To be or not to be a Strategic Research Agenda?

The evolution of knowledge management in IWRM-net

Work package 2
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Work package 3
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SIXTH FRAMEWORK PROGRAMME

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IWRM-NET

Towards a European-wide exchange Network for integrating research efforts on Integrated Water Resources Management

Thematic priority: Integrated water resource management

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Introduction to the project

In 2008 the subjects within the joint call were Hydrological - morphological pressures and impacts on ecological status along with Water Governance.

In 2009 the subjects were climate change, water scarcity and drought and economics and environmental valuation. 11 projects are funded in total

The IWRM-net project was created as an era-net during FP6 to develop a networking tool among national and regional research programmes, to help their managers to exchange good practices, and share knowledge. It started in January 2006 and will end in December 2010, focusing on the field of Integrated Water Resource Management.

21 European partners and 17 research programme managers are currently involved in IWRM-NET. They are research programme managers working at national or regional level and dealing with Integrated Water Resource Management issues. The ERA-Net project IWRM-NET is coordinated by the International Office for Water.

IWRM-Net has launched two calls in its 5 year programme. (2008 and 2009). In 2008 the subjects were Hydrological/morphological pressures and impacts on ecological status along with Water Governance. In 2009 the subjects were climate change, water scarcity and drought and economics and environmental valuation. 11 projects are funded.

A vision of the partners from the beginning was to provide a forum for co-ordination of research needs and programmes on related issues in different countries, including accession states and EU neighbours. As part of the process to reach better collaboration and launch joint calls for water research the partners identified research needs in the short and long term.

This has been achieved by SNIFFER in Scotland (short-term needs) and French Ministry of Ecology, Sustainable development, Transportation and Housing (MEDDTL), ADERA-Ecobag from France and University of Liege from Belgium who worked in the long-term needs. These partners have worked together to create this document as a baseline to support the future ideas for collaboration, by highlighting the common issues that could be taken forward in joint calls in the future.

1. Water Management in Europe

Integrated Water Resources Management (IWRM) is a multidisciplinary and intersectoral approach based on science that brings all actors (stakeholders, industries, agriculture, local authorities, etc.) to determine how to meet society's long-term needs for water and how to maintain essential ecological services and economic benefits. IWRM accounts for social, economic and environmental factors and integrates surface water, groundwater and the ecosystems through which they flow. To deliver IWRM it is necessary to solve a range of interrelated issues, such as

- as balancing water quantity and quality,
- maintaining biodiversity and ecological functions and serv ices etc.
- the variability and changing nature of water supplies as a re-sult of climate change,
- the change of the key factors that's determine a basin's vul-nerability,
- the necessity of including stakeholder and public participa tion in water management decision-making,

Beyond the integrated water resources management, it is now necessary to move to an adapted management. It is impossible today to accept the sector-by-sector and top-down management style that has dominated in the past. Therefore, integrated management is recommended by European legislation for all spatial management (water, flood, soil, coastal area, river basin) in order to develop a sustainable management of the environment and its resources. The decision making is no longer a single decision but is replaced by multi-scale polycentric governance that includes a large number of different institutional or not institutional setting. The governance system supposes to create rules that create convergent expectations and behaviour. The transparency and consultation of the public does not guarantee the acceptance of the public, but they are capital in the decision-making process.

European water management is driven by the implementation of the Water Framework Directive (WFD). 2010 is the celebration of the 10th anniversary of the Water framework Directive and its implementation raises a lot of cross-cutting issues and many different multidisciplinary research questions, in particular it gives the goals but not the methods how to achieve them.

The WFD has induced water managers and policy makers to develop entirely new approaches and operational modes, thus triggering the complete renewal of research demand. The WFD takes into account the increasing internationalization, uncertainties and complexity of water resource management, the increasing number of actors and institutions involved in this process, the economic interests in water supply, and the increasing societal concern and sensitivity towards environmental protection.

Uncertainties are growing with the global change, in particular climate change. Uncertainties should be taken into account in deciding the appropriate action in view of sustainable water management. This action may include further investigation, monitoring and assessment to reduce uncertainties. There can be uncertainty about: the impact of policies already in place or planned and various trends, the effectiveness of measures in addressing an adverse impact on a water body, the assessment of the achievement of good status, the costs associated with measures, the benefits resulting from improvements to the status of water bodies (particularly the calculation of the non-marketable benefits), etc. These uncertainties will have a substantial impact on cost benefit analysis. analysis.The statistical analysis of historical data is now in many cases not sufficient to reduce uncertainties. Therefore, the river basin management needs a deep understanding of key factors that determine the basin's vulnerability. It is necessary to take into account environment, technological, economic, institutional and cultural characteristics of river basin.

This complexity of water management shows our development over the past 20 years. Previous problems can be dealt with confidence but our better understanding means that the unstructured problems are difficult to be solved because all the parties involved are dependant on each other.

The WFD has provided a renewed approach to water management, such as achievement of good ecological status (GES) by 2015 for all surface waters. The GES is defined, in terms of the quality of the biological community, the hydrological characteristics and the chemical characteristics. No absolute standards for biological quality has be set which could be applied across Europe considering the ecological variability. In fact, it is particularly difficult and new to set ecological, chemical or hydromorphological standards for a given body of water. Thanks for WFD, many improvements have been done as, for example, the understanding of the importance of the hydromorphological conditions to achieve the GES.

Finally, quantity is a major issue in particular for groundwater. There is only a certain amount of recharge into a groundwater each year, and of this recharge, some is needed to support connected ecosystems (surface water bodies, terrestrial systems such as wetlands). For good management, only that portion of the overall recharge not needed by the ecology can be abstracted.

Other water related directives

The WFD is not the only European legislation relating to water, as other Directives and policies combine to offer increasing protection from pollution for soil and water. Ongoing research is crucial in implementing these environmental protection measures in the most cost-effective way. All these directives recommend an integrated management.

The Floods directive (2007) aims to reduce and manage the risks that floods pose to human health, the environment, cultural heritage and economic activity. The Directive requires Member States to first carry out a preliminary assessment by 2011 to identify the river basins and associated coastal areas at risk of flooding. For such zones they establish flood risk management plans focused on prevention, protection and preparedness by 2015. The Directive applies to inland waters as well as all coastal waters across the whole territory of the European Union.

Another important text is the Soil thematic strategy and the Soil Framework adopted by the European

Commission. This sets out the objective to protect soils across the EU on the basis that soil is the interface between the earth, the air and the water. Soil is a non-renewable resource which performs many vital functions: food and other biomass production, storage, filtration and transformation of many substances including water, carbon, nitrogen. Soil has a role as a habitat and gene pool, serves as a platform for human activities, landscape and heritage and acts as a provider of raw materials. These functions are worthy of protection because of their socio-economic as well as environmental importance.

The Habitats Directive is important text not only for the Europe's nature conservation policy but also for aquatics and wetlands. As industry, agriculture, domestic waste and transport all leave their dirty marks on the water, many European environmental policies contribute to water protection from various directions e.g. waste, chemicals, industrial pollution prevention, nature protection, pesticides, agriculture, etc. These policies have other aims and other scopes of action, they are not sufficient to ensure an adequate level of protection for all water in Europe but they contribute to improve the state of the water bodies.

It is the consideration of these aspects that has tested the knowledge of water managers and scientists, it has induced water managers and policy makers to develop entirely new approaches and operational modes, thus triggering the complete renewal of research demand and it is this demand for knowledge that is the interest of this document.

2. Identification of scientific needs in support of IWRM

Currently across Europe there are a numerous networks & platforms that considers research needs and the latest scientific understanding of water management. These platforms for discussion and research are supported by a range of methods, including strategic documents, websites, databases, etc, but it is important to highlight the lack of consistency between the many initiatives.

The 7th Framework Program for Research and Technological Development

(FP7) is a key pillar for the European Research Area that was proposed in 2000 by the European Commission to tackle insufficient funding, to stimulate research and to improve the coordination of national research activities and policies. The FP7 is the main European program for research. It will last for seven years from 2007 until 2013. The water related issues are includes in the environmental part of the FP7 that highlight the sustainable management of the environment and its resources. In order to develop an integrated way global environmental issues, it is necessary to improve the knowledge of the interactions between the climate, biosphere, ecosystems and human activities, and developing new technologies, tools and services. Therefore, FP7 put emphasis on prediction of climate, ecological, earth and ocean systems changes; on tools and technologies for monitoring, prevention, and mitigation and adaptation of environmental pressures and risks. FP7 aims also to promote integrated research involving all stakeholders.

In the FP6 and FP7, the objective of the **ERA-NET scheme** is to develop and strengthen the coordination of national and regional research programmes. The aim is to provide a framework for actors implementing public research programmes to coordinate their activities. by developing joint activities or by

"It is important to highlight the lack of consistency between the many initiatives"

mutually supporting joint calls for trans-national proposals. The participants in these actions are therefore programme 'owners' (typically ministries or regional authorities defining research programmes) or programme 'managers' (such as research councils or other research funding agencies managing research programmes). Along with IWRM-net the following environmental ERA-NET have dealt with related environmental issues :

- **CRUE ERA-NET**

The CRUE network has been set up to consolidate existing European flood research programmes, promote best practice and identify gaps and opportunities for collaboration on future programme content. The CRUE ERA-NET was completed in October 2009 but the CRUE ERA-NET continue to co-operate on joint research initiatives and Partners are exploring opportunities for maintaining and extending collaboration in the future. CRUE gather 16 partners from most European countries that have been particularly badly affected by flooding.

The partners in the CRUE ERA-Net are committed to working towards consolidating the variety of actions and initiatives to meet the needs and aspirations of both policy and practice on FRM in order to face the challenge of flooding in Europe. CRUE has launched two calls in

2006 and 2008. Partners are elaborated a Research agenda in order to facilitate the strategic integration of research at the national funding, to promote the sustainable management of flooding risks at the scale of river basins, estuaries and coastal process cells. CRUE's Research Agenda provides a clear set of directions and priorities on programme implementation and will serve as reference for additional flood research related actions taken on a European or national level. CRUE has identified five Strategic Research Areas :

- Developing resilience and adapting to increasing flood risks: climate change and new development,
- Risk assessment and mapping,
- Implementing trans-national based strategies on flood event management and recovery,
- Meeting the multifunctional demands on flood prevention and protection and their sustainable management ,
- Addressing public knowledge of flood risks and enhancing awareness, perception and communications.

- **CIRCLE ERA-NET**

CIRCLE is an European Network of 34 institutions from 23 countries committed to fund research and share knowledge on climate adaptation and the promotion of long-term cooperation among national and regional climate change programmes. 3 calls were launched. A science policy agenda is currently under development. Circle-2 start in may 2010 and will end in 2014.

- **SNOWMAN ERA-NET**

SNOWMAN was launched in 2004 and ended of 2009. The SNOWMAN ERA-NET aims to improve the cooperation in the field of contaminated soils. SNOWMAN has developed transnational cooperation in research funding via coordinated calls for research. Two transnational calls were launched. A Vision paper was elaborated in 2003 that describes the vision of the partners on the topic of transnational research funding. A Research program, based on an intensive discussion with all relevant stakeholders, was elaborated in 2009.

Below is a selection of some of these groups and partnerships.

The Water supply and sanitation Technology Platform (WssTP) was initiated by the European Commission in 2004 to promote coordination and collaboration of Research and Technology Development in the water industry. WssTP gathers 61 members and 210 contributors from Industries, Academics, Research, Policy Makers and Water Utilities. The platform has a strong network of members and contributors involved in its activities including the delivering of research strategic vision and identifying the future research needs. WssTP has published in 2006 and reviewed in 2010, its Strategic Research Agenda that is the first long-term strategy for a European water sector. (the strategy has been reviewed in 2010) The Strategic Research Agenda recognises the approach of Integrated Water Resources Management as overarching concept. The document identifies the main challenges faced by the European water sector and provides recommendations on priorities for research and technological developments needed to address those challenges. The Strategic Research Agenda highlights that it is urgent to develop low-carbon technologies and concepts to produce water, to treat wastewater or process water, and to balance water supply and demand while protecting aquatic ecosystems, reducing environmental impacts on water resources within the concept of integrated water resource management. ..It defines major challenges : coping with increasing water stress, reducing impact of extreme events, managing or lack of infrastructure, facilitating technology transfer. To answer those key challenges, the WssTP has defined six pilot programmes :

- mitigation of water stress in coastal zones,
- sustainable water management inside and around large urban areas,
- sustainable water management for agriculture,
- sustainable water management for industry,
- reclamation of degraded water zones (surface water and groundwater),
- proactive and corrective management of extreme hydro-climatic events.

The Pilot Programme is an organisational structure that embraces the whole conceptualisation, feasibility, prototype development, piloting, demonstration and deployment of cases.

ACQUEAU is the **EUREKA Cluster** for Water. It is an industry driven initiative dedicated to water related technologies and to fund innovation and RTD projects in the water sector. It aims at promoting innovation and market driven solutions to develop new technologies in the European water sector. Its programme needs proposes a close collaboration with WssTP to identify Research and Development Technology needs. ACQUEAU aims to fill gaps for applied research defined by the WssTP. It is a non-profit association founded by industrial companies. It is an initiative, supported by more than 20 countries and 40 industries from Europe. It addresses industries that develop products or services dedicated to water catchment, production, distribution, collection and treatment, that use water in manufacturing processes and that have interest in developing technologies related to the water cycle. ACQUEAU Cluster will initiate RTD calls on a regular basis identifying key 'technology needs' in order to strengthen the technological base of the European Water industry. It will complement other water programmes in order to fund applied research, to boost competitiveness & and innovation through Small Medium Enterprises and to encourage collaboration.

'**Water Challenges for a Changing World – Joint Programming Initiative'** is the first proposal to progress in the direction of the definition and implementation of common research agendas in the field of water and hydrological sciences with jointly agreed-upon multi–annual activities and funding mechanisms. In 2008 the European Commission presented a new policy: 'Towards joint programming in research' with the subtitle 'Working together to tackle common challenges more'. They challenged countries to develop initiatives on joint programming with the purpose of increasing the efficiency and impact of national public funding in strategic areas.

Joint programming targets public research programmes first and foremost, which means public-public cooperation. The concept of the water JPI aims to achieve an “umbrella” to facilitate synergies and complementarities of current EU, national and regional initiatives. This Joint Programming Initiative need to cooperate with the Water Supply and Sanitation Technology Platform (WSSTP) and related stakeholder networks to increase the efficiency and uptake of the research and development capacity of the European water sector. The proposal of JPI Water related (in April 2010) is the first stage of a long process... It will be necessary to define a strategic research agenda and to exchange more information before programming joint research activities. According based on the JPI, the water research faced a growing gap between global water demand and water supply, the overexploitation need of water sources, the discharge of waste water to the environment and increased pollution, the drought, the flood and the damage of the ecosystems due to climate change. Therefore, the European water research should to contribute to enhance the absorbing and self-purification capacity of the landscape and, to improve the ability of water ecosystems to reduce the emission of current and emerging pollutants, to and provide every citizen with clean drinking water and . It also should be based on the need for proper sanitation, to protect European citizens from new emerging water pollutants, to reduce energy input in desalination and water treatment processes and co-generating energy in processes such as sewage treatment.

There are also plenty others initiatives research water related. Here are below some examples of interesting initiatives for the implementation of water policies

The **European Water Partnership** EWP is an action oriented open forum for all stakeholders including governmental agencies, knowledge institutes, privates companies, non governmental organisations, the public and private financial sector, end-users and civil society to exchange views, to find solutions for the water challenges in Europe to stimulate partnerships.

The **Common Implementation Strategy** (CIS) - Science Policy Interface (SPI) aims to support technical milestones of the European water policies and river basin management planning process by linking the research needs of end users with scientific research outputs and promoting partnership relations between researchers and policy makers.

The **Water Information System for Europe** (WISE). This is a library catalogue of information or references. It links publications to a part of the world, so people can find out what is known about a particular wetland, creek, river or catchment. This provides an extremely powerful information tool for managers, scientists and policy-makers. This allows managers and policy-makers to access to the most up-to-date information.

Some formal or informal networks, as for example "Resilience Alliance" or some COST projects, are research organizations gathered organization of scientists and practitioners from many disciplines.

1.1 Managing Scientific Knowledge

The management of scientific knowledge is a complex issue. Beginning with the challenges associated with the classification of knowledge it also raises problems in the manner to which the knowledge is transferred to common use, be that in operational terms for water management or policy at the strategic level. For example when we consider the direction of needs from a water manager at the basin scale, we need to consider how the research can be translated into something 'useable' at the local and regional scale and often this is the most demanding and thus most urgent area for consideration by research programme managers across Europe.

