EPI WATER

Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

Case Studies' Inception Report

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Preface

In 2011 the EPI-Water consortium and the associated overseas expert have completed an extensive (ex-post) review of some 30 economic policy instruments (EPIs) in Europe and elsewhere. The results of the review have been presented and discussed in Berlin in January 2012.

Moving forward, over the next almost two years the consortium will face a new challenge: based on the insights gained and lessons learned so far, we will develop innovative policy solutions, and assess their expected impacts, to real management issue in several river basins throughout Europe.

As shown in the figure below, this work has already started and will last for 20 months. A mid-term review is planned for January 2013 in Madrid. This document provides an initial description of the river basins in which the research and assessment will be implemented. In addition, it describes the governance of the undoubtedly ambitious research undertaken.

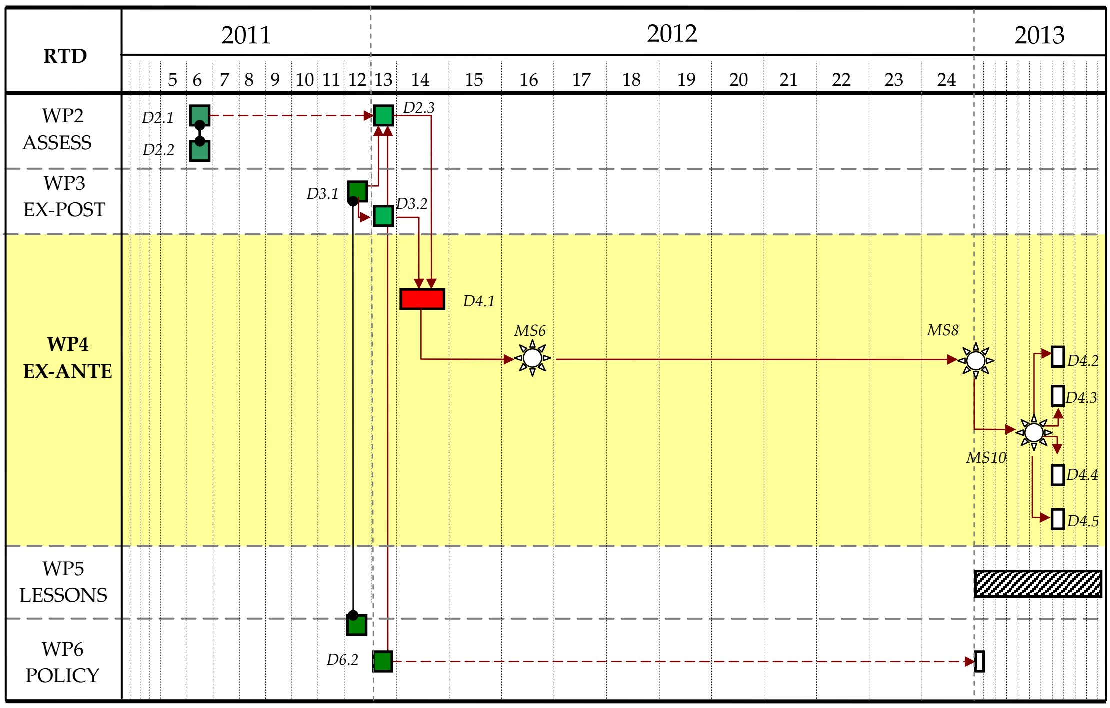

Figure 1. Road map of the EPI-WATER *work packages (in red highlighted this deliverable/document)*

Jaroslav Mysiak,

EPI-WATER project coordinator and

leader of the WP4

Executive Summary

The WP4 Inception Report (IR) serves as initial specification of the WP4. It outlines the management structure behind the ex-ante case studies and provides an initial description of the river basins in which the ex-ante assessment will be conducted. A detailed guidance for the execution of the WP4 sub-tasks that are the same for all ex-ante case studies are discussed in the government structure of the WP4. The tasks 4.1-4.3 are related to floods and excess waters (Tisza), droughts and scarcity (Segura and Tagus) and ecosystem services and biodiversity conservation (Seine-Normandie), respectively. These tasks will be implemented within clearly specified boundaries of a reference river basin, whereas the task 4.4 related to macroeconomic perspectives for water quantity and quality is transversal to other case studies. The reference river basins case studies and the opportunities for EPIs to be implemented in these river basins are discussed in section 4.

In the past, the Tisza river (Hungary) had been streamlined to prevent floods and gain new agriculture land in landscapes where wetlands and marshes dominated before; the same development which is so characteristic for many other river basins. This has further amplified the vulnerability to flood and droughts, the latter being the consequence of low water retention to bridge the meagre summer periods. The analysis focuses on landscape elements including dry polders and areas in their proximity, potential wet reservoirs and deep floodplain areas. The former two cases have initial flood service potential. The areas in proximity to dry polders can provide flood protection service through the overflow of the initial reservoir – as it was the original concept of the Cigánd VTT reservoir. Therefore, the set of potential EPIs in the Tisza river case study include innovative payments for farmers for temporary storage of floods/excess water, financial incentives for permanent land use change, runoff charge for the water management organizations, tax or tradable permit approaches.

Water scarcity in Southern European Regions poses a significant threat over riparian ecosystem sustainability, development dynamics, and even household supply. Supply-side policies have been traditionally used to address these problems. However, environmental outcomes stemming from complex social-ecological systems is often unpredictable (Anderies, 2006), and the successive implementation of command-and-control policies in the Tagus (Iberian peninsula) and the Segura (Southeastern Spain) interconnected basins has resulted in higher water scarcity and uncertainty. Drought and crises are now recurrent occurrences, and the current institutional setting has left decision makers with few options other than to reinforce the current path of the system with further command-and-control policies. Decision-making became reactive and incremental as the system has become extremely vulnerable to external shocks. As a result, the set of potential EPIs include robust

institutional designs for water markets and water pricing for irrigation (as a support instrument, both to promote farm efficiency improvements and as a financial mechanism). Evaluation of environmental outcomes and water markets will also be provided. Experiments with auctions or trading, since these might be relevant at a local scale (i.e. within the same irrigation community) but not for long-term regional transfers (which are not decided by individual users but rather stakeholders) will be performed and evaluation of transaction costs will be also be provided. Moreover, modeling (trading) policy instruments, analysis of asymmetric information, Common Agriculture Policy (CAP) analysis (scenarios and policy design) and a development of land use model will be pursued. Analysis of negotiated arrangement between parties to promote good practices for the reduction of pressures on water resources often linked to subsidies or compensation schemes will also be considered. Finally, an optimization module, developed in Pinios River basin (Greece) to run both the economic and hydrological models to forecast system behavior, will be applied to the Tagus-Segura case study.

The adoption of the Water Framework Directive (WFD) has shifted the water policy debate in France but also throughout Europe from the traditional "water quantity and water quality" debate to questions of ecological status, biodiversity and restoration of the severe morphological alterations to aquatic ecosystems. Overall, the WFD has stressed the need to shift from a uniform aquatic ecosystem to a more diverse aquatic environment that would deliver highly diverse habitats for the aquatic fauna and flora. Article 5 reports and the draft RBMPs (River Basin Management Plans) of many river basins in Europe have stressed the importance of managing morphological pressures as key to the achievement of ecological status for surface waters. Areas in the Seine-Normandie basin offer a variety of opportunities for the development of EPIs. Financial compensation for agriculture services or voluntary agreements can be analysed in the PNR Cotentin (Regional Natural Park), which combines agriculture, wetland protection and eutrophication areas. Financial compensation, voluntary agreements, instruments for promoting river and wetland restoration and reversion could be combined in La Bassée area to protect its biodiversity and ecosystem services associated. Payments for ecosystem services or other voluntary agreements which have been developed (or are under development) in other areas in France, will be considered for the Seine-Normandie basin.

The purpose of water quantity aspects as related to the economy focuses on capturing the fragile balance between water availability and use and modelling it in terms of an accounting system, following the SEEAW- System for Environmental-Economic Accounts for Water (UN, 2003) methodology. Also, it aims to evaluate the impacts of EPIs on hydrology and relate the contribution of water to the economy and the impact of the economy on water resources. The proposed study will be implemented in Segura River Basin and Pinios River Basin in Spain and Greece respectively. For the Segura River Basin, a hydrological model is already in place. A robust Water Resources Management Model will be developed for the Pinios river basin. An economic model to simulate the "water use right markets" in Segura River Basin will be customized and adopted for the Pinios River Basin. The necessary coding will be implemented. Further, the hydrological model and the economic model will be coupled to develop a hydro-economic model, which then will be applied to Tagus-Segura case study.

The establishment of artificial drainage on a large part of the arable land in the Odense River Basin (ORB), which is located in the Funen region of Denmark, modified considerably the aquatic environment in the catchment during the last century. Small water bodies like mires, meadows, watercourses and shallow lakes, and fjord sections have disappeared or been converted to arable land. The ORB is a physical water environment that is strongly modified by humans: many watercourses have been channelized and regulated and are under controlled maintenance. Therefore, some of the natural properties of the aquatic system have been lost, like the self-cleansing ability of the Odense Fjord and of the river basin. This loss has severe implication for the maintenance of good water quality, which is strongly affected by a reduced natural remediation. The SEEAW methodology can be used successfully in producing new insights regarding the potential effects of EPIs on the aquatic system/economy of ORB by dealing with both water quantity and water quality issues. Two approaches are considered within the SEEAW context. The idea is to investigate the complex relationship between surface water quality and quantity of water abstracted by households/agriculture. This can be performed by designing and modeling the effect of a tax on drinking water supply similar to the Danish water supply tax. The second proposal is about modelling the implementation of an EPI that addresses nutrient load, in particular in the form of a tax on nitrogen/nitrogen loss from diffuse sources, which will allow the estimation of the benefits achievable with this EPI in terms of improved water quality via reduced concentration of nitrates. The main modelling framework will be calibrated for the Odense catchment where similar modelling possibilities can be found (in terms of e.g. linking water quality to nutrient emissions from human sources), or where a counterfactual basin could be identified (Seine-Normandie basin).

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D 4.1 - Case Studies' Inception Report

1 Scope of the Inception report

The WP4 Inception Report (IR) serves as an initial specification of the WP4. It outlines the management structure behind the ex-ante case studies (sections 2 and 3) and provides an initial description of the river basin in which the ex-ante assessment will be conducted (section 4).

2 WP4 Governance

2.1 Introduction

This section describes the governance structure of the WP4. It is followed and complemented by a detailed guidance for the execution of the WP4 sub-tasks that are the same for all ex-ante case studies.

Most resources – 20 project months and 167 person months and of the project – are dedicated to workpackage 4 and the ex-ante assessment exercise. The project main conclusions will draw on the results of the WP4. The WP4 is also the most challenging in terms of management. First, all partners participate in WP4 and contribute to two or more ex-ante case studies. It will not be easy to manage their contribution because of geographic distance and language barriers. Second, the WP4 produces deliverables only at the beginning and the end of the WP4 duration, in the month 14 and 32. Third, whereas the tasks 4.1-4.3 will be implemented within clearly specified boundaries of a reference river basin, the task 4.4 is transversal to other case studies.

	Task	Reference basin	Leaders
4.1	Floods and excess water	Tisza	Gabor Ungvari (BCE)
4.2	Droughts and water scarcity	Segura and Tagus	Carlos Gomez (IMDEA)
4.3	Ecosystem services and biodiversity conservation	Seine-Normandie	Pierre Strosser (ACTeon)
4.4a	Macroeconomic perspective: Water Quantity	Segura and Tagus and Pinios	Maggie Kossida (NTUA)
4.4b	Macroeconomic perspective: Water quality	Odense and Seine-Normandie	Mikael Schou Andersen (AU-NERI)

Subtask	Title	Project/calendar months	Key deliverables (Del) and milestones (M)
1	Inception report	13-14 Jan-Feb 2012	Del 4.1 Inception report (March 1st, 2012)
2	Stakeholder advisory group	13-32 Feb 2012 – Aug 2013	M6 First round of SH meetings (May 1st, 2012), M10 Final SH meeting (July 1st, 2013)
3	Scenarios for economic instruments	15-16 March-April 2012	
4	Assessment of the policy instruments	17-30 May 2012 – June 2013	M8 WP4 Midterm review workshop (January 2013)
5	Assessment of transaction costs	17-30 May 2012 – June 2013	
6	Overall assessment	29-30 May– June 2013	
7	Synthesis	30-32 June – August 2013	Del 4.2-4.5 Case study reports (September 1st, 2013)

2.2 Composition of the WP4 task/ex-ante case study teams

All EPI-WATER consortium partners but BCE-REC, IMDEA, ACTeon, NTUA and AU will contribute to two or more ex-ante case studies, optimally distributing the available resources among the case studies. The leading institutions of the WP4 tasks are not asked to get involved in other case studies apart of their own. The allocation of the resources will be reviewed and approved by the Project's Steering Committee (PSC). The use of resources will be duly documented and key inputs and contributions will be laid down on the onset of the WP4. Consortium partners contributing to specific ex-ante case study will be a part of the *case study team*.

