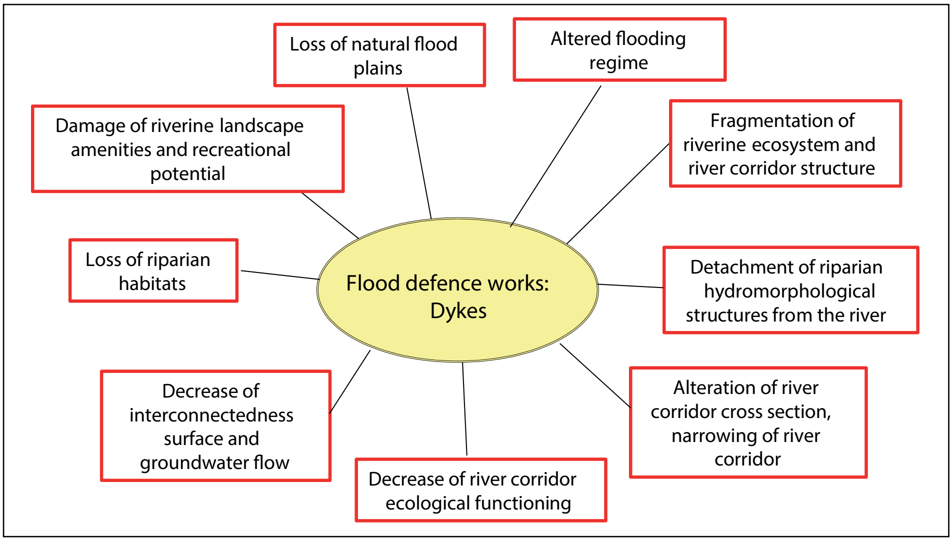


Figure 3.5. Illustrative range of possible ecological alterations and impacts typically associated with flood defence works – dykes.

Flood defence works besides their positive effects on flood safety could cause possible ecological alterations and impacts associated with flood defence measures. Figures 3.3. and 3.4 illustrate such alterations and impacts in case of river channelling and application of flood defence dykes.

Probably the most visible signs of flood risk management are flood defences. Typical hard defenses include embankments, walls, weirs, sluices and pumping stations. Typical use of natural processes could involve using washlands, mudflats and saltmarshes to provide space for floodwater and prevent flooding from occurring elsewhere. At the same time, this can benefit wildlife by providing areas of habitat and are often used in combination with hard defenses to provide areas for recreation and tourism. Upland areas could be managed by restoring peat bogs or blocking artificial drainage channels. Re-planting forests in floodplains will help to slow the flow of water run-off and help it filter through the soil. In urban areas green roofs, permeable paving, surface water storage areas can be used to reduce flood risk. By working with natural processes alongside traditional hard defences a more sustainable approach to flood risk can be achieved.

The development of riparian forests is valuable for retaining water in upstream areas of river catchments and therefore to lower the floodwater levels in the river. Another measure, which has an effect on the water level in the main

Upper Rhine

Due to the man-made changes the flood plain of the Upper Rhine was reduced by 60% or 130 km^2. For example, the flow rate of the flood wave in the Rhine on the section between Basle and Maxau has been reduced from 64 to 23 hours. The Rhine flows through large areas of Germany and the Netherlands. Measures to straighten the river resulted in an increased risk of flooding in the Rhine Delta. The reclamation of historical floodplains is an important means of flood protection. More room for the river: restored floodplains on the upper and middle sections of the Rhine are intended to reduce the height of the flood waves during future flood events. On the other hand, the aim of the measures taken on the lower stretches and in the Rhine Delta is to ensure that the water drains away quickly. In this case, floodplains are being expanded, lowered or supplemented with new or reactivated side channels.

river, is the construction of secondary gullies. But if those are planned very well, the positive effects are dominant.

If densely populated areas are at a risk, still heightening of dikes or the implementation of technical measures is a solution. Especially in urban areas space along the riverbanks is very much limited and therefore, barriers along the river promenade in combination with footpaths or other combination of functions can be a useful option. Cities along rivers should carefully look right now whether planning with the river or water in the city can prevent future problems. Maybe a new consciousness or attitude to floods of the people living in a catchment can contribute to this.

In general, measures for managing flood risk and mitigating hydro-morphological pressures that work with nature rather than against it should be promoted, such as making more room for rivers.

Sustainable flood risk management is a shift away from our predominantly hard-engineering flood defences to a river basin approach, which uses natural processes and natural systems to slow and store water in addition to measures such as flood warning, spatial planning and emergency response. Natural floodplains are allowed to flood and wetlands to act as giant sponges to soak up excess water then release it slowly back into the river.

This is generally a cost-effective way of achieving many objectives, including the good status objective of the WFD and national water policies. For many European rivers, restoring former floodplains and wetlands would both reduce flood risk and improve the ecological and quantitative status of freshwater. Opportunities to enhance the natural environment and improve its capacity to perform ecosystem services should be identified. There are many national activities in Europe aimed at more sustainable flood management and restoring rivers.

3.4 Agriculture

A third of water use in Europe goes to the agricultural sector. Agriculture affects both the quantity and the quality of water available for other uses. Farming can generate a range of diffused pollution, including nitrates, phosphates, pesticides, slurries, soil particles, heavy metals, oil from machinery and faecal pathogens from livestock manure. Pollution of waterways by nitrates and phosphates can encourage excessive growth of aquatic plants and algae in a process called eutrophication.

Nitrates easily leach into water from soils that have been fertilised with nitrogen, or have had manure or slurry applied. High nitrate levels is one of the greatest challenges facing the Water Framework Directive. Action programmes have already been established in Nitrate Vulnerable Zones under the Nitrates Directive to reduce nitrate concentrations.

Phosphates exists naturally in the soil but their level builds up when manure or phosphate fertilisers are spread on the land. Phosphates are not mobile but bond with soil particles and are transported into waterways by soil eroded by wind or water. This occurs in particular when rain falls on slopes, compacted or bare soils, causing soil runoff or loss of organic matter. Soil particles are not only a vehicle for phosphates but can also cause significant damage to the gills of fish and can smother spawning areas. Build-up of sediment may also contribute to localized flooding.

Pesticides used in farming can pollute rivers and ground waters. The amount of a single pesticide tolerated in drinking water is typically 0.1 parts per billion, and certain pesticides regularly exceed this limit in some places. Heavy rain can transport pesticides causing short term high concentrations in surface water. In groundwater, pesticides have a much longer residence time and once an aquifer becomes contaminated it is extremely difficult to clean up. Microbial pollution from runoff or from direct deposition can cause problems at designated bathing water sites.

There are a number of schemes and tools available that can be used to make farming pollute less and meet the requirements of the Water Framework Directive. Legislation is only one way of bringing about environmental improvements. Future reforms of the *Common Agricultural Policy* (CAP), its funds and strategic priorities can also contribute to Water Framework Directive objectives.

This requires farmers who receive Single Farm Payments to maintain land in 'good agricultural and environmental condition' and comply with the Nitrates, Groundwater and Sewage Sludge Directives.

The CAP also provides funding for agri-environment schemes. These can provide direct benefits for farmers and the environment alike.

Irrigation is needed at times of low rainfall when abstraction can exacerbate already low river flows. Careful management of water consumption within agriculture will be necessary to meet the quantitative requirements of the Water Framework Directive, with attention most closely focused on high use activities such as spray irrigation.

One area where new practices and policies can make a significant difference in water efficiency gains is the irrigation of crops. In southern European countries such as Greece, Italy, Portugal, Cyprus, Spain and southern France, the arid or semi-arid conditions necessitate the use of irrigation. In these areas, nearly 80% of water used in agriculture currently goes to irrigation.

However, irrigation does not have to be so water intensive. Water efficiency gains are already being obtained across Europe through both conveyance efficiency (the proportion of abstracted water that is delivered to the field) and field application efficiency (the water actually used by a crop in relation to the total amount of water that was delivered to that crop). In Greece, for example, improved conveyance and distribution efficiency networks have led to an estimated 95% water efficiency gain compared to previously-used irrigation methods.

Policy plays a crucial role in inducing the agricultural sector to adopt more efficient irrigation practices. In the past, for example, water-pricing policies in some European countries did not necessarily require farmers to use water efficiently. Farmers rarely had to pay the true price of water reflecting the environmental and resource costs. In addition, agricultural subsidies obtained through the EU's Common Agricultural Policy (CAP) and other measures were indirectly encouraging farmers to produce water-intensive crops using inefficient techniques. In the province of Cordoba, Spain, for example, the efficiency of cotton irrigation increased by approximately 40% after subsidies were partially decoupled from cotton production in 2004. A water pricing structure favouring efficient users and the removal of adverse agricultural subsidies is likely to lead to significant reductions in the quantity of irrigated water used in agriculture.

In addition to modified irrigation techniques, gains in water and cost savings can also be obtained through training and knowledge-sharing programmes that educate farmers on more water efficient practices. In Crete, for example, water savings of 9-10% have been achieved through the use of an irrigation advisory service. The service informs farmers by phone of when and how to apply water to crops based on daily estimates of the conditions affecting the crops.

Changing agricultural practices can also improve the quality of the water available for other water users in a cost-effective way. Using inorganic and organic fertilisers and pesticides, for example, can address many of the water pollution problems from agriculture. In addition, there is significant potential to improve water quality throughout Europe with little or no impact on profitability or productivity by, for example, reducing pesticide use, modifying crop rotations and designing buffer strips along water courses.

The use of treated wastewater for agriculture is already providing significant water management benefits for some European countries. Through the use of wastewater in agriculture, more fresh water resources can be made available for other needs, including for nature and households. If the quality of the reclaimed water is properly managed, treated wastewater can provide an effective alternative for meeting agriculture's demand for water.

In Cyprus, for example, the recycled water targets for 2014 correspond to approximately 28% of the 2008 agricultural water demand. In Gran Canaria, 20% of water used across all sectors is supplied from treated wastewater, including the irrigation of 5,000 hectares of tomatoes and 2,500 hectares of banana plantations.

Chapter 3 sources:

Ecological and Chemical Status and Pressures of European Waters. 2012. Thematic Assessment for EEA Water 2012 Report. Prague. EEA.

Hydromorphological alterations and pressures in European rivers, lakes, transitional and coastal Waters. 2012. Thematic Assessment for EEA Water 2012 Report. Prague. EEA.

Chapter 4
The Programme of Measures

The status and pressure assessments in the previous chapters revealed that many European surface water bodies currently fail the Water Framework Directive's objective. This raises the following questions:

What should be done to achieve good ecological status?
How can nutrient and pollutant input be reduced and water quality improved?
How are the hydromorphological pressures lowered and the status of altered habitats improved?

The Program of Measures (PoM) included in the RBMPs addresses these issues. The Program of Measures (PoM) describes the actions that must be taken to bring water bodies into "good status", for which the key measures are as follows: reduced pollution emissions into water bodies by better wastewater treatment and implementation of good agricultural practice; and improving hydromorphology via restoration and changed land-use (e.g. buffer strips); ensuring minimum or environmental flows; removing migratory obstacles and transverse structures such as weirs so as to restore river continuity.

Article 11 of the WFD requires each Member state to establish a program of measures "for each river basin district, or for the part of an international river basin district within its territory," and to implement such measures by 2012. The effectiveness of PoM is subject to review at six year intervals beginning in 2015. The WFD distinguishes between basic and supplementary measures (Annex VI Article11(2) and (3) of the Water Framework Directive).

Basic measures, which comprise the minimum water body protection development requirements, are already defined in existing EU directives or serve to meet basic water management requirements (pursuant to Article 11(3) of the WFD), including those laid out in Directive 91/271/EEC concerning urban wastewater treatment, Directive 91/676/EEC relating to nitrate pollution, and Directive 80/778/EEC concerning drinking water.

Supplementary measures are necessary in cases where the basic measures are not sufficient to allow the WFD objectives to be reached. Such measures can include construction programs, rehabilitation projects, legislative, administrative and fiscal instruments, and educational projects.

Having undertaken the analyses of the characteristics of a river basin and the impacts of human activity, as well as an economic analysis of the water use, together with establishing monitoring of water status on a systematic basis, the implementation of the Water Framework Directive moves to another stage. When the examination of the water bodies is completed and appropriate environmental objectives are set, the competent authorities have the responsibility to develop the Programme of Measures. Later the developed for each river basin district Programme of Measures serves as an input to the River Basin Management Plan. The structure of the Programme of Measures is presented in Figure 4.1.

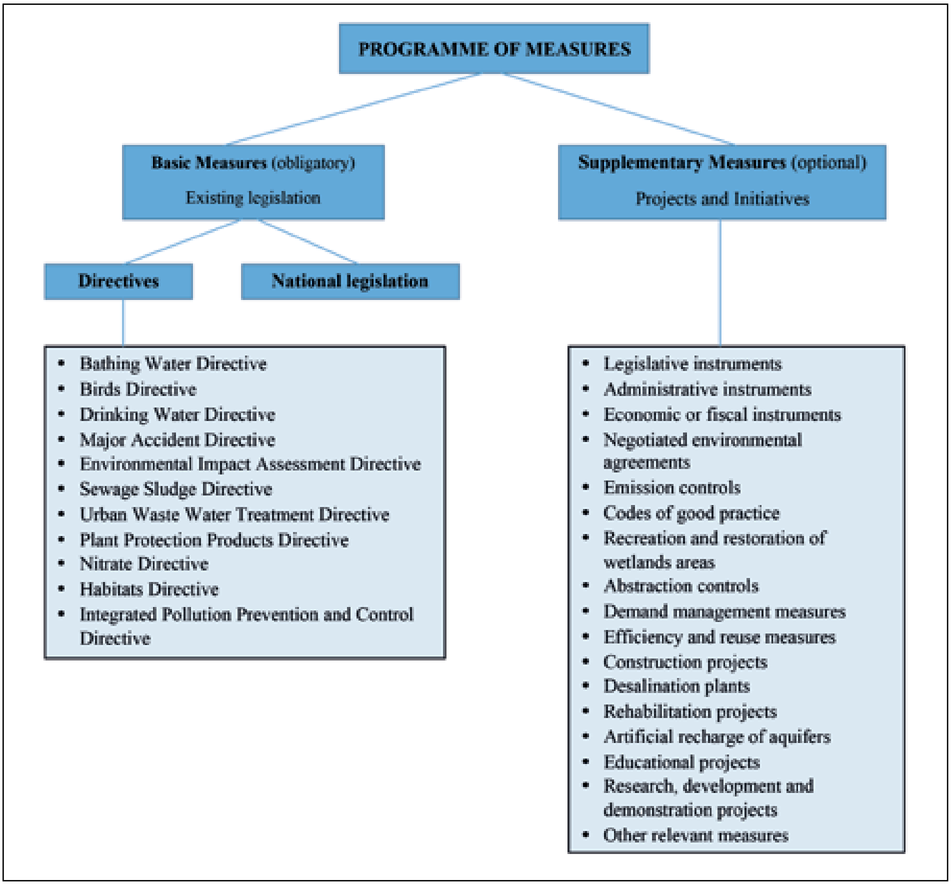


Figure 4.1. Structure of the Programme of Measures (http://watersketch.tutech.eu)

4.1 Basic measures

4.1.1 Basic measures required by existing directives

The Bathing Water Directive (2006/7/EC)

The purpose of the 1976 Bathing Waters Directive is to preserve, protect and improve the quality of the bathing waters and therefore, to protect human health. The Directive set binding standards for bathing waters throughout the European Union and was transposed into Irish legislation through the 1992 quality of bathing waters Regulations (SI 155 of 1992). A new bathing water directive (2006/7/EC) was adopted in 2006 laying down provisions for more sophisticated monitoring and classification of bathing water. It also provides for extensive public information and participation in line with the Åarhus Convention as well as for comprehensive and modern management measures. The classification of water quality at a bathing site will be determined on the basis of a three-year trend instead of a single year's result as at present. This means that the classification will be less susceptible to bad weather or one-off incidents. Where water quality is consistently good over a three year period the frequency of sampling may be reduced.

The Habitats Directive (92/43/EEC) and Birds Directive (79/409/EEC)

Community legislation concerning nature conservation comprises two Directives, the "Birds" Directive and the "Habitats" Directive, which are concerned with the protection of natural habitats, fauna and flora and the creation of a European network of protected sites. The network includes water dependent species and habitats. The conservation aims of both directives are generally the same. Together, the Special Areas of Conservation designated by the Member States make up the European network of protected sites, Natura 2000. All the Special Protection Areas created under the "Birds" Directive form part of this network. The European Union (Natural Habitats) Regulations, SI 94 of 1997 (which have been amended twice by SI 233 of 1998 & SI 378 of 2005) transpose the requirements of both directives.

The Drinking Water Directive (98/83/EC)

The Directive has been transposed into National legislation through the Drinking Water Regulations (SI 278 of 2007). The Regulations concern the quality of water intended for human consumption. The objective is to protect the health of the consumer and to ensure drinking water is wholesome and clean. The Regulations are expected to be updated to synchronise with the provisions of the Water Services Act of 2007. In addition the Water Framework Directive (Article 7) requires measures to be taken to protect drinking water sources.

The Major Accidents (Seveso) Directive (96/82/EC)
This directive concerns the control of major hazards involving dangerous substances and was transposed into National legislation through the European Communities (Control of Major Accident Hazards Involving Dangerous Substances) Regulations (SI 74 of 2006).

The Environmental Impact Assessment Directive (85/337/EEC)
The Directive ensures that environmental consequences of projects are identified and assessed before authorisation is given. Environmental Impact Assessment (EIA) is a procedure for; the systematic examination of the likely significant effects on the environment of a proposed development; ensuring that adequate consideration is given to any such effects; and avoiding, reducing or offsetting any significant adverse effects. The public can give its opinion and all results are taken into account in the authorisation procedure for the project. The public is informed of the decision afterwards.

The Sewage Sludge Directive (86/278/EEC)
The Sewage Sludge Directive 86/278/EEC seeks to encourage the use of sewage sludge in agriculture and to regulate its use in such a way as to prevent harmful effects on soil, vegetation, animals and man. To this end, it prohibits the use of untreated sludge on agricultural land unless it is injected or incorporated into the soil. The Directive also requires that sludge should be used in such a way that account is taken of the nutrient requirements of crops.

The Urban Waste Water Treatment Directive (91/271/EEC)
The Urban Waste Water Treatment Regulations 2001 (SI 254 of 2001) deal with the collection, treatment and discharge of urban wastewater and the treatment and discharge of wastewater from certain industrial sectors. These regulations revoke and generally re-enact, in consolidated form, the Environmental Protection Agency Act 1992 (Urban Waste Water Treatment Regulations, 1994, as amended).

The Regulations:

- give effect to provisions of Council Directive 91/271/EEC of 21 May 1991, as amended, concerning urban waste water treatment, and Directive 2000/60/EC of 23 October 2000 - the Water Framework Directive.
- prescribe requirements in relation to the provision of collection systems and treatment standards and other requirements for urban waste water treatment plants, generally and in sensitive areas

- provide for monitoring procedures in relation to treatment plants and make provision for pre-treatment requirements in relation to industrial waste water entering collection systems and urban waste water treatment plants.

The Plant Protection Products Directive (91/414/EEC)
The Plant Protection Products Directive (91/414/EEC) concerns the authorisation of plant protection product for use or placing on the market. Before an active substance can be authorised it must conform to rigid controls specified in accordance with EU legislation. That legislation is designed to ensure that no harmful effects arise for human and animal health and that there is no unacceptable impact on the environment. 'The Authorisations Directive' has been implemented in National legislation through S.I No. 320 of 1981 as amended, SI 83 of 2003 and SI 624 of 2001. The Pesticides Control Service of the Department of Agriculture, Fisheries and Food, is responsible for operating the authorisation system.

The main elements of the Directive are:
- To harmonise the overall arrangements for authorisation of plant protection products within the European Union. This is achieved by harmonising the process for considering the safety of active substances at a European Community level by establishing agreed criteria for considering the safety of those products. Product authorisation remains the responsibility of individual Member States.
- To provide for the establishment of a positive list of active substances (Annex I), that have been shown to be without unacceptable risk to people or the environment. Active substances are added to Annex I of the Directive as existing active substances are reviewed (under the European Commission (EC) Review Programme) and new ones authorised. Member States can only authorise the marketing and use of plant protection products after an active substance is listed in Annex I, except where transitional arrangements apply.

The main emphasis of the existing EU pesticide regulatory framework has been the authorisation of plant protection products for the placing of these products on the market. In order to strengthen the overall policy framework for the use and management of pesticides, the EU Commission brought forward a strategy for the sustainable use of pesticides in 2002, which has a stronger emphasis on the use phase of pesticides.

The draft proposal for a "sustainable use of pesticides" Directive was published in 2006. The Directive requires Member States to establish pollution reduction programmes addressing pesticides within the framework of the River Basin Management Plans. Types of measures currently proposed in the draft directive include the use of mandatory buffer strips or the use of particular technical equipment to reduce spray drift. Member States may be required to reduce or ban the use of pesticides within safeguard zones identified in order to protect drinking water sources as required by Article 7(3) of Directive 2000/60/EC (Water Framework Directive). The draft proposal also currently provides for significantly reduced or zero pesticide use in protected areas designated under other directives such as Natura 2000 sites.

The Nitrates Directive (91/676/EEC)

The Nitrates Directive concerns the protection of waters against pollution caused by nitrates (and also phosphorus) from agricultural sources. Its objective is to reduce water pollution caused or induced by nitrates from agricultural sources and to prevent further such pollution. The directive has been implemented in national legislation through the European Communities (good agricultural practice for protection of waters) Regulations (SI 378 of 2006).

The Integrated Pollution Prevention Control Directive (96/61/EC)

The objective of the IPPC Directive is to minimise pollution from various industrial sources throughout the European Union. The directive has been implemented in national legislation through the Environmental Protection Agency Acts of 1992 and 2003 and the associated licensing Regulations. Operators of industrial installations covered by Annex I of the IPPC Directive are required to obtain an authorisation (environmental permit) from the EPA.

The IPPC Directive is based on several principles, namely (1) an integrated approach, (2) best available techniques, (3) flexibility and (4) public participation. The integrated approach means that permits must take into account the whole environmental performance of the plant, covering e.g. emissions to air, water and land, generation of waste, use of raw materials, energy efficiency, noise, prevention of accidents, and restoration of the site upon closure. The purpose of the Directive is to ensure a high level of protection of the environment taken as a whole. The permit conditions, including emission limit values (ELVs), must be based on Best Available Techniques (BAT), as defined in the IPPC Directive. The establishment of environmental objectives in river basin management plans will require IPPC permits to take full account of these objectives.

4.1.2 Other basic measures required by Water Framework Directive

Practical steps and measures taken to apply the principle of recovery of costs for water use and measures to promote efficient and sustainable water use

The Water Framework Directive requires Member States to devise and adopt a cost recovery system to ensure that water pricing policies act as incentives towards efficient water usage so as to "contribute to the environmental objectives of the directive" and to recover "an adequate contribution" of the costs of water services from the main user groups, including industry, agriculture and households. The "polluter pays principle" must be applied. Article 9 of the Water Framework Directive provides the overall framework within which water-pricing policy is to be determined and implemented by 2010. The directive furthermore requires measures to promote efficient and sustainable water use. The Government's National Water Pricing Policy adopted in 1998 requires the charging of non-domestic customers for water and waste water services to recover the full costs of providing such services to these customers. This is in line with EU policy on the application of the "polluter pays principle" and Article 9 of the EU Water Framework Directive. A programme is underway for installation of meters on the supply of non-domestic customers and this will facilitate the equitable, transparent and efficient implementation of water pricing policy. Capital, operational and maintenance costs in relation to the domestic sector are met from public funds. This is permitted for a "given water activity" under Article 9(4) of the Directive where it is "within established practice" and "where this does not compromise the purposes and the achievement of the objectives of the Directive".

Measures taken to protect drinking water sources

The Water Framework Directive requires drinking water resources to be protected. Article 7 requires the identification of all groundwater and surface water bodies that are used, or may be used in the future, as a source of drinking water for 50 persons or more, or where the rate of abstraction is more than 10m3 per day. Deterioration in the quality of these water bodies must be avoided so that less treatment is required to render the water suitable for drinking. The treated water must also meet the standards in the Drinking Water Directive (98/83/EC). Article 7 of the Water Framework Directive indicates that "safeguard zones" may be used by Member States where there is an identified need to protect individual drinking water sources.

The most recent drinking water report by the EPA emphasised the need to adopt a water safety plan approach to ensuring drinking water is safe and secure. The EPA recommended that; "local authorities should adopt the World Health Organisation recommended water safety plan approach to the management of drinking water supplies. The three components of a water safety plan, which should be adopted, are:

- risk assessment,
- effective operational monitoring, and
- effective management.

Controls on abstraction and impoundment with an impact on the status of water
Abstraction legislation is set out in the Water Supplies Act 1942, which governs theabstraction, by local authorities of water from various water sources. The Planning and Development Acts 2000-2006 and associated Regulations set out further provisions regarding water abstraction including establishing a role for An Bórd Pleanála; provisions regarding planning permissions for abstraction; associated consent procedures and public notice/consultation requirements; and relevant environmental impact assessments and associated thresholds.

The Water Framework Directive requires controls over the abstraction of fresh surface water and groundwater, and impoundment of fresh surface water, including a register or registers of water abstractions and a requirement of prior authorisation for abstraction and impoundment. These controls must be periodically reviewed and, where necessary, updated. Member States can exempt abstractions or impoundments, which have no significant impact on water status from these controls.

Detailed technical studies are under way, led by local authorities to establish the amount of water currently abstracted, with predictions for the year 2015. Technical methods are being developed to estimate minimum water resource requirements to protect the ecological status of surface water bodies. This work will assist in setting appropriate and sustainable abstraction rates which will support the objectives established for water bodies in river basin management plans.

Controls on point source and diffuse source discharges with an impact on the status of water
The Water Framework Directive requires prior regulation for point source discharges liable to cause pollution. Controls may include prohibition on the entry of pollutants into water, prior authorisation, or registration based on general binding rules and laying down emission controls for the pollutants.

There is adequate national regulatory legislation already in place to deal with point source discharges. The EPA under the Integrated Pollution Prevention and Control (IPPC) Regulations regulates major industrial activities. Under the Water Pollution Acts, local authorities license all other small-scale industrial and commercial premises that discharge to waters and sewers. More recently the Waste Water Discharge (Authorisation) Regulations 2007 (SI 684 of 2007) were made providing for the authorisation by the EPA of discharges from local authority waste water treatment works and collection systems that are released to all types of receiving waters. In the case of discharges from smaller sewage systems, certificates will apply instead of licences.

For diffuse sources of pollution such as agricultural activities and unsewered properties, the Directive requires measures to prevent or control the input of pollutants. Controls may take the form of a requirement for prior regulation, such as a prohibition on the entry of pollutants into water, prior authorisation or registration based on general binding rules.

The European Communities (Good Agricultural Practice for Protection of Waters) Regulations 2006 (SI 378 of 2006) provide statutory support for good agricultural practice to protect waters against pollution from agricultural sources and give further effect to several EU Directives including the Nitrates Directive, dangerous substances in water, waste management, protection of groundwater, public participation in policy development and water policy.

Authorisations of direct discharges to groundwater

Measures to protect groundwater are required by the Water Framework Directive. Article 11(3)(j) prohibits the direct discharge of pollutants into groundwater, but it permits prior authorisation of a number of specific activities related to the reinjection of waters that have been extracted for particular purposes such as dewatering for mining or construction, exploration for oils and injection for storage of gas. Such discharges are only allowed if the groundwater is unsuitable for any other use. However, the injection of small quantities of substances for characterisation, protection or remediation of groundwater bodies is permitted. Construction or civil engineering works which come into contact with, and could potentially influence the water table require authorisation and general binding rules.