The transfer of knowledge is often referred to as science-policy interface (SPI) and it considers a range of issues related to the management of knowledge and making it useful. The SPI means working to improve the quality of policy decisions through the provision of 'scientific' evidence, as well as improving the uptake of scientific outputs by policymakers and implementers. SPI is relevant for most policy fields, but one should not forget that not all science should serve policy nor all policy relies on science.

What IWRM-net is particularly interested in is the improvement of knowledge for water policy, both at the European level and also at the operational level. Through experience, the partners have identified that work at the level of collaborative funding across Europe lends itself to a more strategic and 'scientific' type of research, where the reaction time for knowledge generation is more long term. Here we will try to explain this in more detail.

It can be considered that the research life-cycle goes through approximately the same set of stages as policy; research needs to identify topics, develop a research proposal and search for funding, then research is implemented within a project and managed to reach objectives and deliver outputs that will be evaluated. Policy, in a similar manner, goes from preparation to formulation to implementation and then evaluation.

The interface between research and policy can be started at any point in their cycles, and in any direction, science to policy or policy to science. As a consequence, it is necessary to specify the questions that require specific focus. Amorsi et al (2009) considered *inter-alia* the following issues pertinent to the discussion of SPI and its better implementation across the European research area; (1) the difference in dynamics and expectations; (2) the difference in languages; (3) the complexity of Integrated Water Management in general and the implementation of the Water Framework Directive, and in particular (4) the challenging amount of scientific disciplines to integrate.

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2 When we consider the direction of needs from a water manager at the basin scale, we need to consider how the research can be translated into something 'useable' at the local and regional scale. It is often the case that research tends to bring about more questions than answers, and the problem often lies in the language used within each community. For example, the WFD speaks of 'water bodies'. This term is new to the scientific domain. Also a scientist will try to manage the uncertainties in the research by giving conditional responses, but a policy maker will demand certainties that can be given as evidence as to why a policy is required or taking the example of the basin manager, they would want a tool to support their tasks that is reliable and easy to use.

The level of research funding can often imply a specific type of research e.g. at the local or regional level the (water) authorities require 'consultancy services' and has the strongest focus on application, whereas national or regional science foundations typically emphasize the scientific innovation, and has significantly less focus on application. At the most strategic level, national/regional research programmes run by 'water/environmental ministries' are often of the 'innovation' type. These definitions are not precise but serve as a guide to the complexities of managing scientific knowledge at a pan-European scale.

Clearly, from the long list of topics to integrate in IWRM, it is a challenge to integrate the large variety of scientific disciplines. Where ecological sciences may need to deal on a very local scale that is determined by environmental aspects, scientific developments in the field of water-economy relate to larger spatial, administrative boundaries (e.g. national policies on cost-recovery). Though the WFD has invoked some streamlining of institutional settings by requiring the identification of a competent authority per river basin this does not imply consistency in mandate of these competent authorities and the challenge they face in coordinating the implementation of the WFD. Furthermore, cultural differences between Member States (MS) mean that implementation options in one MS may, due to political and cultural reasons, not be feasible elsewhere. Hence, where IWRM already implies an extraordinary effort to 'integrate', the IWRM-Net projects' focus on the implementation of the WFD provides some clarity on the scope, but on the other hand adds complexity due to the spatial variety in the environment of the European Union and the variety of administrative, institutional and cultural settings.

1.1 Harmonization of knowledge

By harmonizing the implementation of the policy it has allowed a similar harmonization of the scientific research to support this. The Common Implementation Strategy (CIS) has developed several non-mandatory guidelines for implementation on a European level.

One of the key challenges in EC-funded research is that the research usually targets large parts of the European Union. As a consequence results are often difficult to apply since it is difficult to produce a 'European' output and simultaneously provide results required for local use ('one size fits all'). However, in several EU funded projects representatives of the Common Implementation Strategy were directly involved to improve the usefulness of outputs. This document also aims to support the need for harmonizing the language and thus knowledge for IWRM across Europe.

We have already stated that IWRM has to tackle the same kind of challenges by combining environmental knowledge based on an interdisciplinary approach with a growing concern for governance able to take into account public consultation to implement accepted and relevant water policy. In this broad picture the ability to identify the 'good' societal and scientific issues play a major role. Taking into account the WFD and subsequent issues in terms of policy and research, the authors propose this document to elaborate scientific specifications for transnational collaboration.

1.2 Integrating Knowledge

The integration of knowledge is an important question when considering the management of the 'European' level issues. This challenge of integration between different scales becomes very important. Using local knowledge, while valuable in the assessment of knowledge gaps for water management, is too detailed for efficient analysis at a European scale. Using member state programmes is a more strategic system of analysis but leads to issues with the classification of knowledge within each country. The most effective method has been the questioning of experts and IWRM-net used this method very effectively to assess the needs and priority issues that were then evaluated through workshops to arrive at the scientific specifications for each joint call. Within the workshops the delegates integrated their knowledge with each other to arrive at a more homologous result. But here the issue of scale becomes a problem and the small size of the workshop can only be seen as 'representative'.

It also links to the issue of classifying the scientific information relating to IWRM. For the purposes of IWRM-net it was necessary to consider what were the knowledge gaps across Europe and thus required a collaborative research programme to fill these knowledge gaps. Sources of information were the documents supporting the research programmes of member states, EU FP projects, workshops and questionnaires. This a variety of sources leads to the challenge of analysing such a wide range of sources with its wide range of quality and quantity of information. Often information is held within scientific disciplines and there remains another task to integrate this knowledge into a valuable tool for water resource management.

This classification of knowledge is very important for the analysis of needs and also for the continuation of collaborative management of research programmes. By using a common system it becomes easier to follow the development of knowledge and the evolution of water management across Europe, building a stronger network for collaboration. But it also means that as language changes the once relevant thematic become old-fashioned and information relating to similar issues can get lost in outdated language. (Amorsi et al (2009))

1.3 Spatial and temporal scales

The transfer of knowledge is a part of the science policy interface often overlooked in the development of large scale programmes as it is a challenging outcome to measure. The method of communication of results requires consideration of the audience, the type of knowledge being transferred, the time and resources available and has been considered by the IWRM-net project .

The management of research needs to be considered not just in terms of its scientific content but also in terms of spatial and temporal scales. It is the precision of these aspects that will allow the science to be more targeted to the right audience and those reading the research will be able to understand the perspective from which the research was proposed. Here we shall consider the use of scale in research and in particular how it defines the knowledge.

- **Long term perspectives**

In the field of research and innovation policies, long-term perspectives help to plan research and innovation efforts. The first reason is that the time frame between the initiation of research and the delivery of its outputs can take many years. It is therefore necessary to imagine how the WATER SYSTEM will look like in some 5, 10 or 30 years, to anticipate the problems that water managers will have to face. Another reason is that a long-term perspective is needed for water research and policies to counter the habit of designing policies in reaction to current evolutions of the state of water systems to cure already occurring damages or to remedy existing environmental problems. Water policies should also *prevent* damages to occur and thus be more pro-active than re-active. The third reason is that a long term perspective enables a dialogue between science and society that leads to a better mutual understanding and commitment between researchers, the water managers and the decision makers. This dialogue is needed because of a major risk of indifference by the water managers and the decision makers to research results. The fourth reason is that the precautionary principle is an even stronger necessity to look into the future at plausible evolutions and events, even if there is a lot of uncertainty. Exploring the future allows us to identify the necessary research strategy that will help reduce uncertainty.

The objective of sustainability implies looking at future evolutions because it is intrinsically a dynamic concept. It is therefore not a surprise that more and more environmental policies prescribe long term environmental objectives e.g. good ecological status of waters by 2015 or 2021. Sustainability requires not only pre-activity (to anticipate future evolutions in order to be able to react in time) but also pro-activity, which means that we want to anticipate possible futures in order to be able to change them and to propose an alternative desired future.

Having a long term perspective will allow researchers, research programme managers and decision makers, to design what we can call the “operational context' , since the timing of research and the timing of water operators are different. By designing the operational context of research results, it will be possible:

- to take into account the results that are produced before the emergence of the corresponding problems ;
- to program the results that should be obtained to face the problems to come (long-term research needs) ;
- to identify the missing results to face the already existing problems (short-term research needs).

- **Regional, national to European and global scale**

Whatever the temporal scale of the research needs, short-term or long-term, the WATER SYSTEM is made of processes that can be considered as universal and of components (for example a water body) that have local specificity. On this basis there needs to be a hierarchy of research needs or knowledge requirements that consider these levels. Put in terms of administrative boundaries, the research needs to be conducted:

- at a large scale to profit from important human and material support that can be funded at the national level and more and more at the international one;
- at the regional scale to fit with the regional specificity.

For example, modelling water quality and quantity can be done with equations that will represent universal rules (e.g. Darcy's law, Denitrification) but the way to run these models in regional units of management requires adaptation. The development of a European collaborative programme in water research funding needs to consider the link between the various scales. It requires an understanding of how the knowledge and in particular the research outputs can be efficiently transferred between the local projects testing and adapting models and the European requirement for strategic knowledge on the implementation of the WFD.

Another example can be found in the question of dangerous substances. To identify the substances it is necessary to share the information at a large scale since these process are the same whatever the regional specificity. To focus on the *behaviour* of these substances in the WATER SYSTEM and their consequences on the biological and human compartments, it is important to take into account the regional specificity such as climate, chemical background, and social uses.

2. Identifying Research Needs in IWRM-net

The original description of work for IWRM-net defined two work packages that would investigate research needs, the first was regarding short term requirements and the second was to investigate long-terms needs. For the long term research needs (work package 3) A team of three organisation from France (MEDDM, ONEMA, ADERA-ECOBAG) and the University of Liège from Belgium ran an integrative process based on a collective foresight approach which dealt with "strategic research", addressing implementation requirements beyond WFD 2015 to assist program managers in identifying long term strategic research work needs for future integrated resources management. For short term research needs (work package 2) the focus was), SNIFFER in Scotland focused on delivering a scientific specification for the joint calls. This meant the process was refined according to the needs of partners.

1.1 Short term research needs

SNIFFER proposed to consider the Water Framework Directive as the guiding thematic for the research needs and would use the language of the WFD to define the needs. Yet within the partners there was a real desire to consider the whole breadth of ideas and issues associated with integrated water resource management and not to be limited by the set parameters of the WFD. Prior to the event in London in January 2007, the delegates and partners were send the following list of themes with an open questions about research needs;

- Typology & reference conditions
- Classification
- Environmental Quality Objectives
- Biological Classification
- Physico-chemical
- Hydro-morphological
- Economic Analysis
- Heavily Modified Water Bodies
- Good Practice Guidance
- Biological monitoring
- Physico-Chemical monitoring
- Morphological
- Communication tools
- measuring participation and engagement
- Relationship with other plans
- Typology & reference conditions

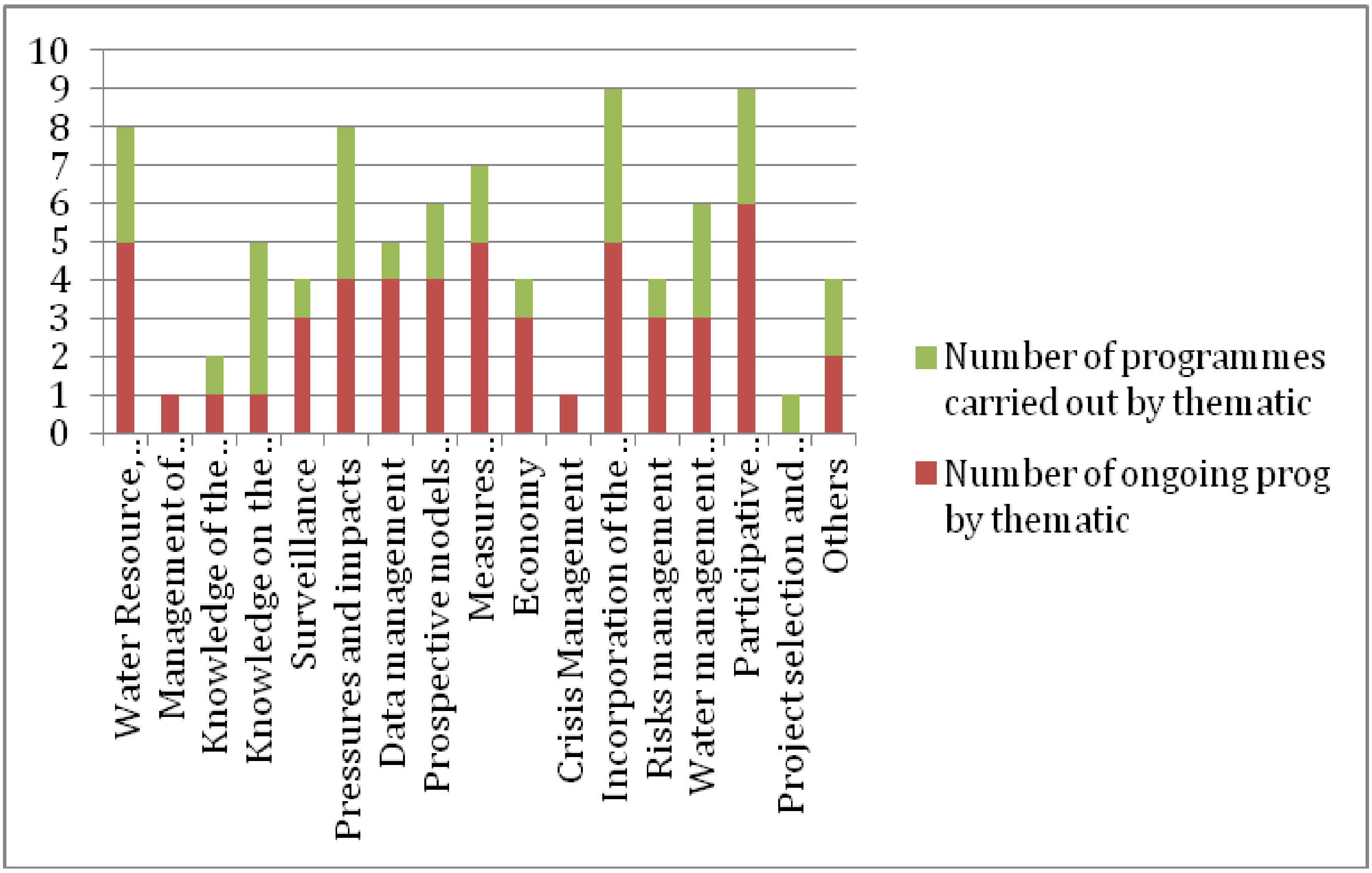
This list was taken from the list of issues raised in 2005 by the CIS working group that considered issues specifically related to the implementation of the WFD and used the network of organisations associated with the CIS, normally the competent authorities tasked with implementation of the Directive.

In 2007 the analysis shows that economy does not stand out as a priority area, whereas areas that are significantly lower are management of groundwaters and crisis management.

In London the list was narrowed down to the following five headings (.5.through discussion internally with partners, (1) characterising the environment, (2) environmental objectives, (3) pressures and impacts, (4) socio-economic issues, (5) monitoring and indicators, through discussion internally with partners.,. During the international workshop, facilitated sessions were used to define more precisely the priority issues.

These priority issues were taken forward to a specific work an IWRM-Net workshop in Edinburgh (May 2007) that focused on creating the scientific specification for the first joint call. It brought together partners and invited scientists and /research programme managers to work collectively. The meeting was an IWRM-Net internal meeting with members of the consortium attending. Some external experts were invited to speak to

Figure 1 : Research Programmes from IWRM partners classified by 'CIS' thematic



provide a scientific overview. The workshop delegates were asked to look at analysis of and analyse current and planned research programmes for the period of 2008-2010 and to find the common areas of research to take forward together or identify gaps in research that are needed as a priority. Each group presented their priority research needs in the format below;

Title

Research questions

Outcomes/deliverables

Funding or Interested partners

Other notes

Agreement was reached on two themes (1) Hydrological and morphological pressures and impacts on ecological status (2) Water governance.