2.3 WP4 Steering Committee

The WP4 task leaders (TLs) bear full responsibility for the quality of results and their timely delivery. They will ensure that the resources allocated to the given WP4 case study are used effectively and efficiently. The WP4 TLs together with WU (WP3 leader) and Ecologic (WP3 leader and leader of the task 5.2) will form a WP4 Steering Committee (WP4-SC). Besides overseeing the application of the assessment framework, the role of the WU will be crucial for the correct implementation of the sub-task 5: Assessment of Transaction Costs. Online or phone conference of the WP4-SC will be held every 6 weeks or whenever necessary.

Table 1 Composition of the WP4 Steering Committee (WP4-SC)

FEEM (Jaroslav Mysiak)	BCE-REKK (Gabor Ungvari)
IMDEA (Carlos Gómez)	ACTeon (Pierre Stosser)
AU-NERI (Mikael Schou Andersen)	NTUA (Maggie Kossida)
WU (Hans Peter Weikard and David Zetland)	ECOLOGIC (Manuel Lago).

2.4 Role of the WP4 task/case study leaders (TLs)

The TLs will coordinate the contributions of team members towards achieving the goals and objectives of the respective task/ex-ante case study. They are responsible for the quality of the deliverables, overall management and timely implementation of the case study research plan, and engagement of the local stakeholders. It is advisable to establish a case study panel (CSP) engaging all partners with substantial amount of resources allocated to the given case study.

2.5 Role of the partners

The contributing partners of a case study have to 1) agree on the research plan and resource use with the case studies; 2) implement the research activities; 3) periodically report about the conducted activities. The research plan may refer to the activities carried out in the territory of the case study, or if appropriate, as a mirror case study in other country/region in Europe.

3 Guidance document to the WP4 tasks

3.1 Describing the reference case

Initial case study description will describe 1) main water uses in the reference basin, 2) key policy/management issues, 3) economic instruments in place, 4) institutional and organisational arrangements, and 5) performance of the system in place. Description of water uses will include an assessment of past and future trends including likely impact of climate change and EU policies. Section 4 of this document offer initial information about the case study river basins

3.2 Building a stakeholder advisory group

In each reference area, a small policy advisory group will be formed, comprised of 5-10 key local stakeholders and policy-makers. The composition of the advisory group will be flexible so as to capture the specific characteristics of the four policy thematic and case study areas. Where felt necessary, advisory subgroups could be proposed. The advisory group will meet at least three times. The first meeting will be instrumental for deciding on the rules of functioning of the advisory group, its role, and the outcome expected from the case study. The second meeting will specify/review the EPI scenario(s) that are proposed for assessment for the subsequent subtask (4.1.3 – 4.4.3). This meeting will also help identifying possible constraints in implementing these scenario(s) as these will need to be analysed and options for solving them proposed. The third meeting will review the results of the ex-ante modelling and assessment exercise. It will help discussing the policy relevance of these results (and in doing so providing inputs to the subsequent subtasks and policy learning proposed under WP5). Overall, the advisory groups will be facilitated using interactive techniques and methods so views and ideas of stakeholders and policy makers are best obtained and mobilised for guiding research carried out in the case study.

3.3 Identifying scenarios for economic instruments

Building on results from the WP3 horizontal case study/reviews and innovative ideas collected from the "Inspiration from beyond the EU" group, this task will propose different economic instrument(s) scenario(s), that is what economic instruments will be tested/assessed, against what baseline (current situation or other), under what assumptions. The scenarios will be presented to the local advisory group (see previous subtask) and adapted according to feedback/comments collected. The scenarios will also be presented and discussed at the PTT, their feedback being used to refine and finalise the definition of EPI scenario(s) that will be investigated in each case study area.

3.4 Assess and analysing impacts/effectiveness/efficiency

Under this task, the WP2 assessment framework will be applied, and where necessary adapted, for the specific needs of the case study/economic instruments and scenarios chosen. The existing (hydro-economic models, macro-economic, etc.) models necessary to assess the chosen EPI will be developed or adapted from existing models and tools (the preferred option) for the chosen scenario(s). Specific attention will be given to the comparison of different policy instruments with the baseline scenario.

3.5 Assessment of transaction costs

This subtask will identify adaptations required for the different economic instrument scenarios to be implemented. It will investigate both activities and changes required at the preparatory stage, and also for full scale/routine implementation. This analysis will be complemented by a stakeholder survey focused on their perception, the implementation constraints identified and possible solutions. The costs linked to adaptations (refined based on the results of the stakeholder survey) will be systematically assessed following the guidance provided under WP2, specific attention being given to the total transaction costs and also to how these costs are distributed/shared (in particular between different public and private actors).

3.6 Implementing new EPI: is it worth pursuing?

This subtask will integrate the results from previous sub-tasks, in particular confronting the expected benefits from new EPI with costs/transaction costs. A multi-criteria matrix combining social, environmental and economic indicators following guidance from WP2 will be prepared for each EPI scenario investigated. Whether EPI scenario(s) are cost-effective as compared to the actual situation will be analysed and discussed, stressing in particular accompanying measures and factors that need to be put in place so EPI scenario(s) are effective/efficient. The preliminary results of this sub-task will be presented to the stakeholder advisory group for discussion and feedbacks. It will help identifying complementary assessments that might be performed for refining and finalising results.

3.7 Synthesis of the case study

The methodologies applied, the data mobilised and the results obtained for the different sub-tasks presented above will be combined in a final case study report. This final report will be submitted to the members of the stakeholder advisory group for final (written) comments.

4 Ex-ante, in-depth case studies

4.1 EPI in the context of flood and water logging

4.1.1 Overview of the river basin

Near the geographical centre of Europe, the Tisza drains an area of 157,218 km^2. The Tisza River Basin (TRB) has a population of 14.4 million and covers parts of Ukraine, Slovakia, Hungary, Romania, Serbia and Montenegro. On its route from the Ukrainian Carpathian Mountains to the confluence with the Danube in Serbia, the Tisza flows mainly through Hungary's Great Pannonia plain. The topography of the TRB is characterized by high, narrow chains of mountains surrounding expansive, flat lowlands. The mountains cause serious flooding when rainwater flows quickly down the slopes and accumulates in lowland areas. With a length of 966 km and an average discharge of 794 m^3s^{-1} the Tisza is the Danube's longest and second largest tributary. Most discharge is generated directly from rainfall but there is a contribution from both snowmelt and subsurface soil water. The Tisza can be subdivided into three main sectors: the mountainous Upper Tisza in Ukraine, including the headwater section upstream of the Ukrainian-Hungarian border; the Middle Tisza in Hungary receiving larger tributaries from the Slovakian, Ukrainian and Romanian Carpathian Mountains, and some rivers draining Transylvania and; the Lower Tisza downstream of the Hungarian-Serbian border.

Source: http://www.grid.unep.ch/product/map/images/tisza_basinb.gif

Figure 1 Map of the Tisza River Basin

In the past, the Tisza river had been streamlined to prevent floods and to gain new agricultural land in landscapes where wetlands and marshes dominated before; the same development which is so characteristic for many other river basins. This has further amplified the vulnerability to flood and droughts, the latter being the consequence of low water retention to bridge dry summer periods.

Flood risk emerges from peak flood waves from the surrounding mountains and the long standing high-water periods of the downstream sections (due to the backward obstruction of the Danube floods). The floods in 2001, 2005 and 2006 affected several hundred thousand hectares and caused damages costing billions of HUF.

4.1.2 Main water uses in the reference basin

The National Water-Basin Management Plan provides a fresh comprehensive summary on the water-uses and the forecasted 2015 status. Meanwhile consumption has declined since the beginning of the 1990s due to economic recession. After a sharp decline this trend has flattened in recent years. The increasing consumption forecasts are based on the expectation that significant economic growth will take place, a fact that hasn't happened ever since. Water-utilities report a decreasing consumption year by year. The recent water use data is summarised in Table 2 that covers all the different uses regardless their resource type.

Table 2 The water uses in the Tisza River Basin of Hungary

	2004 million m3	2015 million m3
Consumption from the public utilites' network:		
Households	117	143
Industry+services	18	23
Agriculture	1	2
Other	96	95
Total	232	263
Consumption from other independent sources*:		
Households	1	0
Industry+services	137	139
Agriculture total	352	496
Animal raising	14	14
Fisheries	183	254
Irrigation	128	201
Total other source	490	635
Total consumptive use	722	898
Cooling water	606	396
In situ use	13533	12380

*It covers all consumptions that weren't supplied via the water utilities' network.
Source : VKI 2010/1

The water utilities supply from sub-surface resources nearly 100%, while the other uses are from mixed sources. The industry uses own wells because big volumes are cheaper than through the public utilities , while the service sector (for example, health) and agriculture uses wells for special quality purposes (for example, thermal water). In the case of fisheries and irrigation the source of use is surface water.

The forecasted increase of the consumptive uses is based on the modest increase of households and the agriculture consumption. In the case of the household consumption this trend is dubious because significant price increases will have to take place to fulfil cost recovery requirements of recent wastewater network and treatment developments as the WDF requires it. The increase of future use in the agriculture sector also included the assumption that with the EU CAP sources the sector will overcome difficulties it faced to finance the operation of the agricultural water supply infrastructure.

Cooling water use will decline due to technology development of the power plants. In-situ use changes with the changes in surface flow, and it reflects no change compared the average.

The utilization level of the different water resources, in general, poses no reason to worry, but it hides some problems. The conventional use of sub-surface resources are well below the limits, but Table 3reveals the high share of indirect water uses that mainly stands for the unintended drainage effect of the excess water system, a simple waste of resources. Since it is an average value with high annual volatility, this effect poses extra threat both on productive uses and ecosystems. Moreover, the table doesn't contain the small scale uses that have no formal permission, but an aggregated estimate according to VKI 2010/2 puts it to the same order of magnitude with the indirect uses and the illegal withdrawals. Putting these elements into the picture, the expansion of the consumption shortly will be realized at the expense of the water supply of the ecosystems based on subsurface water resources (referred as SSR in the Table 3 below).The case of thermal water resources is different, but it has no connection with our case study topic.

Table 3 Balance of subsurface resources and uses (SSR) in the Hungarian Tisza river basin in million m3/year

Total recharge	Ecosystem supplied by SSR	Resource to use	Direct use	Indirect use
901	371	530	340	99

Source: VKI 2010/3

Surface resources are abundant compared to their uses, but there is high seasonal variation in the availability of these resources. This results in excess-water inundations, but the low utilization of natural storage capacities (first of all the soil) resulted in limited ability to mitigate the uneven distribution of precipitation and consequently, the water shortages that frequently characterise the summer periods.

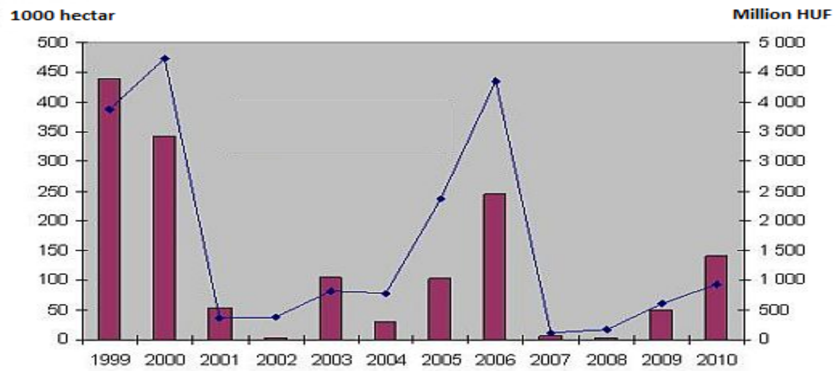
Table 4 Surface water resources and use

Total surface water use 2004	1.4 km3
Total inflow (average 1971-2000)*	24.9 km3
Total outflow (average 1971-2000)*	27.3 km3

*Source: Vituki 2010

Excess water inundation

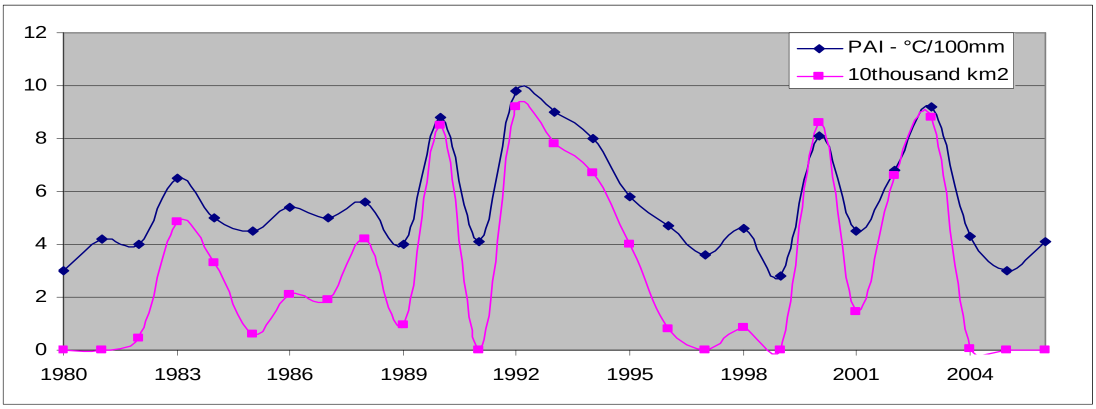
Excess water inundations frequently occur in the Tisza valley, due to the geographical characteristics, these seasonal water surpluses appear not only as floods, but also as temporal water cover and water logging in the low lying areas. The figure 2 below shows the size of the area covered by excess water inundations between the years 1999-2010. The graph refers to Hungary (left hand axis), but the overwhelming majority of the affected area belongs to the Tisza basin. The line shows the defence costs raised by the inundations (right hand axis). It shows that nearly every year there are areas effected by the excess water inundations, while the connecting waterlogged areas unsuitable for agricultural cultivation is higher (with the multiplier 1.5-2). The years 1999 and 2000 were two extremely wet years that would stand out from a longer time series as well, while the other peaks in the years 2003, 2006 and 2010 describe better the average situation.