The Waste Water Discharge (Authorisation) Regulations 2007 (SI 684 of 2007) prohibit the discharge by water services authorities of certain dangerous substances to groundwater, and provide for controls by the EPA, by way of a licensing system, in relation to discharges of other such substances by water services authorities.

Measures to deal with priority substances

Measures are required by the Directive to eliminate pollution of surface waters by 33 priority substances and 8 other pollutants. Measures must aim to progressively reduce pollution from priority substances and cease or phase out emissions, discharges and losses of priority hazardous substances.

Controls on physical modifications to surface waters with an impact on the status of water
The Water Framework Directive requires that the physical conditions of surface water bodies are consistent with the achievement of the required ecological status or good ecological potential for bodies of water designated as artificial or heavily modified. Controls for this purpose may take the form of a requirement for prior authorisation and/or registration based on general binding rules.

Controls on other activities with an impact on the status of water
Invasive aquatic alien species are non-native plants or animals that successfully establish themselves in aquatic and fringing habitats and damage the natural flora and fauna. There is growing evidence that they pose a major threat to the natural diversity of native plants and animals: for example by preying on them, out-competing for habitat or food, altering habitat or introducing pathogens or parasites.

The Department of Environment, Heritage and Local Government is currently considering the introduction of Regulations under Section 52(6)(a) of the Wildlife Act, 1976, for the purpose of "prohibiting the possession or introduction of any species of wild bird, wild animal or wild flora or any part, product or derivative of such wild bird, wild animal or wild flora which may be detrimental to native species.

Measures taken to prevent or reduce the impact of accidental pollution incidents
The Water Framework Directive requires measures to prevent significant losses of pollutants from technical installations (e.g. industrial sites), and to prevent and/or to reduce the impact of accidental pollution incidents, for example, as a result of floods, including through systems to detect or give warning of such events including, in the case of accidents which could not reasonably have been foreseen, all appropriate measures to reduce the risk to aquatic ecosystems.

Major emergencies include, among other things, severe weather, flooding, chemical spills, transport accidents (air, sea, rail, road), accidents at sea and major pollution incidents at sea.

The Framework is designed primarily to provide for the protection, support and welfare of the public in times of emergency. Effective arrangements to ensure public safety in times of emergency also have the benefit of helping to safeguard the environment, the economy, infrastructure and property.

Directives, legislation and supplementary measures

A river water body is badly degraded due to nutrient enrichment from a number of different sources: (i) urban waste water (ii) industrial waste water and (iii) intensive agriculture. The minimum obligation under the Directive is that measures are implemented within the river basin as set out in the Urban Waste Water Treatment Regulations, in the National Regulations that apply to industrial discharges e.g. under the Water Pollution or the Environmental Protection Agency Acts, and in the Good Agricultural Practice for the Protection of Waters Regulations.

If it is the view that these measures alone will not be enough to restore the river water body to 'good status' by 2015, then additional measures will have to be identified and considered. These might include, for example, setting more stringent emission controls than is required by the above mentioned legislation for point source discharges, or require (e.g. by way of local bye-law) stricter controls on agricultural activities within the catchment. Other measures that could be considered might include the re-creation and restoration of wetland areas, educational projects, etc. It is likely that the final approach adopted will consist of a combination of some, if not all of these supplementary measures; the final combination chosen will most likely be the most cost-effective combination of technically feasible measures identified.

Source: http://www.wfdireland.ie/

4.2 Supplementary measures

There will be certain cases where full application of the 'basic measures' will not be enough to achieve the default objective of 'good status' by 2015. In such cases, additional supplementary measures will need to be identified and considered. These 'supplementary measures' are likely in most cases to be identified and implemented at local level, i.e. at the river basin or water body level. The combination of supplementary measures chosen by local authorities should be the most cost effective combination of supplementary measures identified.

The combination of supplementary measures identified for a water body must first be checked to determine whether the measures are technically feasible and that they are likely to deliver the required objectives within the required timeframe (by 2015). The measures should also be checked to determine whether they are disproportionately expensive within the timeframe proposed. If it is technically infeasible or disproportionately expensive to achieve the objectives within the timeframe for the first planning cycle (by 2015) then an exemption may be considered, in the form of an extension of time beyond the first river basin planning cycle.

The identification of supplementary measures should be, transparent, proportionate and pragmatic. The most cost-effective combination of supplementary measures to achieve this goal should be identified in each case.

The following is an example of how measures provided for in the Directive might be implemented in practice.

Chapter 4 sources:

A Handbook for Integrated Water Resources Management in Basins. 2009. Global Water Partnership http://www.unwater.org/downloads/GWP-INBOHandbookForIWRMinBasins.pdf

From theory and plans to eco-efficient and sustainable practices to improve the status of the Baltic Sea – WATERPRAXIS http://www.waterpraxis.net/en.html

Chapter 5
Measures for River and Lake Restoration

Rivers and their catchments provide a wide range of natural, economic and societal services. However, many activities such as channelization, culverting, damming, abstraction, urbanisation, pollution, dredging and intensive agriculture can negatively impact the environment and the services rivers provide.

River degradation has led to an extensive loss of habitats and additional pressures on the aquatic and terrestrial species that use them. It also affects the quality of our drinking water, resilience to climate change and ability to store and hold back flood water. Damage to river systems has been so extensive that an urgent need has emerged, not only to conserve, but to restore these systems.

Best practice river and catchment restoration can deliver multiple benefits including improvements to water quality, biodiversity, water supply security and reductions in flood risk and pollution.

River restoration can be carried out at different scales and working with many different issues (such as morphological, hydrological, biological, chemical and socio-economic). The enhancement of river environments originally began with addressing issues of severe water pollution and the conservation of target species. But changes in attitude towards environmental management eventually led to more integrated river restoration schemes with multiple benefits. Below are a few examples of the most common measures within river restoration.

5.1 Wetland restoration

The benefits of restoration of degraded or destroyed wetlands and creation of new wetlands provide water-quality improvement, flood attenuation, esthetics, and recreational opportunities. The wetlands have been drained and altered to accommodate human needs. These changes to wetlands have directly, or indirectly, brought about changes in the migratory patterns of birds, local climate, and the makeup of plant and animal populations.

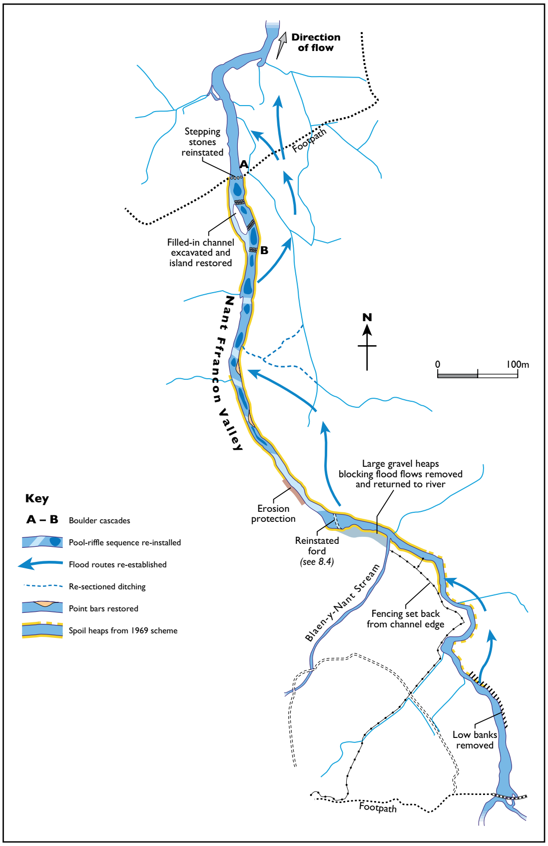


Figure 5.1. River catchment management. http://www.therrc.co.uk/pdf/manual/MAN_5_3.pdf

Wetland restoration is one of the measures mentioned in a number of water plans. The wetland planning process should involve each individual river watershed. The following criteria for designation of wetlands are recommended:

- The project area should have a sufficiently large catchment for being able to remove the demanded amount of nutrients;
- The areas need to be topographically well-defined (the influence on areas outside the actual project area kept at the minimum);
- The project(s) should be located in one of the action areas which can be designated in the municipal plan (in some cases this requirement is not necessary);
- If possible, the area should be agricultural land (include less natural areas);
- Technically simple projects are prioritized;
- The less property owners (the forehand contacts are preferred);
- The synergies with physical conditions of the streams, biodiversity, recreational activities, etc.

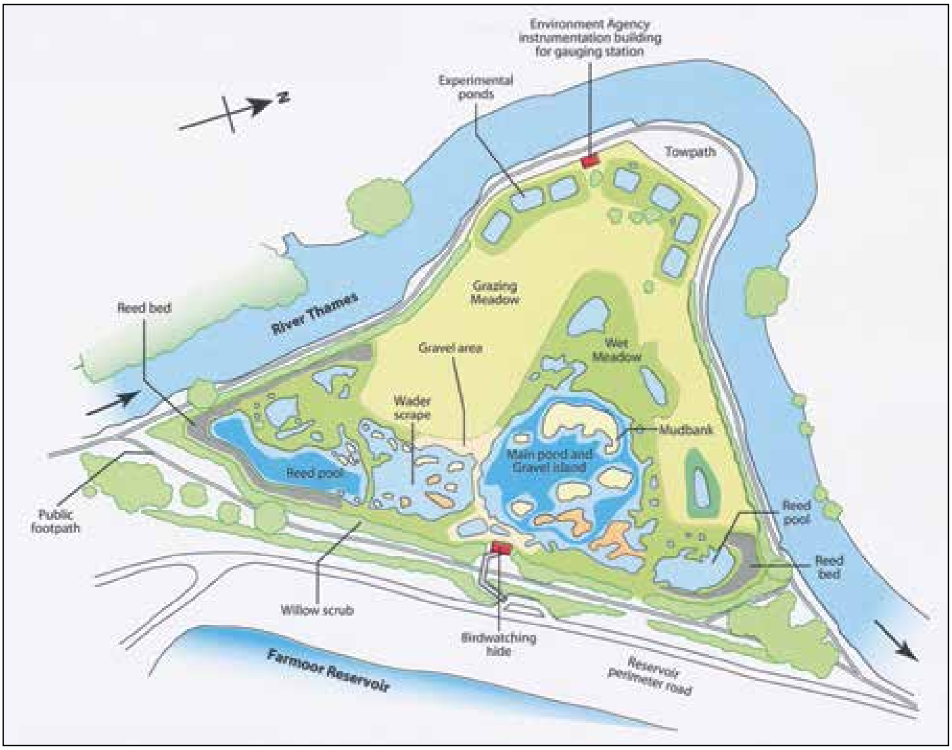


Figure 5.2. Floodplain reconnection and wetland recreation. http://www.therrc.co.uk/why-restore

5.2 Re-meandering

Many river channels have been historically straightened to increase conveyance, improve navigability or accommodate floodplain development (e.g. straightening undertaken as part of railway construction). This measure refers to the re-meandering of straightened river channels, through both creation of a new meandering course and reconnection of cut off meanders.

This measure is applicable to river systems that would naturally be expected to have a meandering but have been modified. It is not appropriate to create meanders within a river system that would not naturally meander through lateral adjustment.

Re-meandering increases morphological and flow diversity in a straightened river channel. These more natural conditions can provide better quality habitats for macrophytes and benthic invertebrates, and as a result also improve habitats for fish. In addition to improving conditions for the biological quality elements,

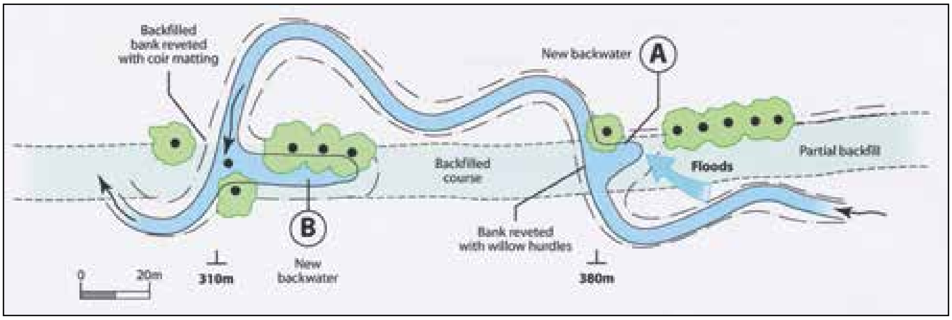


Figure 5.3. River re-meandering. http://www.therrc.co.uk/why-restore

re-meandering could also help to improve habitats for birds and mammals that prey on fish and invertebrates.

5.3 Buffer zones, buffer strips and vegetated filter strips

Establishment of buffer zones along the banks of the water bodies will assist reduction of nutrient load and will improve conditions of flora and fauna. Buffer zone designs vary according to their management objectives — that is, whether they are primarily aimed at maintaining good water quality, controlling erosion, or providing wildlife habitat.

Buffer strips border drainage ditches, irrigation canals and wetlands. They receive the diffuse or scattered runoff from non-point sources such as cropland. Flow of water through a buffer strip is generally small and only occurs following a precipitation event or during irrigation.

Vegetated filter strips are designed to treat runoff water that flows through them. Filter strips are more likely to receive runoff water generated from livestock operations, such as small background feedlots, winter feeding sites, calving pens and manure stockpile sites. The runoff generated by these activities contains higher concentrations of contaminants and may resemble wastewater, compared to the more diffuse runoff received by buffer strips.

5.4 Good practice sediment management

Sediments are a natural part of aquatic systems which are essential for the hydrological, geomorphological and ecological functioning of those systems. Sediment forms a variety of habitats, which directly and indirectly support a broad range of

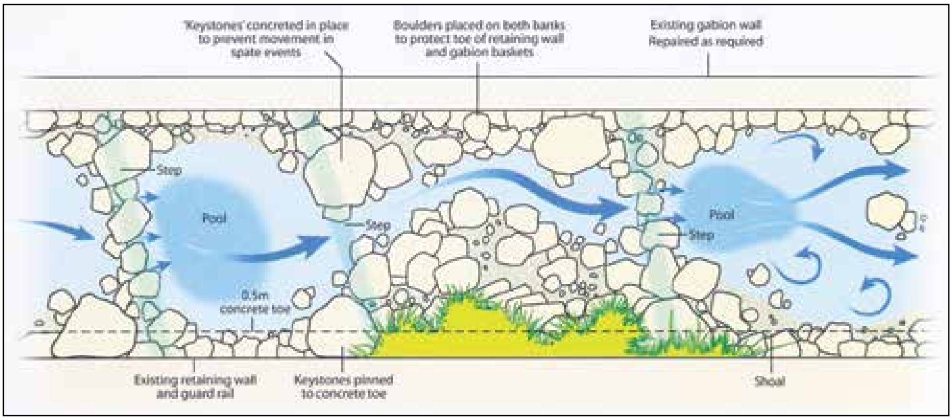


Figure 5.4. In stream enhancement. http://www.therrc.co.uk/why-restore

flora and fauna. Sediment may need to be managed for a number of reasons, including sediment removal or deposition for flood defence purposes; sediment removal and reinstatement for fisheries interest; aggregate extraction; and land drainage.

The following mitigation measures are applied for sediment management: gravel reinstatement in rivers, good practice management of in-channel sediments. These measures are discussed more in details.

Gravel reinstatement in rivers

Sediment removal, particularly of gravel substrate, can have significant adverse impacts on the hydromorphology and biology of rivers. Regular removal is not a sustainable practice as deposition of sediment is a natural response of the river to prevailing flow and sediment conditions. This measure provides guidance on ensuring that appropriate approaches are taken to limit the impact of further sediment removal on hydromorphology and biology. The measure also includes methods of mitigating the impacts of historic sediment removal through reinstatement of gravel substrate within the channel, incorporating both gravel augmentation (or seeding) and direct modification of the channel bed to create substrate features (e.g. riffles).

Good practice management of in-channel sediments

In most cases it is recommended that sediment is retained in the river channel because it is an intrinsic part of the functioning of the river system, contributes to diverse channel morphology, and provides vital habitats for aquatic organisms. However, in cases where sediment removal is necessary to maintain river function

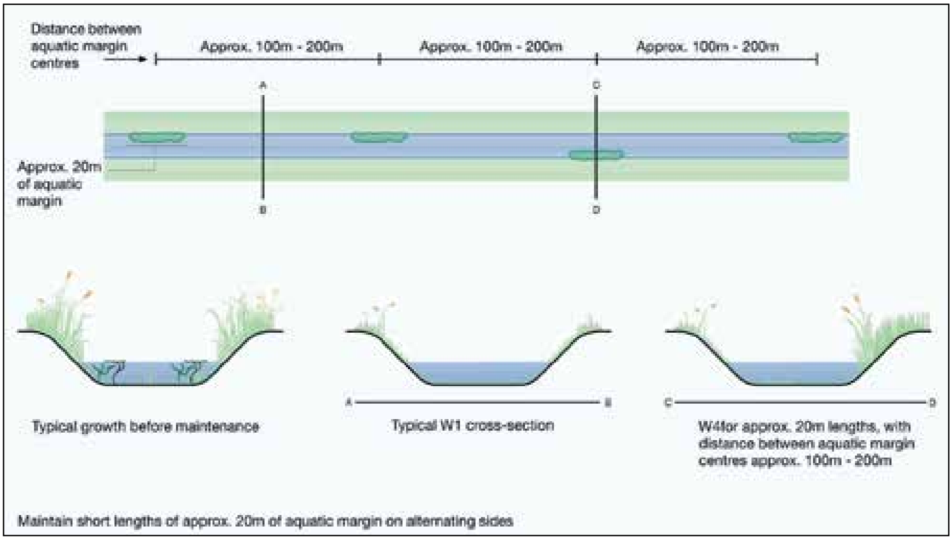


Figure 5.5. Good practice management of riparian vegetation. http://evidence.environment agency.gov.uk/

or would be of demonstrable benefit to ecology and geomorphology, and where sediment supply cannot be controlled, it may be possible to actively manage in-channel sediments. This measure is concerned with ensuring that appropriate approaches are taken to limit the impact of further sediment removal on hydromorphology and biology, in situations where sediment removal is deemed necessary.

5.5 Good practice vegetation management

Vegetation is a natural part of river ecosystems providing shade and cover; promoting bank stability; enhancing physical in-channel features; providing an input of woody debris; filtering sediment and serving as a source of nutrients to support fauna and flora. Management of vegetation in and alongside watercourses is currently undertaken for a range of purposes including agriculture, recreation and flood risk management. Where management is required to maintain the use of the channel, good practice vegetation management measures promote activities which support diversity of vegetation, allow neutral regeneration and prevent the spread of non-native, invasive species.

Invasive plant species are non-native organisms that successfully establish themselves in native ecosystems. Invasive non-native species are not subject to their natural competitors or predators in their new habitats and are therefore able to dominate or out-compete native species reducing diversity and ecological quality. Techniques for controlling non-native plant species include hand removal, cutting, spraying, and replanting with desirable native species.

Where riparian vegetation management is required to maintain a use of the channel, sensitive management helps to maintain the structure and diversity of the riparian zone which has an important habitat value and also influences conditions within the channel. Forward planning of timing and methods used to manage vegetation should be considered.

The purpose of in-channel vegetation management must be clearly reviewed to identify whether any intervention is required. Consideration should first be given to ceasing maintenance and allowing natural recovery. Where in-channel works are deemed to be required, the timing, extent and methods of management should be carefully planned to minimise impact on ecological quality.

5.6 Near-nature river structures

The development of near-nature river structures and the ecological consistency are measures with high priority to reach a good ecological condition. Most of the transversal structures need to be removed or reconstructed; old passages have to be replaced by newer passages with higher discharge and a consistent riverbed. Flow over the obstruction can also cause localised scouring of the bed and banks downstream. In-channel structures can act as a barrier to fish migration (particularly weaker swimmers) and hinder the mobility of other aquatic species.

Removal of in-channel structures

These structures widely differ in size, situation and construction and the most appropriate approach to removal largely depends on the individual structure concerned. For many structures, especially small ones, removal is a relatively straightforward demolition project, although care must be taken to protect the surrounding structures and natural environments. However, the decision-making process as to whether dam or weir removal is the best option, is often complex even for smaller structures. Replacement of the bed with a hard structure may be required as a grade control and examples of hard beds referred to sometimes as ‘riffles’ are shown.

The importance of cancellation of building new in-channel structures in rivers is also worth to mention. As an example, the case of permission for a new dam construction on the last free flowing part of the Elbe river in Czech Republic in 2005 might be considered. This case demonstrated how, with knowledge and perseverance, organizations and individuals with common goals can come together and change both management policies and management attitudes to the benefit of the environment.

Rehabilitation of river banks

This measure may be applied to rivers where bank side habitats have previously been degraded as a result of channel modification or bank protection. For example, re-sectioning (modification of the channel cross section, usually through widening and deepening) can result in unnaturally steep banks with little habitat diversity. It is important to determine whether there is an underlying bank erosion or instability problem and address the cause of the problem and mitigate the effects. Rehabilitation should only be undertaken once an assessment of the reach within the wider river network has been undertaken to ensure that measures put in place are appropriate.

Rehabilitation may begin with the removal of hard bank protection which may be applied wherever it is determined that the protection is obsolete or can be replaced by soft engineering solutions. It is important to consider an alternative solution that avoids the need for bank protection and allow natural adjustment, for example by relocating footpaths away from the river to provide space for natural bank adjustment to occur.

Improvement of fish passages

These measures deal with impacts to fish movement within estuaries and rivers. Structures to facilitate fish passage will not always deal with other problems caused by in-channel structures, particularly impoundment, sedimentation upstream of structures and disruption to sediment transport processes downstream. The optimal solution for restoring all aspects of functionality including fish passage is weir removal (and for some structures, modification). This option should be investigated first and implemented where practicable. Where removal or modification of structures is not possible it might be appropriate to adapt it to local conditions. It is worth noting that where structures can be removed, other measures to improve habitat upstream and downstream should be undertaken after the flow and sediment regime have had time to adjust.

5.7 Management and restoration of intertidal zone

This measure includes management practices which seek to protect or restore the intertidal zone, defined as the area of the foreshore between the average high and low water levels. This area can include many different types of habitats, including beaches, rocky cliffs, saltmarsh and mudflats which support key WFD biological elements indicating overall ecosystem health. The intertidal zone is a highly dynamic region which plays an important role in the structure and functioning of estuarine and coastal ecosystems. The intertidal zone can be susceptible to a number of natural and anthropogenic pressures, including coastal squeeze of foreshore in front of sea defences (erosion exacerbated by sea level rise), pollution, dredging and sedimentation resulting from changes in sediment regime. Intervention is often required to mitigate or support the natural recovery of the intertidal zone associated to a disturbance.

5.8 Lake restoration and management

Lake restoration and management presents special case. This measure involves: i) watershed assessment, ii) planning, and, iii) lake restoration and management activities. Monitoring of the ecological status of the lake is an important component of the action plan.

The following items of watershed assessment and planning process are recommended to be taken into consideration:

- survey of the status of sewage disposal systems of sparsely-populated areas;
- planning of water protection measures for nutrient loading from the fields that are causing substantial loading (together with farmers);
- planning and possible establishment of buffer zones on fields;
- possibility and needs of building of wetlands, sedimentation ponds and a multipurpose ponds;
- survey of restoration of old settling and multipurpose ponds;
- survey of loading from cattle farms;
- survey of possibilities to reduce the diffuse loading from the densely populated areas;
- study on the applicability of the newest restoration and load reduction methods.

The last item might include such innovative approaches for dealing with eutrophication of inland waters as the use of magnetic nano and microparticles for lake restoration or applying new ecotechnological measures to lakes, for example, allowing greater water-level fluctuations (WLF) in lakes in lowland countries like the Netherlands; WLF are likely to allow more space for water, and may lead to improved water quality and higher biodiversity.

Selective and regulated fishing positively effects re-production of more valuable fish species. This could be achieved by following measures:

- biomanipulation methods (the deliberate alteration of an ecosystem by adding or removing some fish species);
- use of appropriate fishing/angling tackles;
- development of fish spawning shores.

Treatment of sewage water

The water plans require purification of sewage in a number of minor watersheds. The development of sewage treatment systems for small settlements and scattered properties should be foreseen. The following prioritization criteria for sewage treatment systems are recommended:

- The recipients with high vulnerability;
- The recipients with high quality requirements (lakes, etc.);
- Sewerage discharges in the upper parts of the streams (priority for up-streamers);
- Priority for those water bodies which have high potential for obtaining a good water quality status;
- Priority for those water bodies where restoration projects are going-on or planned.

The initial prioritization stage should be followed by the cost-effectiveness analysis. Outcomes of the cost-effectiveness analysis are used for a final prioritization.

Chapter 5 sources:

The River Restoration Centre. Working to restore and enhance our rivers. http://www.therrc.co.uk/why-restore

Strategies for a Sustainable River Basin Management – WATERSKETCH http://watersketch.tutech.eu/

From theory and plans to eco-efficient and sustainable practices to improve the status of the Baltic Sea – WATERPRAXIS http://www.waterpraxis.net/en.html

Chapter 6
Economic Methods and Measures Applied in Water Planning and Management

The use of economics is envisaged at a number of places within the WFD, from the preliminary analysis of current and future threats on water bodies, through to the assessment of objectives set and the best measures by which they can be achieved. Finally, economic instruments are a component of the programmes of measures themselves. The role of economics can best be understood by dividing it broadly into two categories: *economics as a contribution to decision-making* or *economic instruments as measures for meeting the WFD*.

Economic analysis will not be able to contribute meaningfully to decision-making unless it is based on and integrated with good technical analysis. For example, cost-effectiveness analysis requires a good understanding of the consequences of a range of measures, while the application of the polluter-pays principle requires analysing who is responsible for pollution and on what scale. Very few analyses performed to date for the WFD have managed this crucial integration.

The process of choosing measures and deciding on alternative objectives (derogations) will by necessity be an iterative process. If a programme of measures is judged as being disproportionately expensive, it will be necessary to review the programme of measures by removing the measures that are least cost-effective, or by choosing the next most cost-effective programme of measures. In a few cases it might be worth repeating the whole process.

6.1 Cost-Effectiveness Analysis

Cost effectiveness analysis (CEA) will be one of the key mechanisms used to select which measures will be used to achieve Good Status. Properly implemented, CEA should identify the best approaches to meeting Good Status and provide important support to innovative approaches. It does not attempt to compare the costs of measures with the potential benefits.

A wide range of different possibilities exist for achieving objective. CEA helps select among these possibilities and choose a programme of measures that need to be put into place to achieve Good Status in those water bodies at risk. It gathers information on the costs and effectiveness of individual measures (or package of measures), on how they interact with each other, it also identifies which combination of measures achieves Good Status at lower costs.

CEA becomes relevant when there are different ways to achieve Good Status. For example, we can reduce phosphates in a catchment area by building a water treatment plant or by focusing on land-use practices. CEA assesses which of these two approaches would most effectively achieve phosphate reduction at the least cost per unit of reduction.

It remains unclear what role CEA will have in assessing morphological improvements, for example the removal of weirs. With pollutants or issues around water quantity, there are likely to be a variety of measures that could be used to achieve the same objective, and CEA represents a tool for choosing between these alternative measures. This is less obviously the case with morphological change, where there might often be just a single restoration option.

The steps we need to take to come up with a cost-effective programme of measures can be summarised in a straightforward way:

1. Identify the nature and scale of the problem;
2. List potential measures needed to achieve Good Status;
3. Assess the costs of individual (or package of) measures;
4. Assess the effectiveness of individual (or package of) measures;
5. Combine costs and effectiveness information for ranking measures based on their cost effectiveness ratio;
6. Combine the most cost-effectiveness measures so as to reach Good Status.