For the development of the second call of IWRM-Net, scientific specification a series of facilitated workshops around Europe were proposed to engage with a more regional audience and to disseminate the work of IWRM-net. This was to try and bridge the gap between the pan-European level of the era-net which closely tied to the thoughts and issues of the Commission and the grass-roots implementation of the Directive at the local and regional level. Subjects were discussed with host countries to identify topics that were pertinent to the region, along with those that could be pan-European. Workshops were located in Valencia in Spain, Sibiu in Romania and Stockholm in Sweden. A final workshop was held in Brussels at the IWRM-mid-term event.

At each event the subjects were developed using an iterative process in discussion with host organisations and the project network. The Valencia workshop proposed the development of decision-support systems and water scarcity and managing erratic flows as the initial subjects and through discussion agreed the following priorities; ; (1) Droughts, floods and ephemeral streams (2) Improving efficiency of use and re-use of water and waste-water. The Sibiu workshop led with the following subjects (I) surface water - organic and nutrient pollution), (II) surface water – hydro-morphological alteration, (III) surface and groundwater - hazardous substances pollution and groundwater quantity. The final agreed priorities were integrated pollution management (including hazardous pollution & arsenic in groundwater), management of river basins and floodplains and good ecological status. Stockholm proposed the subjects of lakes and wetland management, forestry and water management and finally integrated river basin and coastal management. The workshop arrived at the conclusion that the priority subjects would be (1) integrate all water resource demands in the basin in relation to the available supply, (2) Develop policy instruments to protect and manage ecosystem services (3) Improve our understanding of the links between hydro-morphology and ecology.

Again through an iterative process, the debate with the IWRM-net General Assembly concluded with the following thematic proposed for the second call; (1) Climate change impacts and adaptation for IWRM (2) Water Scarcity and Droughts (3) Economics for IWRM: Social and Environmental Evaluation for decision making and Incentive measures to regulate uses (4) Managing priority substances on a catchment scale (5) Governance and Integrated Catchment Management (6) Dams, Reservoirs and Ecological continuity (7) Science policy Interface

1.1 Long-term research needs

The WP3 of IWRM-NET dealt with “strategic research”, addressing implementation requirements beyond WFD 2015 to assist program managers in identifying long term research needs for future integrated resources management.

For IWRM-net the two steps were (1) the identification of the major issues for the WFD, (2) the collective agreement on major issues considering the WFD implementation process. The purpose was to consider the long term process of implementation (2015, 2021 and 2027) of the Directive. This has been done by sending a questionnaire to European water managers to ask them about major issues for the future, knowledge gaps and methodological requirements that they have identified during the elaboration of the 2015 scenarios for the WFD. The next stage was to gather water managers, water scientists and experts in ‘foresight’ to discuss and prioritize the outputs of the questionnaire (WORKSHOP LIEGE 2007). The Workshop was the starting point of the process of identification of research issues that might be important for water management in a near future. The foresight experts , research managers and water managers developed a wide range of issues that were elaboration of WFD baseline scenarios or associated foresight methods in several European countries.

The following questions were suggested during the Liege workshop:

- How to evaluate aquatic systems taking into account socio-economic aspects and environmental aspects?
- What indicators to evaluate the evolution of aquatic systems under the effect of global changes (climate change, agriculture …)
- How to evaluate the effect of measures on the status of the water bodies? Which economic evaluation methods could be used?
- What methods of foresights for aquatic systems?
- How to link foresight on aquatic systems with foresights on other sectors (agriculture, land use, economy …)?

From the Liege Workshop results, a group of experts identified research themes to be discussed within a hybrid forum, held in Paris. (April 2008).

This event gathered numerous experts (water managers, land use planners, leading scientists from several disciplines including socio-economic disciplines, specialists of innovations), users representatives from different sectors (agriculture, industry, tourism, etc.), and NGO’s.

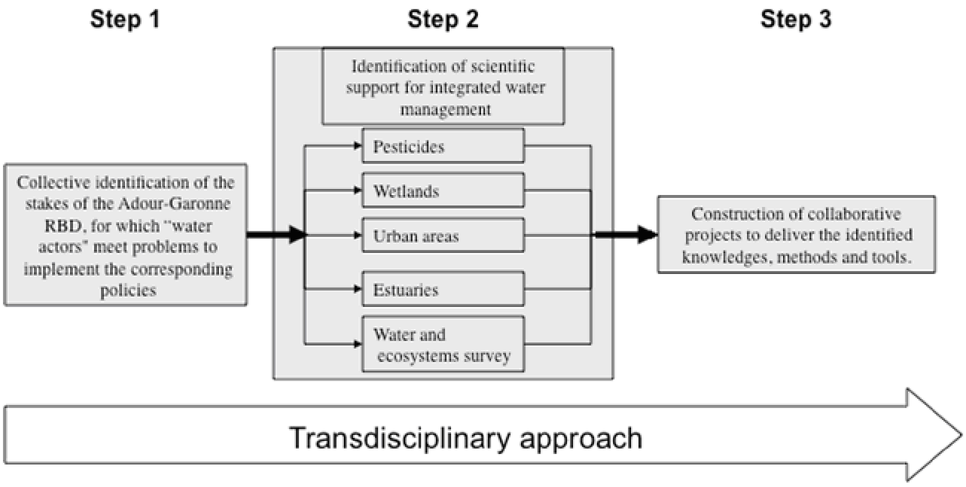


Figure 2: The collaborative and iterative process to identify long term research needs The collective and iterative process proposed by ECOBAG aims to identify the supports (knowledge transfer, multidisciplinary expertise, demonstration, research development) which are appropriate for integrated water management. The process involves from the start non-governmental organizations, small and medium enterprises, industries, water managers and researchers from all the disciplines that are relevant for sustainable development (Vervier et al, 2009).

To organise the discussion, two major issues were identified by the steering committee that prepared the workshop:

1. How to value aquatic systems taking into account socio-economic aspects? How to assess the efficiency of the first programme of measures in order to build up the further ones?
2. What new concepts and tools for a real Integrated Catchment Management? What tools or methods to be able to deal with unknown emerging issues?

Break-out groups worked simultaneously in successive working sessions dedicated to:

1. the gaps and problems unveiled during the first round of the RBMP;
2. the future driving forces and their impact on water management;
3. the key research questions that have long-term implications and should be addressed from a strategic research programming perspective.

The table summarize the key findings of working sessions :

Main future drivers	Future potential changes	Impacts on water management	Research needs
Climate change	Changes in average temperatures, precipitation patterns, magnitude and frequency of extreme events (storms, droughts)	Impacts on water supply, water quality, management of extreme events like floods impacts on the capacities of water system for resilience	***What is the resilience of the ecosystems when faced with extreme perturbations?*** • Definition of indicators which are sensitive to limits and trends toward thresholds (biological and physical indicators but also socio-economic indicators) and development of early warning systems used by water managers to avoid reaching a tipping point • Long-term hydrological and biological monitoring datasets for the detection of ecological effects produced by climate change. • Mitigation and adaptation strategies for climate changes
Societal values and practices	Changes in social perceptions of fairness, Changes in Social perceptions of the environment, in social practices related to the environment Changes in social behaviour	Impact on the recovery of costs – e.g. : - compensation for giving up water rights - changes in the economics of farming, - increasing demand for the application of the 'polluter-pays' principle The value of good ecological status (seen as a social object) could change due to changes in social values of the environment	***How to change social values and practices to improve the legitimacy of measures to conserve water and the perception of fairness and accountability?*** • There is need to provide people with an understanding of the many beneficial services provided by aquatic ecosystems to economic and social welfare. How will the social values of the water and the people's behaviour and practices respond to higher prices of water use (full recovery of costs) • Development of indicators to give a measure of more abstract issues such as human well-being • Development of tools comprehensively taking into account the pattern of interactions between the ecological services, the social actors and the values they assert.
Other sectorial policies	Agriculture, land use and CAP Energy Transport policy Industry tourism	Changes in other sectorial policies may counteract the WFD implementation, e.g. a likely shift of transport of goods from road to inland waterways	***How can the legal frameworks be simplified to integrate different policies?*** • There is a strong need to develop ideas and come up with innovative proposals for institutional arrangements that could help to implement integrated water resource management better.
Regulation and institutions Water governance	Future of the EU Evolution of political priorities (EU enlargement, further policy integration) Evolution of general regulations, especially public-market	Modification of the governance of water systems Changes in allocation of WFD budgets, revenue and expenditure	***How to make the change from supply driven to demand driven water management and balance uses with ecosystem needs, but also balance between different uses?*** • Find ways to build trust and to engage stakeholders more effectively • Create of learning processes between actors • Facilitate communication between involved actors such as ministries, agencies, researchers, local stakeholders.... • Find arrangements, institutions or capacities to work across different levels of government • Develop transdisciplinary approaches in research which integrate non-expert views (e.g. stakeholders views) • Develop new systems of payment for water and WFD to include more effectively the 'distributive' aspects of water economics across all aspects the hydrological cycle ***Does the current governance of the WFD allow it to be adaptative considering the future potential changes?*** • Develop scenarios/ foresight for water management which cover impacts of driving forces at different scales, role of actors and should enable to play through different topics • Develop predictive tools for assessing the consequences of the programme of measures after its implementation
Technology and innovation	Development of new technologies	Biofuels, hydropower and desalinisation plants could have impact on water quantity and quality	• Assessing potential positive and negative impacts of new technologies on integrated water resource management

3. Common Vision on strategic Issues

As the results of the workshops started to accumulate, the partners involved in the development and capture of research needs found common themes throughout the short and long-term needs, but no common mechanism to capture and present these issues as proposals for research programmes or projects. The following section shows the work completed to bring together the development of scientific specifications for the calls and the Foresight programme into a statement on the future research needs for IWRM in Europe. It is not intended to be comprehensive but a support to the anticipated discussions on future collaboration in research funding, such as within the JPI. The future work on collaborative research programmes will bring together different researchers with different visions but the partners hope that this work can form a baseline to guide these discussions and make the process a little easier.

The challenge in creating such a common vision has often been one of language. Not just the difficulties in translating ideas between French and English for example but also between scientists and their own visions of how they believe knowledge should be classified. Thus what follows is 'our' version and is seen as a guide and not a definitive statement.

The questions listed within this section are those provided by the many delegates that attended the WP2 and 3 workshops and meetings throughout the project. The authors have tried to keep them within the context initially developed but they have been edited and framed around the vision proposed here. The questions within this section are the ones chosen as priority examples by the authors, for the full list of questions please visit www.iwrm-net.eu. The future work on collaborative research programmes will bring together different researchers with different visions but the partners hope that this work can form a baseline to guide these discussions and make the process a little easier.

1.1 Describing the Water Eco-socio-Hydro-System

Integrated Water Resources Management aims to protect water resources and human development whilst maintaining sustainable aquatic and associated terrestrial ecosystems. This is a complex task that requires understanding of both individual processes and their interactions and it is, therefore, important to increase the scientific knowledge and associated evidence base on all elements of IWRM, including but not restricted to hydrology and water resources, associated ecosystems as well as end users and society to support policy making and the implementation of the WFD.

The DPSIR framework (cf Annexe 2) attempts to identify an explicit representation of the chain of causal links that cut across Water Resources Management, starting with 'Driving forces' (incl. climatic changes, economic development, population change) that result in 'Pressures' (anomalies in physical parameters, emissions, abstraction, waste) which adversely change the 'State' (physical, chemical and biological) having 'Impacts' on ecosystems and humans, that eventually need 'Responses' (economic, technical, legislative).

The DPSIR methodological framework has been widely used to provide a thinking platform for a range of environmental problems associated with Water Resources Management (incl. inter alia, OECD, (1993), Jorge et al. (2002), Marsili-Libelli et al (2004), Bidone et al. (2004), Kristensen (2004), Smeets et al. (2005), Hameedi (2005), Aubry et al (2006), Borja et al (2006), ETC - Water (2009)). The European Environment Agency in particular, has been using the DPSIR framework since 1999 (Smeets et al. (1999)) for developing indicators of all the major environmental topics (Air pollution, Biodiversity, Chemicals, Climate change, Environment and health, Land use, Natural resources, Noise, Soil, Waste and material resources and Water) in order to provide assessments of the European State of the Environment. In the particular case of water management, the EEA published in 2009 a DPSIR methodological framework for developing an indicator system for Water Scarcity and Drought by creating frameworks, including all of the major water users (Agriculture, Domestic/Public Water Supply, Industry, Energy and Tourism) (ETC – Water (2009)). DPSIR will be used in this report as the underlying narrative structure for the identified research work and needs. In the following paragraphs we will therefore present knowledge (available and required) on Drivers, Pressures, State, Impacts and Responses for Water Resources Management.

1.2 Evolving DPSIR to suit our needs

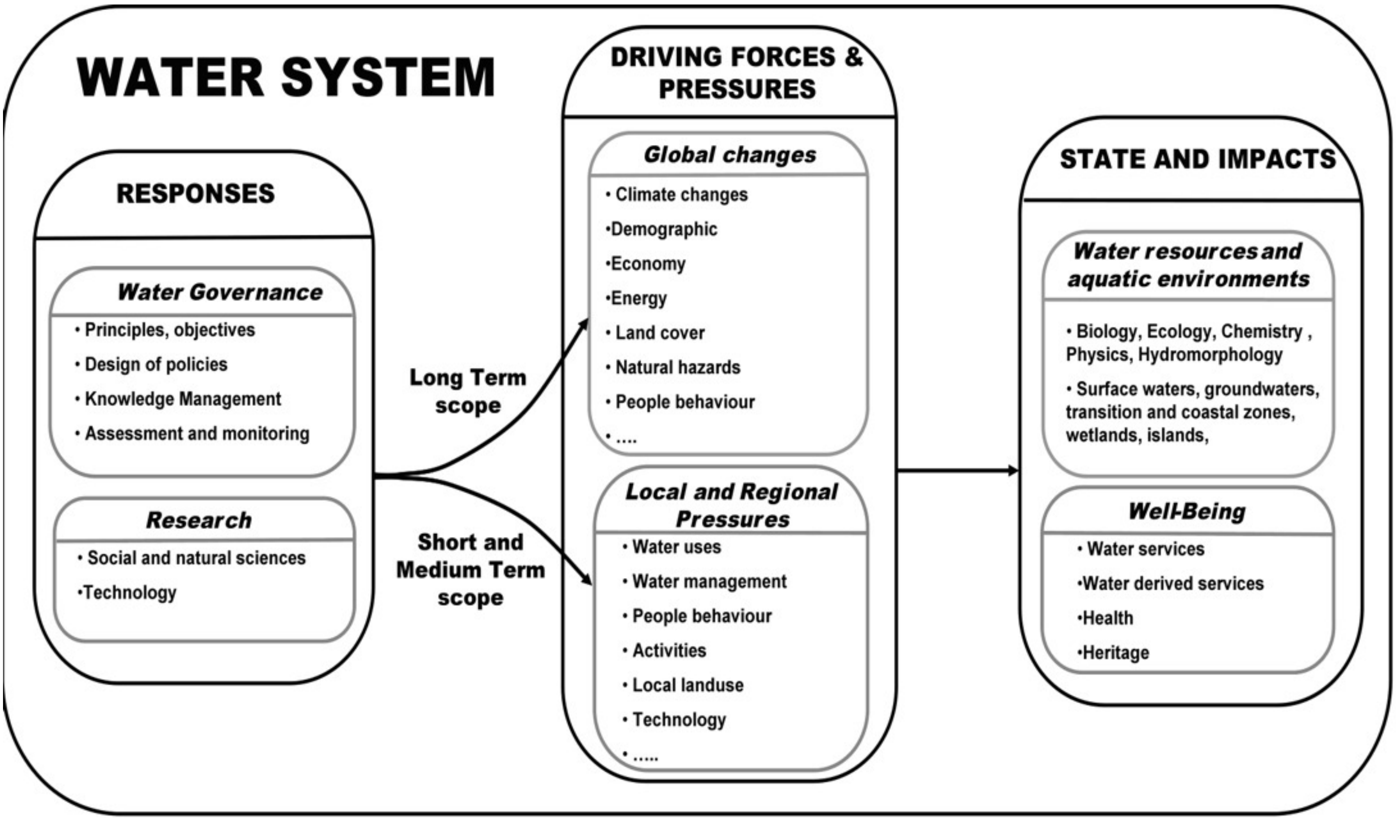
In considering the classification of knowledge and defining the research needs within IWRM-net it emerged that the complexity in cause-effects relationship requires more knowledge on state of water resources and society (and their interactions) from all scientific fields.

IWRM, as a socio-technical system, is affected by the complexity of cause-effect relationships of the interactions between the physical system (e.g. the state of water resources) and the social system (e.g. as drivers of impacts and as mechanisms for responses). This makes it difficult to assess the consequences of management actions and interventions (responses),

particularly in the longer term. There are gaps too between the complexity of the Water System and simple representations of it such as, for example, the models that give a simplified view of the system.