Source: Origo 2010

Figure 2 The size of the inundated areas (1000 ha) and the defence costs (Million HUF) in Hungary between 1999 and 2010

Due to the low level of trans-seasonal water retention, the summer periods frequently face droughts problems. Figure 3 shows the Pálfi Droughts Index and the size of the drought affected area of the whole country over the years 1980-2005. The index summarizes the weather pattern of a year's driest period, and a year with droughts is characterised if the index takes a value which is greater than 6, albeit there could be droughts effected areas in a year when the country-wide index is below the threshold (as it happened during the years 1984-1988). The average value of the index during the period 1980-2005 is 5.5, indicating that on average this period is characterised with frequent droughts, which were occurred in 1983, in 1990, during the years 1992-1995, in 2000 and finally in 2002-2003. Comparing the annual droughts affected areas to the size of the country, the average share of droughts effected areas during the period is 33%.



Source: Vituki 2010 (Table 4)

Figure 3 Pálfi Droughts Index and the droughts stricken area by year

Comparing Figure 2 and Figure 3, it is concluded that there are years such as the 2000 and 2003 when both excess water inundation and droughts took place in the same year. For instance, the central area of the Tisza valley has the highest mutual exposure to floods, excess water inundations and droughts in the Carpathian basin. This situation shows clearly the risks that climate change poses to the area. Not the amount, but the distribution of precipitation will express influence most.

4.1.3 Key policy/management issues

Of the 330 water courses within the Tisza river basin in Hungary, 149 are heavily modified, and almost all of them can be characterized as having poor ecological status. Some areas are characterized by too much water, other areas are burdened with droughts or both, with relatively little of the river basin having a healthy water balance. Multiple factors contributed to this situation.

As far as hydromorphology is concerned, about 150 years ago a major river control program took place on the Tisza in order to reduce the risk of floods. Being the key measure of the program, river bends were cut and flood protection dikes were raised. The length of the river was thus shortened; the speed of water flow increased and much of the former flood plain area was detached from the river. These areas together with the oxbows created by the program became ecologically semi-isolated areas. Wetlands and water demanding vegetation have been declining ever since.

The demand of agriculture to drain excess surface water creates another conflict with ecology. Costly measures are applied to pump water from low lying areas, and then channel and pump the water into the rivers. Many of the former wetland ecosystems within the Tisza river basin are left without sufficient volumes of water.

Agricultural areas with higher elevation, on the other hand, regularly suffer from droughts. Thus, while the overall volume of water within the river basin can be viewed as healthy, its current spatial distribution is heavily skewed. Paradoxically, too much concentrated flood water within the river bed and too little water on much of the surface of the river basin are co-existing problems.

Regarding water quality, the key problems are the high organic and nutrient concentrations, indicated by the lush vegetation within the river bed as well as the occasional mass destruction of fish populations. The pollution originates from insufficiently treated and untreated wastewater, already polluted water coming from upper river sections across the border, excess water drained from the fields or infiltrated through surface and underground streams, already contaminated by intensive agricultural practices. As the typical land use is monocultural without patches of alternate vegetation, the protection of water bodies by buffer zones is meager.

In some locations underground water bodies are over-utilized, partly due to a lack of proper policy-based incentives and partly, as a result of illegal abstraction for the purpose of irrigation. The water level of these water bodies continuously declines. The quality of sub-surface water is also on decline, mostly because of the infiltration of contaminated water from heavy agricultural use. Currently it only impacts layers close to the surface, but in the long run deep aquifers may also be at risk of contamination.

4.1.4 Economic policy instruments in place

Hungary has a water load fee and a water abstraction charge, both described in detail in WP3 of the project. Those instruments have a national coverage and therefore, are applicable in the river basin of the Tisza as well. However, from the perspective of the case study on access water management two insurance schemes are of greater significance. The first deals with agricultural damage, while the other one covers the flood damage of household buildings.

Agricultural damage compensation scheme. Act CLXVIII of 2011 created a fund to compensate for agricultural damages. The fund covers weather related as well as other severe damages (e.g. pest outbreaks). Only those farmers who become members within the fund are eligible for compensation, and membership is obligatory if the size of the cultivated land exceeds a specific threshold (10 hectares for croplands, 5 hectares for vegetable farms, and 1 hectare for plantations). The fund has two sources of revenue: membership fees and contributions from the state budget.

The annual membership fee depends on land use. It is 3000 HUF/hectare for plantations and vegetable farms, and 1000 HUF/hectares for other uses (currently 1 EUR is about 300 HUF). The membership fee can be co-financed by the state and, up to 65% of the fee, also by the European Agricultural Guarantee Fund (143/2011. (XII. 23.) Decree of the Ministry of Rural Development). In case the Fund gets exhausted, the percentage of co-financing is reduced.

State contributions to the fund are set to be equal to or exceed the individual membership fee payments from the previous year, thus on average the state contributes at least half of the fund revenues.

The operating cost of the fund is limited to 4% of its revenues.

Excess surface water related damages can be compensated for up to 3 years in a 5 year period, but not in every single year. This rule provides some incentive to land use change or improved management of excess water.

The degree of compensation varies with the crops, but as a general rule a 30% drop in yields is the threshold for compensation, and up to 80% of the damage is paid for.

State response to the water damage of houses. Regarding the location of households at risk of water damage the following risk categories can be differentiated:

1. Floodplain between two flood protection dikes.
2. Floodplain area unprotected by dikes that can be freely invaded by floods.
3. Area at risk of being flooded by inland surface water in connection with floods: an area that may be flooded by accumulated water.
4. Flood protected areas of former floodplains, but also at risk of flooding occasionally.

For categories 1 and 2 flooding can be viewed as an ordinary event and hence, insurance companies do not provide insurance coverage. For buildings located in areas falling in category 3 and in some locations in category 4 commercial flood or access surface water protection insurance may not be available or it may be prohibitively expensive. To make up for the lack of practical commercial insurance options, with Act LVIII of 2003 [on the Miklós Wesselényi Flood and Surface Water related Compensation Fund], the government created a state-sponsored insurance scheme to affected households.

The insurance fee depends on the risk category of the settlement in which the household is located, reflected by a correction factor varying between 0.6 and 1. The annual insurance fee starts from 5,000 HUF/year for buildings with a value below HUF 1 million, and increases to 26,000 HUF/year with an insured value of HUF 15 million, which is the highest value that can be insured under the Act.

It is worth mentioning that, the insurance is available only for houses which were constructed based on a valid building permit and also have a valid occupancy permit.

As shown by Table 5, the insurance fund is currently used by less than a thousand households. This low popularity may be a reflection of the modest financial position of the households of floodplain areas.

Table 5 Key Financial Data on the Wesselényi Fund

	Compensation payment (million HUF)	Insurance fee payment - revenue (million HUF)	Number of contracts
2005	0.2	1.5	187
2006	45.2	3.9	505
2007	0.15	4.2	1035
2008	0.15	5.5	959
2009	1.5	6	876

Source: Origo 2010

4.1.5 Institutional and organizational arrangements

The institutional system responsible for water management was substantially remodelled at the end of 2011. Environment, nature protection and water management were administered from the same Ministry starting in 2002. In 2010 all these functions and other government bodies responsible for landscape maintenance, land use, and management of basic natural resources were transferred to the Ministry of Rural Development to create a coherent governing place for these interconnected issues. At the end of 2011 the integrated structure dissolved, and water management now belongs to two ministries: the Ministry of Rural Development and the Ministry of Interior, in accord with the amendments of Government Decree 347/2006 (XII. 23.).

The regulatory tasks concerning the environmental aspects of water management (e.g. water quality) now belong to the National Environmental Protection, Nature Protection and Water Management Main Inspectorate and its regional bodies, the regional inspectorates. These organizations are under the auspices of the Ministry of Rural Development. They are responsible for the enforcement of environmental and nature protection legislation, and contribute to the preparation of legislation with their reviews.

The recently created National Environmental Institute also belongs to the Ministry of Rural Development and its key tasks focus on conceptual planning, including river basin management, preparation of regional and national water utility programs, planning future water resources, evaluation of the status of water bodies, and operation of the central and regional water management information systems. In addition, the organization and its regional branches participate in the professional groundwork for the national water management concept and other sectoral concepts; provide their views on the regional, county and sub-county level regional development concepts and programs with regard to the priority regions, and the regional spatial rearrangement plans for the priority regions and the counties. The institute also prepares background analyses and impact assessments. In essence, the strategic elements of the former water management organization were transferred here.

The operative part of the institutional system for water management was placed within the Ministry of Interior. The tasks of the National Water Management Chief Directorate include the operation and maintenance, reconstruction, and development of the water management systems, and defence against water damages. In addition, it supervises the public works that can be used to maintain the water infrastructure. This latter function was one of the justifications to place these organizations inside the Ministry of Interior, which is the coordinating and managing body of the public works program. Another rationale may have been the incorporation of activities related to defence against water damages into the disaster relief operations. The National Water Management Chief Directorate carries out these daily tasks through its regional units, the water management directorates. In case of the Tisza river the management of the flood storage reservoirs as well as the river bed belongs to the central authority of the National Water Management Chief Directorate.

The water management associations (Act CXLIV. of 2009) are organizations created to take care of local/regional water management related public tasks, such as drainage, water damage protection, agricultural water utilisation, operation and maintenance of water infrastructure used for drainage of excess surface water and irrigation. Their operating costs are covered by contributions from the state budget as well as the membership fees of their members. Inland excess surface water management is typically carried out by these organizations.

Flood protection activities are organised by the local government if only one or two settlements are involved, while in case of more than two settlements these tasks belong to the relevant water management directorate.

4.1.6 Performance of the system in place

The maintenance of the current land use activities in the Tisza basin requires three types of mitigating systems: flood defence, excess water prevention (drainage) and irrigation.

Flood defence

The length of the flood defence dykes along the Tisza and its tributaries in Hungary is 2850 km. The area of the protected territory is 16,000km^2. The total of the Tisza catchment in Hungary is 47,000km^2. Flood defence capacity is based on the runoff capacity of the flood-water riverbed (the permeable capacity of the between-the-dykes cross section). It has been increased step-by-step since the channelization works of the 19th century to cope with the increasing peak levels of the flood waves. This system reached its limit, which became obvious at the Tarpa levee breach in 2001. Its performance was challenged three ways. These were long and medium term effects that challenged the sustainability of the system. The sediment deposition between the dikes reduces the available cross-section and the deforestation up-hill increases the sediment transport. Furthermore, the decline of the agriculture sector in the last decades dramatically increased the size of the uncultivated land where quickly grew invasive species dominated forests that reduced the cross-section even further and slowed the flood runoff.

A solution to these problems has been recently adopted; the development of peak-flood dry polders that enable the cut of the extreme flood peaks called Vásárhely's Plan (VTT) described in section 4.1.1. Although improvement in land use patterns may be a more efficient solution. (This will be the focus of our research)

Excess water prevention and irrigation

The canal system that supports the drainage and the irrigation is 30,000 km long in the Tisza basin (it is 75% of this type of infrastructure in Hungary). Since 1940 the length of the system has increased 2.5 fold. The pumping capacity has grown 4.5 fold, with the total capacity of the country currently at 900m^3/s. There is no comprehensive, aggregated time series of the operation. In 2001 the drained quantity was 1400 million m^3 of which 250 million m^3 was pumped. In 2006 the total drainage performance of the systems in Hungary was 2031 million m^3 of which 1578 million m^3 was pumped, it was a 60% increase compared to 2005.

The canal system is overstretched to areas that are unable to economize on the favourable circumstances the service provides. Consequently there is not enough financial resource to operate it in full capacity as in these areas with bad agricultural endowments the recent contributions are even too high (compared to the applied cultivation method). This results in lack of maintenance works (e.g. regular clearing of the channels) that exaggerates the inundation risk. Due to the lack of proper pricing the supply cannot be upgraded without the adaptation of the demand. (The question of demand side adaptation is the topic of the research)

Concerning irrigation, 86% of the agricultural land that has irrigation infrastructure is situated in the Tisza river basin in Hungary. As it can be seen from Table 6 irrigation plays a minor role in satisfying the agricultural water needs and performs well below its potential.