Note that *water environmental costs* are not included in the CEA because they are the ones addressed by the measures under consideration. Programmes of measures – if effective – will achieve Good Status, and hence, water environmental costs will not arise.

As well as costs, any measures taken to achieve Good Status could result in non-water related benefits or adverse impacts (side-effects). Side-effects need to be recorded and be factored into the analysis. Non-water benefits might include recreation opportunities resulting from land use changes (e.g. buffer strips and habitat restoration to reduce to reduce diffuse pollution and sediment loading) or better landscapes resulting from changes in farming practices.

CEA is a complex process that requires many sources and types of information. Not all costs will be available in monetary terms. Equally, effectiveness of alternative measures cannot always be measured in the same units (for example, kg of Nitrates removed). As a result, data on costs and effectiveness will be in various forms, not always comparable and not always additive. In particular, non-water related environmental costs and side-effects are hardly ever estimated in monetary terms, whereas other costs are.

All this information needs to be made available to the decision-maker. The results of a CEA should usually be presented, therefore, as a ranking of cost-effectiveness, along with any relevant information which has not been integrated in the "cost" or the effectiveness side. There is a significant risk that costs and benefits which can't be expressed in monetary terms, including important social and environmental issues, will not be taken into account if only monetary measures are included in the final assessment.

Conducting CEA is costly and time-consuming. There may be an infinite number of solutions, or combinations of measures. Ironically, doing CEA for all of them would certainly not be cost effective. Therefore, we may need to simplify, in particular by screening out some measures. While screening out is important, there are again dangers that good measures may be screened out too early in the process on the basis of inappropriate criteria. If screening of measures is to take place, it should follow well-defined and objective criteria.

Good communication and proper training are crucial to the correct implementation of CEA. Equally, stakeholders play a key role in the CEA process. They not only provide essential information and ideas for solutions but their involvement in the measures appraisal process also ensures the success in the implementation of measures. Involvement of stakeholders needs to take place as early as possible in the implementation process. This needs to be supported by a transparent CEA process. Decisions taken on the screening, selection or non-selection of measures should be recorded and available so that they can be easily tracked.

6.2 Disproportionate Cost Analysis

Disproportionate cost analysis (DCA) can be used to justify alternative objectives. Well applied, it can ensure equitable, fair and even-handed implementation of the Directive. A DCA is not applied to all Programmes of measures, but only in certain cases.

The Directive envisages the use of DCA on four particular occasions, which can be considered in two categories. Where DCA justifies an alternative environmental objective this must be specified in the River Basin Management Plan.

- **Extended deadlines**. Extension of the deadline from 2015 for one or two further updates of river basin plans (i.e. until 2021 or 2027) is permitted where achievement of the objectives by 2015 would be disproportionately expensive (Art 4.4).

- **Less Stringent Environmental Objectives.** Less stringent objectives may be pursued where the achievement of Good Status objectives would be disproportionately expensive (Art 4.5) even with an extended deadline.

In these two cases, the costs of the proposed measure or measures are considered to assess whether they are compared disproportionate. Where costs are judged as disproportionate, alternative approaches to the achievement of the relevant environmental benefit should be investigated.

- **Designating Heavily Modified Water Bodies.** A water body may be designated asheavily modified when the beneficial objectives served by the modified characteristics cannot be met by alternative means that are not disproportionately costly (Art 4.3).
- **New Modifications**. New modifications that cause status deterioration are permitted when the beneficial objectives served by the new modification cannot be met by alternative means that are not disproportionately costly (Art 4.7). (Such new modifications must also satisfy a series of further conditions, including that they be of overriding public interest, and 'sustainable').

There are different ways in which cost disproportionality can be assessed, e.g. by comparing costs of existing measures with costs of supplementary measures required for reaching the environmental objectives of the WFD; by comparing the costs of measures with ability to pay, or by comparing total economic costs to overall benefits. There are also questions with regard to the level at which costs are deemed to be 'disproportionate' – and how disproportionality will be judged will play an absolutely central role in determining the extent to which significant improvements to the freshwater environment will be achieved. If relatively modest measures are judged as being 'disproportionate', the Directive may ultimately result in little action being taken.

Conventional economic analysis typically uses *cost-benefit analysis* (CBA) in evaluating decisions. CBA is a well-recognised technique with an established and rigorous methodology for comparing economic costs and benefits in monetary terms. Proposed projects receive approval only where benefits are judged to exceed costs. Because costs and benefits are compared to aid decision-making, DCA is in a way a modified form of cost-benefit analysis. However, unlike conventional CBA, DCA should allow for the inclusion of non-monetary information. In addition, in DCA there should not be a presumption that a proposal is rejected as soon as monetary costs exceed monetary benefits.

It is important that disproportionality tests are based on a comparison of some form of the costs and benefits of proposed measures. However, while the costs of the programme of measures might be comparatively easy to define, it is often harder to evaluate benefits precisely in a way that can be compared to costs. For example, where costs are largely financial while benefits are mainly social and environmental, attempts at a comparison are clearly not straightforward.

One approach often adopted within economics is to ascribe a monetary value to both costs and benefits, thereby providing a common basis for comparison. A range of approaches exist for placing a monetary value on environmental improvements. These assess both the value of ecosystem functions such as the provision of clean water, but also attempt to assess the value to society of the existence of healthy ecosystems in their own right. Thus, DCA should, therefore, include both monetary and non-monetary assessments of benefits.

6.3 Water pricing and the recovery of the costs of water services

The WFD requires that prices should take account of the costs of water services, including environmental and resource costs. WFD defines water services as: "all services which provide for households, public institutions or any economic activity: (a) abstraction, impoundment, storage, treatment and distribution of surface or groundwater; (b) waste water collection and treatment facilities which subsequently discharge into surface water. The WFD sets out a number of principles:

- **Application of the principle of cost recovery**. This principle suggests that prices should reflect the full range of costs involved in the provision of water and water services. Note that the Directive only requires member States 'to take account' of this principle.
- **Environmental and resource costs should be considered in assessing cost recovery**. Environmental costs are the costs of damage to the environment due to water services and water uses, while resource costs are the foregone values of alternative use of water. Both of these costs should be considered in cost-recovery and, therefore, pricing. For example, where abstraction causes significant damage, this should be accounted for in the price paid for that water service.
- **Ensuring adequate contribution of different water uses (disaggregated into at least agriculture, industry, households) to the costs of water services based on the polluter-pays-principle**. This principle implies that where different sectors are responsible for different costs, this should be reflected in

the prices paid by that sector. For example, where agriculture is responsible for nutrient pollution, the principle suggests that the agricultural sector should be responsible for the associated costs (e. g. a de-nitrification plant).
- **Ensuring that water-pricing policy provides adequate incentives for efficient use of water resources.**

These apparently technical requirements have profound implications for water management in many European countries. The Directive requires that these be achieved by 2010. The first implementation step with regards to cost-recovery and pricing is the characterisation of river basin districts. These should provide an inventory of the present status with regards to cost recovery and the incentive dimensions of current pricing.

It is important however to stress that the WFD does not require a full recovery of the costs of water services. In some cases, Member States can justify existing pricing policies on social, economic and environmental grounds. Overall, transparency in (i) who uses and pollutes, (ii) which services are put in place, (iii) what are their costs, and (iv) who pays for these costs, is the main objective.

It is clear that activities such as water abstraction and waste water discharge (and thus water supply and waste water services) have to be included in the definition of water services. Other water services such as those developed for flood protection (construction and maintenance of dykes), navigation (dredging of rivers and specific infrastructure built), hydropower (building and operation of dams) or agriculture (drainage and land improvements infrastructure) are also water services to which cost-recovery assessments can be developed.

According to the WFD, financial, environmental and resource costs are all to be considered in assessing cost-recovery of water services. Financial costs are the costs of providing and administering services, and can be broken down into a number of elements:
- *Operating costs*: all costs incurred to keep a facility running.
- *Maintenance costs*: costs for maintaining existing assets in good functioning order till the end of their useful life.
- *Capital costs*: costs of new investment expenditures and associated costs, depreciation costs and opportunity costs of capital (an estimate of the rate of return that can be earned on alternative investments).
- *Administrative costs*: administrative costs related to water resource management.

While these financial costs can be evaluated comparatively easily, there are greater challenges in assessing levels of environmental and resource costs.

- *Resource costs* are the costs of foregone opportunities that other uses suffer due to the depletion of the resource. For example, extensive abstraction for public water supply will prevent use of water for agriculture.
- *Environmental costs* represent the costs of damage that water uses impose on the environment and ecosystems. This may include lost production or consumption opportunities as well as non-use values.

Chapter 6 sources:

Esteban A., Le Quesne T., Strosser P. 2006. Economics and the Water Framework Directive. A User's manual. WWF & RSPB.

From theory and plans to eco-efficient and sustainable practices to improve the status of the Baltic Sea – WATERPRAXIS http://www.waterpraxis.net/en.html

Chapter 7
Tools Applied in Water Resource Planning and Management

7.1 Environmental monitoring of the surface waters

The objectives of environmental monitoring are: to track different pollutants, their disturbances and impact on the environment; to establish a reference for the determination of environmental quality; to form a base for planning, implementation and evaluation of protective measures; and to be a resource in comprehensive planning and survey possible impacts of new developments.

A rough classification of results, for example through using water quality criteria, gives an idea on the size and order of different environmental problems. In the planning it is also advantageous if the results are presented in a map. Information on investigations performed within the environmental monitoring can be obtained from different sources on national, regional and local levels. A general problem within most of the programs in the monitoring of freshwater is the large amount of background data necessary for interpretation of cause and effect connections.

Land use, in the form of hydrological interference in agriculture and forestry and the regulation of water courses, has a large impact on water resources in many areas. The environmental monitoring concerning conditions in freshwaters could involve following components.

Monitoring of transport in river mouths

The monitoring of transport in the river mouth enables a quantification of the transport from the elementary river basin to the surrounding areas. Statistics on land use, discharges and deposition, in combination with budget-model calculations, enable the performance of a source analysis.

Use of models, scenarios and predictions can be established and used to describe the sum of effects of different environmental protection measures or future development.

Time series in reference watercourses

This is done to follow the variations between years, the long-term development, to obtain references in time and space for regional and local investigations to describe the effects of the human impacts and thereby enable the interpretation.

Analysis of pressures and impacts at Sulejow Reservoir region in Poland

One of the most serious threats to the environment in the reservoir drainage basin is the insufficient technical infrastructure development and unsolved sewage management in the areas adjacent to the Sulejów Reservoir and those within the boundaries of the Sulejów Landscape Park. The average degree of cities and communities canalization in that area accounts for 10-15%. For comparison, a degree of the inhabitants' access to the sewage system accounts for over 80%. The analysed area requires sewage management to be urgently rearranged and adapted to the developed drinking water supply system.

Among other threats, the land management is one of the main causes of strong anthropopressure affecting biological diversity, landscape values and environmental condition of the areas around the Sulejów Reservoir. Communications availability and environmental

Table 7.1. Matrix of pressures and impacts for the Sulejow artificial reservoir
(Source: Zieminsk-Stolarska et. al. http://www.tandfonline.com/doi/pdf/10.1080/19443994.2013.768043

Sulejow Artificial Reservoir		Physico-chemical quality elements									Biological quality elements						Hydromorphological quality elements			
		Transparency	Temperature	Oxygen conditions	Conductivity	Salinity	Nutrient status	Acidification status	Priority substances	Other pollutants	Macrophytes	Phytoplankton	Planctonic blooms	Benthic invertebrates	Eutrophication	Coliform index	Hydrological regime	Morphology	River continuity	Tidal regime
Status of element		Moderate	Good	Moderate	Very good		Moderate	Very good	Good				Bad		Poor	Poor	Good			
Diffuse sources	Urban drainage			Moderate			Low						High		Moderate	Moderate				
	Agriculture diffuse	Low					Low						Low		Moderate					
	Forestry																			
	Other (birds habitat)																			
Point sources	Waste waters			Moderate			Low		Moderate				High		Moderate	Moderate				
	Industry								Low											
	Mining																			
	Contaminated lands																			
	Agriculture point								Low				Moderate		Moderate					
	Waste managment																			
	Aquaculture																			
	Manufacture																			
Abstraction	Potable supply																			
	Agriculture																			
	Industry																			
	Fish farming																			
	Hydro-energy	Low											Low		Low					
	Open cast coal sites																			
Morphological pressures	Flow regulation	Low											Moderate		Moderate		Low			
	River managment																Low			
	Coastal managment																			
	Other																			
Other anthropogenic pressure	Recreation						Low						Low		Low					
	Fishing/angling																			
	Climate changes	Low	Low	Low									Moderate		Low					
	Land drainage																			
	Exploitation of animals																			
	Introduced species																			
	Introduced diseases																			

Status of element
- Very good
- Good
- Moderate
- Poor
- Bad

Impact & Pressure
- Not present
- No effect
- Low impact
- Moderate impact
- High impact

Continued: Analysis of pressures and impacts at Sulejow Reservoir region in Poland

attractiveness make the region susceptible to the pressure of free land development. Leisure centres, camping sites and catering facilities attracting increasingly more tourists have been developed in large numbers. Free land development plans are so serious that arbitrary land divisions into small holiday plots take place. Excessive parceling up of land into small holiday plots accompanied with high-density housing can lead to the real threat to the quality and condition of the environment in the area of the Sulejów Reservoir and the Landscape Park.

The environmental threats are also caused by farming management. Its impact on the environment is associated with ill-equipped farms that lack the appropriate technical infrastructure and do not apply good agricultural practices, as well as the intensification of agricultural production.

Another significant obstacle to the correct management of the reservoir is the complex system of governance. This applies both to areas around the lake and to reservoir waters. In addition, insufficient funds provided for the needs of municipalities (expansion of water and sewage system, building and modernization of sewage treatment plants or building ecotone zones) significantly delays the investments that are crucial for maintaining good reservoir water quality.

Monitoring of species

The objective of this program is to follow the development of stocks or populations of some specific freshwater species worth protecting. The monitoring of species is an important complement to regional or local environmental monitoring. The species of interest usually have a local distribution.

Monitoring of limnological national interests

Interest in nature conservation allows us to select some waters for their limnological values. The objective of this program is to check the limnological values that were the basis of the national interest.

Habitat mapping

The objective of this program is to monitor the existence of specific freshwater habitats using extensive and comprehensive methods. Some habitats are very important for the biodiversity of untouched patches of running water, lakes with a specific flora or fauna, transition forms between wetlands and open waters, etc.

7.2 Matrix to assist the analysis of pressures and impacts

At present there is no single tool capable of performing a complete pressures and impacts analysis for all types of water bodies, and it is very unlikely that such a tool will eventually exist. Therefore, this guidance describes matrix that considers specific anthropogenic pressures and their impacts on physico-chemical, biological and hydromorphological qualities of the water body.

Before using matrix you must be sure that it fits for the purpose for which you want to use it. You should have a clear objective defined, i.e. what questions you want to answer. The value of local knowledge and experience should not be underestimated or dismissed in favour of a more formal process of decision making. Those undertaking the analyses should consider involving stakeholders since they are likely to introduce complementary knowledge and experience.

The corresponding case study focuses on example of how to use certain matrix with the aim to simplify the approach of the analysis.

7.3 Application of Geographic Information Systems

Material cycling in small catchment areas is expected to give a necessary background information for modeling and management of agricultural and forestry regions. A systematic monitoring of the sources of phosphorus, nitrogen and organic pollution is an integral part of a GIS use in the catchment areas of small rivers. The effects of nutrient loading on water quality can be estimated during any given discharge value.

Usually GIS software is applied for performing hydrological and water quality related computation based on river catchment monitoring data. Typically, GIS-data include watershed boundaries, watercourses, Digital Elevation Model (DEM) and land use classification data.

The software creates a flow layer defining flow directions for all points in the given drainage basin area. This allows outlining the upper catchment of any point of the river channel network. The discharge in every point can be computed from flow measurements in the area.

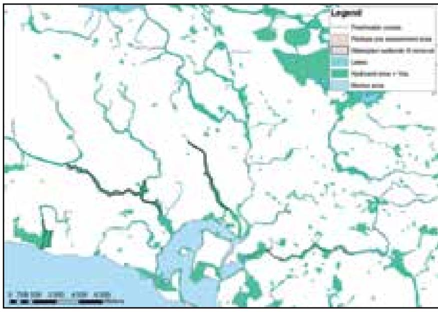
Some possible applications are described below:

- Estimation of the total loading of nitrogen and phosphorus and the proportion of different sources of this loading;
- Estimation of the changes in nitrogen and phosphorus concentrations in the river channel network because of the loading;
- Identification of the most problematic areas of influence in the river channel network;
- Estimation of the effect of the changes in land use (e.g. clear-cutting and soil cultivation) on the total loading and nutrient concentrations;
- Estimation of the effect of water pollution control (e.g. wetlands) on the total loading and nutrient concentrations;

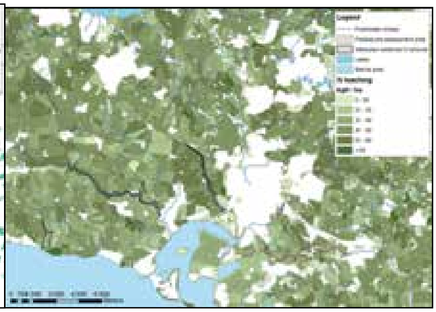
- Location of possible sites for wetland constructed on peat land;
- Defining the drainage areas for small lakes or streams;
- Estimation of the erosion sensitivity of ditches.

Mapping nitrogen (N) risk management at Fladsaa area, Denmark

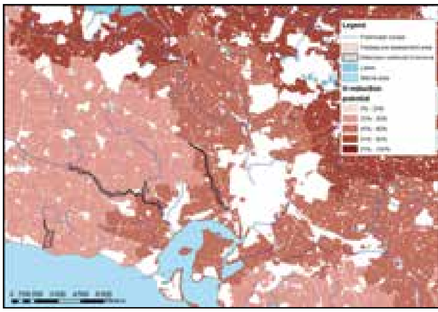
N-risk mapping is a tool developed by NERI and faculty of Agricultural research at Aarhus University. This tool allows identification of high risk nitrogen leaching zones and loads to lakes and coastal areas. The risk is mapped at field block level and combines a model based estimation of the N leaching from the root zone with estimates for the N removal from the bottom of the root zone to the marine environment, i.e. the retention is calculated. The N risk map can be used to model different measures, including wetlands at agricultural soil as well as The GIS-based tool estimates N-indexes. N-index can be well suited for screening large areas because of its low demand for input data and manpower compared to mechanistic, process based models. *Source*: http://www.waterpraxis.net/



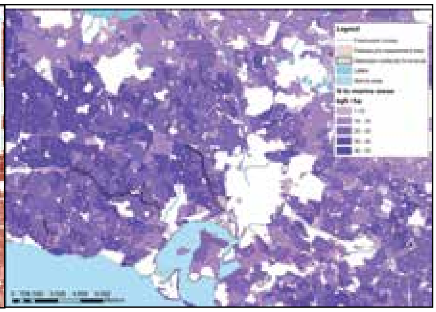
A. Potential areas for wetland restoration



B. Leaching of nitrogen from agricultural areas



C. Potential for nitrogen reduction from root zone to coastal waters



D. Nitrogen contribution for agricultural areas, combined maps B and C

7.4 Computer based Decision Support Systems for river basin management

The management of river basins deals with a variety of user functions and environmental aspects. In the past water resources and water quality used to be carried out separately. Increasingly, the approach to both water resources and water quality management are integrated to enable the assessment of impacts of managerial actions on the quality of surface water, sediments and biota in rivers. A decision support systems (DSS) can be used to support such a complex and integrated approach. The model system that is used for river basin management structures the required data, calculates the impact of intended measures and strategies to present results in a clear way. The river basin oriented computational framework for a specific river basin might include the following main models:

- The hydrological model to simulate the surface water balances and to allocate surface water flows in the network representation of the river basin;
- The water quality model to calculate the time variable transport of pollutants including all relevant water quality processes;
- The cost model to evaluate and assess the overall yearly cost of water quality measures. In particular the measures to reduce the wastewater discharges from point sources of pollution in the river basin;
- The risk assessment model to evaluate the ecotoxicological effects of the deterioration of surface water quality.

The application of decision support system provides decision makers and planners with an effective tool. Furthermore, experience has shown that it acts as an excellent vehicle for discussion and the development of the consensus. It gives possibility for better understanding and structuring of complex issues related to the decision. The process of decision making needs to incorporate the participation of a representative group of individuals who have a direct stake in the outcome of the decisions.

Chapter 7 sources:

Andersen, H.E. and B. Kronvang. 2006. Modifying and evaluating a P index for Denmark. Water, Air and Soil Pollution 174: 341-353.

Kliucininkas L. and Martuzevicius D. 2007. Application of Web-HIPRE decision support tool for a sustainable development of Minija river basin. Reports of Finnish Environmental Institute 12, p. 81-84.

Strategies for a Sustainable River Basin Management – WATERSKETCH http://watersketch.tutech.eu/

From theory and plans to eco-efficient and sustainable practices to improve the status of the Baltic Sea – WATERPRAXIS http://www.waterpraxis.net/en.html

Web-HIPRE decision support tool for a sustainable development of Minija river basin

Introduction

Minija river basin is located in the North-western part of Lithuania. The length of Minija river is 202 km and the catchment area is 2942 km^2. Lakes cover only 0.6 percent of the area of the basin, while bogs and marshes cover 5.2% of the catchment area. The share of forested area in the Minija River basin is about 21%. Southern part of Minija river basin, Nemunas river delta and Curronian lagoon make a unique natural water system.

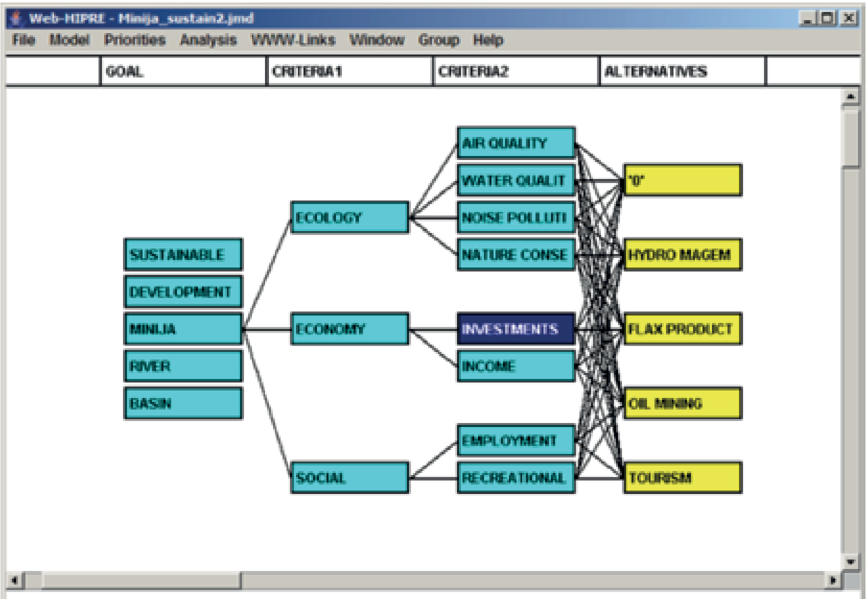
Natural delta complex is important vicinity for about 300 species of birds from which 40 species are included into the Red Book of Lithuania.

Agriculture has been prevailing in the rest of the river basin till the middle of 1990s. Apart from agriculture, most local inhabitants are also engaged in fishing. In particular fishing is popular in the southern part of the basin, where river enters the Curonian lagoon. New activities like ecological farming and water tourism are emerging in the region. Water tourism and agricultural tourism are being developed at the coastline of the Curonian lagoon and in the Nemunas Delta Regional Park. Agricultural tourism has also strong potential in the area of Zemaitija National Park. Tourism and related activities are very important to the local economy.

Structuring Decision Support Procedures

Goal

This case study provides considerations towards environmentally sound, economically balanced and socially agreeable development of Minija river basin. Decision support procedure was performed by applying Web-HIPRE software tool (URL: http://www.hipre.hut.fi/). The software was developed at Helsinki University of Technology.



A. Value-tree for sustainable development of Minija river basin

First order criteria
The general concept of sustainability addresses balance between social, economical and ecological development (Nath et al, 1996):

- socially desirable, fulfilling people's cultural, material and spiritual needs in equitable ways;
- economically viable, paying for itself with costs not exceeding income;
- ecologically sustainable, maintaining the long-term viability of supporting ecosystems.

Minija river basin example provides equal manifestation for all three dimensions of sustainability.

Second order criteria
Identification of relevant criteria was approached by considering local conditions in the Minija river watershed as well as available sources of information (see Fig. A). Ecological/environmental characteristics refer to surface and ground water quality, possible increase of ambient air and noise pollution. Conservation of wildlife and biodiversity was considered as one more criteria important to support ecological sustainability. Considerations towards economical development of the Minija river basin were based on balance between hypothetical investments and incomes. Degree of employment and fulfilment of recreational needs of local people and visitors were decided to be essential criteria for social development of the river basin.

Alternatives
The experts, familiar with the Minija river basin, were asked to make a discussion in order to come up with the suggestions relevant for the development of the region. It was suggested that present situation or "0 alternative" would make a benchmark for predictive scenarios. Water resource management including reconstruction or building up of small hydropower stations was included into the alternative "Hydro management". Traditionally agriculture is significant activity in the river watershed. Flax fibre production and processing have opportunity contributing to the long-term economical and social development of the region. As a result, experts have suggested alternative "Flax production". Today Minijos Nafta is the leading oil producing company in the Baltic States. Currently Minijos Nafta is engaged in an active resource exploration programs and it makes prerequisites for further expansion of oil extraction activities. Thus, the experts have considered that "Oil extraction" alternative would make an important share to the local economy. Experts have concluded that unique nature, rich wildlife and vital ethnographic traditions have high potential for water and agricultural tourism development in the Minija river watershed, especially in its southern part. This alternative was named "Tourism".

Results of the analysis
The decision support analysis has provided considerations and major trends towards sustainable development of the Minija river basin (see Fig. B). Results of the analysis have showed that the highest priority was given to the "Tourism" alternative. This alternative is more than two times higher if compare to the "0" alternative, which presents "status quo" situation. The major input to the alternative "Tourism" was given by the social criterion. The next priority was "Hydro management" alternative. Here the prevailing criterion was ecological / environmental concern. The "Oil extraction" alternative was prioritized as the third one. The dominant criterion in this alternative was economical interest, while ecology and social issues had comparatively low impact. The lowest priority was given to the "Flax production" alternative which was slightly higher as to compare to the "0" alternative.

Discussion
The application of Web-HIPRE decision support system provides decision makers and planners with an effective tool. Furthermore, experience has shown that it acts as an excellent vehicle for discussion and the development of the consensus. It gives possibility for better understanding and structuring of complex issues related to the decision. Analysis of development scenarios has revealed that some of the supposed activities in the Minija river basin are conflicting. Thus, authors do not considered simultaneous implementation of several supposed activities, but compared 'pure' development scenarios. Differently than Minija river basin case study, Web-HIPRE could support decisions on complex implementation of activities, however it would require further quantitative assessment of planned activities.

Source: http://watersketch.tutech.eu/

B. Composite analysis graph of Minija river basin development

Chapter 8
Public Participation under the Water Framework Directive

"If you use a tap and a toilet you are engaging in water management. You are dependent upon extracting high quality water for personal usage and, ideally, consciously managing that water to achieve minimum impacts upon discharge." - from "Theory of Public Participation and Aquatic Awareness Education", Coomhola Salmon Trust, 2006.