So the partners within work package 3 started to develop a refined classification system of the

water system. It considered aspects such as the challenge to define suitable and representative indicators for each characteristic and to understand their inter-relations in different specific contexts. From this the global vision of the Water System framework was created to provide an integrative vision of society and environment to deepen the knowledge on these strategic issues and to develop models (for Pressures-Impacts-State and Processes relations), along with the development of scenarios to enable foresights and comparisons between



different management options and to reduce uncertainties

The main issue is to build a sustainable approach for IWRM taking into account the multi-level context: geography, activities, social-economy, policy, institutional organisation, decision support system, scientific community, history, data management etc.

Figure 3 : presents major issues associated with the management of water resources, using a DPSIR framework as the underlying structure.

4. Discussion and Recommendations

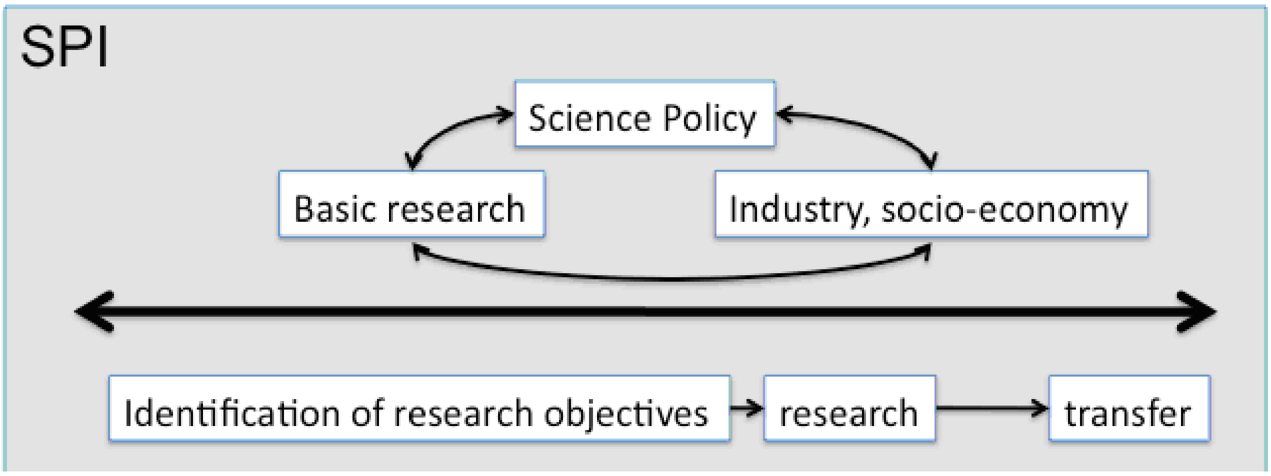
In this document the partners of IWRM-Net have not foreseen the role to be one of scientific conclusions. This is for the peer reviewed publications and the scientific community itself to manage. There are a number of recommendations that are proposed by the partners to continue the life of this information within this document and ensure that the science policy interface is improved in future.

- **Sharing of information.**

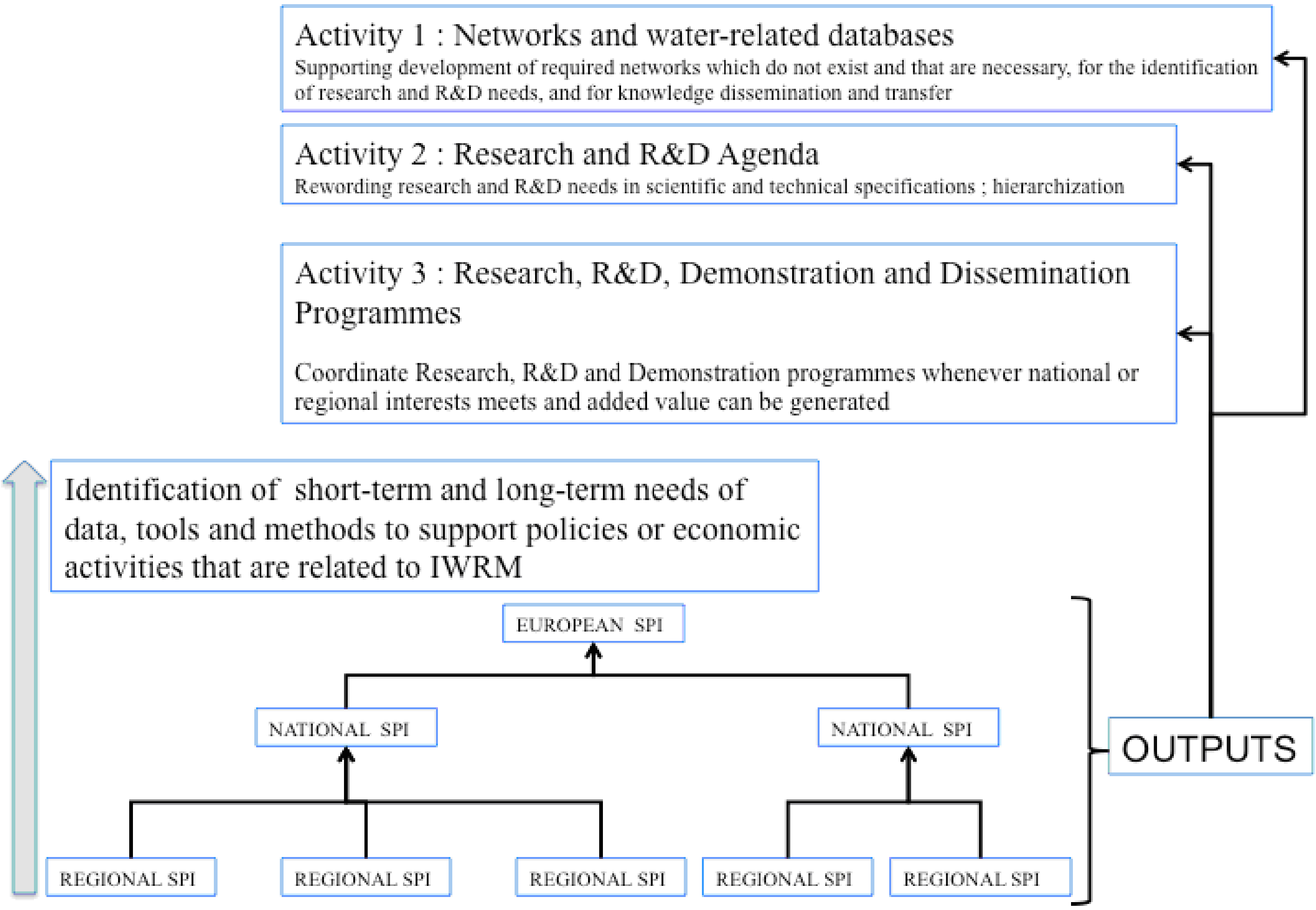
One of the goals of IWRM-Net has been to exchange information regarding partners research programmes and from this perform a gap analysis on knowledge for IWRM. What has been achieved is only scratching the surface of the total volume of research information. Using this classification system can help to create a better synergy between the many programmes available and make the sharing of information easier through a common language of classification.

- **Creating a continuous collaborative process**

One of the difficulties encountered in IWRM-Net was the difference in opinions on the target audience. On one side of the argument were the programmes destined for a scientific audience where the quality of science and improvement of researchers were the main criteria for measurement. On the other side, the target audience was the implementers of the WFD who required evidence and operational tools to use on a regular basis in managing water resources. A programme of research that allows these two distinct groups to work together has not been designed and the differences in opinion between the managers of each type of programme meant that a true consensus was not gained in IWRM-Net. The recommendation is that before collaboration can be truly achieved then clarity on the target audience and the criteria for measuring the outcomes is vital.



It is of prime importance to organize a collaborative process of identification of objectives of research by creating dialogues between researchers and end-users. This will allow to reword difficulties that have to face public and private decision



makers or managers into research questions than can be applied or more basic research.

In addition, creating these interactions between researchers and end-users will allow to adapt the research process continuously to be able to deliver useful and usable knowledge, tools or methods for integrated water resource management.

► **Organising a continuous collaborative process from watershed to european scale**

Since water management is controlled both by European rules and local context (physical chemical, environmental, economical and sociological), it is recommended to create organized interactions between regional an d European levels for the support of IWRM by research.

This diagram shows the basic structure that IWRM-net partners propose to use in developing the European network of interfaces between science and policy. What this does not tackle is the type of organisation or structure to deliver this process. If we consider the science policy interface as a process then there has to be interconnected processes across Europe that allow the transfer of scientific results and knowledge between regions and countries. Often the science policy interface is undertaken by specific organisations such as ECOBAG or SNIFFER and their role is to translate the science into something manageable by busy individuals at the policy or operational level. But each organisation has a targeted audience at the regional level and the transfer of the knowledge becomes challenging when considering the language barriers and the time gaps between the research and the implementation of the product.

To go into more detail, IWRM-found that the development of a pan-European network for science policy interface is not clear step in the development of the ERA. The CIS SPI is a group recently set up to tackle the implementation of the water framework Directive and has a clear remit on that basis. Within IWRM-net there is a broader spectrum of interested organisations in water research and so the level or research is wide ranging, from operational needs to pure science. This makes the development of a network challenging. What needs to be clear in this instance is that the level of information should be very general and clear and it should be seen as a staring point for further development. The scientists will not be satisfied until there is something of value in academic terms and the water managers require an operational tool, while policy makers want to ensure the policy is based on sound evidence.

In developing a database the experience of eranets is that the exchange of information comes across the issue of quality assurance. The first step should be to define the information or data of value for the group. Research programmes can be listed with there titles but then in defining the knowledge within them becomes much more difficult as the range of themes within a programme can be very broad.

A strategic research agenda can tackle this issue by defining the science within the field of research, providing a structure and hierarchy to the knowledge.

This structure and hierarchy should be seen as time limited as the terms and classifications used change over time. The development of a database using keywords was used in IWRM-Net to overcome this challenge. By allowing a keyword search to be used, the keywords can be linked and overtime the changes in language can be accommodated, each search using the new terms will still locate previous programmes and research. It also allows for regional differences in terms and meanings, that can be linked between different European languages?

The final stage is where to fit the interface within the traditional structure of the research programme. Is it a part of the overall management framework with a clear single branding coming from the centre or should it be part of the individual projects role to disseminate and communicate the research findings, and how can this work at a pan European level.

5. References

Amorsi et al 2010. Links to Water National or Regional Research, Policies and Management – IWRM-Net. in Water System Science and Policy Interfacing, Edited by Philippe Quevauviller, Royal Society of Chemistry

Aubrey A. and Elliott M, (2006), "The use of environmental integrative indicators to assess seabed disturbance in estuaries and coasts: application to the Humber Estuary, UK", Marine Pollution Bulletin 53, pp.175–185.

Bates B.C., Kundzewicz Z.W., Wu S. and Palutikof J.P., (2008), "Climate Change and Water, Technical Paper of the Intergovernmental Panel on Climate Change", IPCC Secretariat, 2008 Geneva, 210 pp.

Bidone E.D. and Lacerda L.D., (2004), "The use of DPSIR framework to evaluate sustainability in coastal areas. Case study: Guanabara Bay basin, Rio de Janeiro, Brazil", Regional Environmental Change, Vol. 4, No. 1, pp. 5–16.

Borja A., Galparsoro I., Solaun O., Muxika I., Tello E.M., Uriarte A. and Valencia V., (2006), "The European Water Framework Directive and the DPSIR, a methodological approach to assess the risk of failing to achieve good ecological status", Estuarine, Coastal and Shelf Science, Vol. 66, No. 1-2, pp. 84-96.

CSI 018, (2009), "Use of freshwater resources (CSI 018) - Assessment published Jan 2009", European Environment Agency, accessed online November 2010. http://www.eea.europa.eu/data-and-maps/indicators/use-of-freshwater-resources/use-of-freshwater-resources-assessment-1

CSI 024, (2009), "Urban waste water treatment (CSI 024) - Assessment published Jan 2009", European Environment Agency, accessed online on November 2010 http://www.eea.europa.eu/data-and-maps/indicators/urban-waste-water-treatment/urban-waste-water-treatment-assessment-1#toc-0

de Roo A.P.J., Gouweleeuw B. and Thielen J., (2003), "Development of a European flood forecasting system", Int. J. River Basin Management, Vol. 1, No. 1, pp. 49-59.

EC, (2007), "Communication from the Commission to the European Parliament and the Council on addressing the challenge of water scarcity and droughts in the European Union.", COM (2007) 414 final.

EC, (2009), "Communication from the Commission to the European Parliament and the Council in accordance with article 18.3 of the Water Framework Directive 2000/60/EC on programmes for monitoring of water status.", COM (2009)156 final.

EEA, (2009), "Water resources across Europe — confronting water scarcity and drought", Report No 2/2009, Robert Collins, Peter Kristensen, Niels Thyssen (EEA), Ingo Bräuer, Thomas Dworak, Max Grünig, Eleftheria Kampa and Colette de Roo (Ecologic); Maggie Kossida, Kleio Monokrousou and Yiannis Panagopoulos (NTUA), Elena Cebrian Calvo, Philippe Crouzet, Jan-Erik Petersen and Beate Werner (EEA), European Environment Agency, 2009.

ETC - Water (2009), "Water Scarcity and Drought: towards a European Water Scarcity and Drought Network (WSDN)", Maggie Kossida, Ifigeneia Koutiva, Christos Makropoulos, Klio Monokrousou, Maria Mimikou George Papoutsoglou, Chrysoula Papathanasiou (NTUA), Jaume Fons-Esteve, Alejandro Iglesias (UAB), European Topic Centre on Water, July 2009.

Etzkowitz H, and L. Leydesdorff, (Eds.), Universities and the Global Knowledge Economy. A Triple Helix of University-Industry-Government Relations, Pinter, London and Washington, 1997.

Etzkowitz H, A. Webster and P. Healey (eds), Capitalizing Knowledge. New Intersections of Industry and Academia, 1998, SUNY.

Fassio A., Giupponi C, Hiederer R. and Simota C., (2005), "A decision support tool for simulating the effects of alternative policies affecting water resources: an application at the European scale", Journal of Hydrology, Vol. 304, pp. 462–476.

M. Gibbons, C. Limoges, H. Nowotny, S. Schwartzman, P. Scott and M. Trow, The New Production of Knowledge, The Dynamics of Science and Research in Contemporary Societies, Sage Publications, London, 1994.

Gouweleeuw B., Reggiani P. and de Roo A., (2004), "Final Report EFFS: European Flood Forecasting System", Contract no.: EVG1-CT-1999-00011 sponsored by EC DG RTD, Project co-ordinator: WL | DELFT HYDRAULICS.

Hameedi J., (2005), "Environmental indicators as performance measures for improving estuarine environmental quality", In: Bortone, S.A. (Ed.), Estuarine Indicators, CRC Press, Boca Raton, FL, 2005, pp. 451–465.

Jorge M.R, Nelson Lourenço N., Machado C.R. and Rodrigues, L., (2002), "Measuring, monitoring and managing sustainability in Indian coastal areas: the socioeconomic dimension", Littoral 2002, 22-26 September, Porto, Portugal.