Table 6 Distribution of the irrigated area in the Tisza river basin and in Hungary, 2004

	Hungary	Tisza
Officially licensed to irrigation	205 728 ha	140 209 ha
Actually irrigated area	102 854 ha	86 799 ha
The share of irrigated from licensed	50%	62%
Agricultural land total	5 866 822 ha	3 043 593 ha
The share of irrigated area from the total	1.75%	2.85%

Source: Tisza RBMP, 2010 (Tables 1-6)

Table 6 shows the paradox that in spite of the usual risk of droughts the actual irrigated area is small compared to the coverage of the installed irrigation infrastructure . Since the provision of water is expensive compared to the surplus it can generate, in most cases the role of irrigation is minimized to prevent severe damages of eventual precipitation shortage. The problems of the water management infrastructure further contribute to the low level of utilization for irrigation. Water for irrigation is provided mostly from the same channel network that drains the land so it shares its problems. The WFD NWBP (2010: Ch 8.) raised concerns about the pricing of the channel system's services. Irrigation and fisheries are among the most prominent users of the infrastructure and possibly pay more than their share would justify. High prices reduce demand causing a vicious spiral of increasing individual burden for the rest of the users.

4.1.7 Proposed research methodology

Increasing retention capacity through improved land-use management is at the heart of modern approaches to flood defence and water logging, while paying due attention to provision of ecosystem services. The solution to the nexus of floods/excess surface water and the (frequent) successive droughts gives opportunity to provide services for farmers, nearby villages, cities downstream, and the public: flood defence cost reduction, excess water management cost reduction, water storage for droughts prevention, provision of ecosystem services (e.g. assimilation, prevention of nutrient load to rivers and lakes).

That's why the analysis focuses on landscape elements including dry polders and areas in their proximity. Dry polders are reservoirs for cutting peak floods. The agricultural use of the reservoirs is crop production on arable land. Farmers got an initial compensation for the decrease of the land value and are compensated if the area was flooded. Dry polders are expected to be flooded once in 20-30 years. The areas in proximity to dry polders can provide flood protection service through the overflow of the initial reservoir – as it was the original concept of the Cigánd VTT reservoir.

To cut the peak 1000 million m^3 (1 km^3) of storage capacity was assumed to be implemented in the Vásárhelyi Plan (VTT) in six reservoirs (dry polders), but as an ex post analysis revealed that complex measures using not just the dry polders, but other low lying territories (including the re-connection of 2000 km^2 of floodplain areas at 19 places with the river) resulted in a better outcome. This result highlights the importance of creating a coordinated land use structure that enables improved flood defence, excess water management and enhancement of the areas' ecosystem services.

Previous studies that will be summarized in detail in the report, pointed out the difficulties of reaching these multi-participant agreements. This is the role the economic policy instruments (EPIs) - that are designed to steer the land-use where this change generates the least cost for the current users and the most benefits for the public - could have an important role to play. As the key aspect for enhancing both the flood defence and the excess water management services is the establishment of a transfer mechanism that redistributes benefits and cost of the emerging ecosystem services (including risk reduction, cost reduction, water storage).

The set of potential EPIs in the Tisza case study include:

1) *Innovative payments for farmers for temporary storage of floods/excess water*. Based on the analysis of the existing agro-environmental schemes (AES), we will investigate the benefits of payments for storing the excess surface water on marginal agricultural lands. The proposed payment schemes will combine the current AES payments and payment elements that reflect the services to downstream farmers and water users.

2) *Financial incentives for permanent land use change*

3) *Runoff charge for the water management organizations* that release excess surface water into the river during flood.

4) *Tax or tradable permit approach.*

The research process to achieve the EPIs' testing is split into following steps:

1. Economic assessments to clarify the maintenance and operation cost of the pilot areas water management system and the status of cost recovery.
2. Assessment of economic impacts of excess water inundations
3. Hydro-simulation, a root cause analysis of the emergence of excess water inundations in the pilot areas. Based on the results follows the specification of possible scenarios of water regimes with identifiable differences of water discharge and land cover.
4. Simulation of the EPIs' application, and the calculation of their respective distribution effect on the financial position of stakeholders. It includes the

parallel introduction of the payment for the services (water storage and absence from nutrient load) and the pricing of these services for the ones who non-adapt, this approach is evaluated in the context of the adjustment of the current fee policy of the water management organizations. The latter instrument means the change of the current size-based fee (HUF/hectare) to a scheme that reflects the volume of runoff. The financial impacts on the stakeholders are calculated with and without the assumption of a positive decision on changing the land use to a water tolerable one and the sign up for the corresponding agro-environmental schemes.

5. Economic impact assessment of the different water scenarios. Specific focus has to be given to farmers with characteristically different exposure to water cover.
6. The application of the results on regional level to measure the cost reduction potential of the land use adaptation on flood defence. The simulation of the EPIs' application to provide the collaboration of land users for the joint storage service provision.

4.2 EPI in the context of water scarcity and droughts

4.2.1 Overview of the river basin

Water is a key life-sustaining substance, abundant in some and scarce in other areas. As a part of natural variability, the precipitation and thus the availability of water resources throughout time and space vary within bounds determined by given climate conditions. Droughts are extreme events at the lower bound of climate variability. They are natural and recurring phenomena of prolonged absence or marked deficiency of precipitation. The impacts of droughts are particularly austere when the 'below than usual' precipitations exacerbate already existing water scarcity that may be a result or arid- or semi-arid climate conditions or demand induced overexploitation of the resources.

The growing world population, unsustainable practices and inefficient allocation of water threat to induce and/or intensify water scarcity with disastrous consequences for environment and societies. The reduced water availability and increasing demand for water in agriculture, energy production and by households will – in many places already is – create stress the communities have to learn to live with.

Box 1 · Tagus and Segura Interconnected River Basins

Tagus is the largest river basin of the Iberian peninsula. Its Spanish section covers 55,750 km². Its population of 7.2 million is highly concentrated in Madrid (around 6 million inhabitants). Average consumptive water use amounts to 2.6 trillion m³, mainly of surface water sources over an average resource availability of 12 trillion m³. Despite local scarcity problems and high variability in water resources, scarcity is not widespread and drought vulnerability is still moderate in the river basin. In contrast to that, the Segura river basin, in Southeastern Spain, with a smaller surface (18,870 km²) and lower population (2 million inhabitants) has an increasing demand for water, which in 2008 amounted to 1.9 trillion m³ *per annum* while average renewable resources are estimated to be only 0.76 trillion cubic meters. Shortage of renewable resources is partially compensated by an interbasin transfer from the Tagus river (*circa* 0.2 trillion m³) that, nevertheless, since its opening in 1985 has been always below the planned and announced level of over 0.5 trillion m³). The resulting deficit is mostly covered by the overexploitation of groundwater sources.

Source: Tagus and Segura river basin authorities (2008)

4.2.2 Main water uses in the reference basin

The irrigated area in the SRB is estimated at 253 000 ha (13.41% of total SRB's surface) and is by large the main water user, with an average use of 1 662 million cubic meters (hm³) per year (87.43% of total water demand). In contrast, household consumption (143 hm³/year, 7.52% of total water demand), environmental uses (50 hm³/year[1] and 2.42%) and industrial uses (46 hm³/year and 2.42%) together represent less than 15% of total water demand (SRBA, *op. cit.*). All this in accordance with official statistics: illegal irrigated areas are widespread (WWF, 2006; IDRUICM, 2005; MMA, 2005)[2] and might be responsible for an accumulated groundwater overexploitation which amounts to 7 000 hm³ (SRBA, 2010b).

Water demand is expected to significantly grow in the coming years for every water use. Following SRBA (2010a) urban demand will have increased by 28% in 2015 and

[1] Of which 30 hm³/year are consumptive uses.

[2]In 2005, approximately 100 000 ha were irrigated with illegal resources (IDR-UCLM, 2005). Although the concession of new irrigation rights has been forbidden by decree since 1986, illegally irrigated areas increased at a rate of 6 500 ha/year between 1990 and 2000. See WWF, 2006.

46.9% in 2027; industrial demand will have increased by 16.3% and 34.78% in 2015 and 2027, respectively; and environmental demand will remain constant. However, water demand forecasts in the SRB are based on GDP and population growth rates which are clearly overestimated according to the economic situation prior to 2007, and thus are not very reliable under the current economic juncture. On the other hand, surprisingly agricultural water demand is expected to diminish from a current demand of 1 662 hm^3 to 1 550 hm^3 in 2015, and from there to remain constant until 2027, a rather unlikely scenario given the past trend and the expansion of illegal irrigated lands.

While legal water demand in the SRB amounts to 1 900 hm^3/year, average renewable resources are much lower. The SRB has a semi-arid climate with an average rainfall of around 400 mm/year, which is irregularly distributed throughout space and time (SRBA, 2010b). Extreme events, including flash floods, are common. Most of the water resources are produced upstream the confluence of the Mundo and Segura Rivers. The latter is the only significant river in the whole basin: its tributaries are less important and many of them are perennial rivers, and the remnant catchments flow directly into the sea and are dry during most of the year.

As a result, according to historical data for 1940-2005, the total renewable surface resources are only 823 hm^3/year on average although during the last two decades this figure has been notably reduced and average available resources are estimated to range 650-700 hm^3/year (SRBA, 2010b). This scant runoff is exacerbated by the low storage capacity of the basin, which amounts only to 1 141 hm^3 (of which 1 070 are located upstream in the headwaters or as part of the water transfer infrastructure), which given the current demand is clearly insufficient to face the large drought periods endemic of the area. Under this situation, groundwater demand has soared up. However, renewable groundwater resources in the basin are estimated to range between 121.46 hm^3 and 220 hm^3 (SRBA, 2010b), which are clearly insufficient to cover demand from irrigation (Gómez and Pérez, 2012). Alternative water sources such as desalinated and regenerated water have been promoted but given the current institutional framework their price is high if compared to the legal and illegal water sources and they could not be developed enough: desalination plants and treatment plants have a supply capacity of only 82 hm^3/year and 61hm^3/year, respectively. As a result, total water demand is between 2.23 and 1.94 times larger than available own water resources according to the SRBA (2010a, b)[3]. Besides, climate forecasts show a meaningful trend towards a scenario with less availability of water resources. MARM (2011) predicts a decrease of expected runoff between 11% and 22% for 2000-2030 as compared to the control period (1961-1990) and between 30% and 40% for

[3]According to these, the *water exploitation index* (WEI) of the SRB would be 2.5. This index is defined by the European Environment Agency as the ratio of total freshwater abstraction over total renewable resources (EEA, 2009).

2071-2100, thus increasing the frequency and intensity of drought events. Rainfall events will be more atypical and intense, resulting also in higher likelihood and impact of flood events.

On the contrary, water demand in the TRB is largely urban. Although agriculture is the main water user of the 5 000 hm^3 which are yearly demanded in the basin (38% of total water demand), households and manufacturing uses represent 21% of total demand; 16% of water demand corresponds to environmental uses and 25% goes to non-consumptive refrigeration demand.

Water demand was expected to substantially increase by the time when the River Basin Management Plan (RBMP) was drafted (TRBA, 2010). Growth rates for household demand and industrial demand for 2015 were estimated at 35.7% and 26.1%, respectively, and at 75.6% and 52.1% for 2027. As in the SRB, demand for irrigation was expected to remain at similar levels. Since these forecasts were made using the same methodology as in the case of the SRB, they are also regarded as overestimated for non-agricultural uses.

Water resources in the TRB mostly come from surface sources. Average rainfall in the area is estimated at 652 mm/year during the period 1940-2000 (TRBA, 2008), although rainfall variability is large throughout time (standard deviation of 150 mm/year) and also among regions. As a matter of fact, the major demand is located in the area that shows the lowest rainfall values (the Jarama and Guadarrama sub-basins that supply most of the Madrid metropolitan area). Average runoff is estimated at 11 990 hm^3/year for 1940-2000, which is considerably larger than average demand of 5 000 hm^3/year. However, rainfall variability results in significant runoff variability: standard deviation in that period equals 6 114 hm^3, with a minimum historical value of 2 989.11 hm^3/year considerably below the average annual demand (*ibid.*).

During dry years the system relies at the most on groundwater, which has the ability to provide 1 275 hm^3/year of renewable resources. This is especially true in the Greater Madrid, where as a result of that some of the aquifers have a bad quantitative state (*ibid.*). In the rest of the basin, groundwater resources are largely underexploited. Apart from a relatively abundant amount of water resources, the TRB has a significant amount of water infrastructures capable of storing around 11 000 hm^3, thus more than doubling average annual water demand. Only the dams of Buendía (1 639 hm^3) and Entrepeñas (803 hm^3), from which the Tagus-Segura water transfer collects water, more than double the storage capacity of the whole SRB.