Policy makers widely acknowledge the importance of public participation. The Rio Declaration on Environment and Development (1992) states that environmental issues are best handled with the participation of all concerned citizens at the relevant level. Following this, the Aarhus convention of United Nations (1998) calls for access to information, public participation in decision-making, and access to justice in environmental matters. As a reflection of all the above mentioned, the WFD calls for public participation (PP) in water management: "the success of the Directive relies on close cooperation and coherent action at community, Member state and local level as well as on information, consultation and involvement of the public, including users". The Directive refers to involvement of both the *general public* and *interested parties* (more commonly used as *stakeholders*). The 'general public' can be defined as "one or more natural or legal persons, and, in accordance with national legislation or practice, their associations, organizations, or groups". The term 'stakeholders' refers to "any person, group, or organization with an interest or 'stake' in an issue, either because they will be directly affected or because they may have some influence on its outcome…". Three forms of PP are mentioned in the WFD: Information supply, Consultation and Active involvement. The first two are to be ensured by Member States and the latter is to be encouraged.

There are different methods that can be used for information supply (newsletters, internet, briefings, information repositories, etc.) consultation (interviews, polls and surveys, open houses/exhibitions, public meetings, etc.) and active involvement (advisory committee, task forces, citizens' jury, working conference, etc). The Directive does not elaborate on this issue, and the choice of methods is left to the authorities in Member States. Methods should suit the relevant target group and make public involvement accessible and attractive.

Information supply entails public access to information. It is a one-way relationship in which authorities produce and deliver information to the public. It can be passive - access to information on request by the public, and/or actively delivered by the authorities to the public. Strictly speaking, the Directive only requires access to background information and no active distribution of information: “on request, access shall be given to background documents and information used for the development of the draft river basin management plan”. Active distribution of information, however, is essential for meaningful participation.

The WFD does not mandate the exact form of PP to be taken by Member States. It does, however, give instructions for consultations: “Member States shall insure that for each river basin district they publish and make available for comments to the public, including users…” (European Union, 2000/60/EC). This implies that the public should be consulted during the preparation of the River Basin Management Plan. However, the first document is more about procedure (planned-steps) than about content (of implementing the Directive). Thus, the minimum required aims only at two stages in the planning process. As the public can be consulted in more steps and in further forms, this requirement should be considered a minimum requirement. The Directive also requires that “Member States shall encourage the active involvement of all interested parties in the implementation of the Directive, in particular in the production, review and updating of the river basin management plans”.

This requirement is general and the matter is left to be organized and adapted to national, regional and local circumstances.

There are two main reasons for an extension of public participation. One is that the decisions on the most appropriate measures to achieve the objectives in the river basin management plan will involve balancing the interests of various groups. The second concerns enforceability. The greater the transparency in the establishment of objectives, the imposition of measures, and the reporting of standards, the greater the care Member states will take to implement the legislation in good faith, and the greater the power of the citizens to influence the direction of environmental protection, whether through consultation or, if disagreement persists, through the complaints procedures and the courts. Achieving the WFD’s objective will require more involvement of citizens, interested parties, non- governmental organizations.

A SWOT analysis undertaken by on the PP reveals that the most important *Strength* of including public participation in the planning and decision making process is that the local people usually know their local area better than anyone else and they can this provide detailed insight into local phenomena. In this way, incorporation of local knowledge in the decision making process will be a major strength. On the other hand, the major *Weaknesses* are that public generally does not possess the required knowledge to understand the generally complicated matters related for example environmental impact assessment balancing environmental protection against mainly economic matters. Furthermore, the public does not have all the relevant information. Further, as stated in both the Aarhus Convention and the Agenda 21 the real *Opportunity* for public participation lies in making the citizens more accountable for decisions made by given responsibility. The real *Threat* for the participatory process is related to the antipathy against the politicians and other decision-makers. The potential feeling among ordinary citizens of why they should be involved, if their input would be simply be ignored or even worse misused or distrusted, should not be underestimated.

It is important to recognize that different components of “the public” will have their own views, needs, priorities and expectations. In order to be successful, information, consultation and participation processes need to be tailored for particular target group. These may include: the general public, NGOs, sectoral stakeholder groups within a river basin or sub-basin (e. g. farmers associations), and local residents/water customers. Special interest groups might be expected to participate at a more strategic level, e. g. through representation in river basin advisory committees, whereas local communities are more likely to seek and value participation at the field/action programme level. Intelligent targeting of interest groups can also help to reduce the danger of consultation fatigue where stakeholders feel overwhelmed by information and perceived bureaucracy.

The river catchment action plan serves as an instrument for presenting and balancing different public interests and for promoting a sustainable and multiple usages of the water and land. The work with action plan also provides good opportunities for citizen dialogue. The levels and methods of public participation in preparation and management of river basin action plan are summarized in Table 8.1. (adapted from Mostert 2003).

Chapter 8 sources:

Hophmayer-Tockich, S. 2005. Public Participation under the EU Water Framework Directive – processes and possible outcomes: A preparatory paper for the NOLIMP workshop on public participation and cost effectiveness analysis. In: NOLIMP workshop on public participation and cost- effectiveness analysis.

Mostert, E. 2003. Conflict and Co-operation in the Management of International Freshwater Resources: A Global Review. Paris, UNESCO.

Mostert E. 2003. The challenge of public participation. Water Policy 5, 2: 179-197.

Table 8.1. Public participation, levels and methods

Level of participation	Public participation methods
1. Information The public is provided with or has access to information	1. Leaflets and brochures 2. Mailings 3. Use of the media: press releases, press conferences 4. Information centres 5. Repositories (other than 4, e.g. libraries and city halls) 6. (Travelling) exhibitions 7. Information hotlines/ contact persons 8. Open house 9. Field trips 10. Briefings (at meetings of residents' associations, women's clubs, etc.) 11. Internet and other ICT tools 12. Cultural events (e.g. street theatre, especially for raising awareness)
2. Consultation The views of the public are sought	13. Reply forms 14. Opportunity to comment in writing 15. Public hearings and meetings 16. Interviews 17. Opinion polls 18. "Stakeholder analysis" 19. Gaming 20. Internet discussions 21. Advisory commissions/ boards, focus groups 22. Non-binding referenda Methods 4, 6, 7, 8, 9, 10 and 11 could be used too.
3. Discussion Real interaction takes place between the public and government	23. Small group meetings ("workshops", "charrettes", "coffee meetings", "round tables", "study circles","brainstorm sessions", "planning cells", "citizen juries",etc.) 24. Large group meetings involving splitting up into smaller groups and/ or rotation between front benches and back benches or between subgroups (e.g. working groups, "Samoan circle", "open space meetings", carrousel) 25. Virtual (Internet) discussions Methods 8, 9, 10, 11, 19 and 21.
4. Co-decision making The public shares decision-making powers with government	26. Negotiations, e.g. resulting in a "voluntary agreement" 27. Stakeholders represented in governing bodies 28. Corrective referenda and all binding referenda initiated by government Some of the meeting formats mentioned under 23 and 24.
5. Decision-making The public performs public tasks independently	29. Water users' associations and other NGOs performing public functions 30. Popular initiatives Some of the meeting formats mentioned under 23 and 24 .

Chapter 9
Case Study I: Nemunas River Basin District, Lithuania

9.1 Main characteristics

For greater convenience of water and water resources management, river basins in Lithuania have been integrated into four river basin districts (RBDs): Nemunas, Venta, Lielupe and Dauguva (Figure 9.1), for which river basin management plans will be prepared. All of them are international basins.

The Nemunas River Basin District (RBD) comprises the Lithuanian parts of the Nemunas and Prieglius River basins and of the Curonian Lagoon (Kuršių marios), as well as the Lithuanian Coastal Rivers Basin, plume of the Curonian Lagoon in the Baltic Sea, and coastal waters of the Baltic Sea. The Lithuanian

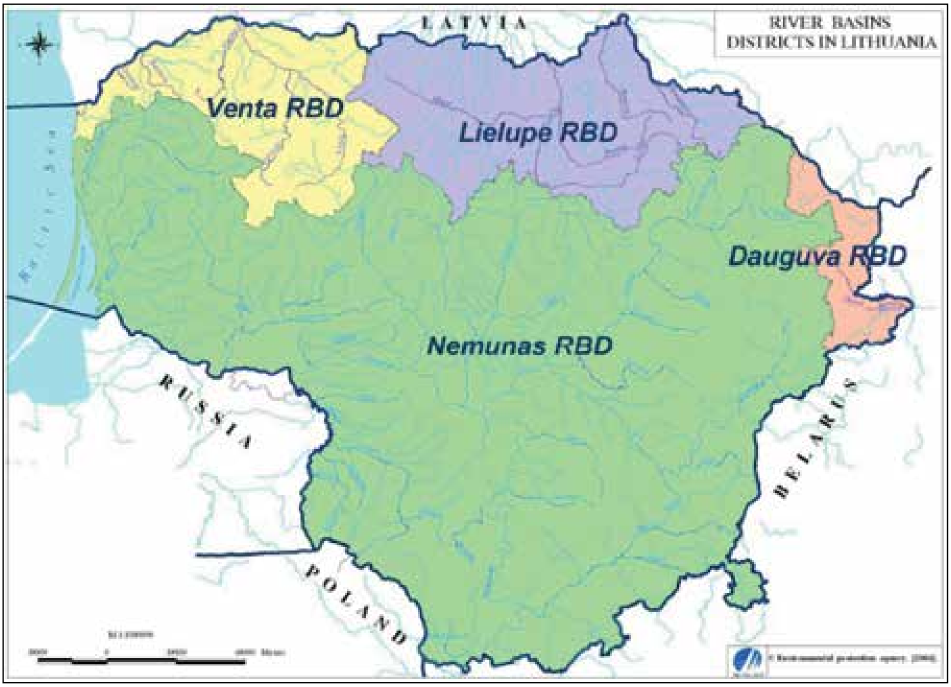


Figure 9.1 River basin districts in Lithuania

Coastal Rivers Basin and the Prieglius River Basin were assigned to the Nemunas RBD for the reason of relatively small areas of their catchments as compared to the Nemunas River Basin.

The Nemunas River Basin lies at 56°15‘-52°45‘ N and 22°40‘-28°10‘ E. The total length of the river is 937 km, and the basin area constitutes 97,928 km^2. The Lithuanian part of the basin covers the area of 46,626 km^2. The Nemunas Basin drains the territories of Belarus, Lithuania, Russian Federation (Kaliningrad Region), Latvia (only about 100 km^2), and Poland. The Prieglius River Basin occupies the area of 15,500 km^2, of which only 88.4 km^2 belong to Lithuania. The area of the Lithuanian Coastal Rivers Basin is 1,100 km^2. The resulting total area of the Nemunas RBD in Lithuania (excluding the coastal and transitional waters assigned thereto) is 47,814 km^2. The total area of the Nemunas RBD, including the transitional and coastal waters, is 48,443.7 km^2.

According to Nemunas RBD Management Plan, 584 water bodies falling within the category of rivers, 276 lakes and ponds with the surface area over 50 ha, 12 groundwater bodies, 4 coastal water bodies and 2 transitional water bodies have been identified. It has been established that at present the requirements of high or good ecological status or good ecological potential are met by 240 rivers with the total length of 4,556 km (41% of the total length of all the water bodies in the category of rivers) 186 water bodies in the category of lakes (67% of the total) and ponds larger than 50 ha satisfy the requirements of good ecological status or good ecological potential. 9 groundwater bodies are at good chemical and quantitative status. Other water bodies – rivers, lakes, ponds, transitional and coastal waters – are classified as worse than good status.

9.2 Status of water bodies in the category of rivers

Out of 584 water bodies falling into the category of rivers 54 water bodies with the total length of 1,173 km were identified as Heavy Modified Water Bodies (HMWB), and 4 water bodies with the total length of 40.2 km are artificial water bodies.

The assessment of the ecological status of water bodies (Figure 9.2) revealed that the requirements of high ecological status are met by 102 water bodies within the Nemunas RBD, the total length of which is 1,935 km. This accounts for about 17% of all water bodies in the category of rivers. 135 water bodies accounting for almost 23% of all bodies are at good ecological status. The total length of water bodies classified as being at good ecological status equals to 2,589 km. The largest group of water bodies within the Nemunas RBD is the one where the ecological status is classified as being moderate. Such water bodies total to 258,

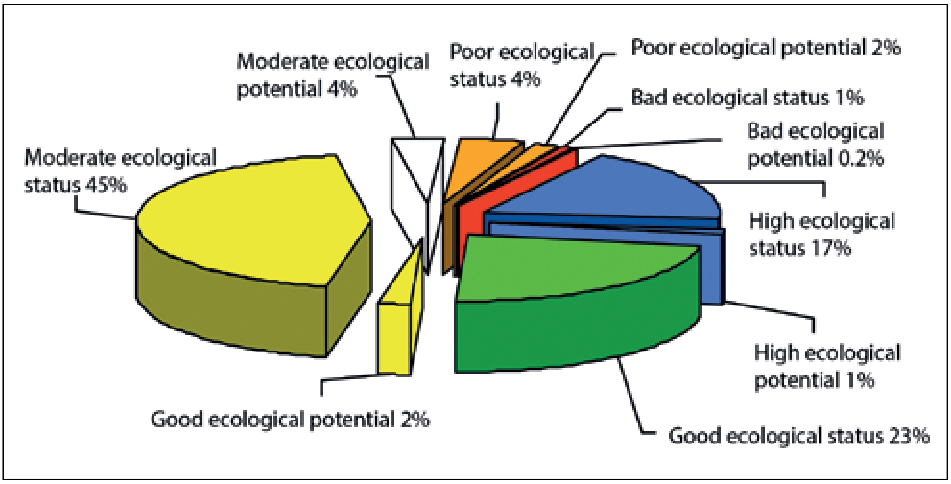


Figure 9.2. Ecological status and ecological potential assessment results for water bodies in the category of rivers in the Nemunas RBD

or 44%, and their total length is 3,955 km. Water bodies rated as having poor or bad ecological status constitute a minor part in the Nemunas RBD. Poor ecological status was identified in 26 water bodies with the total length of 466 km, and bad ecological status – in 5 water bodies with the total length of about 38 km. Accordingly, water bodies identified as having poor ecological status account for mere 4% and those having bad ecological status – about 1% of the total number of water bodies.

Maximum ecological potential was identified in 8 water bodies in the Nemunas RBD which are attributed to the group of HMWB. These water bodies accounts for about 1% of the total number of water bodies, and their total length is 151 km. 13 water bodies in the Nemunas RBD, or 2%, with the total length of 189 km are identified as having good ecological potential. 22 water bodies identified as HMWB are classified as having moderate ecological potential. These bodies account for 4% of the total number of water bodies, and their total length is 623 km. Poor ecological potential was found in 10 water bodies, which accounts for 2% of the total number of water bodies within the Nemunas RBD, and their total length is 207 km. There is only 1 water body rated as having bad ecological potential, and its length is 1.8 km.

The ecological potential of three artificial water bodies with the total length of 32 km is deemed to be maximum, one artificial water body with the length of 8 km was classified as being at moderate ecological potential.

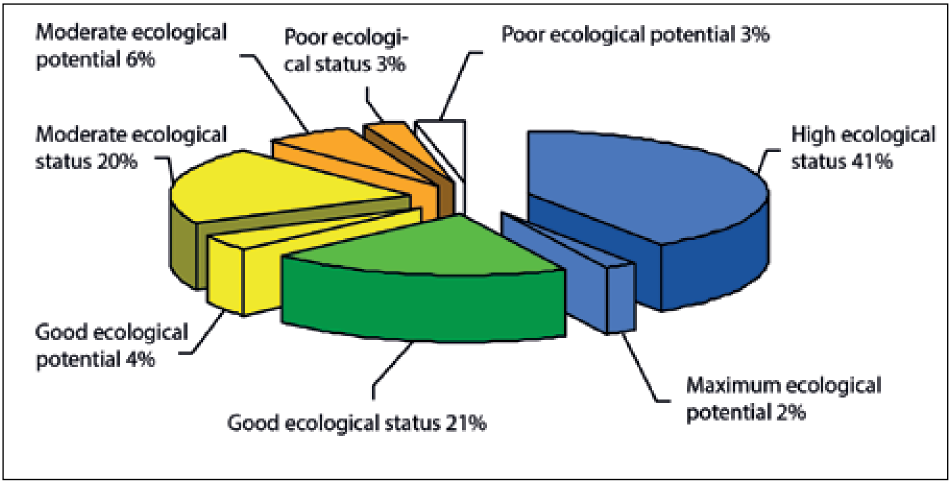


Figure 9.3. Ecological status and ecological potential of lakes and ponds in the Nemunas RBD

9.3 Status of water bodies in the category lakes and ponds

The ecological status of lakes in the Nemunas RBD was assessed on the basis of the following three information sources:

- national monitoring data;
- data presented in the study *Identification of Lithuanian lakes subject to restoration and preliminary selection of restoration measures for these lakes for improvement of their status*;
- mathematical modelling results.

When classifying the ecological status of lakes and ponds, priority was given to the national monitoring data, that is, in case of availability of national monitoring data on indicators of the ecological status of a lake or pond, the water body was attributed to the status class indicated by the monitoring data, meanwhile the modelling results and the findings of the study were not taken into consideration. The modelling results were used in determining the ecological potential only if no monitoring data was available.

An assessment of the ecological status and ecological potential of lakes and ponds (Figure 9.3) showed that at present 112 water bodies in the Nemunas RBD are meeting the requirements for high ecological status, 57 water bodies are at good ecological status, 56 – at moderate, and 8 – at poor ecological status. Maximum ecological potential was determined in 6 water bodies, good ecological potential was observed in 11, moderate – in 17, and bad ecological potential – in 9 bodies of water.

Monitoring of hazardous substances was conducted only in lakes and ponds of the Nemunas RBD where exceedance of the maximum allowable concentrations of these substances had been expected. Measurements show that concentrations of hazardous substances in monitored lakes and ponds do not exceed the established environmental quality standards, that is, all of them are at good chemical status. Consequently, it is assumed that good chemical status has been achieved in all water bodies in the category of lakes in the Nemunas RBD.

An assessment of the ecological and chemical status of water bodies in the category of lakes and ponds in the Nemunas RBD demonstrated that good status or good potential has been achieved in 186 water bodies in the said category, meanwhile 90 ones are failing such status.

9.4 Status of groundwater

In 2008, the national groundwater monitoring was conducted under the National Environmental Monitoring Programme 2005-2010.

Groundwater samples were taken only in the shallow aquifer, once a year, in April-May. 120 samples were taken for a brief chemical analysis and identification of biogenic elements and COD. The elements analysed in the water samples were as follows: general chemical indicators (total hardness, index of permanganate and bichromate), the main anions (Cl, SO_4, HCO_3, CO_2), cations (Ca, Mg, Na, K), and biogenic components (NO_2, NO_3, NH_4, PO_4). The data obtained characterises the chemical status and quality of shallow groundwater which is formed under different natural and anthropogenic loads. Also, 11 samples were taken for the analysis of chloro-and phospho-organic- and triazine-pesticides. The pesticide analysis results showed that there are almost no pesticides in shallow groundwater under conditions of diffuse pollution. The concentrations of all pesticides in ten samples were lower than their detection limit.

9.5 Programme of measures

Having assessed the current status of water bodies, natural and anthropogenic reasons for this status and established criteria for achieving good status, as well as analysed pressures of economic activity and their impacts on water bodies identified as being at risk of failing to achieve good status by the deadline (hereinafter – water bodies at risk), the Environmental Protection Agency and the Lithuanian Geological Survey has drawn up Programme of Measures for the Nemunas RBD. The Programme analyses the effects of the basic measures and proposes supplementary measures which are necessary in order to achieve good status for water bodies.

The *basic measures* include the implementation of all the measures, actions and programmes which have already been envisaged in water legislation and financed or included in financing programmes (construction of wastewater treatment facilities in agglomerations with a p.e. of more than 2000, installation of manure storage facilities on large farms, compliance with recommendations of good agricultural practice, solution of drinking water quality problems, etc.).

Supplementary measures are proposed for those water bodies where the basic measures are not enough to achieve good status. Supplementary measures comprise the improvement of the operation of the existing wastewater treatment facilities, mandatory and voluntary (optional) measures aimed at reducing adverse effects of agricultural activities, research intended to specify pollution sources and/or the environmental effect of the measures being implemented, feasibility studies examining pollution causes, as well as legal, educational, remedial and other measures.

The analysis of the state of the environment upon the implementation of the basic measures by means of modern technologies (mathematical-computational models) allowed assessing the effects of their implementation on the status of water bodies. The analysis revealed that the basic measures will not improve the status of water bodies significantly. The main cause lies in the fact that most large agglomeration (with a p.e. of more than 2000) which are subject to these basic measures (most of these measures are related to the development or reconstruction of water supply and wastewater systems) already comply with the wastewater quality requirements. In fact, the allowable concentrations are still exceeded in discharges from certain agglomerations, but usually only slightly. Moreover, wastewater dischargers usually release wastewater into large rivers which are capable of diluting discharges.

The implementation of the basic measures aimed at reducing agricultural impacts which are mainly related to the requirements of the Nitrates Directive will not make any significant contribution to the improvement of the status of water bodies either. This is due to the fact that 14.5% of all livestock are already kept on farms having manure storage facilities, thereby not damaging the environment. This number reaches 34% in some basins and sub-basins within the Nemunas RBD. The implementation of the key measures envisaged in the Nitrates Directive should increase the number of livestock kept on farms having manure storage facilities within the Nemunas RBD to 48%.

It has been established that even after the implementation of the basic measures, there will be 320 rivers with the total length of 5,267 km, 64 lakes, 26 ponds, 3 groundwater bodies, 4 transitional water bodies and 2 coastal water bodies within the Nemunas RBD still at risk of failing to achieve good status by 2015. With the view to improve the ecological status of these water bodies, supplementary measures are envisaged in the Programme of Measures.

Supplementary measures have been considered and proposed for the following main areas:

- reduction of an impact of household wastewater;
- mitigation of impacts of agricultural pollution;
- mitigation and regulation of hydromorphological changes;
- improvement of the status of lakes and ponds;
- reduction of an impact of recreation;
- improvement of the status of groundwater wellfields;
- improvement of the status of coastal and transitional waters;
- reduction of an impact of industrial enterprises.

The programme of supplementary measures encompasses measures which can be grouped together on the basis of the following aspects:

- type of the measure: measures can be legal and administrative; technical (investments); various studies, educational and pilot projects, and economic measures;
- application scope of the measure: measures can be national; applicable to problematic areas; applicable to specific areas only;
- time of application;
- sector of economy responsible for the implementation of the respective measure: measures can be implemented by national institutions, municipal administrations, including water supply companies, and the private sector (farmers, owners of hydropower plants, industrial enterprises).
- In addition, supplementary measures can also be selected according to the type of water bodies (lakes, rivers, transitional and coastal waters) and individually for certain specific pollution types (like pollution with hazardous substances).

Having implemented supplementary measures, good water status will be achieved only by 56 river water bodies and 1 lake by 2015. However, these measures will help to maintain the current high or good status and/or good potential in 240 water bodies falling within the category of rivers and 186 water bodies falling within the category of lakes, as well as the current good chemical status in 9 groundwater bodies and good qualitative status in all 12 groundwater bodies, and will also prevent deterioration of status in transitional and coastal waters.

Supplementary measures have been prioritized by settung out *mandatory measures* which are necessary for the whole of Lithuania and will contribute to pollution prevention and the implementation of the polluter pays principle. Other measures are *optional*, but compensatory mechanisms should be foreseen to support their implementation. Preconditions for achieving the set objectives include well-formulated conditions for the granting of support, attractive compensations and control over the implementation of measures.

Supplementary measures have been chosen on the basis of such indicators as *effectiveness* and *applicability*. The agricultural sector was most favourable for such analysis since the list of potential measures identified for the agricultural sector was longer than necessary to achieve the objectives. Measures in the agricultural sector for every problematic basin were chosen on the basis of the ratio between the pollution reduction effect of a particular measure (e.g. reduction of kgN per hectare) and the costs of that effect. Relatively cheapest measures are proposed to be taken in the first place. Where that measure, taking into account the potential area of its application, is not sufficient, other more expensive measures are further suggested.

Two alternative pollution reduction techniques have been proposed in the area of pollution reduction from wastewater treatment facilities. The first technique is based on a wider application of mechanical/automatic measures which are more power consuming, but ensure higher reliability of treatment and may be controlled as needed. The second one is based on natural measures which are energy efficient, but require a larger area, and the treatment process is more difficult to control. Costs have been calculated according to average prices. In each specific case, selection of a technique for a particular settlement is subject to detailed local studies and the analysis of its applicability.

Measures aimed at mitigating hydromorphological changes have been chosen according to specific proposals by technical experts. There have been no alternatives to the calculation of costs in these cases. However, the costs of one measure – renaturalisation – will be known after study (pilot) projects which are proposed in the first phase of the implementation of the Management Plan.

Along with the mentioned measures, it is important to take supportive measures, namely, education and information, as well as control measures. Even though they do not produce direct effects, they are very important in implementing other measures. Their implementation is recommended throughout the whole territory of Lithuania, focusing on areas affected by significant pollution from agriculture or wastewater treatment facilities.

The implementation of the basic and supplementary measures will still fail to achieve good status in a number of water bodies. The extension of the deadline for achieving water protection objectives will be requested in respect of 264 river bodies, 63 lakes and 26 ponds, 2 coastal water bodies, and 4 transitional water bodies.

Upon the accomplishment of the tasks set for the first stage, the level of achievement of water protection objectives will be measured. The monitoring and assessment of developments in the status of water bodies to be carried out in the first stage of the implementation of the Programme will help to better understand the objectives to be pursued and the tasks to be set in the second and third stages. Tasks for the second stage will be set depending on the actual outcomes of the first phase, while tasks for the third stage will be based on the results of the first two stages.

The Programme of Measures will be updated every six years.

9.6 Extension of the deadline for achieving environmental objectives

The provisions on environmental objectives laid down in Article 4 of the WFD include extension of the deadline for achieving these objectives, which means a possibility of short-term, medium-term or long-term deviation from good ecological status, which is otherwise to be attained by 2015.

Failure to achieve good ecological status by 2015 may be justified on the grounds of at least one of the following reasons given in the WFD:

- the scale of improvements required can only be achieved in phases exceeding the timescale, for reasons of technical feasibility;
- completing the improvements within the timescale would be disproportionately expensive;
- natural conditions do not allow timely improvement in the status of the body of water.

An additional analysis has been carried out upon the identification of the water bodies at risk within the Nemunas RBD (320 rivers, 64 lakes and 26 ponds) in order to identify possibilities of achieving good ecological status or good ecological potential in these water bodies during the first cycle of the implementation of the Programme of Measures (2010-2015). It is forecasted that good status or good potential during the first cycle will be achieved in 56 water bodies in the category of rivers and in one body of water in the category of lakes. Point pollution reduction measures will enable achieving good status/potential in 15 water bodies in the category of rivers. Good status/potential in other 41 rivers will be attained upon the implementation of diffuse pollution reduction measures. Critical status in one lake (Lake Pravalas) is conditioned by fluctuation of the water level due to activities of Arnionys fish farm. Good ecological status of this lake should be ensured by regulating uptake of water for the purposes of the fish farm and thus reducing fluctuation of the water level. For the remaining water bodies at risk (264 rivers, 63 lakes, 26 ponds, 4 transitional and 2 coastal water bodies), extension of the deadline for achieving environmental objectives is proposed for reasons of technical feasibility, disproportionate costs or natural conditions.