Kossida, M., Papoutsoglou G. European indicator-based assessment of Water Scarcity and Drought. Presentation to the Thematic EIONET Workshop

"Water Quantity and Use", 10-11 October 2007, EEA, Copenhagen
Kristensen P., (2004), "The DPSIR Framework", Workshop on a comprehensive/detailed assessment of the vulnerability of water resources to environmental change in Africa using river basin approach, UNEP Headquarters, 27-29 September 2004, Nairobi, Kenya
Magnuszewski P., Sendzimir J. and Kronenberg J., (2005), "Conceptual Modeling for Adaptive Environmental Assessment and Management in the Barycz Valley, Lower Silesia, Poland", International Journal of Environmental Research and Public Health August 2005, 2 (2), pp. 194–203.
Makropoulos C., Butler D. and Maksimovic C., (2008), "Building Decision Support Systems based on Fuzzy Inference", Practical Hydroinformatics, Water Science Technology Library, 2008, Vol. 68, Part 3, Springer-Verlag Berlin Heidelberg 2008.
Marsili-Libelli, S., Betti F. and Cavalieri S., (2004), "Introducing River Modelling in the Implementation of the DPSIR Scheme of the Water Framework Directive", Proc. IEMSs 2004, International Congress "Complexity and Integrated Resources Management", Osnabruek, Germany, June 2004.
Mauser W., Marke T. and Stoeber S., (2008), "Climate Change and Water Resources: Scenarios of Low-flow Conditions in the Upper Danube River Basin", IOP Conf. Series: Earth and Environmental Science 4, 2008.
OECD (1993), "OECD core set of indicators for environmental performance reviews: a synthesis report by the group on the state of the environment", Environment Monographs 83, Organisation for Economic Co-operation and Development, 1993, Paris.
Quevauviller P., P. Vervier and M.P. Miossec 2010. Concept of interfacing and perspectives. in Water System Science and Policy Interfacing, Edited by Philippe Quevauviller, Royal Society of Chemistry
Smeets E. and Weterings R., (1999), "Environmental indicators: Typology and overview", Technical report No. 25, European Environment Agency, 1999, Copenhagen. 1. E. Erno-Kjolhede, Managing Collaborative Research: Unveiling the Microdynamics of the European Triple Helix, Copenhagen Business School Press, 2001, 345 pp.
Vervier P., J. Depasse, M. Combarnous, H. Ayphassorho, M. Gaeckler, M. Jarry. 2010. ECOBAG : a regional "science –policy" interface, in Water System Science and Policy Interfacing, Edited by Philippe Quevauviller, Royal Society of Chemistry

ANNEX 1

Glossary of Terms

Good status

The aim of the WFD is long-term sustainable water management based on a high level of protection of the aquatic environment. Article 4.1 defines the WFD general objective to be achieved in all surface and groundwater bodies, i.e. good status by 2015, and introduces the principle of preventing any further deterioration of status. The main environmental objectives in the Directive are the following elements (for surface waters, groundwaters and protected areas):

- No deterioration of status for surface and groundwaters and the protection, enhancement and restoration of all water bodies;
- Achievement of good status by 2015, i.e. good ecological status (or Potential) and good chemical status for surface waters and good chemical and good quantitative status for groundwaters;
- Progressive reduction of pollution of priority substances and phase-out of priority hazardous substances in surface waters5 and prevention and limitation of input of pollutants in groundwaters;
- Achievement of Standards and objectives set for protected areas.

Hydromorphology

The Directive provides some requirements that renew the water approach as the good ecological status (GES) for all surface waters. The GES is defined, in terms of the quality of the biological community, the hydrological characteristics and the chemical characteristics. No absolute standards for biological quality can be set which apply across the European Community considering the ecological variability. Therefore, each Member State interprets the procedure for identifying it in a consistent way and to ensure comparability. But it is particularly difficult and new to set ecological, chemical or hydromorphological standards for a given body of water in order to achieve the GES. The importance of the hydromorphological conditions to achieve the GES is a novelty.

Quantity

Quantity is also a major issue in particular for groundwater. There is only a certain amount of recharge into a groundwater each year, and of this recharge, some is needed to support connected ecosystems (surface water bodies, terrestrial systems such as wetlands). For good management, only that portion of the overall recharge not needed by the ecology can be abstracted - this is the sustainable resource, and the Directive limits abstraction to that quantity.

Scale

An other point is however recognised that different scales (national, basin, sub-basin, water body) may be appropriate for different assessments or different aspects of the same assessment. For example, transboundary issues have to be assessed on a transboundary scale. However, the choice of the scale should be justified by the provisions of the WFD.

Economics

An other parameter of WFD change is the importance of economics. The WFD need using environmental valuation. Valuation exercises are expensive and regulators are not very used having time or money to fund original valuation studies for every catchment.

The decision to use a WFD approach is now driven by the desire to estimate values for different component parts, or aspects, of water quality. The WFD enshrines several economic principles in pursuit of GES and rationalising water use in society.

Uncertainties should be taken into account in deciding the appropriate action. This action may include further investigation, monitoring and assessment to reduce uncertainties and this could contribute to the justification for the phasing of measures across cycles. There can be uncertainty about: the impact of policies already in place or planned and various trends, the effectiveness of measures in addressing an adverse impact on a water body, the assessment of the achievement of good status, the costs associated with measures, the benefits resulting from improvements to the status of water bodies (particularly the calculation of the non-marketable benefits), etc. These uncertainties will have substantial impact on cost and benefit estimates.

Public participation and transparency

The implementation of WFD need an early acceptability of public. Even if transparency and consultation of the public does not guarantee the acceptance of the public, they are capital in the decision-making process. Public information and consultation is not only an obligation but should be provided in the river basin management plans the reasons for the action, the delay, the timetable, the 'disproportionality justification', the assessments the explanation of no relevant alternative financing mechanisms available, the consequences of non-action, etc.

Prioritisation criteria and results should be transparent and should be disclosed to the public. The prioritisation approach should also give information on the further timescale to reach the environmental objectives. The prioritisation process should take into account a set of relevant criteria as : synergies with other directives, e.g. habitat directive, flood risk management directive, cost-efficiency / benefits of measures, consequences of non-action, certainty / uncertainty ("no regret measures"), measures which could be implemented short term, urgency of problem to be solved (severe consequences/high cost of non action, protection of drinking water supplies), existence of available financing mechanisms, acceptance by the public etc.

Integrated water resource management

Integrated Water Resources Management (IWRM) is a multidisciplinary and intersectoral approach based on science brings by all actors (stakeholders, industries, agriculters, local authorities, etc.) to determine how to meet society's long-term needs for water and how to maintain essential ecological services and economic benefits. IWRM helps to protect the environment, economic growth, sustainable agricultural and industrial development, to promote democratic participation in governance, and to improve human health and well-being. Water policy and management need to reflect the interconnected nature of hydrological resources. IWRM is emerging as an accepted alternative to the sector-by-sector, top-down management style that has dominated in the past.

Some of the principal components of IWRM:

- Managing water resources at the basin or watershed scale: This includes integrating land and water, upstream and downstream, groundwater, surface water, and coastal resources.
- Optimizing supply: This involves conducting assessments of surface and groundwater supplies, analyzing water balances, adopting wastewater reuse, and evaluating the environmental impacts of distribution and use options.
- Managing demand: This includes adopting cost recovery policies, utilizing water-efficient technologies, and establishing decentralized water management authorities.
- Providing equitable access to water resources through participatory and transparent governance and management: This may include support for effective water users' associations, involvement of marginalized groups, and consideration of gender issues.
- Establishing improved and integrated policy, regulatory, and institutional frameworks. Examples

are implementation of the polluter-pays principle, water quality norms and standards, and market-based regulatory mechanisms.

- Utilizing an intersectoral approach to decision-making, where authority for managing water resources is employed responsibly and stakeholders have a share in the process.

Annex 2

Research needs Using DPSIR

Drivers

Driving forces correspond to the environmental, social, demographic and economic developments in societies that affect life styles, overall levels of consumption and production patterns. Driving Forces include both anthropogenic phenomena (incl. population change, changes in living conditions, economic development and land cover changes) and natural phenomena (including for example climatic changes such as changes in rainfall distribution and temperature patterns) (ETC – Water, 2009).

The Intergovernmental Panel on Climate Change (Bates et al., 2008), has identified precipitation, temperature and evapotranspiration as the most dominant climate drivers for water. Temperature is particularly important in snow-dominated basins and coastal areas, the latter due to the impact of temperature on sea level. Other driving forces that require monitoring and analysis are socio-economic and demographic information.

Increase of the potential to associate specific changes of anthropogenic and climatic drivers to specific changes in the environment in terms of clearly understood cause-effect relationships: This requires a drastic improvement in the homogenisation of and open access to social, environmental and economic data and information at the European Level and at the RBD scale.

Research needs related to Drivers are identified by the "**7th Framework Programme for Research and Technology Development**" and can also be found among thematic areas of the 2nd call of **IWRM-Net**. These needs refer to climate, ecological, earth and ocean systems change.

The main challenges

Despite the effort made so far to understand the drivers that affect the management of water resources, as discussed above, a number of more specific research issues are still pending, including, inter alia, the following:

1 Improvement of the ability to understand, decouple and model socioeconomic factors that act as drivers to water resources management. This requires more targeted multi-disciplinary research between physical and social scientists and engineers.
2 Improvement in the ability to dependably assess (or forecast) medium to longer term physical drivers and changes at the local and regional level. This requires improvements and GCMs and a better link between the climate and hydrology communities.
3 Increase of the potential to associate specific changes of anthropogenic and climatic drivers to specific changes in the environment in terms of clearly understood cause-effect relationships: This requires a drastic improvement in the homogenisation of and open access to social, environmental and economic data and information at the European Level and at the RBD scale.

Pressures

Water resources experience constant, complex and inter-related anthropogenic and natural pressures: Anthropogenic pressures on water resources include inter alia the release of substances (emissions) and physical and biological agents, the use of water resources (both surface and groundwater) and the increased demand for infrastructure. The pressures exerted by natural phenomena are mainly in the form of anomalies (e.g. precipitation anomaly) (ETC – Water, 2009).

The WFD focuses on the identification of water resources pressures such as point and diffuse source pollution, water abstraction, flow regulation and hydromorphological alterations at River Basin District level (WFD 2000, Annex II). The improvement of knowledge, and the scientifically sound diagnosis and forecasting of pressures on water resources (and their drivers/causes as discussed above) will enable water policy to move towards a more proactive/preventive management approach.

An alternative, but complimentary way to assess pressures is via indicators and indexes. The European Environment Agency (EEA) for example, develops and updates the Water Exploitation Index (WEI), which is a relatively straightforward indicator of the pressure of water abstraction on freshwater resources. This index is calculated annually as the ratio of total freshwater abstraction to the total renewable resource and gives an indication of the sustainable use of the water resources (CSI 018, 2009). To provide a more disaggregated assessment the EEA is now in the process of updating the WEI by creating a regional WEI at the River Basin District level.

There are also other "non-traditional" pressures that affect water resources such as siltation, new toxic substances and alien species. Therefore, it is necessary to develop more integrated diagnostic metrics to assess ecosystems and water resources holistically (Hering et al., 2010).

The main challenges

4 Identification of patterns in the interaction between organisms, ecological functions and river hydromorphology
5 Identification of reactions of eco-hydromorphology to climate change, water abstraction and river regulation.
6 Exploration of synergistic effects of multiple causes resulting in multiplication of significant pressures.

State of Water Resources

Improved knowledge on the physical, chemical and biological state of the water resources is of vital importance for IWRM, both as a means to decide and prioritise interventions and as a means to assess the effect of management practices and policies.

State characteristics such as flow regimes, terrestrial and water types of the area of interest (coastal, estuary, river, wetland, lake, urban/rural environment) and their cross-cutting relations have to be considered when trying to evaluate the state of water bodies. Furthermore, the assessment of the quality and quantity of physical phenomena (such as rainfall), biological phenomena (such as fish stock) and chemical phenomena (such as nitrate concentrations) in a certain area provides a comprehensive picture of the state of the water resources when considered in a dynamic perspective.

Yet, the measurement of such intrinsic determinants is not sufficient for the characterisation of the state of water bodies. There are also other issues to be considered in this evaluation which are more complex and often hardly, if at all, quantified, such as socioeconomical factors and infrastructure. The social dimension and dynamic is a fundamental input for life and society (including health, economic and social aspects). It is also a prerequisite for establishing an integrated water resources management with a dual (environmental and human) set of objectives.

Further to the assessment of the state of water resources through monitoring, research is also focused on how to enhance the information content of the data collected. For this purpose, innovative sensors that minimize errors, advanced remote sensing techniques and novel measurement technologies can be used. For example, ground measurements such as rainfall depth, soil moisture, temperature etc. are calibrated and corrected based on satellite data. For precipitation for example, which is a fundamental hydrological parameter, research is moving towards utilising mobile phone networks coupled with weather radar networks to provide a real-time update and correction of the precipitation measured by ordinary gauges.

Finally, one the most challenging topics in terms of the state of the environment is the issue of "Good Ecological Status", which has been identified as a general objective to be achieved in all surface and groundwater bodies in the WFD (Article 4.1). Unfortunately, it is currently debatable if the characterization of GES, as defined in the RBMPs is sufficient to maintain aquatic biodiversity and the associated parameters (Hering et al., 2010).

The main challenges

A series of issues hence remain at the forefront of work on the state of water resources, including:

7 Better conceptualisation and quantification of the evolution and adaptation capacities of ecosystems and social systems in response to various changes.
8 Better definition of “Good Ecological Status” and “Good Ecological Potential” as dynamic processes, which vary both in space and time.
9 Development of interdisciplinary approaches able to assess the state of physical, chemical, ecological processes as well as socio-economic processes.
10 Improvement of monitoring of and open access to parameters that support the characterisation of the state of the environment
11 Improvement of methods to turn data from large databases into information, e.g. via data mining approaches.

Impacts

There is a great interrelation between pressures and impacts. Impacts on water resources are evident in all aspects that characterise a society’s well-being such as health, human activities, water related services (e.g. food, energy, transportation, recreation), people’s behaviour and the economy. Such impacts also affect the balance of ecosystems and biodiversity.

For example, over-abstraction of groundwater (a pressure) may result in saline intrusion (an environmental impact), which may in turn result in loss of crop production (a socio-economic impact). From this interrelated nature of the parameters of the DPSIR scheme, emerges a major challenge in the identification, assessment and quantification of potential integrated impacts on the water bodies in a time dynamic context, including cumulative and chain effects, phenomena of inertia (since effects may propagate through time) and resilience of water bodies and ecosystems.

For example, the decrease of water availability due to abstraction can lead to the decrease of water quality due to the reduced ability of the water bodies to dilute pollutants. Excessive groundwater abstraction may lead to saline intrusion and ground subsidence which may cause geomorphological impacts (EEA, 2009). Such indirect and synergistic effects are often difficult to predict and analyse.

The main challenges

Clearly significant progress has being made so far in the quantification of these two fundamental impacts (floods and droughts). Impact-related research is now focusing on questions of identification as well as quantification of “total” impacts. Such issues include for example:

12 Improvement of interdisciplinary knowledge on the boundaries between physical, chemical and ecological processes.
13 Identification of longer term social and economic costs and benefits and their inclusion in decision making processes
14 Elicitation of social values in their true dynamic form.
15 Standardisation of impacts metrics, both spatially and temporally.

Responses

Responses are an attempt to prevent, compensate, ameliorate or adapt to changes in the state of the environment. It can also refer to attempts by ecosystems themselves to respond (e.g. by adaptation or migration). The identification of the driving forces, their pressures and impacts on the state of water resources are essential to organize society’s responses via IWRM to address environmental, social and economic objectives.

Research needs related to responses exist in the research agendas of practically all networks, partnerships and platforms. Responses were among the priorities of all three workshops (Valencia, Sibiu and Stockholm) for the development of the 2nd call and of course covered several thematics proposed for this call. The response-related generic terms identified are the following: prevention, mitigation and adaptation of pressures and risks, sustainable water management for large urban areas, agriculture, industry and floodplains, reclamation of degraded water resources, improvement of water use and re-use efficiency, integrated pollution management, integration of water demands with available water supply, management of ecosystem services, enhancement of science-policy interface and governance.

The issue of responses is perhaps the most open-ended in terms of additional knowledge required.

The main challenges

Several challenges in selecting, implementing and assessing responses are listed below:

16 Improving the evidence base of new responses (incl. new high tech and low tech solutions, policy and economic instruments that have not been applied before).

17 Improving the integration of policies within a River Basin Management Plan and assessing the degree of their actual implementation and impact

18 Improving the access to and standardisation of models and datasets that are used to compare alternatives – to ensure comparability of results.

19 Designing and testing new pricing policies before they are implemented at a large scale. Combinations of pilots and new social simulation tools are currently being developed and used but this work is at its infancy.

20 Developing shared visions, between stakeholders of the end-result of policy interventions.

21 Improving the involvement of all stakeholders within a common, transparent framework of governance that is adaptable to change and includes improved dialogue, participation and co-evolution of a common perception/vision.

22 Building in the responses the potential for adaptation, and avoiding lock-ins, considering potential future changes.

23 Changing social values and practices to support measures to conserve water and promote perceptions of fairness and accountability.

24 Improving the understanding of the social part of the system of IWRM, including for example aspects such as social capital that are often neglected in river basin management.