Some preliminary climate change scenarios suggest that surface water resources can decrease within the next decades. According to MARM (2011) runoff is expected to decrease between 7% and 17% for 2000-2030 as compared to 1961-1990, and between 23% and 49% for 2071-2100 (*ibid.*). If this scenario is confirmed, droughts would increase their frequency and intensity and threaten sustainability of current water demand schemes under extreme junctures. Further, the whole basin is expected to increase its dependence on the Tagus headwaters; unlike the rest of the basin, rainfall may be slightly higher in average in this area during this century (10-20 mm/year increase) (*ibid.*). For all these reasons, long-term water security might become a sensitive issue in the negotiation about future water transfers from the Tagus to the SRB.

The structural water scarcity of the SRB motivated the construction of the Tagus-Segura water transfer in 1979. It takes water from the Bolarque reservoir downstream the large dams of Entrepeñas and Buendía and transports water mostly to the SRB, being the Andalusian Mediterranean Basins and the Jucar River Basin also marginal beneficiaries. The capacity of this infrastructure is around 1 000 hm^3/year, although the maximum amount to be transferred is limited, by law, to 600 hm^3/year. Transportation efficiency is around 90%; hence a maximum of 540 hm^3/year reach effectively the SRB. So far, most of these resources are aimed at supplying water for irrigation (400 hm^3/year); indeed, 140 hm^3/year are managed by the *Mancomunidad de Canales del Taibilla* (MCT), which also supplies irrigated areas. Around 14% of available resources (75 hm^3/year) finally supply urban areas or irrigated lands outside the SRB (SRBA, 2010a). However, these 540 hm^3/year are rarely transferred. The current legal framework establishes that when water stored in the Entrepeñas and Buendía dams is below 240 hm^3, no water should be transferred; in addition, when water resources are above this threshold but below a monthly level that ranges from 456 to 564 hm^3, the decision on the amount of water to be transferred is the Cabinet’s responsibility.

As a result, since its construction the water transfer has supplied an average of 334 hm^3/year, although the SRB uses as a reference value for available resources the average amount of water yearly transferred during the period 1980-2005 (434.2 hm^3) (SRBA, 2010b). In any case, the Tagus-Segura water transfer has not accounted for more than 30% of the Segura water demand, while the SRB authority planned that it should contribute to meet 55% of total water demand in the SRB and 35.78% of the irrigation demand between 2005 and 2010 (*ibid.*).

The water transfer, even operating at its full capacity, may be insufficient on its own to balance the structural deficit. In addition to that, political decisions on each transfer are affected by regional perceptions about water security and by the different role played by water in the two river basins. For obvious reasons the political discussion is more acute during drought when the transfer need in the SRB is even more pressing but also when water is perceived as more valuable in the TRB (*ibid.*).

4.2.3 Key policy/management issues

Water scarcity

Water scarcity has been an issue of major concern in the SRB for many decades, and this has been reflected in the successive management strategies implemented. As it was stressed above, these strategies have been mostly supply-oriented and have brought as a result a large amount of infrastructures for water management. This includes the Tagus-Segura water transfer, but also the complex transport system of the MCT and a series of dams, canals and other regulation infrastructures which are now of crucial importance for the supply of an area with irregular water availability.

Irrigation demand in the SRB grew as water availability increased and traditional rainfed crops, such as olive tree or grapevine, were progressively replaced by more profitable and now profitable irrigated lands (including irrigated olive trees and vineyards). Soon it was evident that any attempt to reduce pressures over water resources had to deal with irrigation, and again the chosen policy was supply-oriented. The modernization of irrigation infrastructures has been publicly supported in the SRB during the last two decades and favoured by the positive response of farmers and irrigation communities. This modernization has been particularly intense in areas where scarcity is more evident, such as those supplied with groundwater, alternative resources and water from the Tagus-Segura water transfer. On the other hand, traditional irrigated lands and the areas supplied with SRB's own surface resources show the lowest efficiency rates. Apart from that, current irrigation efficiency in the SRB is amongst the highest in Spain: 53.25% of irrigated lands have sprinkler irrigation (70-85% efficiency), 41.23% gravity irrigation (50-65%), and 5.11% use the more efficient drip irrigation (90-95%) (SRBA, 2010a).

However, empirical evidence as well as a large body of literature have shown that higher technical irrigation efficiency is not necessarily associated to lower water demand. On the contrary, higher efficiency is directly translated into lower costs and may result in higher demand in an effect commonly known as "rebound effect" or the "Jevon's paradox" (Gómez, 2009; Alcott, 2005 and 2008; Brookes, 1990; Khazzoom, 1989). This has effectively happened in the SRB. However, modern infrastructures do exist and can be translated into lower demand if the necessary instruments are put in place.

Water scarcity, although not as severe as in the SRB, is also a relevant problem in the TRB, especially in areas close to high demand urban areas. As in the SRB, policies have been aimed towards increasing the supply capacity of the system to satisfy increasing demands. Under some circumstances where water infrastructures are not enough to cope with increasing priority urban demand even when water resources are abundant, new infrastructures are a true need. This is the case of the Trujillo and Alto Tiétar urban areas, where small dams have proved to be insufficient to provide resources needed during peak demand periods. Yet, in most cases new infrastructures respond to water conflicts among different water uses which could have been more efficiently and effectively addressed via EPIs without further increasing water availability and jeopardizing environmental and even urban water demand. This is the case of the modernization of irrigation systems and the small inter-catchment water transfers planned in several areas along the basin (such as in Tiétar, Henares Canal and Middle Tagus irrigated lands). Furthermore, the improvement of the water supply systems in some urban areas (such as Cáceres, Toledo or Madrid) was a response to increasing agricultural demand upstream and decreasing runoff, although water storage capacity was large enough to cope with urban demand.

Different water availability in both basins is reflected in the current tariff structure. Prices are higher in the SRB than in the TRB (EUR 2002), although there is no significant difference in the tariff structure. Urban water is more expensive in the SRB (EUR 1.29per cubic meter) than in the TRB (EUR 0.97per cubic meter), including abstraction, storage, treatment and distribution costs in both. Average water tariff for irrigation is also lower in the TRB than in the SRB, where higher benefits allow a higher willingness to pay: surface water price is EUR 0.061per cubic meter in the SRB and EUR 0.038 per cubic meter in the TRB, and groundwater price in the SRB ranges between EUR 0.117 and EUR 0.33 per cubic meter depending on the aquifer's depth while in the TRB prices were only of EUR 0.10 per cubic meter. The price for the services of the irrigation communities does not differ in both basins for own resources (EUR 0.03 per cubic meter in the SRB and EUR 0.02 per cubic meter in the TRB), although in the case of water coming from the Tagus-Segura water transfer in the SRB these costs are considerably higher (EUR 0.13 per cubic meter) (TRBA, 2010; SRBA, 2010a).

Environmental status of the water bodies

Environmental issues gained momentum in water management to some extent once the WFD was adopted. Further than the minimum flows of the previous RBMPs the more stringent environmental requirements of the WFD might actually reduce water availability for other purposes once the RBMPs are implemented, and may result in further scarcity threatening the fulfilment of the WFD environmental targets in some relevant water bodies (SRBA, 2010b). Yet, the WFD cannot be said to be actually implemented until RBMPs are approved.

The expansions of irrigation as well as new technological developments that allow pumping out from a deeper stratum have resulted in an estimated annual groundwater overexploitation of 210-300 hm^3/year (SRBA, 2010a), which can be much larger during drought events (Gómez and Pérez, 2012). The imperfect definition of water use rights makes groundwater play the role of a buffer stock and increases the risk of overexploitation in drought periods. According to WWF (2006), illegally irrigated lands might demand 400 hm^3/year on average. In some areas such as the Ascoy-Sopalmo Aquifer groundwater overexploitation has amounted to 25 times its recharge. Accumulated overexploitation may round 7 000 hm3 and as a consequence it would take more than a century for some groundwater units to recover even in the absence of additional abstractions (SRBA, *ibid.*).

In the SRB there are no minimum ecological flows in force and in many stretches water flows are negligible, including the Segura River estuary. Diffuse pollution, mainly from intensive agricultural practices, is also an important problem in the SRB. Nitrate concentrations in some groundwater bodies such as Campo de Cartagena (200-300 mg/l in several points), Vega Media y Baja (140 mg/l) and Bajo Guadalentín (over 300 mg/l) are well above the maximum acceptable for human consumption (50 mg/l as defined by the Groundwater Directive 2006/118/EC) (SRBA, *ibid.*).

Another relevant environmental problem in the SRB is the irregular occupation of riverbanks and floodplains (which are part of the public domain by law) by urban and agricultural land uses, which have resulted in a poor ecological status and a higher vulnerability to flood events. This situation and the decrease and variability of runoff have resulted in a significant degradation of riparian ecosystems and forests.

River basin authorities recognize the challenges ahead. This fact together with the derived difficulties to agree on a viable strategy to reach the environmental goals might be one important reason explaining the current delay experienced in the approval and implementation of the RBMP (SRBA, 2010a, b).

In the TRB, environmental problems are less scattered. The most important environmental problems are related to the pollution stemming from the densely populated and industrial metropolitan area of Madrid. The resulting pollution of rivers Guadarrama, Jarama and Manzanares that supply this area is high and also affect other areas downstream (such as the dams in the confluence of the Tagus and Alberche Rivers and the Jarama-Castrejón stretch). Groundwater bodies under this area (Guadarrama-Manzanares, Manzanares-Jarama and Guadalajara Aquifers) are also highly polluted. In order to solve these problems, new treatment infrastructures have been built, illegal dumping has been dealt with and industrial discharge systems have been improved (TRBA, 2010). However, as demand increases, so does the need for more expensive infrastructures.

In addition, the minimum ecological flows demanded by the WFD are a relevant issue in some areas of the TRB where runoff is scarce as a consequence of increasing agricultural and urban demand. All these problems have been largely addressed with the construction of additional infrastructures, as above, although recently the development of EPIs to reflect the actual cost of water has also been considered (*ibid.*).

4.2.4 Economic policy instruments in place

EPIs have the potential to play a key role in the alleviation of water scarcity in overexploited and extremely overexploited river basins, as well as during temporary drought events. However, the implementation of this kind of policies in the TRB and the SRB has been of marginal importance and largely conditioned to emergency contexts. This was the case of the 2005-2008 drought, which favoured the development of some legal reforms that allowed water trades with the objective of alleviating the severe conditions of the most affected basins, including TRB and SRB. It is critical, though, to point out that the use of economic instruments in the study site can be largely explained by spontaneous agreements between water users rather than an *ad-hoc* planned intervention of the water authorities. As a result of the potential for water trading and the apparent willingness to exchange of some water right holders, different types of trades have been occurred, both at an intra- and inter-basin level, under the different stages of the water law (the 1999 Reform Water Law and the Decree 15/2005), most of them referring to the SRB:

- Outlawed and informal trading: Irregular water markets can be said to be common practice in the SRB for the provision of water (abstracted without explicit reference to formal water entitlements) in legally and unlawfully irrigated lands and coastal urban areas which have an insufficient water supply – precisely as a result of those abstractions (WWF, 2006). There is also informal trading at a local level amongst users holding water rights. These trades depend on available water transportation infrastructures (Garrido and Calatrava, 2009), and may consist on permanent or temporary exchanges of water rights. The former are characteristic of groundwater rights, while the latter relate to both surface and groundwater resources. Prices of water for irrigation in horticulture range from EUR 0.1 to EUR 0.4 per cubic meter in normal hydrological years (EUR 0.15 per cubic meter on average) and between EUR 0.15 and 0.6 per cubic meter during drought events (EUR 0.35 per cubic meter on average) (Rey et al., 2011).
- Purchase of land by irrigated agricultural districts in other areas of the basin to transfer water: Some agricultural districts have been willing to buy irrigated lands upstream to use their water rights. The River Basin Authority keeps a share of the transferred water; therefore not all water rights belonging to the acquired land are actually transferred. The cost of water for the irrigated areas downstream is between EUR 0.20-0.25 per cubic meter (*ibid.*).
- Formal lease contracts: The 1999 Water Law made these contracts feasible. However, as users usually do not want to publicly exchange water, there are only a few examples as yet. In the SRB 10.1 hm^3 were transferred in 35 exchanges between 2000 and 2005 (Calatrava and Gómez-Ramos, 2009). In the TRB, the water utility of the Sorbe Water Community signed a lease contract

with the irrigators of the Henares Canal to exchange 20 hm^3 yearly (see EPI-Water WP3 *ex-post* Case Study #1).