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Chapter 10
Case Study II: River Temmesjoki Water Protection Action Plan, Finland

10.1 Temmesjoki river basin

10.1.1 Main characteristics

River Temmesjoki is located in the municipalities of Liminka and Tyrnävä in the North Ostrobothnia Region in Northern Finland (Fig. 1). It discharges into the Liminganlahti Bay, an internationally significant nature conservation area. The Temmesjoki river basin belongs to the Oulujoki-Iijoki River Basin District. Its drainage basin covers 1,181 km^2 and the river is 73 km long. River Temmesjoki has two main tributaries, River Tyrnävänjoki (60 km) and River Ängeslevänjoki

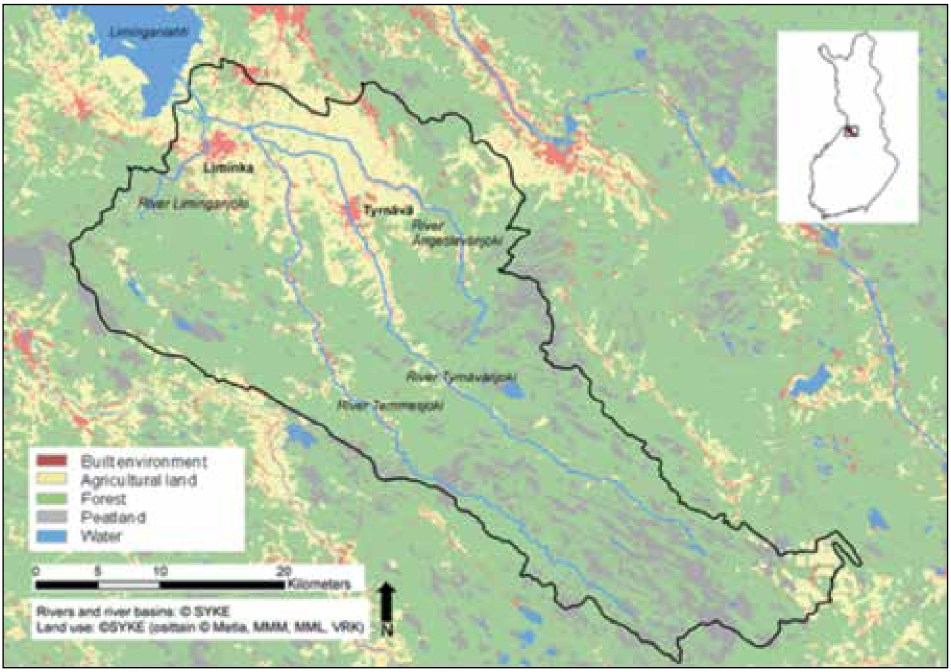

Figure 10.1. The Temmesjoki River Basin

Figure 10.2. River Temmesjoki. Photo: Anne-Mari Rytkönen

Figure 10.3. Forest on moist peatland in the upper part of the river basin

Figure 10.4. Open agricultural landscape near the mouth of River Temmesjoki. (Photo: S. Hellsten)

Figure 10.5. Dredged channel of the upper parts of River Ängeslevänjoki. (Photo: A. M. Rytkönen)

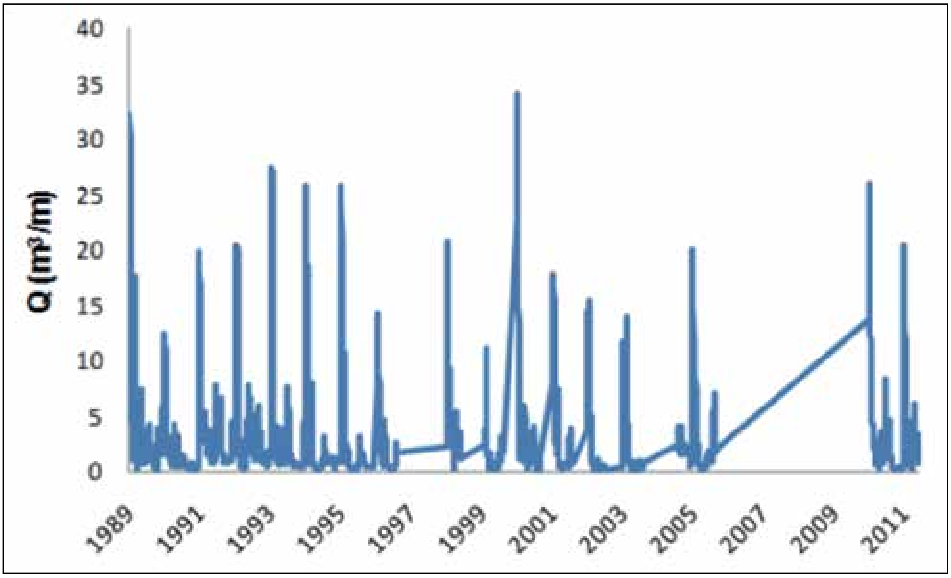

Figure 10.6. The discharge values of River Tyrnävänjoki 1989-2011.

(37 km) who discharge to River Temmesjoki near its mouth. River Liminganjoki is connected to River Temmesjoki by a channel. There are 25 very small lakes in the drainage basin, and the lake percentage is only 0,5%. There are about 12,000 inhabitants in the area.

The upper parts of the drainage basin are mainly peatland. A part of them is intensively drained for forestry purposes while some peatland areas are protected by Nature Conservation Act. Lower parts of the area are in intensive agricultural use.

10.1.2 Main pressures and present ecological state

Water quality is strongly affected by great amount of peatlands especially in upper parts of the area. As well, the intensive agriculture near the river mouth causes loading of nutrients and suspended solids into rivers.

The ecological classification of River Temmesjoki and its tributary, River Ängeslevänjoki, has been made based on only the physical-chemical water quality elements as no biological data has been available. The ecological classification of River Tyrnävänjoki is based on biological data, supported by physical-chemical data. The rivers are either in bad or poor state (Fig. 10.7.).

PH values are occasionally very low due to drainage of the acid sulphate soils (Fig. 10.8), and high nutrient concentrations (Fig. 10.9) cause eutrophication. The anthropogenic loading of phosphorus to the river system is 30 t/a and of nitrogen

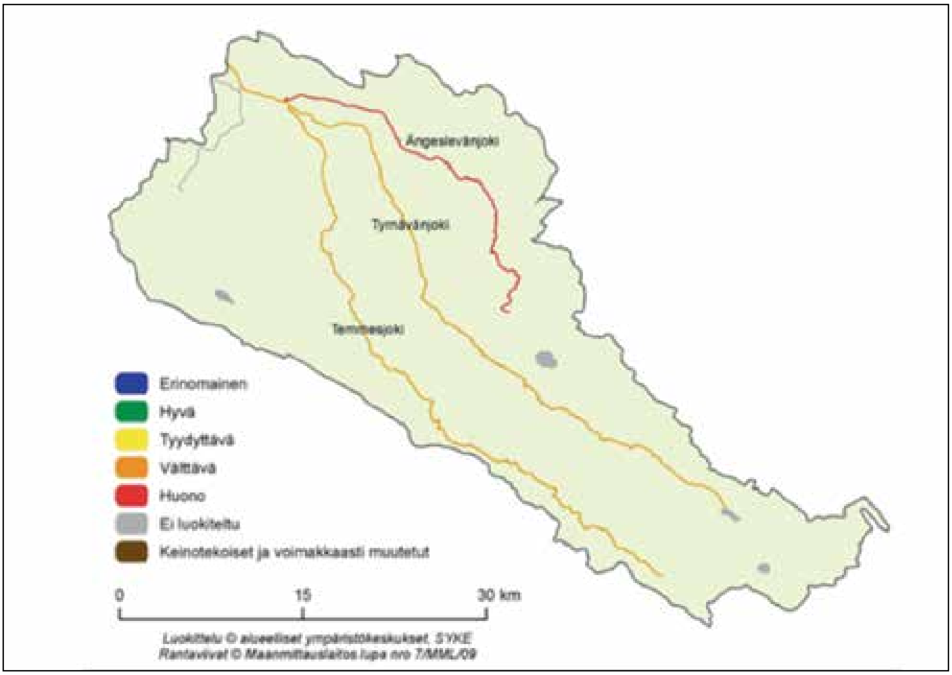

Figure 10.7. The ecological state of River Temmesjoki and its tributaries

221 t/a. The total loading of suspended solids from River Temmesjoki to the Liminganlahti Bay is more than 5,000 t/a (Pohjois-Pohjanmaan ympäristökeskus & Kainuun ympäristökeskus. 2009b). Also eroding riverbanks and low water level in summer are harmful for ecological state and recreational use. Many fish populations have declined and for example, the freshwater crayfish has disappeared completely from the river.

According to the Programme of Measures of the Temmesjoki River Basin (Pohjois-Pohjanmaan ympäristökeskus & Kainuun ympäristökeskus 2009a-c), the total loading of phosphorus should be decreased by more than 70% in order to achieve the concentration 40 µg/l, the upper threshold value for the good state is estimated only using the water quality data.

10.2 Planning of water management measures

In the EU Water Framework Directive (WFD, 2000/60/EC), water management measures are divided into basic and supplementary measures. The new measures, which are or will be implemented based on the present legislation and decisions,

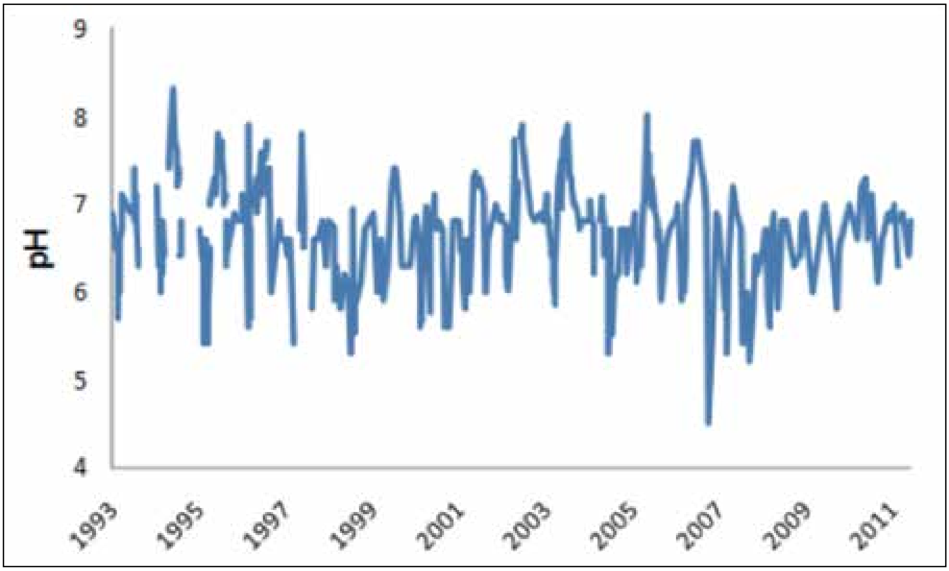

Figure 10.8. The pH values of River Temmesjoki 1993-2011

are reckoned in the basic measures. Any other new measures are supplementary. If a water body meets the objective of the WFD, the good ecological state, or will achieve it during the planning period until 2015 by the water management measures applied at present, no supplementary measures are needed. If a water body won't achieve the objective, supplementary measures have to be planned. In many cases, they are the same as the basic measures applied already, but they have to be implemented in wider scale. Also the development of new policy instruments is reckoned in the supplementary measures.

The planning system of water management measures in Finland is sector-based. All sectors of human activities having an impact on waters have been considered separately. In most cases, the wastewaters from population centres, industry, peat mining and fish farming are sufficiently treated and supplementary measures are seldom needed. Supplementary measures are commonly needed in agriculture and forestry. The enhancement of wastewater treatment of scattered settlements is based on the present legislation and is therefore reckoned in the basic measures. The measures for scattered settlements should be fully implemented by 2016.

10.2.1 Basic measures for achieving good ecological state

According to the Programme of Measures (Pohjois-Pohjanmaan ympäristökeskus & Kainuun ympäristökeskus 2009a-c), the basic water management meas-

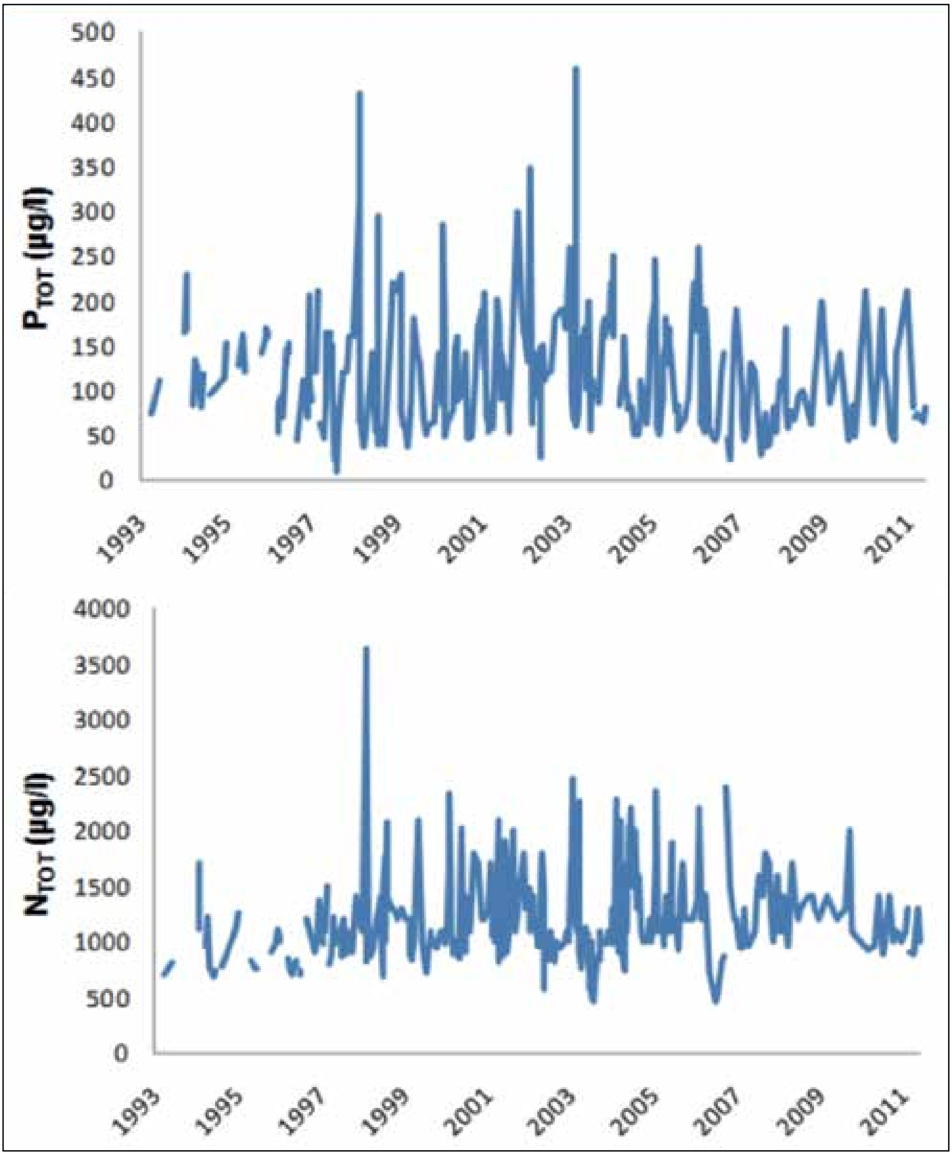

Figure 10.9. The total phosphorus and nitrogen concentrations of River Temmesjoki 1993-2011

ures already applied in the Temmesjoki River Basin are able to decrease the nutrient loading at some extent, but not nearly enough. The need to implement more and new management measures is acute. Even if supplementary measures can be fully applied as planned, the River Temmesjoki and its tributaries will not achieve the objective of the good ecological state before 2027. The basic measures applied in the area in different sectors causing loading to waters are described below. The planned supplementary measures planned are described later.

Housing

There is only a small wastewater treatment plant in the Temmesjoki river basin purifying wastewaters from Pelso prison in the uppermost parts of River Tyrnävänjoki. The wastewaters from the centres of Liminka and Tyrnävä municipalities and the village of Temmes are pumped to the Lakeus wastewater treatment plant located outside the Temmesjoki basin.

There are about 2,000 households without connection to the sewer network in the area. The wastewater treatment of scattered settlements is regulated by the Law of Environmental Protection and the Government Decree on Treating Domestic Wastewater in Areas outside Sewer Networks. They require that all households must treat their wastewaters before they are discharged to the nature. The households can either be connected to the sewer network or they have to construct a treatment system of their own, for example a leaching or infiltration bed or a small-scale treatment plant. The deadline for organizing the wastewater treatment for all households is year 2016.

Industry

The only industry sector having impacts on water quality in the river basin is the peat mining. If the production area is bigger than 10 ha, an environmental permit is required. The permits require applying the Best Available Techniques (BAT) and the Best Environmental Practice (BEP) in all industrial activities. If the production area is bigger than 150 ha, the Environmental Impact Assessment (EIA) has to be carried out. There are 7 peat mining areas in the uppermost parts of the Temmesjoki River Basin, of which 5 are still in active production. Some old production areas don't have the BAT techniques (usually in Finland the overland flow wetland) in the treatment of their run-off waters, but the production in these areas will be closed before 2015.

Agriculture

There are about 340 active farms in the Temmesjoki River Basin. Almost 100 farms carry on animal husbandry and the rest crop husbandry. Total cultivated area is more than 21,000 ha. The most cultivated crops are grains (63%), grass (18%) and potato (7%). One tenth of the fields are fallow.

More than 90% of the farms in the Oulujoki-Iijoki River Basin District have committed themselves to apply the basic water management measures, which are required in the present environmental subsidy system in agriculture. The basic measures included in the subsidy system are mainly based on the nitrate legislation and on the Act of Environmental Protection. The nitrate legislation sets requirements and restrictions, for example, on the nitrogen analysis, storing and spreading manure, the methods and timing of spreading fertilizers, animal husbandry (shelters, pastures), and on treatment of silage effluents. If the animal shelter investment plans are very big, the environmental permit has to be applied. The environmental subsidy system consists of the EU and national funds and they form the Development Programme for Rural Areas in Finland 2007-2013.

Forestry

Almost 80% of the Temmesjoki River Basin area (~93,000 ha) are covered by forests or are different kinds of mires. The water pollution control of forestry is enacted in the Finnish legislation by the Act of Environmental Protection and the Water Act. The Forestry Act requires the sustainable management of forest resources. The Act of Financing of Sustainable Forestry enables the forest owners funding for environmental-friendly forestry measures, such as for construction of more effective water pollution control measures. Almost all actors in forestry sector have committed themselves to the PEFC Forestry Certification System. In addition, there are many guidelines for planning the water management in forestry in Finland. The mostly applied basic measures in water management in forestry are the sedimentation ponds and small-scale overland flow wetlands in ditch networks and buffer zones between the cutted and fertilized areas and the lakes and streams.

Soil acidity and basic drainage

The acidity of soils is a major problem in the coastal areas of the Bothnian Bay of the Baltic Sea. There are lots of soils near the sea coast mainly under the elevation of 60 m above the sea level which contain a lot of sulphate. The acidic soil layers are usually quite close to the ground surface, in less than 3 meters deep. When the groundwater level is lowered due to drainage, the sulphate is oxidised to sulphuric acid. The lowest pH value of the rivers in the Temmesjoki River Basin has been about 4.5. The acidic conditions can also dissolve metals to water, which can have toxic impacts in ecosystem.

There is no separate legislation related to soil acidity in Finland. The basic drainage is enacted by the Water Act, but the ditching processes don't usually need any environmental permits. There is not yet enough data available where the acidic soils are exactly located but wide field surveys for locating them are going on at the moment. Due to lack of data, it has been difficult to plan measures to compete against the acidic leaks. The most important basic measure applied so far in the Temmesjoki River Basin has been controlled subsurface drainage.

Restoration of watercourses

About 12% of the river channel length has been modified. Many meanders have been straightened and rapids have been dredged. The hydraulic construction works have destroyed many spawning areas of fishes and have decreased the biodiversity in general. As well, the extensive ditching of the whole drainage area has changed the hydrology of the watercourse substantially. So far, no ecological restoration activities have been carried out in the River Temmesjoki watercourse.

Abstraction of water

Many potato fields are irrigated with water pumped from the rivers. As the discharge in dry periods of summertime can be very low, a very big share of water can be used for irrigation. There is no legislation restricting the water abstraction for field irrigation and no permits are required. No data is available yet of the amounts of pumped water or of the effects of pumping to river ecology but many experts share the opinion that it can be harmful to the rivers' ecological state. It is clear, however, that the lack of water is a disadvantage to recreational users of rivers.

Supplementary measures for achieving good ecological state

As stated earlier, the basic water management measures applied already in the Temmesjoki River Basin are not sufficient to reach the objective of good ecological state. The supplementary measures planned in the Programme of Measures (Pohjois-Pohjanmaan ympäristökeskus & Kainuun ympäristökeskus 2009a-c) are listed in the Table 10.1. below. More information of measures is available after the Table. The total yearly costs caused by the implementation of the supplementary measures have been estimated to be about 2,3 Million Euros.

Housing

If the requirements of the legislation on wastewater treatment for scattered settlements can be fulfilled during the first planning round in all households, no supplementary measures are needed for housing sector in the Temmesjoki River Basin. The requirements of legislation were moderated after compiling the Programme of Measures thus there can be a need for supplementary measures in some water bodies.

Table 10.1. Programme of Measures for the Temmesjoki River Basin

Measure	Amount and unit	Yearly total cost calculated for the whole life time of investments (thousands of €)
Agriculture		1,869
Optimal fertilization / Nutrient balance calculations	22,500 ha	1,125
Reduced fertilization	3,810 ha	191
Cultivation of energy plants	100 ha	45
Vegetation coverage in wintertime	2,600 ha	130
Manure spreading into the soil	240 ha	108
Long-term grass cultivation on peat grounds	250 ha	13
Buffer zones	30 ha	14
Sedimentation ponds	8 pcs	14
Wetlands	15 pcs	27
Controlled subsurface drainage, adjustable irrigation and recycling of irrigation water	660 ha	185
Education and consultation of farmers	57 farms	17
Forestry		33
Wetlands, overland-flow wetlands, infiltration zones, submerged and pipe weirs	82 pcs	28
General planning of water management	191 ha	1
Education and consultation of forest		
owners	23 owners	4
Soil acidity and basic drainage		405
Adjustment of drainage depth	2,387 ha	358
Survey of acidic soils	1,353 ha	41
Education and consultation of land owners	20 owners	6
Restoration of watercourses		8
Survey of channel restoration needs and possibilities	1 pc	4
Survey of water intake for irrigation and suggestion for measures	1 pc	4
TOTAL		2,315

Industry

At present, the environmental permits for new peat mining areas require all-year run-off water pollution control measures. Even though the present measures applied in the peat mining areas are not sufficient and don't meet the requirements of the present legislation, no new requirements will be set for the areas already in production in this planning round until 2015.

Agriculture

A lot of supplementary measures are needed for agriculture in the lowermost parts of the river basin. Firstly, there is a need to change cultivation methods to more environmental-friendly to prevent erosion and leakages of nutrients to watercourses. The main measures suggested to the cultivation in the Temmesjoki River Basin are the optimization and reduction of fertilization by using nutrient balance calculations, cultivation of energy plants, vegetation coverage in wintertime, manure spreading directly into the soil and long-time grass cultivation on peatland fields.

As well, the construction of water pollution control measures should be promoted, such as buffer zones, sedimentation ponds and wetlands. The Programme of Measures recommends the preparation of the general wetland plan for agricultural areas of the river basin.

In addition, the use of controlled subsurface drainage, adjustable irrigation and recycling of irrigation water are recommended. More advice and education for farmers on environmental issues and possibilities to apply financial subsidies should be also offered.

Forestry

In effective water pollution control from forestry areas, the measures based on infiltration are recommended, such as overland-flow wetlands and infiltration zones. As well, the construction of common wetlands and submerged and pipe weirs slowing down the flow velocity are promoted.

As in agriculture, also in forestry the general plan of water management measures is recommended. More advice and education for forest-owners on environmental issues should be offered as well. The need for more effective water management in forestry is growing in the future, as the strategic Regional Programme for Forestry in North Ostrobothia suggests increasing the maintenance of old drainage ditches and the fertilization of forests.

Soil acidity and basic drainage

It is not well-known how much and where the acidic sulphate soils are located in the Temmesjoki River Basin. Therefore, the Programme of Measures recommends a survey of acidic soils. There are not many technical measures for preventing the acidic loads available at the moment. The best measure is the controlled subsurface drainage which has already been applied at some extent in the area. However, new measures for preventing the acidic loads are desperately needed and therefore, a lot of research and development projects have been started in Finland in recent years.

The Temmesjoki River Basin is very effectively drained and there is no need for new basic drainage projects. When the maintenance projects of the ditch network are planned, the special attention should be paid on acidity prevention.

Restoration of watercourses

It is stated in the Programme of Measures that it is reasonable to focus on the reduction of nutrient loading in the first river basin planning period until 2015. In later planning periods, the focus can be set on restoration initiatives in order to increase the biodiversity of the river channels. The provisional survey of restoration needs and possibilities has been planned for the first planning period.

Abstraction of water

The survey of the amount of water pumped for irrigation and its impacts on the river ecology will be carried out during the first planning period. In relation to these surveys, also suggestions for measures to diminish the harmful impacts will be made.

Implementation of measures

The Programmes of Measures in Finland are very superficial planning documents. They summarise the present state of waters, identify the major pressures and estimate the need for supplementary measures. They also list the management measures that can become in question for different sectors and give very rough estimates of how much different measures should be implemented to achieve the good ecological state. However, it is not stated the Programmes of Measures, where, when, by whom or by which funding the measures should be implemented.

As the Finnish Government approved the first River Basin Management Plans, it ordered that a national implementation programme has to be prepared to ensure the implementation of measures. The Ministry of Environment led a group of experts from different ministries and stakeholders who prepared the programme. It handles, for example, the prioritization of measures and development needs of funding mechanisms and policy instruments. As well, the responsible actors are defined in the national progamme. The national programme also required that separate regional-level implementation programmes have to be prepared in all River Basin Districts. The regional programme in the North Ostrobothnia region should be finalised in September 2011 (Pohjois-Pohjanmaan elinkeino-, liikenne- ja ympäristökeskus 2011).

10.3 Economic analysis

As agriculture is the main loading source to watercourses in the Temmesjoki River Basin, the most focus in economic aspects was put on assessing the environmental and economic impacts on water management measures for agriculture. The lowermost part with very intensive agriculture was chosen for further studies.

At first, the impacts of water management measures in agriculture on loading of nutrients and suspended solids were assessed by VIHMA model (Puustinen et al.2010). The model provides estimations of comparative changes of erosion, phosphorus and nitrogen when changing cultivation methods, such as different tillage and cultivation methods and all-year vegetation cover. The estimations are based on the soil type, slope, P-test value of field soil and crop cultivated. The model contains also water pollution control measures, such as wetlands, sedimentation basins, buffer zones, and different drainage methods (ditch drainage, subsurface drainage).

In order to compare the effects of different cultivation methods to nutrient loading, multiple scenarios were created. The baseline scenario describes the cultivation methods applied at the moment in the river basin. In other scenarios cultivation methods were changed towards more environmental-friendly by increasing the area of direct sowing and wintertime stubble. These increases were made either by providing the method evenly across different field slope classes or by allocating them to as steep fields as possible. Also a scenario were the only method was ploughing was included to the study. In all scenarios the area of grass and fallow remained the same.