Annex 2. Research needs using IWRM-net classification - Illustrated examples

1 - Which governance framework and tools for the Water System management

The purpose is to build a sustainable approach for IWRM taking into account the multi-level context: geography, activities, social-economy, policy, institutional organisation, decision support system, scientific community, history, data management etc. IWRM requires a global governance framework based on common social, economical and institutional principles and rules, a better integration of stakeholders in the decision process, modelling and decision support and quantification of issues for IWRM.

1.1) How to improve the decision making process in water management?

When implementing policies, the institutional, economic, social and cultural components need to be understood to ensure that the policy is accepted. There is a need to provide people with an understanding of the many beneficial services provided by aquatic ecosystems to economic and social welfare .The education structure becomes more important as people need to better understand the continual changes to the water resource and supply and demand issues.

What are the levers to reach an efficient, integrated, fair and sustainable management?

How to involve all the stakeholders? How to define a framework for governance?

Strategic issues

1 Science Policy Interface
2 Public participation
3 AdaptiveLegal and institutional framework
4 Social values and practices

1.1.1. How best to organise stakeholder dialogue, participation and perception?

Strategic issues

5 Integrated River Basin Management
6 Harmonization and inter-calibration
7 Indicators and models
8 Classification tools
9 Economics, Environmental valuation

For example, the DANUBIA DSS consists of 16 models for the simulation of Global Change in the Upper Danube Catchment (Germany, 77.000 km^2). This DSS produced scenario results for the period 2011 to 2060, which are available online (http://www.glowa-danube.de/atlas/atlas.php). These scenarios demonstrated that the slight decrease in rainfall (Driving force) and the increase in evaporation due to temperature increase (Driving force) in combination with the reduction of snow storage (Driving force) in the Alps result in a forward displacement of the seasonal availability of water from summer to spring (Pressure) and to a decrease in the low flow discharges of the main rivers (Pressures) in the Upper Danube catchment. The main impacts resulting from these changes were the reduction of hydropower production and the restrictions posed on navigation in low water periods. (Mauser et al. (2008)).

- How to set up comprehensive management tools, not only for water but also for energy and economy?
- How to produce interactive maps of priorities - pressures and impacts and contacts?
- What are the methodological tools, jobs and skills required in order to create an integrated water management system in order to match research needs of decision-makers with scientific skills?
- Can we produce a methodology for stakeholder validated descriptions of the distributional significance of IWRM options?

For example, the European Environment Agency (EEA) develops and updates every year the Water Exploitation Index (WEI), which is a relatively straightforward indicator of the pressure of water abstraction on freshwater resources. This index is calculated annually as the ratio of total freshwater abstraction to the total renewable resource. The indicator is in place in order to assess whether the use of water resources is sustainable (CSI 018, (2009)).Nonetheless, EEA is now in the process of updating the WEI by creating a regional WEI on a River Basin District level in order to provide a disaggregated assessment of the different RBDs within the same country. An example is given in Figure A where the difference between the country level WEI and the RBD level WEI is evident.

2- How to improve knowledge on state of water resource and pressures? DPSIR

State
- Hydrology
- Water quality
- Hydromorphology
- Biological inventory
- Ecosystem

Pressures
- Identification of pressures
- Quantification of pressures-impacts relationship

Responses
- Sectorial policies

The scientific knowledge of water ecosystems must be strengthened to support the WFD implementation. The more accurate the knowledge is, the more efficient the measure should be. State characteristics such as flow regimes, terrestrial and water types of the area of interest (coastal, estuary, river, wetland, lake, urban/rural environment) and their cross-cutting relations have to be considered when trying to evaluate the state of water bodies. Furthermore, the assessment of the quality and quantity of physical phenomena (such as rainfall), biological phenomena (such as fish stock) and chemical phenomena (such as nitrate concentrations) in a certain area provides a comprehensive picture of the state of the water resources when considered in a dynamic perspective.

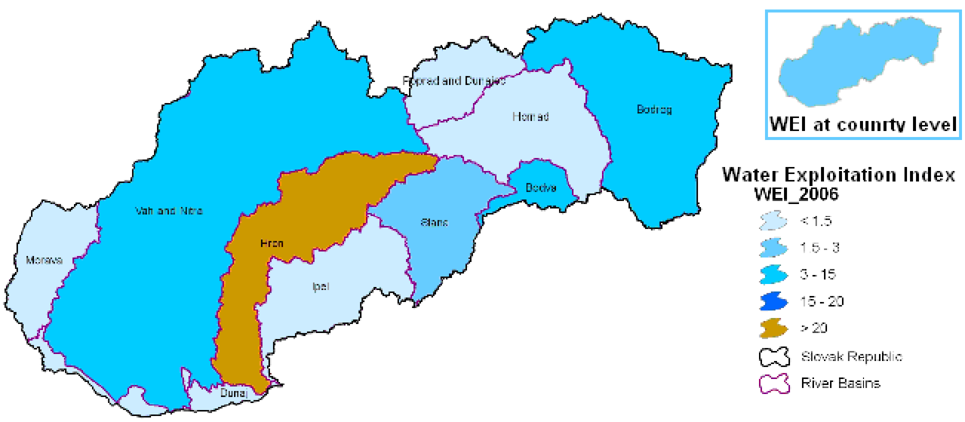


Figure A : Regional WEI for Slovak Republic on a Country and RBD level for 2006 (Source: Kossida et al., 2007).

Yet, the measurement of such intrinsic determinants is not sufficient for the characterisation of the state of water bodies.

There are also other issues to be considered in this evaluation which are more complex and often hardly, if not at all, quantified, such as socioeconomical factors and infrastructure features of the area of interest. The social dimension and dynamic is a fundamental input for life and society well-being (e.g. for health, economical and social aspects). It is also a prerequisite for establishing an integrated water resources management with a dual (environmental and human) and indivisible set of objectives. The state of infrastructure (including its existence (MDGs) and quality (WSSTP)) is central to the problem of evaluating the state of water resources and creating a set of existing structural responses.

Therefore, in order to assess the state and develop a better understanding of the hydrological, hydrochemical and ecological processes of the water bodies and their interactions further trans-disciplinary research is needed. A high levelled knowledge on the State of water resources which is derived by such a research not only supports the hydrological research in general, but also can be used to address key issues related to European water policy (e.g. the implementation of European Directives, the UN Framework Convention on Climate Change).

To improve the knowledge on the state of water resources, there is need to quantify various hydrological and hydrochemical properties of water. Existing infrastructures that address this need include monitoring networks which measure quality and quantity characteristics of the water. These networks possess long-term hydrological, meteorological and/or hydrochemical data records and also data concerning human activities and quantifying socioeconomical factors and thus affecting the hydrological, hydrochemical and ecological processes.

According to the EU Commission concerning the implementation of the Water Framework Directive (EC, 2009) monitoring efforts across the European Union are satisfactory, since more than 107.000 monitoring stations were reported for the assessment of surface water and groundwater under the WFD, even though inconsistency of the data that describe water characteristics is evident for most countries. The monitoring of the State of water resources is mainly undertaken by national agencies, whereas numerous research institutes and universities have established and manage monitoring networks in the framework of the implementation of several EU-funded projects and therefore possess reliable, long-term records of water related information.

Existing networks sometimes serve complementary objectives (e.g. the Global Runoff Data Centre (GRDC) gathers and manages only streamflow data, World Meteorological Organisation only meteorological data and the International Cooperative Programmes under the UN-ECE Convention on Long-range Transboundary Air Pollution only hydrochemical data) and the research supported by such hydrological observatories tended to be national-oriented. However, in the framework of IWRM a merging approach should be established. Therefore, Organisations and Competent Authorities tend to jointly establish networks of hydrological observatories throughout Europe, which are based on existing infrastructures, long-term monitoring schemes and data management services.

Two European research networks, PEER (Partnership for European Environmental Research) and EurAqua (European Organisation of Water Research Institutes), have already established a network of 26 observatories that cover most European countries (http://www.euraqua.org/, http://www.peer.eu/). These observatories have long and representative hydrometeorological and hydrochemical records, provided by reliable, efficient and state-of-the-art instruments. A map showing the locations of the observatories is presented in Figure B.

Figure B. The locations of the PEER – EurAqua hydrological observatories
(Source: http://www.euraqua.org/).

The European Environment Agency has established a network to collect and organise environmental data at European level. EIONET (European Environment Information and Observation Network) is a partnership network of EEA and its member and cooperating countries. EIONET gathers information relevant to all environmental reporting obligations that EEA member countries have towards DG Environment, European Marine Conventions, EUROSTAT, OECD, UN, UNECE, as well as the EEA itself (http://www.eionet.europa.eu/).

In addition to the EIONET network, the European Environment Agency, DG Environment, EUROSTAT and the Joint Research Centre created jointly the WISE (Water Information System for Europe) platform. WISE is an interactive internet tool that provides information on water resources state policy at European level. Through this platform, public access is offered to water related data and information reported by MS to the EEA and the EC in the framework of the implementation of the WFD (http://www.eea.europa.eu/highlights/new-water-information-system-for-europe-wise-unveiled).

A similar initiative in the US is an internet-based system for sharing hydrologic data which has been developed by CUAHSI. This system comprises of several databases and servers which are connected through web services and offer client applications allowing for publication, discovery and access of data. (http://his.cuahsi.org/index.html).

Further to the assessment of the state of water resources, through monitoring, research is also focused on how to enhance the information content of the data collected. For this purpose, innovative sensors that minimize errors, advanced remote sensing techniques and novel measurement technologies can be used. For example, ground measurements such as rainfall depth, soil moisture, temperature etc. are calibrated and corrected based on satellite data. For precipitation for example, which is a fundamental hydrological parameter, research is moving towards utilising mobile phone networks coupled with weather radar networks to provide a real-time update and correction of the precipitation measured by ordinary gauges. Furthermore, 3D electrical imaging methods are being developed to monitor the temporal and spatial pattern of groundwater recharge, a parameter which is very hard to reliably estimate.

moisture, are the factors that contribute to droughts (Bates et al. (2008)). The EDO is still

Strategic issues

10 Water scarcity and drought
11 Climate change
12 Ecotoxicity
13 Diffuse pollution
14 Cumulative impacts

Impacts on water resources are evident in all aspects that characterise a society's well-being such as health, human activities, water related services (e.g. food, energy, transportation, recreation), people's behaviour, and the economy. Such impacts also affect the balance of ecosystems and biodiversity. The interrelation between pressures and impacts is illustrated in the following example. Over-abstraction of groundwater (a pressure) may result in saline intrusion (an environmental impact), which may in turn result in loss of crop production (a socio-economic impact). From this interrelated nature of the parameters of the DPSIR scheme, emerges a major challenge in the identification, assessment and quantification of potential integrated impacts on the water bodies in a time dynamic context, including cumulative and chain effects, phenomena of inertia (since effects may propagate through time) and resilience of water bodies and ecosystems.

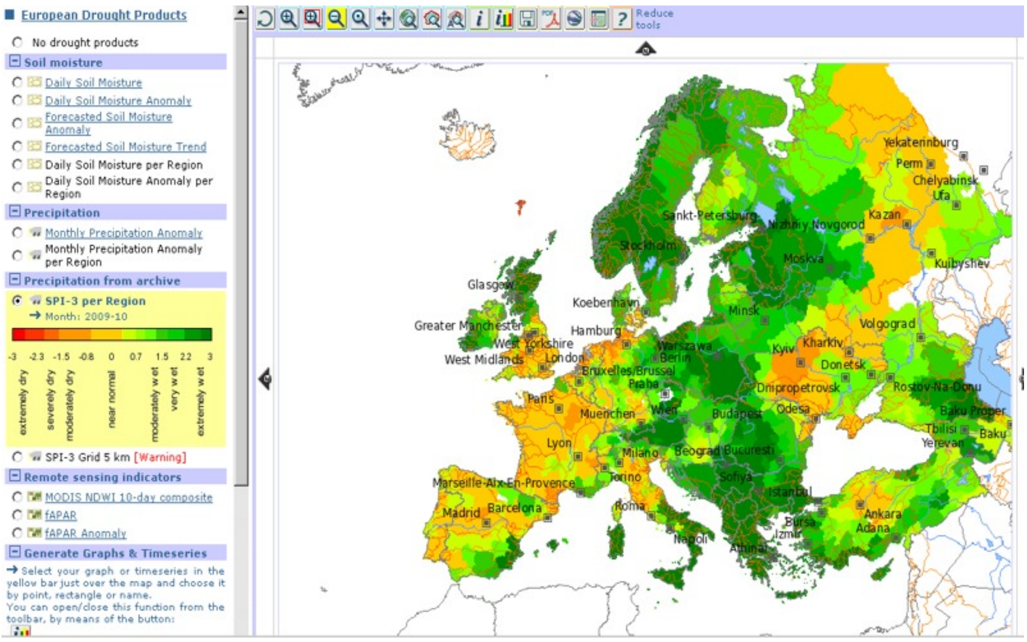
For example, the decrease of water availability due to abstraction can lead to the decrease of water quality due to the reduced ability of the water bodies to dilute pollutants. Excessive groundwater abstraction may lead to saline intrusion and ground subsidence which may cause geomorphological impacts (EEA, 2009). Such indirect and synergistic effects are much more difficult to predict and analyse. For the case of Europe, two of the most important impacts (associated with several interlinked drivers and pressures) are floods and droughts.

Floods are among the most hazardous impacts on human life and several methodologies and practices have been developed to address them. Flood Forecasting Systems, for example, make use of real-time precipitation and streamflow data, which are imported in hydrological (rainfall – runoff) and hydraulic models to produce channel flows and water levels for different time periods, ranging from a few hours to some days ahead, depending on the desired detail of the outcome, data availability and spatial extent of the study area. In an attempt to extend the lead-time of the forecasting, precipitation forecasts are often being used instead of real-time precipitation data. Early Warning Systems make use of the outcome of Flood Forecasting Systems to support real-time decision making and minimise social and economic impact.

The European Flood Forecasting System (EFFS) was the output of a study implemented within the 5th Framework Programme of the EC (2000 – 2003) that aimed towards the development of a Pan-European flood forecasting system for major river basins in Europe. The results of the project demonstrated the success of the developed early warning system, which proved to function properly based on the usual 3 days of flood forecast available to National Water Authorities and captured successfully historic flood event (Gouweleeuw B. et al (2004), de Roo A.P.J et al. (2003), http://databases.eucc-d.de/plugins/projectsdb/project.php?show=249). The EU's Joint Research Centre (JRC) has undertaken the continuation of the EFFS, by developing a European Flood Alert System (EFAS) and thus providing policy support on flood issues, especially focused on cross-border river basins.

JRC is currently using the experience and the availability of data from the European Flood Forecasting System, to develop the European Drought Observatory (EDO). Drought is an impact of the change of climatic variables and in particularly the decreased land precipitation in combination with increased temperatures that increase evapotranspiration and decrease soil moisture, are the factors that contribute to droughts (Bates et al. (2008)). The EDO is still under development and provides at the moment non validated, experimental data on monthly precipitation anomaly, daily top soil moisture and moisture anomaly, and daily forecasted top soil moisture and moisture anomaly maps in Europe. Furthermore, EDO provides maps of the Standardised Precipitation Index for Europe which is one of the most commonly used indicators for assessing rainfall anomaly. SPI-3 is defined as the Observed rainfall in mm over 3 months minus the Average over 3 months divided by the Standard Deviation of 3 months.

Figures C and D show two SPI-3 maps of Europe presenting rainfall anomaly for October 2009 and 2010. Comparing these two maps, it is evident that in October 2009 France and Spain had reduced rainfall while this was not the case for October 2010.