- Interbasin temporary trading: These types of contracts are possible since the implementation of the Decree 15/2005 and have been a success as compared to alternative legal instruments. Only in 2006, interbasin trading allowed exchanges that were larger than all the exchanges approved in the period 1999-2005: 31.5 hm^3 per annum were transferred during three years from the Estremera Irrigation Community (Comunidad de Regantes de Estremera) to irrigated lands in the SRB at EUR 0.19 per cubic meter in 2006, increasing up to EUR 0.22 per cubic meter in 2008 (Calatrava and Gómez-Ramos, 2009); also the MCT bought 40 hm^3 of water from farmers in the Upper Tagus (Comunidad de Regantes del Canal de las Aves) at EUR 0.28 per cubic meter in 2006, and 36.9 hm^3 at EUR 0.23 per cubic meter in 2007 (Rey et al, *op. cit.*)
- Purchase by water agencies: Public authorities are allowed to issue a public tender to acquire water rights (OPAD) according to which private water rights can be temporary and voluntarily leased to satisfy domestic and environmental uses. In 2007 and 2008 two OPADs were issued targeting the farmers upstream, with a budget of EUR 700 000 and a maximum price of EUR 0.18 per cubic meter. In 2007, 2.93 hm^3 were purchased at an average price of EUR 0.168 per cubic meter and with a total budgetary cost of EUR 495 000.

Nevertheless, these trades are not numerous (neither in number of trades nor in the volume of water exchanged). They cannot be said to be part of a water market itself but rather show the potential for water trading in the area and build a history of the relevance of economic instruments (water trading schemes in this case), to reallocate water and, in principle, furthering use efficiency.

4.2.5 Institutional and organizational arrangements

The modern process of hydrological planning in Spain started in 1985 after the *Ley de Aguas* was passed (Water Law, 29/1985, 2nd August). Under this law there were two key legal references: the National Hydrological Plan (Law 10/2001, 5th July) and the corresponding RBMPs (RD 1664/1998, 24th July). Under this legal framework water management in both basins has largely responded to the growing water needs with further water infrastructures that increased the regulation capacity of the basins. In the SRB when the regulation capacity could not be further expanded new laws were passed but were not enforced to stop the expansion of irrigated lands – (this is the case of the Decree that forbid the granting of new irrigation concessions since 1986). Only under emergency situations alternative policies have been explored. This legal framework has led to a growing water demand that has worsened shortages and aggravated the water crisis in both basins (SRBA, 2010b; TRBA, 2008).

The situation changed after the implementation of the Water Framework Directive (WFD). The national legal framework has been modified accordingly, and it was established that new RBMPs had to be enforced for every basin. The passing of the new RBMP, initially due to 2008, is now expected for mid 2013.

One of the most recent and significant modifications of the current legal framework has been the introduction of the Drought Management Plans (DMPs) (*ibid.*). DMPs have been applied only in a few European countries, though the European strongly encourages its implementation (EC, 2008). Spain has been pioneer in its implementation (law 907/2007) and now the most relevant Spanish basins have their own DMP. DMPs remove the institutional randomness characteristic of the measures that are implemented under drought. DMPs clearly define drought thresholds (normality, pre-alert, alert and emergency) and the restrictions that are to be binding in every case. As a result uncertainty stemming from drought is reduced to the variability inherent to the event dynamics (rainfall, water stock and runoff). However, DMPs focus exclusively on surface waters, thus putting additional pressure on uncontrolled groundwater resources, a situation with potentially devastating effects on the SRB (Gómez and Pérez, 2012).

There are many institutions involved in water management in Spain. This includes the central government (through the Ministry of Agriculture, Food and the Environment, the Ministry of Health, Social Affairs and Equity and the Foreign Office), the regional governments along which the river basin is located and the corresponding local authorities. This complexity is articulated by the Competent Authorities Committee (SRBA, 2010a and TRBA, 2010). The chairman and secretary of this committee is the SRBA's chairman and secretary, while there is a vocal for every Ministry and Regional Government, one for the General Central Administration and another one for the local entities.

4.2.6 Performance of the system in place

In spite of a number of measures taken in the last decades to cope with water scarcity and droughts in the SRB, the main conclusion that can be drawn from above is that water policy has failed to align water use decisions across the river with renewable resources available in the river basin. As a result of that, water uses have led so far to higher scarcity and a significant reduction of the drought resiliency in both basins. In the SRB a water demand has largely exceeded water availability during normal hydrological years, even taking into account additional resources coming from the TRB through the Tagus-Segura interbasin water transfer. The ratio of total freshwater abstraction over total renewable resources or Water Exploitation Index (WEI) in the SRB was of 1.27 in 2003 according to the European Environmental Agency (EEA, 2009), already showing significant overexploitation levels. Previous research estimated that water withdrawal was actually higher, about 2.25 times larger than available renewable resources (Martínez et al., 2002). In any case, by 2009 the EEA established that the overexploitation in the SRB had shot up to 2.5, the worst of all the basins considered in the analysis (EEA, *op. cit.*).

On the other hand, in the TRB there is no such overexploitation, though as a result of the set of policies implemented in the last two decades droughts are now more persistent and frequent (TRBA, 2008).

In both basins there has been a significant loss of resiliency, which is expected to be exacerbated by climate change dynamics that presumably will significantly reduce the amount of renewable resources available (MARM, 2011). As resources have become scarcer, EPIs have started to be used in both basins, especially in the SRB, although their relevance is still marginal and does not allow reaching a permanent and sustainable solution for water scarcity.

Contrary to structural policies, EPIs have in principle the potential to accommodate individual decisions with collectively agreed constraints on the overall water use. Through its potential to improve water allocation EPIs also have the ability to reduce welfare losses associated both to water scarcity and to more stringent environmental standards. Along the same line, EPIs, such as water trading and income insurance, might provide improved resilience against droughts and reduce incentives to overexploit groundwater and reduce environmental floods in periods of water shortage.

4.2.7 Proposed research methodology

Severe water scarcity and drought risk in the Segura river basin is the combined outcome of natural and economic factors but its persistence and the worsening trend observed within the last decades reveals a long-term institutional failure in curbing water use down and in providing collective and coordinated responses.

Although economic policy instruments have been implemented, they still play a marginal role: its use is limited to extreme situations being typically part of emergency responses rather than an integral part of ordinary water management.

In coping with scarcity, priority has been given, both by the private and public sectors, to expanding infrastructures for water abstraction, storage and transport; enhancing the efficiency with which water is used elsewhere (but mostly for irrigation); and the development of alternative sources of water (mainly from desalination and regeneration of used water).

Water management has been successful in implementing the selected measures and storage and transport infrastructure have been upgraded; water is used more efficiently elsewhere; and significant amounts of desalinated and recycled water are currently available. Thus, structural measures have augmented and managed water supplies without much concern for strategic demand management according to the long-term limits of natural water supplies.

Moreover, these strategies have been ineffective in reducing water scarcity and risk and may even be considered as counterproductive. Unfulfilled expectations over future water supply from new sources and new water transfers together with increased per-drop productivity might have had an effect in fostering water demand instead of limiting water use to actual water availability.

The institutional failure behind this paradoxical outcome stems from the contradiction between a collective course of action designed for just one purpose and individual responses driven by incentives to behave right in the opposite direction. Hence, the failure of structural management of water supplies derives from the inability to assess both actual incentives provided to users to either consume or save water, and to adjust their long-term pattern of water demand.

- Aqueducts to transfer water do exist, but the agreement to transfer water rights has been blocked by local owners, other stakeholders and regional political coalitions. Conflict resolution in the presence of the potential veto from multiple stakeholders requires a shared perception on the benefits of exchanging water use rights. A necessary condition for reaching an agreement demands evidence about the real benefits that all stakeholders and water users might obtain through exchanging water rights. **Although there might exist significant potential welfare gains from reallocating water, the institutional framework required for the agreement to be possible, within the range of affordable transaction costs, is not still in place**. This institutional change needs to be considered as part of building response capacity to water scarcity and risk.
- The technical efficiency of irrigation systems has been remarkably improved within the last two decades. This trend has been favoured by the spontaneous response of farmers and irrigation communities in water scarce areas (such as the Segura river basin), and has been mostly the result of public support in more water abundant regions (such as the Tagus river basin).
- Furthermore, the reduction in water used per crop and area unit has not resulted in a reduction of water used overall in the irrigation system. In fact, a more effective irrigation system means that water is now a more productive input and incentives might push water demand in the existing irrigated land and stimulate investment on expanding irrigated land. In addition, more crop per drop means less water that was previously flowing into groundwater or ecological uses.

  Empirical evidence shows that the more efficient the irrigation system the more the water demanded and effectively used. Potential efficiency gains of improving irrigation systems do exist but they will not be automatically translated into decreasing water scarcity and better-conserved water sources. **What is required to convert efficiency measures into effective responses to water scarcity and drought risk is a set of individual incentives not to put all the water thus saved into the irrigation system (which is actually the most likely outcome in water scarce areas). Economic incentives can provide the missing link between public objectives and private responses.**

- The whole water supply system might now count on substantial amounts of desalinated and treated (and potentially reusable) water but demand is low and even non-existent at current water tariffs. This non-conventional water source is intensive in costly human-made capital rather than in underpriced natural capital.

  Being a "produced" input, the financial cost of new water sources is high. Moreover, the **environmental cost** might be low, in the case of desalinated water, and even negative, when re-used water avoids pollution damages and improves the quality of surface and groundwater. On top of that, in both cases the **resource cost** is negative (as both resources replace water that would be taken from Nature otherwise).

  On the contrary, freshwater might be financially inexpensive, as it is produced by Nature, and water users do not even pay for the full financial cost. But in turn, it is economically expensive, as the associated environmental and resource costs are significant (and increasing with water scarcity). For this reason, the economic advantages of substituting old by new water sources would not become evident until financial incentives, driving individual decisions, were not in accordance with the desired or collectively preferred economic outcomes.

  Additionally, the collective benefits of using alternative sources might be considerable (as this may reduce scarcity, increase resilience to future droughts, reduce the cost of maintaining the ecological status of water bodies, improve environmental services in those water flows which got better, reduce the energy cost of extracting groundwater). As a result of this, **agreements to share the cost amongst many potential beneficiaries might reduce the financial cost and increase the willingness of the potential water users of alternative water sources**.

- Along the same line, individual responses to drought risk will require to be coordinated as part of a collective strategy. When led to individual, spontaneous and competitive responses, drought consequences tend to result in higher water scarcity increased future risk and lower resilience.

This is what has happened in the past when water supply fell back from what was expected by water users. The traditional response to surface water shortages was to use more groundwater and avoid uncertainty about surface water flows by relying on increased used of the presumably more secure groundwater stocks.

Other alternative responses include anticipating water demand, storing water under farm or irrigation communities' premises, in order to prevent water shortages in the harvest season. Although these actions are individually perceived as the best available responses for individual farmers, they aggravate scarcity, increase future uncertainty and leave society with a worse capacity to respond to droughts in the future.

Instead of that, response to drought risk needs to be collective rather than individual; planned rather than spontaneous; and coordinated rather than competitive. **Drought risk management economic policy instruments can bridge the gap between individual incentives and collective responses**.

EPIs are means to an end. The previous section has presented what can be considered as the key advantage of a successful implementation of economic policy instruments for water management: its potential to make individual actions coherent with socially agreed outcomes.

Apart from the need to coordinate individual actions with social goals, **EPIs might also have gained momentum for a number of reasons**. In irrigated agriculture and hydropower generation, water scarcity is equivalent to increasingly unused production capacity, lower value of existing infrastructures and lower incentives to invest. Even if farmers could compensate for the lack of surface water with (more predictable) groundwater resources, extraction costs would increase with aquifer depletion. When irrigated agriculture is still profitable, water scarcity represents an incentive to invest in more effective irrigation devices. Yet, lower water use comes at the expense of a higher water application cost (or lower supplies are going to cost more per unit for a given demand); increasing energy costs would raise the willingness to pay for water. Furthermore, higher drought risks are associated with increased willingness to pay for reliable water sources and then for stable and self-enforcing rules and agreements to allocate water amongst its different potential users.

Opportunities for making EPIs part of the solution firstly derive from the significant efficiency gains that can result from: re-allocating water resources amongst activities and regions, enhancing water efficiency, optimizing the combination of alternative water sources, and so forth. Should these opportunities exist it will be evident that the same economic benefits that are currently obtained from water use services might also be derived from using less water; that is to say by reducing water scarcity and drought risk. In addition, and this is also important for implementing EPIs, some of these potential welfare gains can be used to address the issue of implementing economic incentives, making also lower scarcity and reduced risk the best individual responses.

Nevertheless, realizing these opportunities is only possible by coping with current challenges. Some of them, resulting from past experience; some others from the traditional reservations and suspicions inspired by markets and prices in the water community.

Economic incentives can only work when water rights are properly defined. When the use of groundwater is not observable, a price increase might shift water use from formal sources to informal or even illegal ones.

When scarcity is an issue, water use rights become nominal rather than effective, as far as they cannot be satisfied by the water authority, even in rainy years. In fact, as it is the case in the Segura river basin, formal use rights rather than representing the effective access to a certain amount of water every year are only an increasingly uncertain option to have access to a maximum amount of water from the public authority.

To be implementable, EPIs require a substantial advance in the definition of existing formal and informal property rights. This is not to say that EPIs implementation needs to wait until the correct structure of property rights is in place. Rather, as other experiences clearly show **the improvement in the definition of property rights, and their conditionality and attributes need to be an integral part in the EPI design and implementation process**.