According to VIHMA in current situation (i.e. the baseline scenario), the erosion was 6,388,634 kg/a, total phosphorus load 16,724 kg/a, and total nitrogen load 392 192 kg/a. This current loading and the changes compared to it in different scenarios are presented in Table 10.2. It should be noted that even though the amount of erosion and the loading of particulate phosphorus and total nitrogen can be decreased by the methods selected to analysis, the loading of dissolved reactive phosphorus (DRP) and thus the total phosphorus will increase in all scenarios.

10.3.1 Cost analysis of changing agricultural cultivation methods

As the costs used in the cost analysis are based on the present environmental subsidy system in agriculture, the costs presented here can be interpreted as the cost for the society, but obviously not for a farmer. In the River Temmesjoki Basin, the only subsidy suited for wintertime stubble and direct sowing is the measure Plant coverage and reduced tillage (11€/ha/a). This is the only cultivation method cost

Table 10.2. Changes in nutrient reduction for different scenarios

	Erosion	PartP	DRP	TotP	TotN
Load (current situation), kg/a	6,388 634	7,890	8,834	16,724	392,192
Changes in load					
Ploughing	9%	6%	-6%	-0.1%	9%
50% wintertime stubble	-4%	-3%	3%	0.0%	-2%
Allocated 50% wintertime stubble	-5%	-4%	3%	-0.3%	-2%
100% wintertime stubble	-17%	-13%	11%	0.0%	-13%
50% direct sowing	-15%	-7%	14%	4%	-7%
Allocated 50% direct sowing	-18%	-8%	15%	4%	-7%
100% direct sowing	-40%	-20%	34%	9%	-23%

considered in this study for the different reduced cultivation method acreages described earlier and only for one year.

Unit costs of reduced particulate phosphorus and total nitrogen kilograms are shown in Figure 10.10. As the wintertime plant coverage and reduced tillage increase the loading of dissolved reactive phosphorus (DRP) and thus also the loading of total phosphorus, it excludes the possibility of calculating unit costs for reducing TotP. Also because the unit cost of reduced erosion stays below 0.10 €/kg in all scenarios, that has also been left out of the Figure 10.10. In this study, the ploughing was considered free of costs whereas all other cultivation methods cost 11 €/ha/a. So Figure 10.10. describes the unit costs of the scenarios compared to the situation where all fields are ploughed.

As can be seen from the Figure 10.10., unit costs of direct sowing are distinctly lower than those of wintertime stubble for both particulate phosphorus and total nitrogen. But meanwhile the unit costs in current situation are the highest for particulate phosphorus, for total nitrogen they remain below the unit costs of wintertime stubble. The allocation of methods to steeper fields would lower the unit costs of particulate phosphorus a bit with both reduced cultivation methods because the same subsidy would produce bigger phosphorus reductions when applied only on steepest fields. However, because steepness of the field plays no role in development of nitrogen runoffs, this allocation would have no effect on unit costs of total nitrogen.

In the same way the unit costs of nutrient reductions achieved by buffer zones were calculated assuming the subsidy being 350 € per buffer zone hectare per year. For total phosphorus, the unit costs for buffer zones with ploughed fields above rises considerably as their acreage increases because more of them are

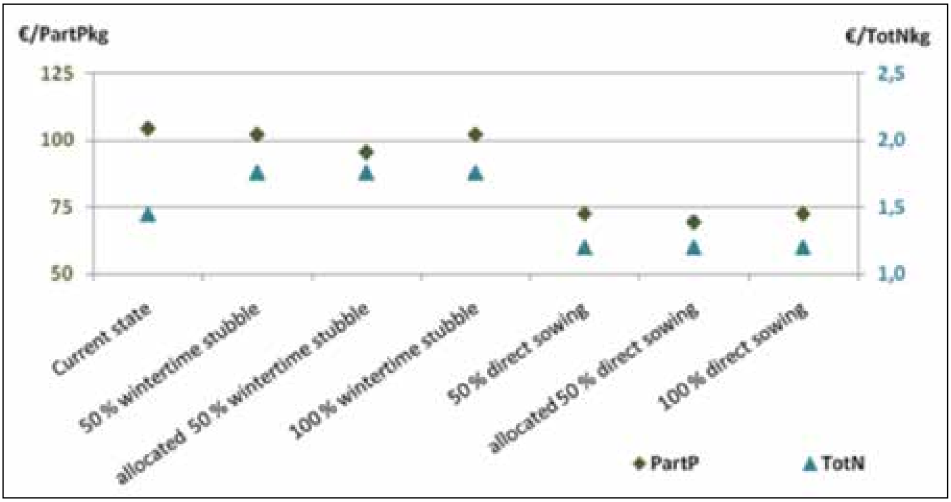

Figure 10.10. Unit costs of cultivation scenarios calculated including agriculture environmental subsidies

being established on the flat, where their ability to cut nutrient runoffs decreases significantly while the costs remain the same. For direct sowing the unit costs are substantially lower though the development is the same. This also applies for erosion and nitrogen in all scenarios. Unit costs increase when buffer zone acreages increase, but more moderately with the exception that direct sowing is the most expensive and ploughing the cheapest method.

10.3.2 Cost-efficiency analysis

In addition, unit costs of different measures were also calculated with the KUTOVA tool (Kunnari 2008), which provides cost-effectiveness analyses of water protection measures for loading of phosphorus from diffuse sources of agriculture, peat mining and wastewaters from scattered settlements. In agriculture, it calculates the costs more from the farmer's point of view considering e.g. yields from the grain produced. In this tool the user can choose how much of the particulate phosphorus is included in total phosphorus; everything between 0 to 100% is possible. In the calculations made for this study, the shares of PartP were 0%, 50% or 100% and the nutrient reduction methods involved were direct sowing and buffer zones for agriculture and different kinds of measures for treating wastewaters of scattered settlements by property-specific sewage treatment plants, land filtration or connecting the houses to the sewer network. There was no peat mining in the study area.

KUTOVA estimated that the biggest total phosphorus reductions possible in this area would be 30% or 35%, depending on how much of the particulate phosphorus is included. From the total costs and reductions provided by KUTOVA, the unit costs of different measures were created simply by dividing the costs with the reductions. This was done for both phosphorus and nitrogen, the erosion is not included in KUTOVA. It is good to remember that KUTOVA selects the most cost-effective measures only considering phosphorus reductions. But the same measures might not be the most cost-effective ones for nitrogen. Another problem with KUTOVA is that it considers all agricultural measures to be done always to the whole acreage of one steepness class and this inability to share the measure for only some portion of a steepness class reduces the cost-effectiveness of that measure considerably.

For both nutrients the costs of agricultural measures are significantly lower than those for scattered settlements. But when considering only the DRP loading (PartP emphasis 0%), KUTOVA recommends only scattered settlements' measures. Only when 50% or 100% of the particulate phosphorus loading is being included to total phosphorus, the tool recommends also the agricultural measures on the side.

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Chapter 11
Case Study III: BEAM: An Economic Model for Water Use

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COWI A/S, DHI and Global Water Partnership Source: http://poster.worldwaterweek.org/

BEAM (Basin Economic Allocation Model) is a hydro-economic model that serves as a decision support system for water use in transboundary river basins. The model estimates economic welfare associated with water use at regional, country and sector levels (agriculture, energy, industry, domestic and nature). Economic optimization is used to allocate water based on assumptions made by the user. Such assumptions may concern crop prices, energy demands, existing agreements on water allocation and new infrastructure projects, such as hydropower projects.

The model has been customized for the Aral Sea Basin. It may be applied in other transboundary river basins. These basins may comprise one or more countries depending upon the size of countries and basins.

The Aral Sea BEAM Version 1 was developed by DHI, Global Water Partnership and COWI A/S on behalf of Executive Committee of the International Fund for Saving the Aral Sea with financial support from USAID in 2011-2012. Currently, the Aral Sea BEAM Version 2 is being developed by DHI and COWI A/S on behalf of the World Bank.

11.1 Scope of BEAM

It covers the Aral Sea Basin, including important irrigation locations, reservoirs and hydropower facilities. It calculates welfare changes associated with how water is allocated to different uses in the five Central Asia countries (Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan) and a part of northern Afghanistan.

The model considers the economic value of water in five sectors: agriculture (including the irrigated production of wheat, cotton, alfalfa, rice, fruit, vegetables, and other crops); hydropower; environmental flows to the Aral Sea; households; and industry. The model estimates tradeoffs between the benefits of hydropower generation and agricultural production, as well as tradeoffs between economic

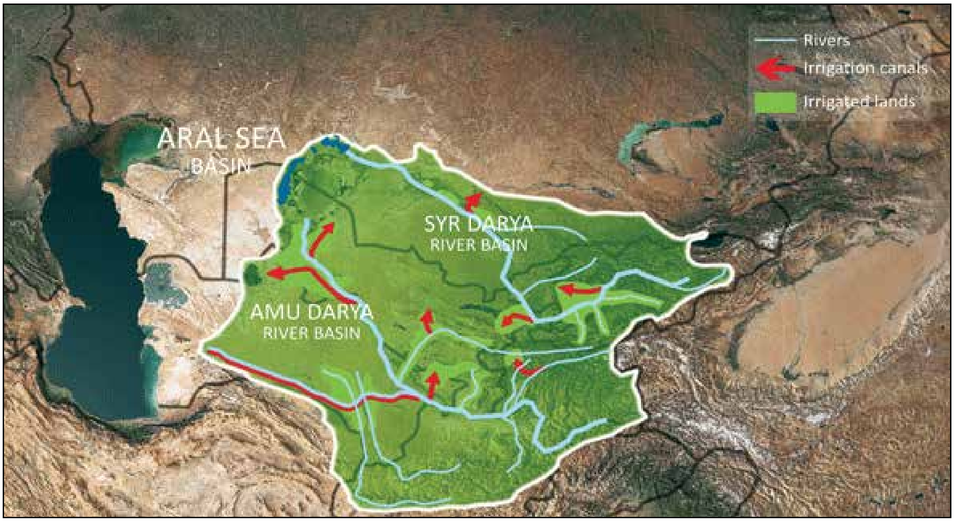

Figure 11.1. BEAM combines hydrology, agronomy and economics, including energy economics.

uses of water in different parts of the basin, and at different times of the year. The model simulates infrastructure and policy options to improve water management, including irrigation efficiency measures, new reservoir and hydropower facilities, and market reforms in the energy and irrigation sectors.

The model aims at addressing the following issues of relevance for economic management of water resources:

- Efficiency (estimating how investments in irrigation efficiency affect economic welfare);
- Effectiveness (estimating how increases water use in one sector, such as hydropower, at the expense of water use in another sector, such as agriculture, affect welfare);
- Equity (who will gain from changes in allocation of water from one sector to another and who will lose?).

The model routes water through the river system using economic optimization criteria.

The model is programmed in GAMS (General Algebraic Modeling System) – a software developed by a group of economists at the World Bank. It has been constructed to serve as a Decision Support System that attempts to "put value on water use" and explore the sustainable use of water resources in support of development.

It may be used by policy makers, researchers and others when

- Negotiating about water allocation;

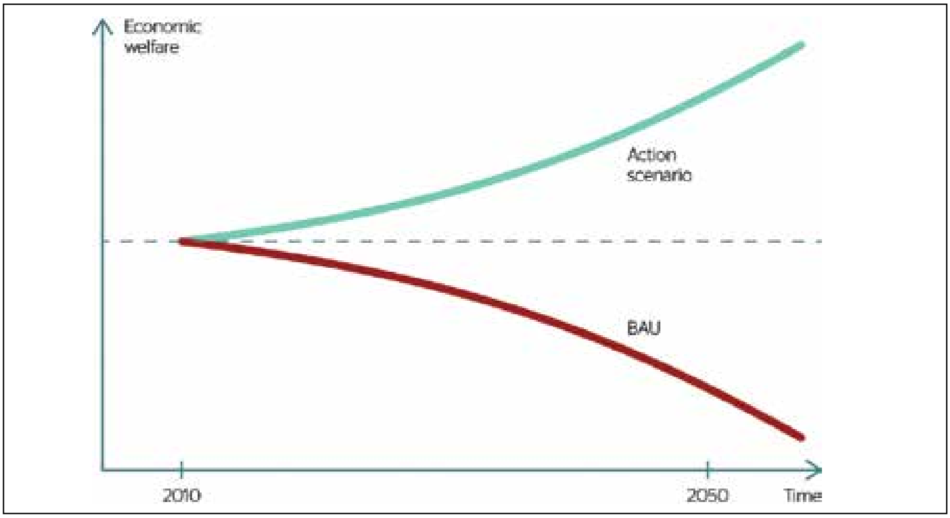

Figure 11.2.The relationship between Economic welfare and Business as Usual (BAU)

- Considering major investment projects in the water, food and energy sectors;
- Exploring consequences of climate change for the economic development in the basin.

The model computes outputs for a single year. Outputs include hydropower produced and estimates of resulting consumers and producers surplus in the energy sector. The model estimates agricultural production for a variety of crops, along with agricultural revenues and input costs. Agricultural production is estimated as a function of irrigation water use using a methodology based in FAO-33. Crop land use change is constrained based on land suitability and policy constraints. Crop water requirements are pre-processed using FAO CROPWAT.

11.2 BEAM optimizes economic welfare

Optimization is used to allocate water across space and time to maximize economic welfare subject to constraints:

- Basin-wide welfare is defined as the sum of economic welfare added in the agriculture and energy sectors;
- Economic welfare in agriculture is measured in terms of producers surplus;
- Economic welfare in the energy sector is measured as the sum of producers and consumers surplus.

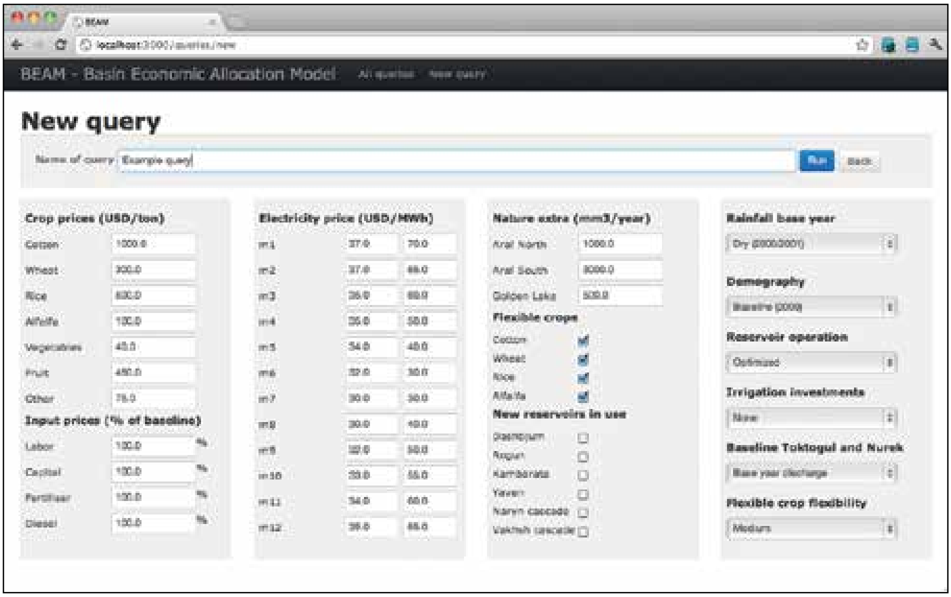

Figure 11.3. Excel output format facilitates flexible reporting of results

Decision variables (or constraints) in objective function developed are crop areas and water use (by crop type) and reservoir/hydropower releases, and construction of new thermal power facilities. They are many, including:

- Agricultural production constraints, energy market integration constraints and individual country optimization (constraints on the extent of regional cooperation);
- Environmental, domestic, and industrial water uses are implemented as constraints.

11.3 Scenario analyses are in focus

Questions are investigated through scenarios:

- A scenario is a set of model assumptions
- 282 scenarios (2011 and 2030; 2/3 concerns 2030)

Various assumptions may be modified by the user, including:

- Hydrological conditions;
- Crop sales price;
- Energy market characteristics;
- New reservoirs and hydropower facilities;
- Level of investment in irrigation efficiency improvements;
- Transboundary water-sharing agreements;

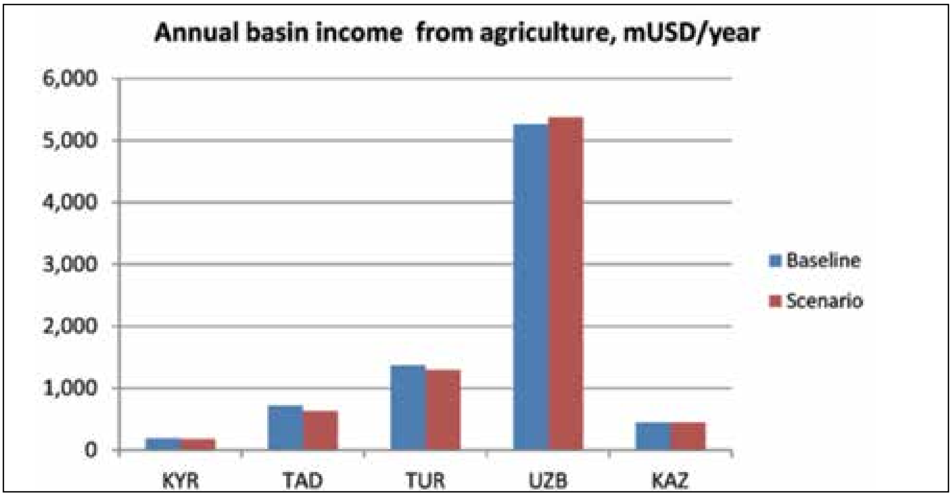

Figure 11.4. Comparison of baseline and economic optimum

- Market and land reforms;
- WSS investment costs.

Hence, BEAM allows scenarios and sensitivity analyses. It facilitates what-if questions, such as:

- What are the welfare and water use impacts of:
- Expanding ROR hydropower?
- Regional energy trade?
- Electricity exports to South Asia?
- Existing water-sharing agreements (i.e., Nukus)?
- Regional water use cooperation?
- Investments in irrigation efficiency?
- Labour and market reforms in the agriculture sector?
- Climate change?
- Population growth to 2030?
- Constructing large new storage facilities, such as Rogun Dam?
- Deliberate attempts by upstream countries to inflict harm on downstream countries through reservoir management?

A few key questions in the Aral Sea basin:

- How might the welfare of Uzbekistan be affected if the Kyrgyz Republic increases hydropower production considerably?

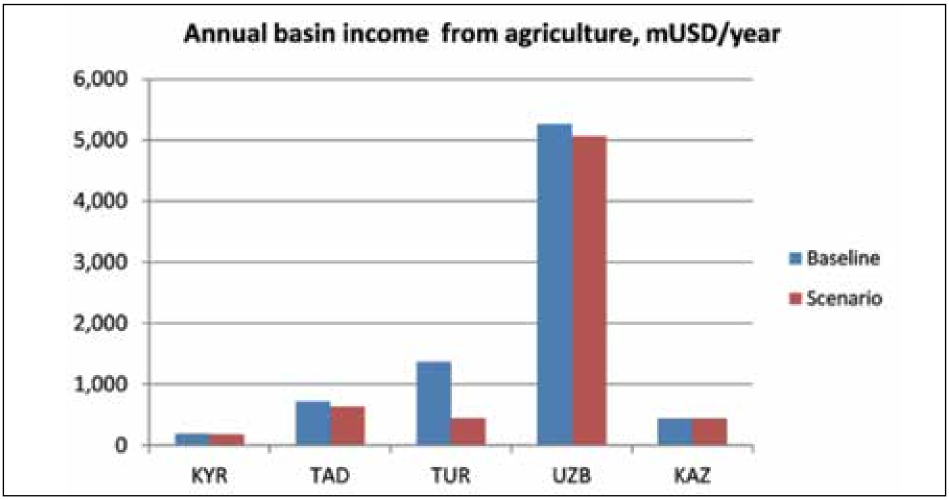

Figure 11.5. Comparison of baseline and economic optimum with water scarcity

- How might welfare and water use in Turkmenistan be affected by a change in the price of cotton?
- How might changes to the crop mix in different parts of the basin affect welfare and water use?
- What are the employment impacts of changes to water allocation?
- What are the costs and benefits of introducing improved irrigation technology? Or new reservoirs and/or hydropower facilities?
- What are the opportunity costs of reserving more water for the Aral Sea?
- How might economic optima be affected by dry conditions and/or climate change? Should irrigation water use in some countries/planning zones be reduced?
- What should an annual compensation scheme under a bilateral agreement on water look like?

Through scenario analyses - through comparisons of different scenarios, maybe through sequencing of scenarios - it is possible to estimate the gap between an action scenario and a business-as-usual scenario.

Accessibility matters

Much attention has been paid to the user-interface. It shall be possible for the user to do scenarios on his/her own by changing selected decision variables. Ideally, the model shall be public available on the web.

Stakeholders in the region have been involved in the development of the model, and about 10 national experts, including staff from the International Fund for Saving the Aral Sea (IFAS), have been trained in using the model. The model is publicly accessible through a web-based user interface that allows users to investigate scenarios and perform sensitivity analyses on their own.

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Chapter 12
Case IV: Cotton, Water, Salt and *Soums* – Research and Capacity Building for Decision-making in Khorezm, Uzbekistan

Authors:
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12.1 Introduction

The widespread, and ever increasing physical and economic water scarcity in the Aral Sea Basin, exacerbated by climate change and land degradation, is threatening ecological sustainability and economic development in Central Asia. The economic transition that Uzbekistan is undergoing further complicates the restructuring of resource management. These problems are exemplified in the Khorezm region, a district located in the northwest of Uzbekistan. Khorezm depends to a large extent on agriculture. Thus, development is essentially based on the economic, ecological and social sustainability of agricultural land use. To increase our understanding of the linkages between human and environmental security, an interdisciplinary project was developed between the Center for Development Research (ZEF) of the University of Bonn, Germany, and the University of Urgench, Khorezm. The "Khorezm Project" followed an interdisciplinary approach that unites natural and human sciences to analyze the problems from different perspectives.

In contrast, the Soviet approach emphasized production maximization without taking environmental and social issues into account. This may have brought temporary economic development but also created the unsustainable situation that today is known as the "Aral Sea Syndrome" (WBGU 1998). The transition countries that inherited this situation suddenly found themselves under pressure to deliver improvements. However, with other, more pressing problems on their agenda, and their science institutions poorly prepared for the task, they often could not generate the needed change to the underlying structural problems. A deeper understanding of the complexity of the underlying problems and the means to ameliorate them was lacking. There seemed to be a need for an integrated approach in order to find the true causes of stagnation in behavioral and technological change

This case study introduces the book entitled ("Cotton, water, salts and Soums - economic and ecological restructuring in Khorezm, Uzbekistan") invokes the major components of the problem setting:

- *Cotton* is the main crop, currently planted on about half of the irrigated agricultural land and using about half of the water that flows into the region (cf. Djanibekov et al. this book, 2011b). Other important crops are wheat and rice. In this book, conditions of crop production, irrigation and fertilization are analyzed and the introduction of conservation agriculture in the region is discussed. The physical environment to which all innovations must be adapted is also described. This includes an analysis of environmental conditions and climate change.
- Irrigation *water* is used in great quantities, leading to an average water use of 1,600 mm (i.e.; 16,000 m^3 per hectare and year), one of the highest water use rations in the world. This sharply contrasts with the potential annual evapotranspiration of about 1 400 mm and annual crop requirements of about 700-800 mm. The resulting perculation leads to a very shallow water table for most of the year in the region (cf. Djanibekov et al. this book, 2011a; Tischbein et al. this book). This case study ~~book~~ analyzes water management from different viewpoints, be they hydrological, social-anthropological and economic in nature. The result is a more integrated view of water resource management.
- *Salts* are contained in all surface water and accumulate in the topsoil when groundwater is brought to the surface through capillary rise where the water evaporates and the salts remain. If salinity levels build up too high, crop growth is affected. Thus, soil salinity is a major indicator of sound resource management and is reflected in agricultural productivity. Direct and indirect options to regulate water management and soil salinity are discussed in several chapters of the book.
- Finally, wealth is potentially created by agricultural production, here expressed in Uzbek currency *Soums*. Farmers produce crops to ensure a livelihood. However, state regulations may prevent farmers to be sidelined with wealth going to the state. This affects rural development, poverty, and food security. In several chapters, economic analysis is undertaken to elucidate economic mechanisms to improve the current resource governance, for the benefit of human livelihoods and ecological sustainability.

We analyzed these and many other elements of the problem, to come up with suggestions for restructuring land and water use at the field, farm, and regional management levels. It is also recommend restructuring the economic framework conditions that govern natural resource use in Uzbekistan. The research and educational goals of the Khorezm Project are aligned with the Millennium Development Goals of eradicating poverty and hunger and achieving food and water security, and also with the United Nations conventions on desertification/land degradation and climate change. They are also providing support to the long-term strategic programs that the EU and Germany developed for Central Asia. These aim at regional security, environmental protection, sustainable development, and a higher quality of life for the present and future generations.

12.2 Khorezm

Khorezm, an administrative district of Uzbekistan, is located in the northwest of Uzbekistan in the lower reaches of the Amudarya River – formerly the largest tributary of the Aral Sea. As part of the Turan Lowland of the Aral Sea basin, Khorezm is situated about 250 km south of the present shores of the Aral Sea.

Khorezm is one of the oases of the great historic civilizations of Central Asia, fed by the ancient river Oxus, today the Amudarya. For at least 3000 years, waters from the Amudarya and Syrdarya rivers supported thriving agricultural communities (Tolstov 1948) – and since Soviet times a flourishing fishing industry – in the Aral Sea Basin (Figure 12.1). But during the Soviet era, and more so since the late 1950ies, the Amudarya and Syrdarya waters were abstracted excessively and used in greatly expanded irrigation systems to secure the production of cotton, the "white gold". The area of irrigated cropland in the Aral Sea basin almost doubled, from 4.5 million ha in the 1950ies to 7.9 million ha in 2006 (cf. Tischbein et al. this book). This dramatic expansion of the irrigation system resulted in a substantial decrease in water inflow to the Aral Sea from 43 km^3 $year^{-1}$ in 1960ies to an average of 9 km^3 $year^{-1}$ during 2001-2005. Consequently, within decades the Aral Sea shrunk from being the fourth largest freshwater lake in the world (6.8 million ha surface area) to less than 20% of its former size. By 2006, the sea's level had dropped 23 m, the volume decreased by 90%, and the salinity risen to more than 100 g L^{-1} (Micklin 2008). The term "Aral Sea Syndrome" was coined to denote problems "associated with centrally planned, large-scale projects involving water resource development" (WBGU 1998) which aim at providing secure supplies of irrigation water and thus, food security, but fail to address the ensuing environmental disaster.