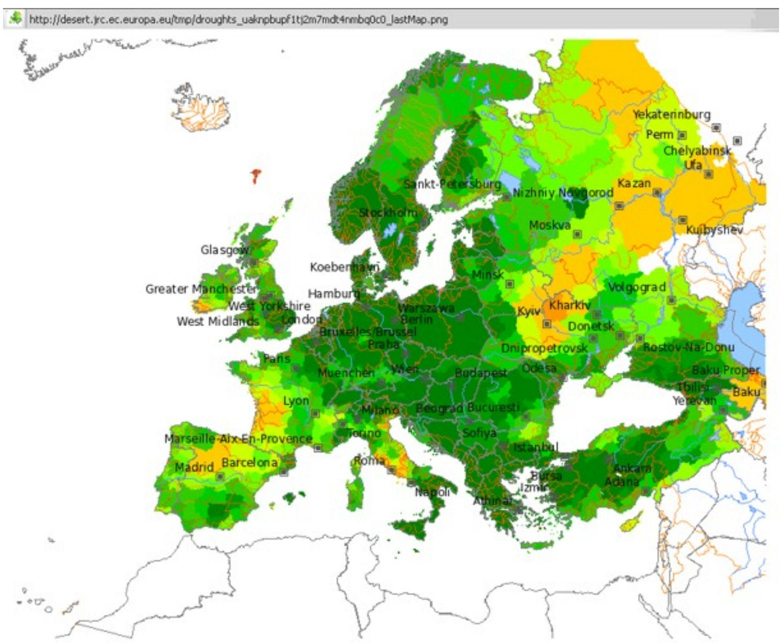
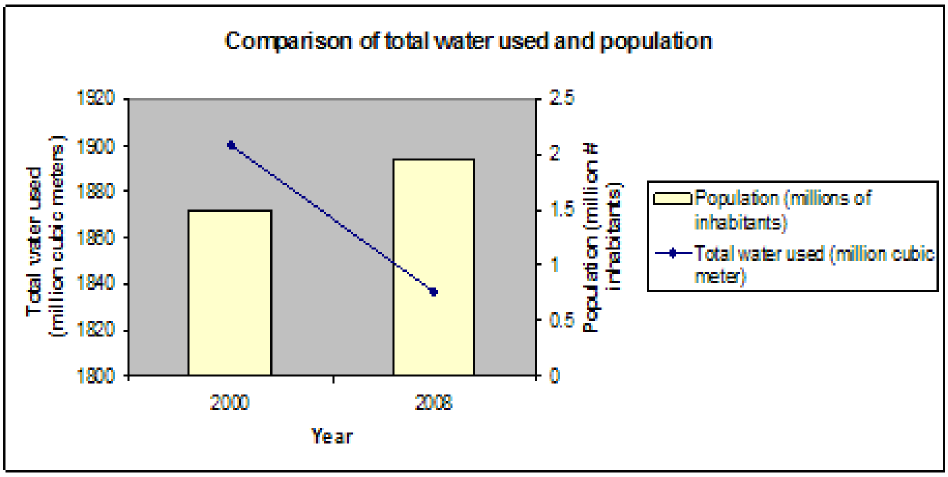


Figure C SPI-3 for October 2009. (Source: JRC http://edo.jrc.ec.europa.eu)

Figure D. SPI-3 for October 2010. (Source: JRC http://edo.jrc.ec.europa.eu)

As illustrated from the examples above, knowledge of the drivers (in general and the specific RBD) is crucial in the understanding of the problem and the correct identification of interventions. The key research issues that arise while trying to understand the drivers that affect the management of water resources can be summarised as follows:

- Improvement of the ability to understand, decouple and model socioeconomic factors that act as drivers to water resources management. This requires more targeted multi-disciplinary research between physical and social scientists and engineers.
- Improvement in the ability to dependably assess (or forecast) medium to longer term physical drivers and changes at the local and regional level. This requires improvements and GCMs and a better link between the climate and hydrology communities.
- Increase of the potential to associate specific changes of anthropogenic and climatic drivers to specific changes in the environment in terms of clearly understood cause-effect relationships: This requires a drastic improvement in the homogenisation of and open access to social, environmental and economic data and information at the European Level and at the RBD scale.

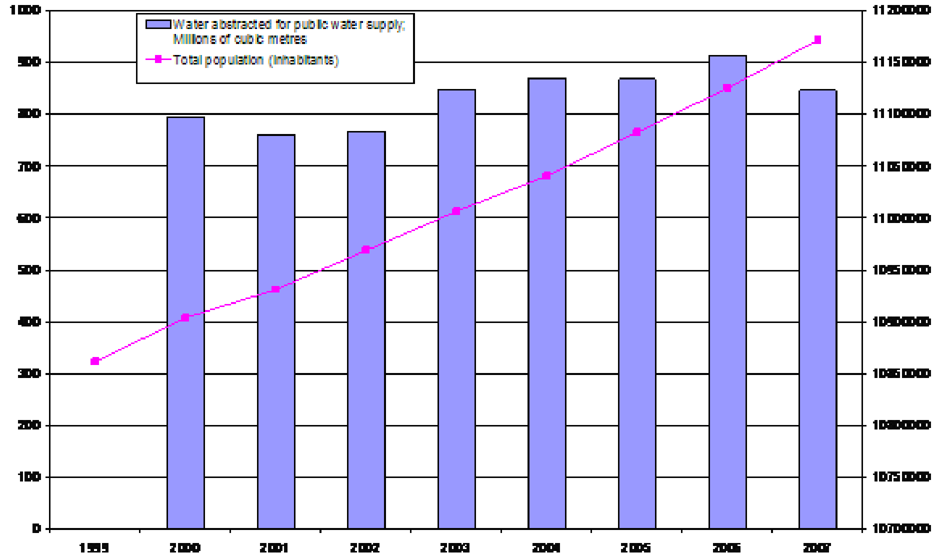


The Intergovernmental Panel on Climate Change (Bates et al. (2008)), has identified precipitation, temperature and evapotranspiration as the most dominant climate drivers for water. Temperature is particularly important in snow-dominated basins and coastal areas, the latter due to the impact of temperature on sea level. Monitoring of these at both national and European scales is fundamental the potential for improvingtheir effects asand the potential Although such observations are routinely made, the lack of a European Hydrological Observatory makes seeing the larger picture for Europe more difficult. Currently, EUROSTAT is the hub of such information for Europe. For example, EUROSTAT holds data relevant to population change (natural, residential, migration, tourists) and population projections (until 2045), living conditions, and economy. However, this information is mainly available at the Country scale, which is not always appropriate for assessments of these driving forces at the RBD level. The need for identifying links and synergistic effects between socio-economic and physical drivers can be seen in the example of water scarcity: Figure D presents an example of such combination for the Segura River Basin District in Spain. From 2000 to 2008 there is a decrease of domestic water use by 5%, with an increasing urban population and tourism. This leads to the conclusion that increases of the population in this particular case does not affect water use probably because of management actions taken at the RBD level.

Figure E Comparison of Total Water Used with Total Population (Source: http://www.chsegura.es and Data received from the Expert Network on WS&D in May 2010).

In contrast to this picture, another example is the comparison of water abstracted by public water supply from 1999 to 2007 in Greece combined with the population (Figure F). In this case, the conclusion of relevance to water resources management is that it is the population that drives the increased water use.

Figure F: Water abstracted by the public water supply combined with the population of Greece (Source: Eurostat)



Strategic issues

15 Integrated pollution management
16 Adaptation to climate change
17 Water scarcity and drought
18 Floods
19 Global change (demography, land-use, energy…)

Responses are an attempt to prevent, compensate, ameliorate or adapt to changes in the state of the environment. It can also refer to attempts by ecosystems themselves to respond (e.g. by adaptation or migration). The implementation of the Water Framework Directive in particular requires the development of effective Programs of Measures (POMs) at the River Basin District level in order to reach better ecological status. The identification of the driving forces, their pressures and impacts on the state of water resources are essential to organize society's responses via IWRM to address environmental, social and economic objectives.

Scientific knowledge of each component of the DPSIR scheme and their links is essential in order to select appropriate and (cost)effective responses. The assessment of the efficiency of the selected responses is important for evaluating existing policy strategies. The European Environment Agency developed and every year updates a Core Set of Indicators for water resources within which it includes indicators on Responses. For example, an indicator on Waste Water Treatment is in place in order to investigate the effectiveness of existing policies in reducing discharges of nutrients and organic matter to water courses. The data for supporting this indicator have been provided by EUROSTAT while EEA has developed the assessment methodology (CSI 024, 2009).

The issue of responses is perhaps the most open-ended in terms of additional knowledge required. Several challenges in selecting, implementing and assessing responses are listed below:

- Improving the evidence base of new responses (incl. new high tech solutions, policy and economic instruments that have not been applied before).
- Improving the integration of policies within a River Basin Management Plan and assessing the degree of their actual implementation and impact
- Improving the access to and standardisation of models and datasets that are used to compare alternatives – to ensure comparability of results.
- Designing and testing new pricing policies before they are implemented at a large scale. Com-

binations of pilots and new social simulation tools are currently being developed and used but this work is at its infancy.

- Developing shared visions, between stakeholders of the end-result of policy interventions.
- Improving the involvement of all stakeholders within a common, transparent framework of governance that is adaptable to change and includes improved dialogue, participation and co-evolution of a common perception/vision.
- Building in the responses the potential for adaptation, and avoiding lock-ins, considering potential future changes
- Changing social values and practices to support measures to conserve water and promote perceptions of fairness and accountability?
- Improving the understanding of the social part of the system of IWRM, including for example aspects such as social capital that are often neglected in river basin management.

A number of research challenges remain open, including:

- Explanation and quantification of the link between driving force and pressure, and assessment of the potential to address the driver directly as a means to address the pressure.
- Quantification of key pressures to the water resources system and identification of “leverage” points
- Exploration of synergistic effects of multiple causes resulting in multiplication of significant pressures

ANNEX 3

Questions of research from WP2 and WP3 of IWRM-NET

1 - Which governance framework and tools for the Water System management?

How best to organise stakeholder dialogue, participation and perception? What are the levers to reach an efficient, integrated, fair and sustainable management? How to involve all the stakeholders? How to define a framework for governance?

To implement policies, the institutional, economic, social and cultural components need to be understood to ensure that the policy is accepted. There is a need to provide people with an understanding of the many beneficial services provided by aquatic ecosystems to economic and social welfare .The education structure becomes more important as people need to better understand the continual changes to the water resource and supply and demand issues. There is a strong need to develop ideas and come up with innovative proposals for institutional arrangements that could help to implement integrated water resource management better.

1-1 How to improve the decision making process in water management?

Which governance framework and tools for the Water System management?

1 How to build trust and find ways to engage stakeholders more effectively?
2 How to develop methods to facilitate a compromise between stakeholders and researchers?
3 How to include recognition of the various phases of implementation of measures?
4 What information should be provided and to whom?
5 How to create learning process between actors? How to facilitate the communication between involved actors?
6 How can we manage and reduce the asymmetry of information among stakeholders?
7 How can we improve the evaluation of the impact of participation?
8 Does access to information and legitimacy of stakeholders play a role (and how) to ease the public participation thanks to a homogenization of knowledge?
9 How to communicate benefits of achieving environmental objectives to engage public interest?

How to improve the communication between citizens?

10 How do we implement a system to communicate with stakeholders in a sustainable manner and not only in times of crisis?
11 How to do a preventative communication to improve crisis management?

Does the current governance of the WFD allow it to be adaptative considering the future potential changes?

12 How to develop scenarios/ foresight for water management which cover impacts of driving forces at different scales, role of actors and should enable to play through different topics ?
13 How to develop predictive tools for assessing the consequences of the programme of measures after its implementation?
14 How to improve abilities in adaptive management and learning?

How can the legal and institutional framework be adapted/simplified to integrate different policies

The dynamic development of policy and legislative instruments directly affects the selection and choice of water resources management responses. The Water Framework Directive, for example, has requested Member states to implement River Basin Management Plans that will define the RBD status and will propose a Programme of Measures targeting a higher status for the RBD's water bodies. Although the WFD is not fundamentally designed to directly tackle issues relevant to water quantity, the European Commission has recognised the water quantity challenge, for example in the Communication on water scarcity and droughts in a 2007 (EC, 2007a). The communication outlines the importance of the issue and presents a set of policy options to address water scarcity and drought Europe-wide.

Can we develop methodologies and good practice to integrate biodiversity action plan targets & other legal EU environmental duties with water management at a landscape scale?

15 How should the structures and organisations be organised?
16 How to find arrangements, institutions or capacities to work across different levels of government?
17 What is the right territorial scale for management?
18 With so many networks already in place, what is the eligibility of these networks, how do we assess them?

How to change social values and practices to improve the legitimacy of measures to conserve water and the perception of fairness and accountability?

19 how do we produce a common vision of the system for participation, negotiation, and consensus building, assessment of risk and uncertainties?
20 Can we evaluate and compare planning cultures and participatory cultures?
21 How is the WFD being understood by different stakeholders in different national contexts?
22 How do we evaluate behaviours?
23 How to incorporate the many pressures on the water resources in a comprehensive and holistic management system?
24 How to prove benefits of water policy to the society?
25 Who will value ecosystem services and other social theories? What values will inform the knowledge production? What is the role of science? What makes knowledge pertinent to societal needs and who decides?
26 How to better understand the systems and organisations to improve knowledge transfer/participation (mapping of stakeholders)?

How to improve and develop methods that incorporate social capital in river basin management?

27 How do we integrate social, political aspects into characterisation reports?
28 How do we apply the methods and tools to analyse society and the environment?
29 What are the links between social benefits and ecological improvements?
30 How to improve our ability to ensure measure for river basin management such as regulation, voluntary information, education and economic measures take account of social context?

1-2 What are the tools and methods for implementing IWRM?

Decision makers need methods and tools to assist them in identifying measures that will prevent or mitigate the impacts to water resources. In so doing, decision makers have to consider global consensus on policy objectives, take into account existing scientific knowledge on the state of both water resources and society and apply existing tools and methods. Models and scenarios can be utilised to aid this process in different spatial (regional, national, European and global scale) and temporal (short-term, long-term) scales. In order to further enhance the knowledge on water resources and to identify and assess the effectiveness of water resource management responses it is essential to involve the stakeholders in the decision making process.

Which decision support systems to support decision making?

In order to support water resources management a number of Decision Support Systems (DSS) have been developed that integrate models, analytical engines, GIS and spreadsheets and include intelligent components (fuzzy inference, learning algorithms and evolutionary optimisation), that are able to address interacting issues and may communicate results to stakeholders (Makropoulos et al. 2008).

The majority of these systems allow the decision makers to identify the pressures on the state of water resources and their origins and to quantify their impacts. Such decision support tools require data of the state of water resources (precipitation, river flow, groundwater capacity etc) and the state of anthropogenic factors (population, land use etc) as well as scenarios of driving forces (climate change, population change, urbanisation etc) in order to identify the applied pressure on water resources (water abstraction, discharge of water effluent treated or untreated etc).

31 Can we develop a decision support system(DSS) that allows assessment of risk and uncertainties? Can we develop a DSS based on transfer of knowledge? Can we develop a DSS that integrates different aspects of water management for assessment and comparison of options including cost-effectiveness? Can we develop a DSS that builds consensus by negotiation and participation? Can we produce a methodology for stakeholder validated descriptions of the distributional significance of IWRM options?

32 What are the methodological tools, jobs and skills required in order to create an integrated water management system in order to match research needs of decision-makers with scientific skills?

33 How to set up comprehensive management tools, not only for water but also for energy and economy? How can economics support decision-making?

34 Can we produce integrated models, simple models as decision-support tools? How to develop a common strategy for typology and reference sites?

35 Can we better implement DPSIR methodology? How to produce interactive maps of priorities - pressures and impacts and contacts?

36 Can we produce scenarios for possible future rivers lakes and estuaries and coasts, accounting for climate & socio-economic & governance?

How to improve data monitoring? Which data do we need?

37 How to improve data monitoring methodologies? Which compliance methods?

38 How to promote the combination of existing datasets of the IWRM participating countries? How to protect existing long term datasets for the future?

39 Can we standardize a Water quality monitoring considering physical, chemical, biological aspects?

40 What techniques do we need to monitor & collect data for good ecological status?

41 How to seek out examples to pilot integration of different types of datasets? Can we integrate them?

42 Can we represent compiled historical, spatial and temporal data on selected river basins?

43 Can we integrate harmonised Data with GIS?

44 Are the techniques good enough for quantification?

45 What timelines shall/may be applied for defining reference conditions when historical data are lacking – basin-wide comparability?

46 What kind of long-term hydrological and biological monitoring datasets do we need for the detection of ecological effects produced by climate change?

How does modelling of integrated datasets at different scales affect

decisions as to programmes of measures that should be used towards WFD?

How to improve the definition of GES and GEP?

47 Better definition of "Good Ecological Status" and "Good Ecological Potential" as dynamic processes, which vary both in space and time.
48 Can we develop methodologies in order to set environmental objectives for hydro-morphological pressures in WFD? How can the WFD and assessment tools keep up with changing knowledge (e.g. taxonomical or bio-geographical issues)? Can we link biological, chemical/physical and hydro-morphological information to reach a definition of ecological status?
49 How can/may new pollutants or species (native, non-native) be integrated into reference conditions and assessment tools?
50 How to define GES and develop methodologies considering the natural, social and political background? What are the drivers behind the concept of GES as a process of dynamic interactions i.e. is good ecological status a definition of environmental science, social science or political science?
51 Can we have a definition of GES that is a pragmatic and operational compromise? How can we improve the incorporation of public worth and social values into the definition of ecological status?
52 What are the main natural and anthropogenic drivers to GES? What affects achieving good ecological status (obstacles)? What are the social and political drivers of GES?
53 Can we better specify the five classes of good ecological status? Can we develop a survey of what do we know now about Good Ecological Status, including potential?
54 What are the impacts of heavily modified water bodies on Good Ecological Potential?
55 Can we create a Practical Ecological Flow Definition?
56 How can the decision making for HMWB be supported, e.g. designation process?