To make water efficiency an individual option for farmers and utilities they might have the possibility to put the water thus saved into some financial value. By reducing leaks, utilities increase water sales, reduce the cost of drinking water provision and might also avoid the construction of a new treatment plants. In the same sense, irrigated agriculture, the sector with the higher potential to save water, needs to have an incentive.

Groundwater irrigated systems are more efficient than those using surface water. The reason being that by enhancing the efficiency of applying water, farmers increase water stocks and reduce energy costs. In most cases, though, these incentives are not in place. This is more likely to happen in areas using publicly provided surface water, in relatively abundant water areas and in extensive agriculture supported by public subsidies. If these farmers had the option to get paid for saved water, they would be more willing to use water efficiently and to voluntarily agree transferring water use rights to places and activities where water is more valuable.

EPIs can make a real contribution to overcome the "use it or lose it" situation, which is still conditioning water demand in many areas in what is indeed an important institutional challenge for water institutions.

Transferring water within and between basins is considered a long-term instrument in Spain. The required infrastructures to make it at affordable costs are in place, and the potential gains from re-allocating water from low to high productivity areas and activities is more or less evident.

Nevertheless, past experience also authorizes the common perception that without an important institutional change the most likely outcome of transferring water consists upon extending to other parts of the country those severe problems already existing in the Southern river basins.

Additionally, there are important concerns about environmental impacts as: efficiency improvements upstream might reduce water returns and water supply downstream. When water transfer does not ensure the preservation of the environmental status of the basin of origin any reallocation of water across the space will have effects over the dynamics of water ecosystems.

Setting the rules of a bargaining process in which all stakeholders share concerns and reliable information to assess the alternative outcomes will provide a framework where hidden information is less likely and transparency and participation may become agreed institutional principles.

Economic incentives, when properly designed, might make a real contribution to deal with moral hazard.

The recognition or the entitlement of a water use right that can potentially be sold in a cap-and-trade market or exchanged for money of other benefits in a voluntary agreement can depend on the demonstration than this water has been previously saved somehow by reducing the crop area or by improving irrigation.

Receiving compensation for drought damages can be contingent on the demonstration that farmers have experienced verifiable yield losses and, consequently, they have not used informal underground water to compensate for water shortages. Metering is a condition for price discrimination and for rewarding good water use performance.

All mentioned examples show that, contrary to current situations when the Administration needs to inspect private behaviour, economic incentives might create a new framework where the burden of proof is inverted as the water user is the one with a vested interest in showing how much water he or she has actually used. This may make a real contribution to improve water regulation enforcement.

As EPIs are designed and implemented to coordinate individual actions with collectively accepted targets, these targets need to be well defined and the effects of different courses of action over these outcomes will need to be identified and measured. Past experiences show that, in general, **it is not true that economic incentives are less information demanding than "command and control" alternatives. However, EPIs can be designed and implemented to minimize**

information costs. EPIs can also be effective with much less information as the possibility of reaching an agreement makes arise mutually beneficial opportunities even without previous knowledge of the supply and demand of water use rights.

What's an innovative EPI? Innovation should be seen as a process that renews something that already exists and not, as it is sometimes believed, as the introduction of something strictly new. It will be new as a result of an application in a different policy context, for instance, but not a hitherto unknown instrument, an unprecedented one. When applied to economic policy instruments for water management, it should be clear that what is new is the process, not necessarily the instrument itself. Innovation is therefore the realization of an invention, i.e. the application, in a different way, of an economic instrument.

Within the context of EPIs, when the process of innovation unfolds, it often involves a combination of instruments, unlike invention, which often concerns a single instrument. Furthermore, it is not only that innovation is not the same as invention; it does not even require invention. This does not preclude, however, that invention contributes to innovation.

From our viewpoint, EPI-Water may explore the field of incentive design, the definition (both on conceptual and practical grounds), of new EPIs. Yet, it may be necessary to place as much emphasis, at least, on innovation based on the combination of EPIs, on finding their optimal place within decision-making processes and management systems, and on the design of instruments for specific contexts.

Although it should be clear, this note is not against innovative EPIs but rather on the opposite, but departing from a clearer definition of what is to be understood by "innovative".[4]

Having shown the potential of EPIs, the existing opportunities and some of the challenges ahead, an interesting question relates to which is the particular instrument or set of instruments that, according to our previous analysis, can make a significant contribution in coupling individual actions with collective goals.

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[4] ONEMA (2009) includes the proceedings and working documents from the seminar (Paris, December 9th-10th, 2009) on *Economic instruments to support water policy in Europe: paving the way for research and future development*. The adjective "innovative" is mentioned 13 times. None of them includes a definition. This is the case of *Box 2*, for instance (*ibid.*, p. 6), where auctions in water use rights in Chile are presented as an innovative approach. Water markets and auctions were doubtless innovative in Chile in 1981. However, it should be noted that, on one side, auctions were never used at a major scale; on the other, that instrument was innovative in Chile in 1981 but it would not be today. What would be innovative today in Chile? Mechanisms for compensation of water use right market externalities, instruments for minimizing transaction costs, rights based upon effective use (rather than nominal ones), expiration of non-used rights, economic instruments to stimulate co-ordination of uses at a watershed level, etc. This is to say that innovation must be seen from a dynamic perspective.

The answer to this question can be found step by step by recalling the different situations where the desired voluntary agreements and actions are apparently compatible with reducing water scarcity and drought risk. Situations where this is possible can be identified.

1) High scale re-allocation of water among regions and or economic activities

A high scale re-allocation of water among regions and or economic activities in order to:

- To look for environmentally beneficial or neutral ways to re-allocate water from lower to higher productivity uses and regions. Differences in water productivity in the Tagus and the Segura agriculture indicate that these gains might be significant.
- To foster technical improvements in water abundant but low productive areas where significant water savings are still feasible at relatively low cost but financial incentives are not in place. This might be the case of extensive agriculture in the Tagus river basin where entitlements of tradable water use rights may be contingent on water savings.
- To reduce the supply cost of the different regions. Water transferred from the Tagus is used near the Mediterranean coast. Meanwhile, some inland areas might be forced to compensate the deficit by using desalinated water that needs to be transported from the coast. A voluntary agreement might reduce transport costs to parties, as well as minimizing energy consumption and making more feasible the use of alternative water sources.

The specific EPI consists of **a regional and intersectoral bargaining framework designed to allow for voluntary agreements amongst stakeholders**. The water authority (acting as the principal) has an important role to play in (a) the definition of the bargaining rules, (b) the setting of the conditions under which interchangeable property rights are recognized and the conditions under which they can be sold and bought, (c) ensuring that the agreement is environmentally neutral or beneficial and making the provision, (d) setting the alternative outcome of the negotiation process, in case that no agreement is reached,

2) Local system of incentives

A local system of incentives, farmers or individuals belonging to the same irrigation community or district in which the environmental and third-party effects do not depend on who and how much water is used. Objectives at this level are:

- To foster efficiency gains by internalizing them as the avoided water cost.

- To maximize the collective revenue within the cooperative or the region in order to raise resources that can be used to compensate for water transfers in the interregional or intersectoral bargaining processes.
- To create financial revenues, in areas where water is more productive, that can be used to induce water savings in other areas.

The EPIs for this purpose are: Firstly, **a water use right spot market** to know how much water could be collected for a given price in water excess areas and providing the required information for stakeholders and the government participating in the above-mentioned bargaining process. Secondly, **a right auction system** in the receiving basins in order to allocate water obtained in the negotiation among potential water users. The allocation of this water is not conditioned by prevailing property rights and this mechanism is compatible with any other used to allocate pre-existing resources. In this case only temporary use rights are allocated and, different from cap and trade, local stakeholders are able to capture the revenue in order to pay for new resources in the regional and sectoral bargaining level.

3) Collective response to share drought risk

A collective response to share drought risk in order to:

- Avoid spontaneous individual responses that can potentially increase scarcity and risk.
- Reduce risk exposure by sharing risk coverage and damage costs.
- Minimize the potential of perceived risk in reducing capital demand in the exposed sectors.

The EPI for this purpose is **a drought insurance system** able to cope with moral risk, making compensations conditional to effective yields of permanent crops and with rebates on capital costs.

4) A collective response to make the use of alternative water resources financially attractive in cases where the benefits of these options for the environment and the economy make it a rational option. All this in order to:

- Promote the substitution of water sources in order to reduce water abstractions and allow for the recovery of aquifers.
- Identify situations where water substitution is an option to improve the status of water bodies rather than implementing alternative measures.
- Promote the substitution of water in order to improve the biophysical flows of environmental services provided by water-related ecosystems.

- Capture positive externalities associated to the substitution of fresh by regenerated and desalinated water such as improved amenities, hydropower generation, avoided water treatment cost, etc.
- Increase buffer stocks in order to enhance water security year by year, reduce scarcity and increase resilience.
- Increase the demand of alternative water sources in order to take advantage of the existing scale economies as well as reducing water provision costs.

Using recycled and desalinated water to substitute freshwater is a way to reduce scarcity and drought risk and the potential benefits may spread over all the activities in the economy using water or using the environmental services provided by water ecosystems. If a part of these benefits may be collected, they might be used to make water substitution financially viable, by subsidizing the use of the alternative resources, and to share the short-term costs of increasing water supply and drought resilience in the long term. EPIs consist of **a combination of taxes, levied on potentially benefited activities, and subsidies to the production and use of "non conventional" water**.

An example is the combination of a fee paid by a hydropower utility per each additional cubic meter of water used, which is then used to subsidize the use of recycled water upstream. Another contribution may come from a water utility that can pay in exchange for a reduced purification and post-treatment cost. Alternatively, all water users can pay for higher water security.

Co-operation with other partners

IMDEA will coordinate research activities in Task 4.2, according to the DoW.

Agreed collaboration with those partners who have explicitly expressed their interest, both while in Venice (kick-off meeting) and since then (with an *ad-hoc* consultation process after the Berlin Conference), in response to the delivery of the Concept Note on Task 4.2, consists of:

1. **FEEM.** Inputs from FEEM will mainly be on building robust institutional designs for water markets and water pricing for irrigation (as a support instrument, both to promote farm efficiency improvements and as a financial mechanism). A shared mirror case study (with UNIBO, if agreed between the Italian partners), would allow FEEM to produce additional outputs. This needs to be further discussed, since the proposed basin (Po River Basin) is far from being, as today, a water scarce and drought-prone area, and EPIs are to be considered by their contribution to reduce scarcity and enhance drought resilience both for the market economy and the environment. Additional

inputs will be provided on the basis of outcomes drawn from other European projects: PREEMPT, Water2Adapt, and XEROCHORE.

2. **ECOLOGIC.** Besides ECOLOGIC's advisory role within the WP4 Steering Committee to ensure the link between WP3 and WP4, cooperation has been agreed on drawing lessons and policy-relevant outcomes, in line with the upcoming work packages (WP5 and WP6). In addition, assistance will be provided to extrapolate results to other drought-prone areas in the EU. Ecologic can also provide expertise on the economic valuation of environmental outcomes and water markets.
3. **ACTeon.** As part of a cross-cooperation scheme (IMDEA will contribute to the Seine-Normandie case study), ACTeon and IMDEA will formally review each other's outputs. Furthermore, ACTeon will provide inputs regarding the policy relevance of conclusions from the Tagus-Segura case study and their extrapolation to other EU areas. IMDEA, in turn, will contribute to the case study led by ACTeon regarding voluntary agreements to couple economic and environmental performance at a watershed level.
4. **WU.** WU will assist in the evaluation of the situation and potential reallocations. IMDEA and WU will jointly explore the feasibility of experiments with auctions or trading, since these might be relevant a local scale (i.e. within the same irrigation community) but not for long-term regional transfers (which are not decided by individual users but rather stakeholders). These experiments are contingent to finding the right, representative, and collaborative, farmers willing to take part in the experiment. Further to that, they are extremely dependent on framing conditions. WU will work on validation, perceptions, acceptability, and transaction costs, potentially relying on direct methods (surveys, experiments, etc.), that will in addition serve to endorse results obtained by those using indirect methods (simulation, demand analysis, etc.). Work on transaction costs will be done as part of their more generic role under WP4.
5. **NTUA.** This collaboration is also part of a reciprocal agreement by which NTUA will provide inputs for the Tagus-Segura case study and IMDEA will do the same in the Pinios (Greece) mirror case study suggested. NTUA will develop a hydrological model for the Pinios river basin; IMDEA will develop an economic model for the Segura river basin. As a result of that, NTUA may adopt this economic model to Pinios' specific conditions, and link it to their hydrological model. In turn, since an optimization module will be developed to run both the economic and hydrological models to forecast system behaviour, IMDEA will apply this optimization module (coupling of models and algorithms) to the Tagus-Segura case study.