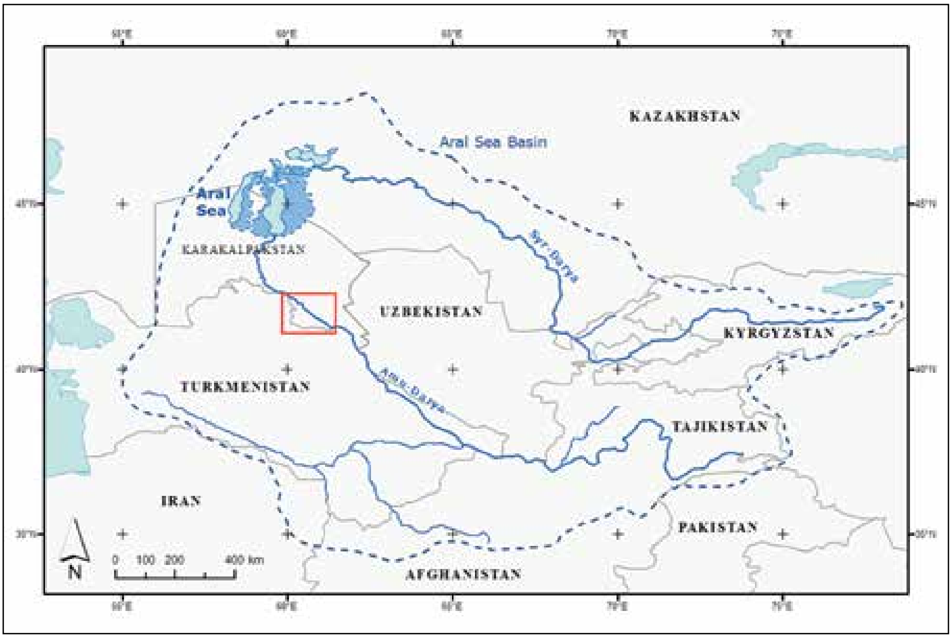

Figure 12.1. Location of the Khorezm region (red square) and the Aral Sea Basin (blue dashed line) in Central Asia.

Khorezm covers an area of about 680,000 ha of mostly arid deserts, of which roughly 270,000 ha have been developed for irrigated agriculture. With an average annual precipitation of ~90 mm only (cf. Conrad et al. this book), agricultural production and rural livelihood in Khorezm rely entirely on irrigation water supply. For this purpose, a dense network of about 16,000 km irrigation channels and ca 8,000 km drainage water collectors has been developed, mainly over the last decades of the Soviet period (Figure 12.2).

This complex network of irrigation and drainage canals was designed to deliver water to large-scale collective farm units based on a centrally organized irrigation water scheduling and delivery system. Land reforms initiated after independence in 1991 have, however, resulted in the disintegration of the large collective and state farms into numerous smallholder farms (in Khorezm, from 117 *shirkats* in 2001 to 18 381 private farms by the end of 2008. This has led to a serious mismatch between the irrigation water supply system and the actual demand by the new private farmers. The establishment of Water Users Associations (WUAs) largely along the administrative boundaries of the former collective farms has been an attempt to bridge the gap between the higher-level water pro-

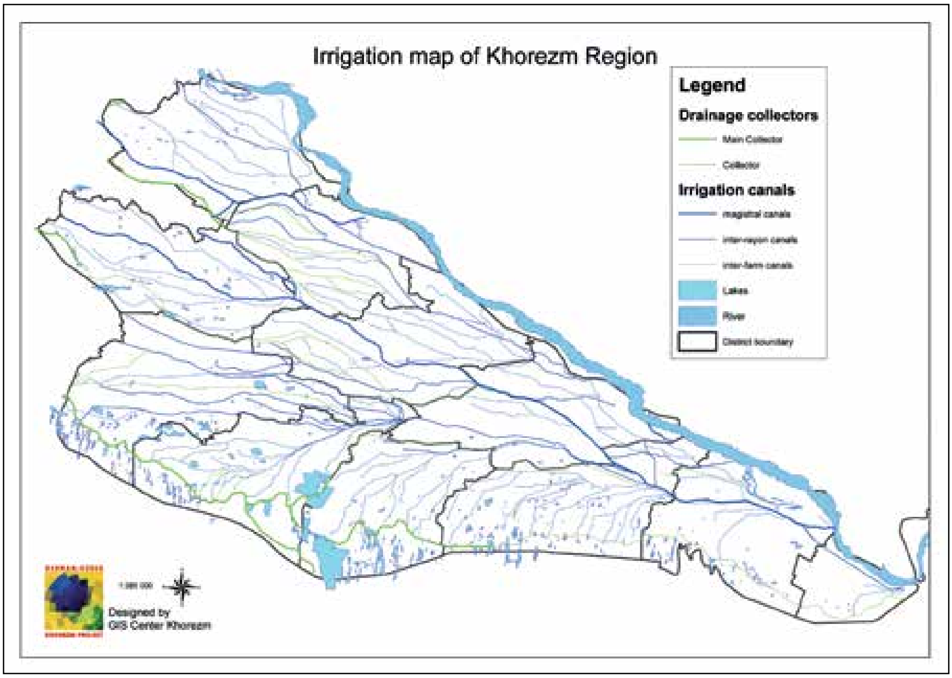

Figure 12.2. Irrigation map of the Khorezm region.

viders and the farmers (Zavgorodnyaya 2006). Due to lack of human and financial resources, the WUAs, however, have so far not been effective in organizing farm-level water supply management.

Another farm optimization process initiated by the Uzbek government in November 2008 reversed the process of land fragmentation, and led to the re-creation of larger farm units of at least 80-100 ha in size. This is too recent to analyze the effects of this reversal, but despite the various reforms, inefficient use of land and water resources continue. Moreover, inappropriate institutional settings and support frameworks, and underdeveloped agro-processing and service sectors are among the key constrains of economic and ecological improvement in the region.

In 2008, agriculture contributed 37% to the regional GDP. Agriculture is also important as a way of living and employment for the rural population. It is the main provider of raw materials for the agro-industrial sector. Of the 1.5 million people living in Khorezm, over 70% reside in rural areas and are mostly engaged in cotton, wheat and rice production (Djanibekov 2008). About 27.5% live below the poverty line of 1 US$ per day (Müller 2006).

Soils are generally low in fertility, and organic matter content (cf. Akramkhanov et al. this book), and substantial amounts of chemical fertilizers are used for the cultivation of the major crops (Kienzler 2010). Due to the application of large amounts of water during leaching and irrigation events, ground water tables reach critically high levels during the cropping season causing secondary soil salinization and land degradation – a widespread problem in Khorezm (Ibrakhimov et al. 2007).

12.3 The Khorezm project

The overall goal of the Khorezm Project is to provide a comprehensive, science-based concept for restructuring of agricultural production systems in the Khorezm region. It was expected that – as Khorezm is representative for the irrigated systems in the lowland areas of Central Asia – innovative technologies and concepts developed here would have a potential for being up-scaled to the larger region and serve as examples for development in other, similar environments. To achieve this goal, project research has been focused on various system components: land use, production systems, economy and society and institutions (Figure 12.3). The core project research activities included monitoring and mapping of natural resource endowment and degradation, analyzing agrarian change and rural transformation with a special focus on gender perspectives, developing remote sensing and model-based technologies for improved irrigation water management and soil salinity control, analyzing socio-technical dynamics of irrigation water distribution and drainage management, value chain analysis of agrarian commodity sectors, such as cotton, winter wheat and vegetables, elaborating options for the phyto-remediation of degraded, saline land through set-aside programs for afforestation, adapting conservation agriculture equipment and practices, as well as crop rotation to sustainably improve the productivity of cropping systems. Implementing and adapting innovations with stakeholder groups, a process known as "Follow the Innovation" (Hornidge et al. 2011), and policy outreach and dissemination were an integral part of this project. These activities are grouped as shown in Figure 12.3.

Simulation modeling has been an essential instrument of the project for integrating the disciplinary scientific findings, up-scaling the results, and predicting the long-term impacts of current and alternative land and water management options and policies. The overall restructuring concept is thus based on recommendations for

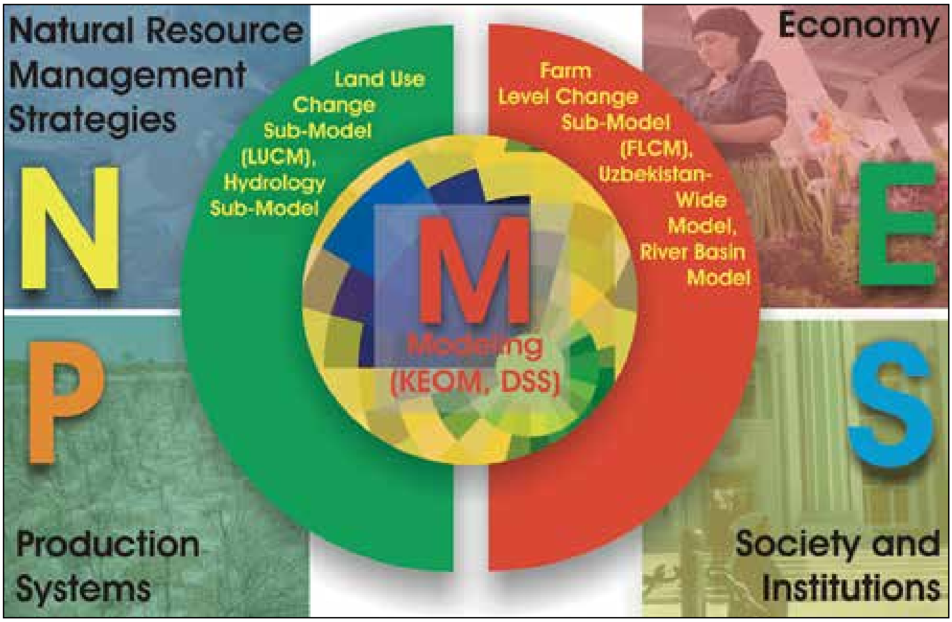

Figure 12.3. The thematic areas dealt with in the Khorezm project during 2001- 2007.

- innovative technologies to enhance the economic viability and ecological sustainability of agricultural systems at the field, farm and WUA level;
- improved agricultural policies at regional and national levels and institutional restructuring for a more sustainable natural resource use.

12.4 A GIS center in Urgench

The establishment and maintenance of a lab for Geographical Information Systems (Khorezm GIS Center) at the state University of Urgench (UrDU) has been one important component in the project. The GIS layers in the Central Data Base (CDB) comprise raster and vector data such as administrative boundaries (fields, WUAs, district, and region), infrastructure (irrigation and drainage network, roads, machinery and tractor parks), soil characteristics, groundwater information, and climate data. Regional GIS raster layers from satellite image analysis include among others land use, crop yield, and evapotranspiration. In addition socio-economic data (commodity prices, census data), and various reports are collected. As the only existing GIS lab in the Khorezm region, the project's GIS Centre has been fulfilling demands for spatial data, information and maps not only from the project staff but also from the local scientific community and regional authorities. Since the data for the CDB has been derived from different sources (field sampling, remote sensing, and secondary sources), the first task was a geometrical adjustment of these data sets to high-resolution satellite reference images. The database serves as the central system for the dynamic analysis of the resource endowment of the region, be it natural, human or economic, and provides data for the models developed in the project. The Khorezm GIS Center can be consulted for data by interested institutions and researchers.

12.5 Capacity building

As one of the major internationally-funded long-term research projects in Uzbekistan, the Khorezm Project makes a significant contribution toward education and training of young local scientists. Since the onset of the project in 2002, 50 Ph.D. students, about half of them from Uzbekistan, have conducted their research in the framework of the Khorezm project and 23 have successfully defended, of which 11 are from Uzbekistan (April 2011). The Ph.D. candidates conducted their research under supervision of local and foreign experts while themselves supervising a large number of local M.Sc. (about 100) and numerous B.Sc. students. Furthermore, the capacity of University of Urgench staff was built as several of them obtained their Uzbek professorship in the project framework.

12.6 Structure of this book and overview of contributions

This book is the second book based on this project. Wehrheim et al. (2008) analyzed legal, economic and social constraints for agricultural production and innovation in Khorezm. This book addresses the biophysical environment, describes cropping and irrigation management systems and takes an economic and anthropological look at the region's problems. The book summarizes work carried out during the first six years (2001-2007) of the project in Khorezm.

In the following sections we will give a brief overview of the contents of the book that is now in front of the reader.

12.6.1 Section II: The physical environment

Irrigated agriculture has been in this arid region for a long time. It was the basis for the blooming of the empire of the Khorezmshakh in the 12th and 13th centuries, and of the 17th century, later the Khiva Khanate. Today this region is known as Khorezm (Al-Iqbal 1999).

Using mid to long-term weather and climate records, Conrad et al. (chapter 2.1) suggest that the agro-climate condition in this region favour annual, warm-season crops such as cotton, wheat, rice and maize. Current air temperatures and growing degree-days are favorable for the main crops grown in the region. However, increasing winter temperatures have been observed, which improves the conditions for growing winter wheat. Soil temperatures, relevant for estimating the first planting days of crops such as cotton, have risen. Climate change is manifest in Khorezm by temperature increases, especially during the winter period. The ten-year average of summer temperatures in 1981-1990 was 0.2-0.5°C above the long-term average in 1930-1990. Thus the current state recommendations for planting cotton from mid-to-end April are becoming conservative; earlier planting dates may be adopted in the future to make use of the longer vegetation season. Spatial variability between the central and marginal parts of the irrigated "oasis" of Khorezm, and the desert itself appear to be small, but variability, and hence, risks increase towards the oasis margin.

The riverbed changes of the meandering Amudarya river over the millennia, as well as the most recent expansion in irrigated agriculture in Khorezm in Soviet Union times, have markedly influenced the development and formation of soils in the region (Akramkhanov et al.; chapter 2.2). The result is a spatially diverse mosaic of soil conditions. While the irrigation and land use activities have made the top layer of soils, the agro-irrigation horizon, rather uniform, the underlying soils consist of a multi-layered and differentiated illuvium. The soil texture is dominated by silt loam, sandy loam and loams, characterized by rather low soil organic matter contents, and slightly- to medium- soil salinity. The top 60 cm are in general moderately to strongly saline reaching levels affecting crop performance. Soil microbiological activity is closely linked to soil organic carbon content whereas soil fauna reacts to land management. Thus, conservation agriculture combined with residue retention may help improve soil conditions in this region.

Cotton is the predominant crop in Khorezm. MODIS-satellite remote sensing data revealed the spatial distribution of cotton yields, which is not evident from district-aggregated official statistics. A regional crop yield model was developed by Ruecker et al. (chapter 2.3) relating the spatial distribution of cotton yields to management factors. This revealed the effect on cotton yields of soil texture, irrigation delivery, and water management. This knowledge can help target land use and infrastructure rehabilitation at regional and district levels, and at the level of water user organizations and individual farms. Being based on satellite data, the procedures developed by these authors is easily transferrable to other irrigation systems.

Large amounts of water are used for irrigation and soil salinity leaching in Khorezm, and this is a major cause of the observed shallow groundwater levels. These, in turn, lead to widespread soil salinity, which consequently demands more water for leaching (Akramkhanov et al. 2008). Currently, 25% of the total annual water supply to the region is used for leaching. This vicious cycle is of great concern in a situation of insufficient water supply and there is a urgent need for improved irrigation and cropping practices. It is not so much the increase in salinity of the irrigation water as the soil salinity caused by saline groundwater, which reduces agricultural productivity in the irrigated drylands of Uzbekistan. In a comprehensive analyses across sscales from fields to water users association (WUA) to the district level (i.e., whole Khorezm), Tischbein et al. (chapter 2.4) show that present irrigation water management leaves much room for improvement: overall technical irrigation efficiency is about only 27%. Drainage-water output reaches as high as 62%-67% of the irrigation water input. The ill-functioning drains, the excessive leaching and the high water losses from the irrigation (conveyance and distribution) network are among the major causes of shallow groundwater tables. With gross water inputs of 2,600-2,800 mm, water supply regularly falls short of demand in tail-end locations. A series of irrigation assessment indicators (e.g. relative evapotranspiration (RET), depleted fraction (DF), drainage ratio (DR), or irrigation efficiency at field, network and scheme level) all indicate that, the region experiences an economic water deficiency due to weak infrastructure management and insufficient planning efficiency. For example, due to insecurity in water supply, farmers actively block the drainage system, to increase their water security. This factually improves the abovementioned efficiencies, but bears the strong risk of soil salinization. The authors argue that modernization should aim at optimizing the current system, introducing a flexible, model-based irrigation scheduling to replace the present rigid norms, and through improving infrastructure, maintenance and institutional water management procedures. Innovative technologies (e.g. drip and sprinkler irrigation) can then be considered as a next step. Likewise, improvements needed in the drainage network should first focus on major and local outlets before more costly interventions such as narrowing drainage ditch spacing and a more widespread introduction of tile drainage can be considered.

12.6.2 Section III: Society and Institutions

The project addressed the complex of land and water use planning in a confusing decision-making environment. The goal was to provide science-driven decision support. Both, the bio-physical as well as the institutional aspects were analyzed.

During the farm restructuring reform between 1992 and 2008, virtually all collective land was allotted to producers. This process resulted in a large number of small-scale farms that comprise multiple fields, scattered and located often at far distances from each other, and of various soil qualities and shapes. The original set-up of the infrastructure, suitable for a small number of large-scale farms, was not suitable for this array of many small-scale private farms, and agricultural efficiency and sustainability deteriorated. In response, the Government of Uzbekistan opted for a land consolidation to improve the overall efficiency in crop production. However, Djanibekov et al. (chapter 3.1) convincingly argue that as long as the land consolidation is not accompanied by additional institutional reforms, the anticipated boost of resources use efficiency is unlikely to take place. Among these are easing the state procurement system, ensuring land stewardship by producers, and increasing the efficiency of the organizations providing agricultural services (ASPs).

Research by Niyazmetov et al. (chapter 3.2) addresses the efficiency and functioning of ASPs in Khorezm. ASPs suffer from serious flaws, preventing the efficient delivery of services to farmers. Property rights are poorly respected with local authorities having decision-making powers in ASPs and on farms. Corporate management is often poor because local authorities interfere in the election of ASP heads, making them more accountable to local authorities than to the business interests of the ASPs. Contractual arrangements are weak, affecting the reliability of interaction of the ASPs with their clients. Frequently, farmers cannot meet the demands for early payments for the services rendered. Commercial banks and their mini-bank branches in the villages face notorious cash-flow and liquidity problems whilst the farmers' direct access to their own bank accounts is constrained by regulations.

In chapter 3.3, Veldwisch et al. describe socio-political aspects of the reforms introduced since independence in 1991, with a focus on agricultural water management. The reform has led to the establishment of basin boundaries and water user organizations (WUAs). These reforms were implemented by the national administration without much participation of farmers or water managers. In spite of the national administration's declared intention of introducing a certain level of decentralization, the authors conclude that "*... policies developed in 'society-centric policy processes' cannot easily be applied in countries with 'state-centric politics'*. In essence, water management remained virtually unchanged since independence, In fact, some aspects have worsened considerably.

The latter is illustrated in the quality of drinking water and the incidence of water-related diseases that have become alarming (Herbst et al.; chapter 3.4).

A large share of the rural population relies for their drinking water supply on unprotected groundwater dug or drilled wells. Both sources are frequently fecally contaminated and pose a risk. Particularly children are strongly affected by diarrheal diseases. A general of proper health-related behavior, food hygiene, sanitation facilities and their maintenance and sewage disposal increases the risk of these diseases. These are also some of the entry points for preventive measures to improve domestic drinking water management and use.

Affordable, secure and environmentally friendly energy is key to welfare, economic growth and sustainable development (Eshchanov et al.; chapter 3.5). Suitable reform policies are needed taking into account the price and income elasticity of residential electricity consumption, which consumes 39% of all energy in Uzbekistan. This lies far above the world average of 28%. Electricity production is based o natural gas supplies, and the high share of domestic consumption reduces the countries' option to export fossil fuels. Using macroeconomic models that considered income, price of electricity, industrialization rate and an increase in residential space, the authors found that a price increase could result in an increased efficiency of residential electricity consumption.

12.6.3 Section IV: Land management improvement options

Water and land in the agricultural landscape need to be considered together to increase resource productivity and achieve sustainable development.

After independence in 1991, the Uzbek government declared domestic wheat production a prime objective to achieve self-sufficiency in staple food. Wheat became the second strategic crop in the state order system after cotton. As irrigated wheat production has only a history of less than two decades, opportunities to improve productivity may still be available. The optimal combination of nitrogen (N) fertilization and irrigation, losses of the applied N and costs and benefits have therefore been studied by Ibragimov et al. (chapter 4.1). Given the high impact of a combination of N-fertilization and irrigation-water management on N_2O emissions (a greenhouse gas), they show that management practices should be modified to mitigate N_2O emissions and to sustain higher N-fertilizer use efficiency. The amount and timing of the N-fertilizer application and irrigation events can be manipulated to reduce N losses. Concomitant N fertilization and irrigation is to be avoided whenever possible. In general, management practices that have been shown to increase the N-fertilizer use efficiency in irrigated systems, such as sub-surface fertilizer application, fertigation and drip irrigation, will likely also reduce the N_2O emissions and thus are expected to lead to more sustainable agriculture.

Improved N-management provides stable crop yields of good quality and preserves the environment. Groundwater contributes considerably to satisfy crop water demand in the irrigated areas of Khorezm, and high nitrate levels in the same groundwater also represent a significant supplemental contribution to the soil-N balance and plant-N uptake as shown by Kienzler et al. (chapter 4.2). If groundwater levels are reduced to avoid salinization, this forfeited N supply may need to be substituted to avoid N deficiency.

The studies reported by Bobojonov et al. (chapter 4.3) revealed manifold ecological benefits gained from increased crop diversification, including the reduced probability of crop failure and an increased economic stability. Crop diversity is thus an important factor for risk management.

Degraded lands still being cultivated are a drain on the resource base of Khorezm. An alternative use of degraded or marginal land is the establishment of tree plantations. This is the topic of the contribution of Khamzina et al. (chapter 4.4). Trees provide ecosystem services such as enhanced soil fertility and carbon sequestration and concurrently provide timber, fruit, fodder and fuel-wood. The assortment of appropriate tree species and silvicultural techniques for converting degraded, salt-effected land into small-scale forest plantations are extensively evaluated by the authors. Bio-physical processes (soil-plant-atmosphere) following the establishment of the tree plantations, i.e. tree water use, N_2-fixation, litter fall turnover are described, as are the magnitude of ecosystem services generated by afforestation i.e. supply and quality of fuel-wood and fodder. Mixed-species tree plantations can thus exploit marginal, salt-affected land – about 15% of the area in the Khorezm region. This frees resources that can be directed to the productive croplands, increasing the overall land and water use efficiency.

Deforestation of the riparian tugai forests in has contributed to the emission of substantial amounts of carbon dioxide (CO_2) to the atmosphere and reduction in C storage in soil and vegetation (Scheer et al.; chapter 4.5). The conversion of tugai forests into irrigated croplands releases N_2O and CH_4 equivalent to 2.5 tons of CO_2 per hectare per year. The return degraded unprofitable cropland into perennial plantations would compensate for these greenhouse gas emissions, and farmers could gain additional income if Uzbekistan would be ready to create or enter a carbon market.

12.6.4 Section V: Land and water management tools

By linking models for crops, water, soil, and salinity with Geographical Information Systems (GIS), various tools were developed in the Khorezm Project to improve land and water management.

A farm-level economic ecological optimization model was developed as a land-use planning and decision-support tool that couples ecological and economic optimization of land allocation (Sommer et al.; chapter 5.1). The model produces consistent and plausible outputs that can be used for quite complex scenario simulations. The simulation results enable a better understanding of the impacts of different cotton policies on the farm economy as well as on farmers' decisions with respect to land and water use in Khorezm. This has sparked a discussion on policy options that are available for promoting income and food security for rural producers in other areas with agronomic and economic conditions closely resembling those observed in Khorezm.

Oberkircher et al. (chapter 5.2) investigated three WUAs and their member farmers to assess their actual water access and their perceptions on water-saving practices. The authors used a GIS to integrate social science with physiographic data. The farmers are aware that water access is strongly related to the proximity of WUAs to the river but could be improved with water-saving practices. Farm location within the WUA and land elevation also seems to influence access to water and shape water use behavior.

The vast infrastructure built for irrigation, together with an ill-functioning drainage network has lead to a build-up of very shallow groundwater, followed by water logging and salt accumulation in the soil profile. Awan et al. (chapter 5.3) identify deficits in the management and maintenance institutions, inappropriate and inflexible irrigation strategies, and poor linkages between field level demands and in the operation of the network. The groundwater contribution to crop water use is quantified and a model is developed that allows mitigation strategies to raise irrigation efficiencies, reduce the impact of water stress on yield and thus improving water productivity. It also is the first managerial tool that integrates surface water from the irrigation system and groundwater and that therefore would be able to support managerial decisions on optimization conjunctive use of surface and groundwater under the deficit water supply.

Bekchanov et al. (chapter 5.4) argue that improving crop water productivity is a key to reduce food and water insecurity. To compensate for the general lack of information for farmers on soil salinity and available irrigation water, the authors used a mix of tools to estimate water allocation for cotton, wheat, rice, vegetables, and fruits. All these crops consume much higher amounts of irrigation water than presently recommended with cotton and rice as the highest water consumers. There is a large variability of crop-specific water productivity over the different regions and within the regions according to the location of farms and fields. Introducing water-wise options and less-water consuming crops remains a daunting challenge but would be beneficial particularly for downstream districts. A regionally differentiated cropping portfolio that accounts for variability in water availability and soil quality would go a long way to improve water productivity.

12.6.5 Section VI: Economic system-management reform

Economic, agriculture-based development of the country and Khorezm in particular has been analyzed with a general equilibrium model (CGE) (Bekchanov et al.; chapter 6.1). The CGE model was developed for Khorezm's regional economy and the national economy of Uzbekistan, which permits the comparison of drivers and policies at both levels. It also allows comparison of the current state of affairs with various alternative scenarios. The national and regional databases include production, final demand, and input-output relations for 20 sectors of the economy, 7 of which relate to the agrarian sector. A liberalization of the present cotton production policy would not necessarily have immediate impacts on national and regional incomes, but policies aimed at increasing productivity of the main crops and of livestock production would raise private and government revenues. The authors concluded that regionalizing the development strategies in Uzbekistan would lead to better use of the comparative advantages of regions than the current central approach of a uniform nationwide development program.

This view is substantiated by the findings of a Value Chain Analysis of the cotton and wheat sectors (Rudenko et al.; chapter 6.2). It reveals the potential of the agro-processing industry in Khorezm to impact both land and water use if the presently underused processing capacities would be better employed. Increased local processing of cotton fibre, for example, and export of textile products with higher value added could almost double regional export revenues. Developing this sector would maintain the targeted level of export revenue of the region with a lower rate of raw cotton production, which in turn could reduce land and water use. The freed-up land could be used for less intensive and resource-consuming crops such as tree plantations or pastures.

The introduction of water service fees has often been suggested as a 'silver bullet' solution for water use inefficiency. With a mathematical programming model that considers regional welfare, cropping patterns, export structure and the economic attractiveness of crops to agricultural producers, Djanibekov et al. (chapter 6.3) analyzed the local potential for introducing water service fees. Introducing such fees would generate sufficient funds to cover operation and maintenance of the irrigation and drainage system only if set at very high levels, and introducing fees as a stand-alone measure would likely fail to achieve these targets unless supported by additional changes, such as the reduction of state production targets on crops.

12.7 Conclusions

The research conducted in the Khorezm Project between 2001 and 2007 in the irrigated areas of Khorezm, allows conclusions that may be applicable across Central Asia, in the Caucasus, and in other irrigated regions of the world that share similar characteristics (flat, irrigated drylands). The decades-long production of the "white gold", cotton, during the Soviet Union era allowed investments in schools, infrastructure, health provision and much more. However, it also has resulted in widespread land degradation and the demise of the Aral Sea. Continuing unsustainable agricultural practices threatens the environment and livelihoods alike. But irrigated agriculture, also offers the opportunities to address the challenges. Increasing land and water productivity is a major pathway to supporting and stabilizing the national and regional economy as well as providing options for individual prosperity and sustainable livelihoods.