How to produce a set of reliable and sensible indicators ?

57 Can we combine the monitoring with development of sets indicators ?
58 How to use indicators developed by an Expert Network to compare and assess water resource management in selected basins?

How to develop interdisciplinary (physical, chemical and ecological processes and socio-economic aspects)?

59 How to develop transdisciplinary approaches in research which integrate non-expert views (e.g. stakeholders views)?
60 How to develop inter-disciplinary approaches not only looking at data, providing technical solutions modelling future measures, but combining social, industrial, ecologic & improving confidence in decision-making and the assessment of risk?
61 How to integrate hydrology, geomorphology, water, economics and social issues?
62 How to improve our understanding of the relationship between flow and ecology based on appropriate data and site specific studies (linked to hydropower also) ?
63 How transferable and adaptable are measures? What are the methodological components?

How to improve transfer of knowledge?

How to reveal social values?

64 How to assess the awareness of people regarding the importance of eco-system services accruing from the scarce resource water?
65 How can we improve the expression of diverse values?
66 Can we develop indicators to give a measure of more abstract issues such as human well-being?
67 Can we develop tools comprehensively taking into account the pattern of interactions between the ecological services, the social actors and the values they assert?
68 How to assess welfare accruing from changes in the availability and quality of drinking water with contingent valuation or attribute-based choice modelling (choice experiments etc.)?

How to value the ecosystem services of Water System?

69 What are the components of the value of water?
70 How to develop Cost Efficiency Analysis / Cost Benefit Analysis?
71 How to quantify monetary benefits of hydro-morphological measures under WFD?
72 How to improve the operating tools for management and the utilisation of disproportionate cost?

73 How can we evaluate financially the benefits of re-establishing functional aquatic ecosystems (e.g. tourism and nature benefits for communities)?
74 How do we evaluate economic flows in environmental services?
75 How to reduce (or take account of) uncertainty in economic assessments to improve decision-making?

How to design pricing policies?

76 How to decide in pricing policies according to member states programme of measures.
77 Which new systems of payment for water to include more effectively the 'distributive' aspects of water economics across all aspects the hydrological cycle (not only for drinking water)?
78 Can we develop decision-support tools that assist in allocating charges between the beneficiaries and the polluters? How to allocate the correct charges fairly and transparently?
79 What are the effects of pricing policies?
80 What are the cross-cutting effects of other EU policies on the management of water resources such as subsidies to agriculture?
81 How to improve the link between water treatment and the original quality of the water to improve efficiency of treatment and reduction in costs?
82 How will the social values of the water and the people's behaviour and practices respond to higher prices of water use (full recovery of costs)?
83 Cost Efficiency Analysis / Cost Benefit Analysis
84 How to make the change from supply driven to demand driven water management and balance uses with ecosystem needs, but also balance between different uses?
85 Which tools and measures to manage water through demand?
86 How does demand management allow water resources to be a strong multi-sectoral component of development?

1-3 How to develop framework for policies integration and assessment?

How can we assess the WFD, the RBMP?

87 Which impacts of the measures identified in the river basin management plans under WFD?
88 Which measures to assess the efficiency of water use?
89 How to assess the effectiveness of measures in groundwater?
90 How can we evaluate the financial impacts of measures? in particular the financial impact on social and economic sectors. i.e. economic indicators/cost effectiveness/cost recovery/investment affordability.
91 What are the correct details for impact assessment?

How to improve integration of policies in River Basin Management Plan?

92 How to integrate the Waste Water Treatment? Can we develop programme for organic and nutrient pollution in order to understand the costs associated with? While looking for cost efficiencies?
93 Can we get the spatial resolution right to be more effective?
94 Can we improve our understanding by water body grouping?
95 How to integrate the relationship between the urban and rural (communities, water demands etc)?
96 How to integrate ecological and socio-economic objectives at a basin scale?
97 How do you take a catchment based approach to heavily modified water bodies, including trans-boundary issues ?
98 How to integrate terrestrial, transitional and coastal waters in the management process?
99 How to assess the status of intermittent (ephemeral) water bodies?
100 Can we improve our understanding of erratic flows (both flood and drought) and the impact on ecology/ecological status?
101 How to improve the management of shallow aquifer ? How to delineate territory for leaving shallow aquifers/stagnant water for ecological benefits? How can we improve decision-making abilities for management of shallow aquifers? How can we improve the management of abstraction from aquifers (by agriculture/industry/domestic)?

2 - How to improve knowledge on state of water resource and pressures?

To improve water management, it is necessary to understand how water bodies are functioning: physical, chemical and ecological processes and how they are altered considering the various components of the water system as flow regimes, area (coastal, estuaries, rivers, humid zones, lakes…, urban/rural…), water bodies (ground waters, surface waters, stored waters…). It is also important to understand how the drivers are functioning and their influence on the water ecosystems (state and mechanisms). For that, it is necessary to have a better conceptualisation and quantification of the evolution and adaptation capacities of ecosystems and social systems in response to various changes. There is need to develop interdisciplinary approaches in order to assess the state of physical, chemical, ecological processes as well as socio-economic processes. There is also need to improve the monitoring and the open access to parameters that support the characterisation of the state of the environment.

2-1 How to improve knowledge on ecological, chemical and physical processes?

What are the gaps of knowledge on physical processes?

102 How to improve our understanding of morphological changes to estuaries and rivers ?
103 How does river bed degradation affect the management of (restoration) of hydro-morphological issues e.g. floodplain connectivity?
104 How to avoid saltwater intrusion in stored water ?
105 How to influence it with water effects on extremes on low flows in different landscapes/land-use, climate change on infrastructure, water supply and groundwater?
106 How do we link engagement across scales from reaches to catchments, inter-intra catchment continuity?
107 What is the role of flash floods?
108 What are the links between sediment transport and coastal erosion?
109 How will rising sea levels, altered flow regimes and sediment transport affect coastal areas in terms of deposition, erosion and management?

What are the gaps of knowledge on chemical processes?

110 Can we specify the priority hazardous substances?
111 How to improve our knowledge of NO3 movement in zones and groundwater?
112 How much NO3 in groundwater is attenuated before entering the river?
113 How to improve our understanding of the processes involved in the transfer/residence times of chemicals in basin?
114 How to develop a tool for pollution migration (dispersion)?
115 How to improve knowledge of the buffer capacity of soil on pollutants ?
116 How pollutants are modified during transport through a catchment?

What are the gaps of knowledge on ecological processes?

117 How to better understand the environment and the ecological processes?
118 How to improve our understanding of the relationship between flow and ecology based on appropriate data and site specific studies?
119 How to better understand of the processes and interactions across the eco-hydrology surface-GW interface to better quantify GES?
120 What are the ecological aspects of sediment transport changes?
121 What is the inter-relation between river ecosystem and other terrestrial ecosystems?
122 What are the drought effects in wetlands and the relationship with stream ecology?
123 How to improve knowledge on Alien Species?
124 Can we specify bioindicators, biomarkers?
125 How to improve the management of Eutrophication? What are the causes (specifically for lakes and coastal waters)?
126 How do we estimate the water volumes for ecologically safe water use for trans-boundary gauging stations on the rivers?
127 Can we develop a reliable site specific method for managing change in flow due to abstraction to avoid environmental damage?

2-2 What are the current and the future impacts on the water system

Research in the field of impacts is focusing on different issues:

Improvement of interdisciplinary knowledge on the boundaries between physical, chemical and ecological processes

Identification of longer term social and economic costs and benefits and their inclusion in decision making processes

Elicitation of social values in their true dynamic form.

Standardisation of impacts metrics, both spatially and temporally

How could Climate Change affect Water System and ecosystems?

The Climate change is the main driver. Therefore, it is necessary to monitor the climatic and hydrological variables to improve our understanding of these drivers for modelling their future evolution.

128 How will the climate change impact the water resource characteristics and processes? How will changes in climate affect catchment scale processes?
129 How will climate change impact on the hydrology e.g. flow amplitude, frequency and variability?
130 What is the resilience of the ecosystems when faced with extreme perturbations?
131 What are the ecological impacts of an increase in the temperature of water bodies? Is it predictable?
132 How will the changing land-cover (in particular forestry) impact on the water quality and quantity
133 Which impact of climate change on energy policies? How does it affect the water management, the water quality and quantity?
134 What are the impacts on ecology, energy policies and navigation of changes in water supply by alpine glaciers in summer? Is it affecting achievement of good ecological potential (GEP)?

How anthropogenic drivers are affecting the Water System and ecosystems?

How to improve our knowledge agriculture impacts on water and aquatic ecosystems? How pollutants are modified during transport through a catchment? How much NO3 in groundwater is attenuated before entering the river? How to improve our knowledge of NO3 movement in zones and groundwater? How to improve our understanding of the processes involved in the transfer/residence times of chemicals in basins? How to improve knowledge of the buffer capacity of soil on pollutants?

135 How does the size and character of reservoirs affect water quality (e.g. termperature, oxygen saturation) and sediment transport (eg.reservoir flushing)?
136 How does land use impact on the hydrology?
137 Can we link Urbanisation/Disperse settlement patterns and their impacts on water management?
138 How to improve our knowledge tourism impacts on water and aquatic ecosystems?
139 How will the changing land-cover (in particular forestry) impact on the water quality and quantity?
140 What about demography, growth, exchanges and cultural aspects?
141 How wildfires and its impact on land-cover affects water quality and quantity?

How to develop understanding of cause-effects relationships?

142 How can we do Pressure and Impact models?
143 How to assess potential positive and negative impacts of new technologies on integrated water resource management?
144 Which tools for better estimation of soil buffer capacity on priority pollutants in the recharge areas of the groundwaters?
145 Can we create an integrative database for unsaturated and saturated soil zone including pF (retention), porosity, structure?
146 How can we stimulate chemical/physical changes to reduce pollution in groundwater?
147 Which techniques to develop for the removal of arsenic from Groundwater (relates to DWD) and the improvement of cost-effectiveness of these techniques?
148 How to improve the ability to model and plan measures to deal with contamination in both groundwater and surface water?
149 How to improve our ability to separate out the effects of individual pressures and then the cumulative effects of pressures?
150 How can we reach an acceptable level of uncertainty in pressure /impact results to invest in action
151 How to develop scenarios/models for organic and nutrient pollution reduction, in order to size the effect of the measures?

2-3 Responses to pressures: How to manage the consequences of pressures e.g. prevention, mitigation and crisis management?

How to face perturbation related to climate change?

152 How to define indicators which are sensitive to limits and trends toward thresholds (biological , physical and socio-economic indicators)?
153 Can we develop early warning systems? (for water managers to avoid reaching a tipping point)
154 Which mitigation and adaptation strategies for climate changes?
155 How to precise adaptation measures for water quality and quantity?

156 Can we produce regional climate change models with better certainty about effects on water management?
157 Can we improve models to help water managers to understand and predict how a water body will react to climate changes, in particular at regional or river basin scale?
158 How to reduce the siltation of dams following on from wildfires?

How to improve the drought management?

159 How can we improve the management of critical drought situations? Can we improve operational management of droughts?
160 How to facilitate transfer knowledge of operational management of droughts?
161 How can we use artificial recharge of waters as a drought management measure?
162 How to locate the ideal place for storing water in aquifers as a drought management measure (links to saltwater intrusion question)?
163 How to set clear definitions for arid/parched/drought areas and have mapping of these areas?
164 How to improve our ability to value competing uses to compare these and assess the most important use or find ways of achieving a balanced and fair distribution of resource use?
165 Can we collect data on watersheds that currently or often have drought issues? Can we collect data on watersheds that deal with water scarcity issues due to water usage?
166 What are the ecological impacts of drought?
167 What is the impact of drought on the economy? How to assess the cost of ecological problems carried out by drought (oxidation of peats and soil-setting)? Which cost-effective measures to deal with this problem?
168 how to improve our understanding of erratic flows (both flood and drought) and the impact on ecology/ecological status?
169 How can seasonal changes in erratic flow be managed (e.g. storage capacity, methods to recharge aquifers)?
170 How to improve and extend indicators to Mediterranean countries and then to rest of Europe?

How to improve the flood management?

171 Can we improve our understanding of how the Hydro-Morphology regulations of the WFD impact on flood risk management strategies?
172 How can seasonal changes in erratic flow be managed (e.g. storage capacity, methods to recharge aquifers)?
173 How can priorities be defined in river basin management, flood management?
174 How to develop our understanding of river restoration? How benefits-implementation?

How to improve the pollution management?

175 Can we integrate our understanding (and thus management) of nutrient pollution with biology, chemistry and physical aspects? Can we integrate our knowledge with other disciplines?
176 How to improve our modelling of hazardous substances in space and time, integrating both surface water and groundwater?
177 How to develop guidelines specific to typology (e.g. upper and lower reaches of river) to manage nutrient pollution, which have the support of the inter-calibration process?
178 Can we develop new tools for managing pollution e.g. phosphate free detergents, improving technology in industries generating organic pollution?
179 Can we develop tools for better estimation of soil buffer capacity on priority pollutants in the recharge areas of the groundwaters?
180 Can we develop environmental objectives for hazardous substances in marine coastal regions in sediments and biota?
181 Which methods for estimation of the background content (metals, oil, hazardous substances, nitrate) and of the anthropogenic input, links to Drinking Water Directive and the existence of natural contamination and achieving European Standards for DWD?.
182 Do we know the efficiency of the pollution reduction measures, can we measure their efficiency?

Which responses to face agricultural pressures?

183 How can we change agricultural practice to reduce the input of pollutants into the environment?
184 Can we improve management and efficiency of use for nitrates?
185 How will changing agricultural practices impact on water quality and quantity?
186 Can we develop new techniques including cost benefit analysis for nutrient pollution from agricultural sources? (e.g. buffer capacity of soils, nitrate content in soils, linkages with groundwater, measures affect the environment)
187 Can we develop methods to reduce the maximum (peak) concentration of $NO3$ in groundwater to 50mg/l?
188 Can we develop scenarios/models for organic and nutrient pollution reduction, in order to size the effect of the measures?

Which responses to face industrial pressures?

189 How can we change industrial practice to reduce the input of pollutants into the environment?

190 Can we develop technologies for re-use – recycling of water and waste water?
191 Can we implement 'Best Available Techniques and Environmental Practices' for hazardous substances
192 Is it possible to develop new tools for managing pollution e.g. phosphate free detergents?
193 Is it possible to improve technology in industries generating organic pollution?

Which responses to face energy policy (hydropower) pressures?

194 How can the impacts of residual flows be assessed, how do they affect river restoration programmes
195 How can the impacts of hydro-peaking (quick fluctuating flow levels) be assessed? How do they affect river restoration programmes?
196 How to maintain water quality during the process of infill of dams and the measurement of quality (considering the fluctuations of the state due to the infill process)?
197 Can we develop fish migration facilities for extreme heights, e.g. sturgeon passage at the Iron Gate
198 How to improve the management of the trans-boundary issues associated with residual flow and hydro-peaking with hydro-power dams? (Hungary)

Which responses to face other anthropogenic pressures?

199 How to manage urbanisation/settlements?
200 How to develop methodologies for the ecological rehabilitation on navigational routes?
201 How to manage infrastructures? How can we ensure that Environmental Impact Assessments and/or a Strategic Environmental Assessment during the planning phase of future infrastructure projects ensure that hydro-morphological changes do not adversely affect the ecological status of the water body?
202 How to manage tourism?

"During the implementation of ***IWRM-Net project***, a network of 21 European partners and 17 research programme managers has been established and has collaborated on IWRM-related issues. The current report is the outcome of the collaboration of several partners concerning the description and evaluation of long-term and short-term IWRM-related scientific needs identified during the project."

- Photos
- Cramond Fish - Forth Estuary Forum
- City of Bremm and Moselle river, Wikimedia
- Caler Reservoir, wikimedia
- Boats on the River Belon, Wikimedia
- Seals at Inminch, Forth Estuary Forum

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