At the field level, the project findings suggest that it would be beneficial to use marginal, strongly salt-affected and unproductive cropland for more suitable purposes that benefit the ecology and livelihoods of the population. When diverting the resources thus spared to more productive areas, overall resource conservation and increased water productivity will occur without compromising on agricultural productivity at the farm and regional level. Increased resource use efficiencies can be reached through state-of-the-art methods on more fertile land, with the use of GIS and remote sensing tools, rapid and near real-time soil salinity mapping, and the use of conservation agriculture principles and crop diversification. Innovations can minimize energy use, reduce operating costs and greenhouse gas emissions.

Progress at the field and farm level can only be made in this regard if the Government of Uzbekistan takes on the challenge of institutional and economic reform. The Uzbek government repeatedly has affirmed its willingness to deploy funds and resources to ensure water supply. While this may be the case, it may not be sufficient to address future exacerbation of water problems, due to increasing claims by upstream water users and by climate change. The supply of "low-hanging fruits" is dwindling, and more complex solutions may need to be created that look at efficiency and productivity increases. This will require further scientific support. Given the future role of agriculture in Uzbekistan, investments training of human resources that can solve some of these intricate problems should be given high priority.

Education is considered a key element to successful economic growth, because jobs of the future will require higher level of skills. The Khorezm Project has strengthened research capacities at a higher-education establishment in Uzbekistan. This offered the advantage of integrating research with educational capacity building of local staff and students. The project was able to show that that this continuous effort has borne fruit. Yet, the success will ultimately depend on the partner country to take up the challenge, carry on with the capacity building and scale it out to other regions. An institutional reform of private and public agricultural extension is needed to be able to transfer knowledge to the inexperienced farmers, many of whom are former state-workers gone farming. They are novices in sustainable resource use and efficient enterprise development, and the investment will unlock improvements in the environment and rural livelihoods.

According to United Nations (2010), real GDP growth in Uzbekistan amounted to 8% in 2010, which was not only the highest in Central Asia but also has brought Uzbekistan to the top of the list with highest expected growth rates in 2011 (7%) and 2012 (8%). In some chapters of this book it is argued that the prosperity of Uzbekistan lies in the economic pursuit of a strategy of export-led-growth. Uzbekistan may prosper from manufacturing high-value products that can be exported and sold at competitive prices. This argues that farmers need better links to markets and trade, which may be achieved through the development of a thriving private sector. The alternative will be an endless continuation of subsidies. Cutting the present unsustainable subsidies and encourage home production may result in price increases of fuel and chemicals (fertilizers, pesticides) that need to be compensated by for instance higher farm-gate prices.

Recent experience worldwide has shown that emerging economies may be hit hard by booming oil prices since they use more oil per unit of output than rich countries do. The economy of Uzbekistan is energy-intensive and it profits from a highly subsidized petrol and gas price. But higher farm-gate prices are likely to be introduced when restructuring the commodity value chains, and higher prices would allow farmers to earn more income from their produce and increase their farm capital. This in turn could be used to invest in better, more efficient irrigation systems.

Cereal production in Central Asia needs to be boosted in both quantity and quality to ensure food security for the growing populations. At present, the producers in Uzbekistan are unable to react quickly to world market price movements, e.g. the food price hikes in 2008. Farmers in Uzbekistan are exposed to increased risks when producing alternative or additional crops. These risks stem from the needed up-front investments in all production factors for those new crops, including seeds, fertilizers and, eventually, machinery, under uncertain returns. The present unreliable water supply and imperfect market conditions often render investments unprofitable. The double goal of shielding farmers from risks and increasing security of returns on their investments can only be achieved by national strategic decisions. Minimum price guarantees or insurance schemes linked to water supply might overcome the risk aversion. Once such conditions are in place, sustainable development will be more easily achieved in the irrigated Central Asian drylands, to the benefit of people and nature.

Initiatives to address climate change in Central Asia are gaining ground. The present thinking by various international donor agencies is that not only Uzbekistan but also the other Central Asian countries should put further agricultural reforms ahead of other concern such as energy. But given the present inefficiency in the use of precious resources, energy management should remain a priority. Also the looming problem of rising food prices around the world should remain the focus of attention. Finally, much needs to be done to ensure water supply in downstream countries such as Uzbekistan. The five states in Central Asia including Uzbekistan must coordinate their efforts and work out a sustainable and transparent mechanism for cooperation on water and energy and while committing to preserving the environment. Working under the principles of fair, sustainable and reasonable use of transnational water resources will be critical in this context.

12.8 Outlook

The interdisciplinary Khorezm Project addresses resource-use efficiency, economic viability and environmental sustainability of land use and agricultural production systems and aims to provide a science-based comprehensive restructuring concept for improved management of land and water resources in the region. Elements of such a concept emerge from the pages of this book, and a number of more general conclusions come into view.

Policies. It has become evident from several of the studies that Uzbekistan would greatly benefit from creating a more market-oriented policy environment that would lead to changes in land use and irrigation water management. However, this liberalization will benefit from careful studies of the options and consequences of judicious adjustment of the policy environment. In order to allow for better policy-making, the impacts of various scenarios and alternative options need to be investigated in an integrative manner. We now have models that allow optimization of the policy mix, and a forecast of the long-term effects of these policies. Tentative steps may be under way, as one ADB document (ADB 2006) concluded, "These processes need to be supported with sound recommendations based on scientific research, examples *the ongoing agriculture sector reform initiative in Uzbekistan … seeks to reduce the mandatory state procurement targets for cotton and wheat* of which are provided in this book."

Efficient land use and water-saving technologies can only be introduced in an enabling policy environment. However, the right policy environment is of little consequence if the institutions are not in place to translate and implement these policies. In turn, institutional change would have little effect if there are no real options available to the farmers and decision-makers to gain efficiency, sustainability and profitability. The interplay of interventions at various spatial and temporal levels can be analyzed using computer simulation models, tools, and discussion-support tools developed in the framework of this project.

Institutions. Poor performance of irrigation systems and low water productivity and crop yields in Khorezm points to severe institutional shortcomings that need to be overcome, e.g. with regard to water management institutions and service provision by agricultural organizations at the regional level. As all land management is related to agriculture, improvements in this sector will automatically increase the performance of natural resource management.

Institutions act at different levels. At the regional level, water distribution and government structures (such as the Basin Department of Irrigation Systems (BUIS) and hokimiat) decide on timely water distribution to the different parts of Khorezm. This level corresponds to the whole hydrographic basin of the lower Amudarya region, the 'basin' of Khorezm, and the smaller sub-basins of management (so-called TEZIMs of variable size) that are run by management sub-units of the BUIS. At the micro-catchment level of a WUA (typically of 2000-3000 ha size), water and land allocation are decided. At the high-resolution level of a farm (80 ha) or a single field (1-3 ha), the more specific problems of how land is prepared and used for crops need to be dealt with in an iterative manner. In the case of water management, it is here that farmers deal with irrigation management, fertilizer strategies, crop rotation, etc.

Land use is dealt with at all levels of intervention. Farm, land and resource use optimization require political decisions which, to be successful, will have to be supported institutionally. Technological decisions are chiefly dealt with at the farm-level scale. Information about successful land management alternatives can inform decision-making on policies, for example through farmers that have gained experience with these technologies. They can champion these technologies into the policy arena, so that adequate policies are created to enable the technological advancements. Training and capacity building and the creation of 'centers of excellence' that cover the region are urgently needed to support this process. The Khorezm Project has shown how this "academic uplifting" can be achieved.

Technological innovations and their adoption. Technologies that can help increase resource-use efficiencies and that can shift the current system toward more rational land and water use and sustainability of agriculture have been developed in the Khorezm Project. They have been tested under farm-level conditions in an integrated fashion to demonstrate their potential for the region. The next milestone will be the out-scaling through on-farm participatory approaches, preferably with governmental support providing the enabling policy and institutional environment.

However, as Vlek and Gatzweiler (2006) argued: 1) global environmental change is proceeding at a fast pace, 2) values and norms systems are necessary fundamental institutions for defining man-nature relations, and 3) institutional change at the level of embeddedness at which values are located, occurs slowly. This book contains but a few examples of social-anthropogenic research addressing this latter aspects (cf. Oberkircher et al. this book). Later publications will emphasize this line of research.

Although at the national political level in Uzbekistan institutions change rather rapidly, there is little effort made to change the underlying value and norm system. As Diamond (2005) says, human beings "cling to those values which were the source of their greatest triumphs" but are now inappropriate. Overcoming reluctance and inability to change in the face of looming disaster are the key challenges for Central Asia.

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Chapter 13
Case V: Virtual Water along the Uzbek Cotton Value Chain

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13.1 Introduction

Cotton (*Gossypium hirsutum* L.) production in Uzbekistan, located in the ecologically threatened ASB, utilizes about 41% of all irrigation water and about the same share of all irrigated land (Rudenko et al. 2009). To intensify cotton production, a vast irrigation and drainage network has been constructed since the 1960s to divert water from the two rivers that used to feed the Aral Sea, the Amudarya with an annual flow of around 75 km^3, and the Syrdarya with 34 km^3 of annual water flow (Tischbein et al. 2012). Since cotton continues to be a centerpiece of Uzbekistan's agriculture and its national and regional economy, a considerable effort over the long term is required to reduce the country's dependence on this crop while combating ecological degradation.

Not only Uzbekistan but also all countries in the ASB are urged to proactively confront the risks and vulnerabilities. They are thus challenged to identify feasible options for a more efficient water use not only on various management levels but also within various sectors of the economy. Taking into account the present economic and ecological situation, it is compulsory to assess options that not only give high return on investments but also prioritize the environment and, in particular, increase the resilience of the rural landscape and livelihoods. A comprehensive assessment therefore demands a methodological approach that considers financial and ecological aspects of regional development while focusing on interrelated agricultural and subsequent industrial activities rather than on single sectors.

The value chain analysis (VCA) describes the full range of activities in a commodity chain that are required to bring a product or service from the design through the different phases of production to the delivery to final consumers and the disposal after use (McCormick and Schmitz 2001). While the VCA of cotton includes the products, describes the underlying production cycles, and estimates the financial gains of each sector in the chain, it does not consider the water use during each stage (Rudenko et al. 2009). The water use and the virtual water content in various products can be estimated through the water footprint analysis (WFA) (Hoekstra and Hung 2002; Chapagain and Hoekstra 2004), which thus complements the VCA by considering the key environmental indicator. In this study, the cotton VCA and WFA were combined to: (i) quantify the water footprint of the entire cotton value chain (CVC) in the Khorezm region in Uzbekistan, (ii) estimate the virtual water content of various cotton products, and (iii) calculate the water footprint value index.

13.2 Materials and methods

13.2.1 Study site

The case study region Khorezm is a 680,000 ha large administrative district located in the lower reaches of the Amudarya River in northwest Uzbekistan (41°41’ N latitude, 39°40’ E longitude and altitude 113 m). In the sharply continental, arid climate of the region characterized by low precipitation (annually 100 mm) and high evaporation rates (up to 1,400-1,600 mm), agriculture is made possible through irrigation. Annually, 4.5-5 km^3 of water are diverted from the sole source, the Amudarya river (Tischbein et al. 2012). The probability of receiving sufficient water for irrigation has been decreasing in the last decades (Müller 2008). In addition, it is expected that as a result of climate change, the availability of water in the Syrdarya and Amudarya rivers may decrease by as much as 30% and 40%, respectively (Perelet 2007). The recurring water scarcity is caused not only by external factors, such as the impact of climate change and the growing demand for water resources in the upstream countries (Djanibekov et al. 2012), but also by internal factors, including the expansion of irrigated areas to support the growing population in the region, and the poor condition of the irrigation and drainage networks, which causes high water losses (Tischbein et al. 2012).

13.2.2 Calculation of value added and virtual water content

Value added methodologies measure the increase in wealth for a nation as a whole, and include remuneration for labor, interest charges, taxes and the net margin (profit) of the producers. From a financial point of view, the value added represents the worth that has been added to a product or a service at each stage of production. In simple words, value added is the difference between the value of the product and the value of the purchased inputs ((McCormick and Schmitz 2001). The value added along the Uzbek cotton chain was calculated as the difference between sales price of a product and its primary cost, i.e., its total production costs (Rudenko et al. 2008).

The virtual water content of cotton products was calculated according to Hoekstra and Hung (2002) and Chapagain and Hoekstra (2004). In total, the virtual water content (m^3 ton^{-1}) and financial indicators of eleven types of cotton products (raw cotton, fiber, yarn, fabrics, T-shirt, absorbent cotton, cottonseed, cottonseed oil, cottonseed meal and cake, soap) were calculated. The virtual water of the raw cotton was calculated based on its irrigation water requirements in Khorezm. The virtual water content of all processed cotton products was calculated based on product and value fractions. The value chain method helped to trace the flow of cotton products and to estimate water use at each stage of production and processing.

From the field to semi-finished or finished products, cotton passes through a number of production stages, which in the study were subdivided into agricultural and industrial stages. Agricultural water use (AWU) under the irrigated practices in Uzbekistan includes: (i) water for leaching salts from the crop root zone, (ii) water used for irrigation during the entire crop-growing period, (iii) water conveyance losses in the main and on-field canals, and (iv) the water virtually needed to dilute, for instance, pollutants such as pesticides and fertilizers percolated to the groundwater, the so-called “grey water component”.

$$AWU = Leaching + Irrigation + Losses + Grey \quad (1)$$

Total virtual water (TVW) was calculated as the sum of AWU and the water amount used at each industrial stage (IWU):

$$TWV = AWU + IWU \quad (2)$$

Only that fraction of agricultural or industrial water was assumed for each subsequent processed product, the corresponding fraction of which was used to produce this subsequent product. For example, the total virtual water of cotton fiber was calculated as the sum of 33% of agricultural water use plus industrial water use at ginning.

$$TWVfiber=(Leaching+Irrigation+Losses+Grey)*33\%+IWUginning \quad (3)$$

Finally, the water footprint value index was calculated as the ratio of a value added to a certain cotton product to its virtual water content, as an indication of the monetary return on each m^3 of virtual water spent for producing various cotton products.

13.2.3 Data collection

The data collection methods, borrowed from formal and informal survey methods, allowed generating a data set on product fractions and flows. Semi-structured interviews using questionnaires were conducted with the main actors of the chain. Technical coefficients, parameters, and water use requirements at various processing stages and the processing organizations along the cotton value chain in Khorezm were previously estimated by Rudenko et al. (2009).

13.3 Results

13.3.1 Cotton Value Chain: From raw cotton to textile products

The CVC consists of cotton farmers, ginneries (cotton refining plants), textile companies, and oil extracting plants. The flow of products starts with raw cotton being transferred to the ginneries. Ginneries produce cotton fiber that, in Uzbekistan, is up to 33% of the raw cotton. Cotton fiber is mostly exported, while the remaining part is forwarded by the ginneries to the domestic textile companies for further processing.

Cottonseed, constituting up to 54% of the Uzbek raw cotton, partly flows back to farmers as seeding material for the next agricultural season but to a larger extent it is used as an input for oil extracting plants. Cotton oil and cottonseed meal and cake from these oil-extracting plants are then sold locally or exported. Finally, textile products, such as yarn (29% of raw cotton), fabrics (28.5%) and ready-made garments (28.5%) from textile producers are either consumed in the country or exported. However, since a larger part of the produced cotton fiber is exported, domestic cotton processing factories (spinning, weaving and textile) are not functioning to their full capacities, especially in the remote provinces of Uzbekistan such as Khorezm, where the capacities utilized are below 50% (Rudenko 2008; Rudenko et al. 2012).

13.3.2 Cotton Value Chain: Value added and virtual water of cotton products

The newly industrialized countries have built up a diversified export and industrial structure, since this strategy is more sustainable due to the access to large, diversified markets, the economy of scale, and the competitive effects (Stamm 2004). The underlying argument is that the more processing stages raw materials

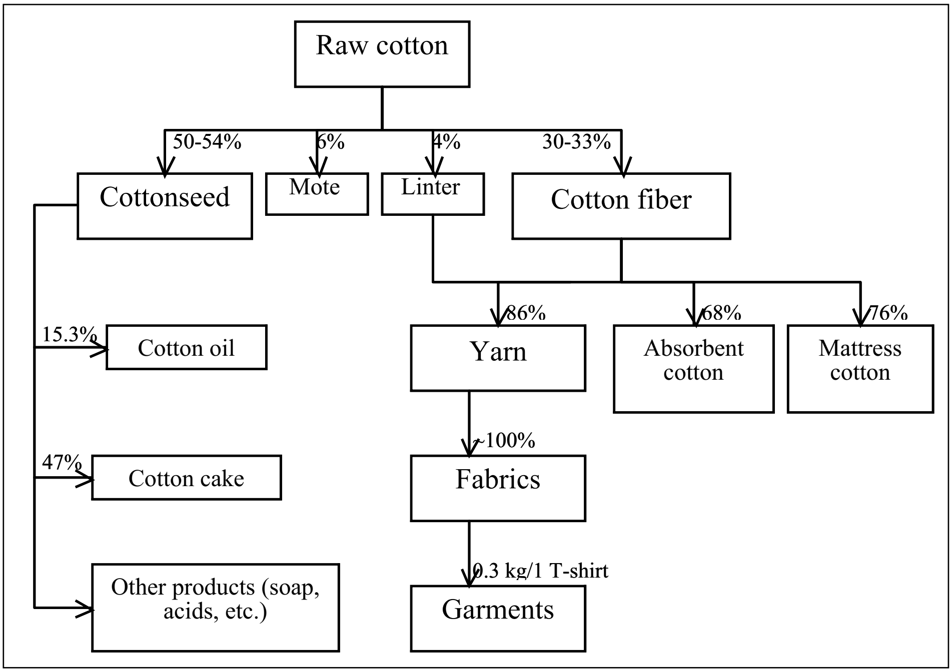

Figure 13.1. Cotton product flows and output fractions

pass through, the higher are the prices that can be obtained, and that the higher value is added with every additional production cycle. In line with this argument, value added to the raw cotton produced was about US$ 50 per ton, whereas it doubled for cotton fiber and continued to increase for all the subsequent products such as yarn, fabrics and garments (Table 13.1). The highest value added (0.66 US$ per unit or 2,000 US$ for 1 ton) was estimated for T-shirts produced domestically and then exported.

The agricultural stage consumes the most water due to the irrigation practices and the deficiencies of the irrigation and drainage networks. According to BUIS (2006), the water demand of cotton production in Khorezm ranges from 6,000 to 8,000 m^3 ha^{-1} including the water for leaching, and yields are on average 2.6 tons. In contrast, in this study, total AWU (considering also water seepage loss in the canals) for cotton production in 2006 was estimated at 17,729 m^3 per ha or 6,819 m^3 of water per ton of produced raw cotton (Table 13.1).

Once the volume of water used at each subsequent production stage, i.e., the IWU, was added to the virtual water of the preceding cotton product, the findings showed that the processing of raw cotton into cotton fiber consumed about 1 liter

Table 13.1. Value added and virtual water of cotton products in Khorezm, Uzbekistan

	Value added	AWU	IWU (cumulative)	TVW	Water footprint value index
	US$ per ton	*m^3 per ton*	*m^3 per ton*	*m^3 per ton*	*US$ per m^3*
Raw cotton	50	6,819	0	6,819	0.007
Fiber	112	6,819	1	6,820	0.016
Yarn	284	7,759	(1)+0.7	7,761	0.037
Fabrics	313	7,895	(1+0.7)+789	8,686	0.036
T-shirt (1 T-shirt – 0.3 kg)	2,000	2,074	(1+0.7+789)+0	2,865	0.698

of water per kg, rendering the virtual water content of fiber equal to ca. 6,820 m^3 of water per ton (Table 13.1). The most water-intensive processing stage along the cotton chain (which refers to the textile industry) was weaving or producing cotton fabrics. The IWU in the weaving process amounted to 789 litres of water per 1 kg of fabrics, since the bleaching, washing and dyeing consumed a large amount of water and produced much waste water.

The water footprint value index, illustrating the monetary return on each m^3 of virtual water spent for producing various cotton products, showed, as expected, the highest monetary return at the level of finished textile products (T-shirt, Table 13.1). Interestingly, the index for yarn was somewhat higher than that of cotton fabrics. This means that from a financial consideration, the virtual water is more efficiently spent in yarn production than in the following fabrics production.

13.4 Discussion

Experience shows that nations specializing in exports of primary commodities (e.g., cotton) are vulnerable to fluctuations in the world markets (Stamm 2004). Uzbekistan, for example, lost about USD 1.5 billion due to the low global cotton prices in 1998-2001. In the light of such experience, a shift from the primary commodity exports to the export of value-added commodities and removal of trade barriers with the aim of facilitating trade became an important part of the reform package in Uzbekistan, which among others targeted at reviving light (textile) industry. In order to achieve the benefits of the value chain development and of producing and exporting goods (agriculture based) with higher value added, it is important to create a favorable environment for increasing exports. For this, the Uzbek export regime has to be properly defined and to including financial, fiscal and other instruments in compliance with international settings, rules, and standards (Abdurazakov 2006). In addition to the creation of favorable export settings, it is also necessary to support the industrial upgrading of local producers and also the subsequent product upgrading, which could lead to higher competitiveness and world recognition of the Uzbek (cotton) products. Some lessons could be learnt from the textile and clothing sectors in the European Union, which had responded to a highly competitive and demanding world market by factors other than price, i.e., the quality of production and "fashion content", the capacity to develop the highly demanded brands, the ability to deliver the products in a fast and reliable way, and finally the sustainability and safety of industrial systems with respect to the environment and the employed workers (Commission of the European Communities 2003).

Our findings confirm that the highest water use along the CVC occurred at field level for leaching and irrigation, as was postulated earlier (Aldaya et al. 2010). Due to the deficiencies in the irrigation network resulting in high conveyance losses along the entire irrigation network, additional water is supplied to compensate for these expected losses (Bekchanov et al. 2012). Hence, decreasing the conveyance losses and simultaneously increasing water use efficiency in the entire CVC would be needed for sustainable use of this natural resource.

Agricultural stage of the CVC. Practices at the field level can be improved not only by technical solutions or resorting to water-saving irrigation techniques, but also by economic-oriented (e.g., water pricing) and management-oriented solutions (Bekchanov et al. 2010). The potential benefits of water-wise innovations are estimated to be huge. However, the impact strongly varies with the technology, and more water-efficient technologies usually are more capital-intensive (Bekchanov et al. 2010; Bekchanov et al. 2012). For instance, the introduction of irrigation water-saving technologies in the Khorezm region could reduce water demands by 1.5-3.0 km^3 annually (Bekchanov et al. 2010). With an estimated 70% water saving potential, drip irrigation is most efficient but needs relatively high financial investments. Considerable amounts of irrigation water (between 0.4-0.9% annually) in the field could be saved with improved irrigation methods such as double-sided furrow irrigation, alternate dry furrows, and shorter furrows, which are simple and low-cost solutions (Bekchanov et al. 2010). Between 25-30% of water can be saved by employing a laser-guided land leveler, an expensive equipment that might be introduced through extension service providers or farmers' cooperatives (Egamberdiev et al. 2008). Management-oriented solutions for reducing AWU include introducing alternative, less water-demanding crops such as maize or aerobic rice (Devkota 2011). However, these would reduce not only irrigation water demand, but also farmers' income due to lower yields and the associated profits.

A reduction of AWU can also be tackled beyond the field level. Since irrigated agriculture is with 85-95% by far the largest water-consuming sector in Uzbekistan, a reduction in water demand can be expected when investing in improvements to the irrigation and drainage networks. At present, less than 30% of the canals are lined, and only 12% considered waterproof, resulting in high seepage losses and rising groundwater tables (Tischbein et al. 2012). Furthermore, the average irrigation system efficiency is with about 30-40% low (Tischbein et al. 2012). Rehabilitating and renovating the irrigation and drainage systems, e.g., by concrete lining of channels, could reduce irrigation water losses, but would require high investments in human resources and materials (Micklin 2002).

Industrial stage of the CVC. Our findings suggest that increasing overall water use efficiency along the CVC can be achieved by diversifying the economy and processing of agricultural output by less water-consuming, domestic industrial sectors. For instance, total water use can be reduced by encouraging the manufacture of yarn or ready-made garments. Such a shift from the present strategy of exporting mainly cotton fiber to that of exporting manufactured products could maintain similar cotton export revenues while reducing the land area currently used for cotton production by up to almost 70%. Additionally, this alternative strategy bears the potential to free about 0.5 km^3 of irrigation water annually and to reduce the present state subsidies by about 14,000,000 US$ (Rudenko et al. 2009). The value chain study of the cotton sector in Khorezm reveals that cotton products (yarn, fabrics and garments) produced by the local manufacturers (equipped with modern German, Swiss and Turkish machinery) were highly demanded beyond Uzbekistan, particularly in the neighboring CIS countries but also in Turkey, to where virtually 100% of the Khorezm yarn was exported (Rudenko 2008). According to interviews with producers, the largest share of ready-made cotton garments is also exported from Khorezm to Russia. These locally produced cotton products are rarely available at local markets, and local consumers buy either expensive Turkish textiles or cheap Chinese textiles of low quality. Thus, the demand for Uzbek textile products exists both inside the country and abroad, but local cotton processors need strong support (including from the state) in order to operate at full capacity.

However, what needs to be stressed is that ‘clean’ production has to be intensified in the region, especially in the light of the presently low capacities for wastewater treatment. Despite the low IWU in the total cotton chain, which is below 10% of the total water use, water pollution is an important issue, as its magnitude depends on the processing stage and its intensity. To avoid environmental contamination by industrial pollutants in the cotton processing, the scope for treating and re-use of wastewater in the industrial sector has to be explored. For example, combining the VCA and WFA via the water footprint value index indicated the feasibility of exploring the cotton value chain up to the point of the production of cotton yarn. The latter does not require much IWU, hence does not produce much wastewater but brings higher export earnings than cotton fiber and higher financial gain per unit of water used. This calls for the development of the CVC up to the stage of yarn production, which has the second highest water footprint value index. Development of the weaving industry, although economically beneficial, would require much more water and lead to extensive pollution. Therefore, this is not recommended in the case of remote provinces like Khorezm unless additional efforts and investments are made for upgrading their cleaning facilities, i.e., treatment of wastewater.

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UZWATER

This compendium is produced for a master level course in the UZWATER project. It consists of some newly written material as well as previously published texts extracted from freely available books, reports and textbooks on the Internet, dominated by publications from the Baltic University Programme. The sources used for each chapter is listed at the end of the chapter. The compendia of the Uzwater project are produced exclusively for Master students free of charge at the participating Universities and is not to be sold or be freely available on the Internet.

The UZWATER project is an EU TEMPUS project. It includes 8 universities in Uzbekistan and deals with university education for sustainable water managment in Uzbekistan. Uppsala University and Baltic University Programme is one of the six EU partners in the project. Lead partner is Kaunas University of Technology.

The main objective of the project is to introduce a Master level study program in environmental science and sustainable development with focus on water management at the eight partner universities in Uzbekistan. The curriculum of the Master Programme includes Environmental Science, Sustainable Development and Water Management.

The Sustainable Development unit will include the basic methods used in Sustainability Science, in particular introduce systems thinking and systems analysis, resource flows and resource management and a series of practical tools for good resource management, such as recycling, and energy efficiency.

The specific objectives of the project are:

- to establish study centers at the partner universities in Uzbekistan
- to improve the capacity to train master students with expertise to address the severe environmental and water management problems of the country;
- to support the introduction and use in Uzbekistan of modern education methods, study materials, and e-learning tools;
- to encourage international cooperation at the partner universities;
- to strengthen capacities to provide guidance to authorities and the Uzbekistan society at large;
- to ensure the visibility and promotion of the Master Programme through web pages, printed material and cooperation with society;
- to ensure continuity of the Master Programme and long-term support of the project outcomes at partner universities beyond Tempus funding.

http://uzwater.ktu.lt