6. **UNIBO.** The co-operation between UNIBO and IMDEA will be based on three levels: modeling (trading) policy instruments, analysis of asymmetric information, and (if found relevant after discussion with stakeholders), with their expertise on the CAP (scenarios and policy design). The contribution on water markets might be exploited through a mirror case study (Po river basin, if agreed with FEEM). This co-operation scheme will benefit from UNIBO's involvement in another EU research project (Water Cap & Trade). Yet, since the modeling part of that project is still not very developed, both partners will further discuss specific outputs of UNIBO's involvement in Task 4.2.
7. **MU-FHRC.** MU will be involved in the Tagus.-Segura case study both on governance in IWRM and stakeholder involvement, as well as land-use models. Specifically, a land-use model might be built for the Segura river basin. A member of IMDEA's research team (Carlos D. Pérez) stayed in Middlesex for a few months within the scope of EPI-Water. This co-operation will thus build on that previous result of this partnership as well.

4.3 Opportunities for EPIs in ecosystem services and conservation, the case of the Seine-Normandie river basin (France)

4.3.1 Overview of the river basin

The adoption of the Water Framework Directive (WFD) has shifted the water policy debate in France but also throughout Europe from the traditional "water quantity and water quality" debate to questions of ecological status, biodiversity and restoration of the severe morphological alterations of aquatic ecosystems.

Overall, the WFD has stressed the need to shift from a uniform aquatic ecosystem to a more diverse aquatic environment that would deliver highly diverse habitats for the aquatic fauna and flora. Article 5 reports and the draft RBMPs (River Basin Management Plans) of many river basins in Europe have stressed the importance of managing morphological pressures as key to the achievement of ecological status for surface waters. The question of ecosystem services also emerged from the first round of the WFD as a potential key to be developed during the next round to achieve the objectives of the Directive. Ideally, this approach will help Member States to think more comprehensively about water management and nature protection. It is also expected to favour preventive measures over remediation ones.

The importance given to the ecological dimension of water and of biodiversity has also been emphasized by parallel policy debates at different decision making scales:

- The Millennium Ecosystem Assessment (MA, 2005) placed ecosystems goods and services at the forefront of environmental policies, including for aquatic ecosystems and connected wetlands. Economic valuation has been stressed as a tool for restoring, conserving or enhancing the sustainable use of ecosystems. The TEEB reports (the Economics of Ecosystems and biodiversity, 2010) contributes to the recognition of the concept of ecosystem services showing "*how economic concepts and tools can help equip society with the means to incorporate the values of nature into decision making at all levels*".

- At the European scale, the importance of biodiversity was already emphasised by NATURA 2000, with water being an important component of many of the NATURA 2000 sites. In addition, the Floods directive that promotes "soft" measures for reducing flood risk, in particular the need to give "more space to the river" and reconnect the river main stream to historical floodplains, also contributes to the recognition of the dynamics and importance of some functions of aquatic ecosystems. Finally, the Environmental Liability Directive referring to the principle of compensation (the need to replace an environmental good by a good of similar value if efforts for keeping this good in place are not possible) is further emphasizing the question of value for the environment and the need for (organisational, financial) mechanisms for putting such principle in place.
- With the *Grenelle de l'Environnement* in France, specific attention has been given to wetland protection and restoration. The *Grenelle* has proposed the acquisition of 20 000 ha of wetlands to ensure their protection. How this will be put in place in operational terms in terms of financing and organisation remains to be decided. Specific operational objectives in terms of wetland acquisition have however been included in each French river basin as part of the first RBMP to comply with the WFD.

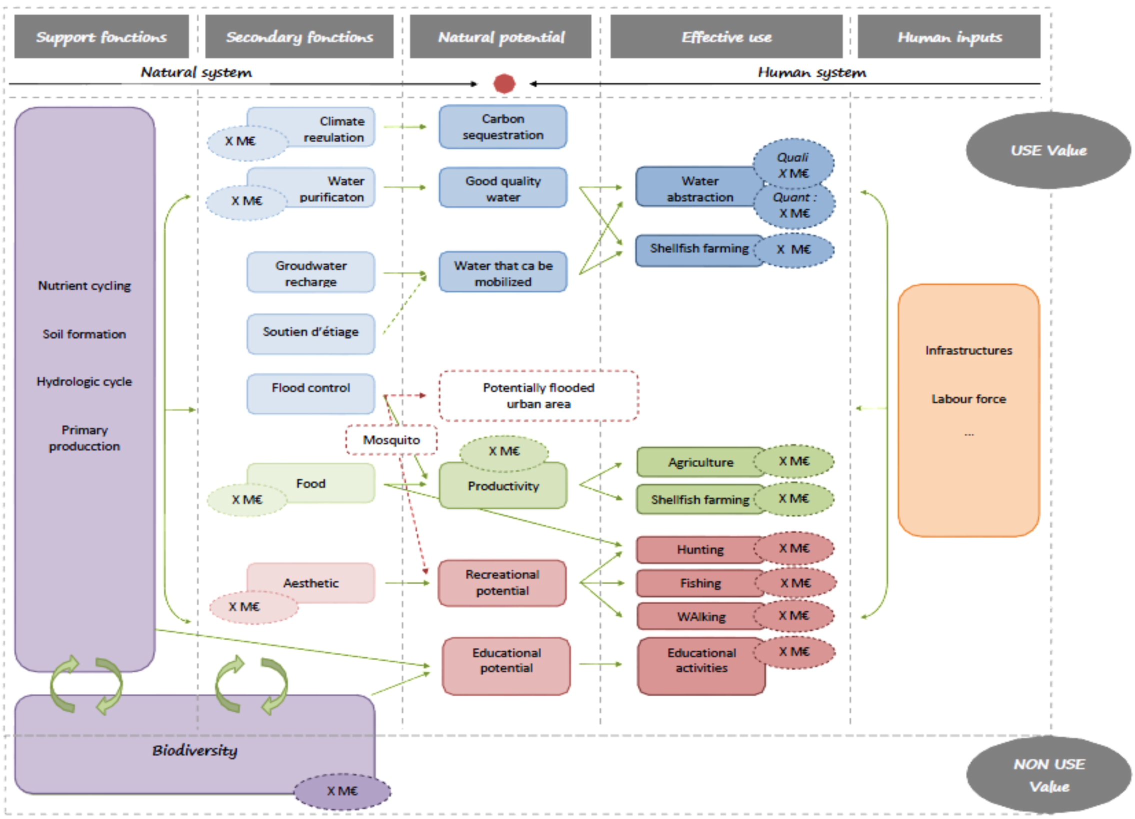
As indicated by their River Basin Management Plan (RBMP), morphological alteration impacting on the ecological status of water bodies is one of the sources of major concern in all French river basins and needs to be tackled to achieve the environmental goals of the WFD. At the same time, the objectives of wetland restoration proposed by the forthcoming "Grenelle laws" (following the *Grenelle de l'Environnement*) apply to all river basins, although with different levels of importance. And the question of biodiversity, in particular linked to aquatic ecosystems and connected wetlands, is equally important for all river basins in France.

The Seine-Normandie river basin covers about 100 000 km^2 (around 18% of the national surface). It population of 17.3 million is highly concentrated in the Paris metropolitan area. The hydrographic network of the basin comprises 55 000 km of water courses. The major part of this system converges toward the Seine which drains a basin of 78 000 km^2. The coastline of the basin is 640 km long. The analysis of major pressures on the environment and negotiation with regional and local stakeholders resulted in the delineation of 413 surface water bodies, 53 groundwater bodies, 19 coastal water bodies and 6 transitional water bodies, characterised by a diversity of conditions. Finally, from the point of view of natural heritage and environment, the basin counts 3 650 Natural Zones of Ecological Interest, covering 26 500 km^2 (source: AESN, 2004).

The Seine-Normandy river basin has been selected as a case study for several reasons:

- The diversity of aquatic ecosystems (including marine and terrestrial water-related ecosystems), of water users and of pressures imposed on these ecosystems and connected wetlands in the Seine-Normandy river basin. Indeed, this basin is one of the largest river basins in France, including both large urban areas (Paris) and rural areas from its hilly parts in the East to the Beauce plain and to the coastal areas. Thus, it is expected that this case study (with specific local case studies that will be selected in due course for detailed investigation based on advices from the advisory group) will provide a large range of ecological, water management and socio-economic conditions;
- The importance of significant existing and on-going water-related research in this basin combining "hard" and "soft" sciences (see for example the PIRENE Seine research programme financed by the Seine-Normandy water agency, but also several EU-funded and national research activities at different scales). Thus, there is a significant amount of available knowledge, models and tools in this basin that can be mobilised, providing the opportunity to allocate most resources to activities specifically dedicated to economic instruments.
- The Seine-Normandy river basin is the basin where economic assessments required by the WFD has been developed in the most robust manner, being in some cases referred to as best practice at the European scale. One can mention the work done for the development of the baseline scenario, but also assessments of the incentive character of water tariffs/water pricing or detailed analyses of financing for the agriculture sector – including for dealing with nature conservation and morphological restoration. With the largest team of economists from all water agencies in France, this ensures that research carried out in the context of the EPI-Water research project can benefit from good quality socio-economic information and also from economic operational expertise.

  There are different initiatives focusing on the economics of water ecosystems and on innovative economic instruments that are underway in the Seine-Normandy river basin, providing opportunities for synergies and effective dissemination of research results of the EPI-Water project. E.g. ONEMA is launching a study in the Beauce region on innovative economic instruments including tradable permits/quotas; researchers and Phd Students are currently working on the nitrogen pollution and the role of economic approaches to tackle it; the French Research Institute for Exploration of the Sea (IFREMER) also experiments on case studies in the Seine-Normandy river basin (Le Havre) and could be part of the advisory group (tbc); and the *Commissariat Général au Développement Durable (CGDD)* of the Ministry of Ecology has recently developed a study on the valuation of goods and services of wetlands and aquatic ecosystems, whose results can be mobilised as basis to investigate payment for ecosystems goods and services. For example, a general approach of ecosystem services has been developed based on systemic analysis. The Figure 4 shows how an ecosystem can be represented based on services it is providing. Opportunities for the implementation of economic instruments can be identified and some of their expected effects followed. Given the exploratory nature of the ex-ante assessment, this framework provides a guide analysis, in addition with the overall assessment framework developed WP2.



Source: Adapted from ACTeon, EcoVia (2010). Evaluation économique des zones humides sur trios sites tests du basin Seine-Normandie. CGDD-MEEDDTL

Figure 4 Ecosystem and services

- There is increasing interest from local stakeholders for new economic instruments to finance water management and protect water resources. This includes, among others, the city of Paris which is currently investigating the possibility of offering payments for ecosystem services to the farming community as a means to protect strategic drinking water resources.

4.3.2 Main water uses in the reference basin

The main water uses are described for the whole Seine-Normandy river basin based on AESN, 2004, contributing to the identification of the main issues of the basin. A specific description of each case study context will be done once they are chosen with specific attention to the relevant relationships(s) (e.g. agriculture / water quality protection or hydromorphology / hydroelectricity). The description of water uses will then include an assessment of past and future trends including likely impact of climate change and EU policies.

With regard to domestic users, 55% of the population is concentrated in 2% of the territory (the Paris metropolitan area) leading to a wide variation in population density, ranging from 35 to 20 000 inhabitants/km^2. The highest concentrations of population are located along the water courses leading to high pressures from domestic uses for rivers with small flow rates. However, 84% of the population (14.7 million inhabitants) benefits of public sewerage systems though.

The industrial sector constitutes a significant economic strength of the Seine-Normandy river basin, with 14 000 firms representing 1.6 million employees and a turnover of EUR 330 billion. The industries are located close to the main rivers particularly along the Seine between Paris (concentration of consumers) and Le Havre (one of the two major seaports of the basin).

There are more than 100 000 farms in the Seine-Normandy basin, covering 6 million hectares and representing 15% of the farms in France and 25% of the economic weight of French farming. Agriculture employs 145 000 persons and generates around 150 000 jobs in the agri-food industry. However, trends show that the number of farms has been falling by 3% each year on average. With the UAA of the basin remaining stable, this indicates the increasing size of the farms.

The navigable network covers 2 450 km (less than 5% of the length of the network) but beneficiates from 3 of the 6 largest river ports in France, including the Autonomous Port of Paris, which is the largest river port in France and the second-largest in Europe. The turnover of this activity is around EUR 370 million, among which 65% are generated by navigation for recreational purposes.

Hydroelectricity is a relatively low cost renewable energy form, but it is linked to strong environmental impacts on the aquatic environment. The Seine Normandy river basin is characterised by a high density of structures that are often barriers to ecological continuity while the relief is relatively flat with an average altitude difference of 160 meters: in 1995, 514 power generation sites were listed among which 274 were in service (producing 144 MW) and about 40% did not comply with the compulsory minimum flow at all times.

4.3.3 Key policy/management issues

The first round of the WFD focused on water quality in the Seine-Normandy river basin: morphological pressures were identified but were not considered as a priority when looking at the program of measures and the question of floods falls under another Directive (EU Floods Directive). In addition, available data was relatively scarce. Water scarcity and drought is not a priority in the Seine-Normandy basin, except at local scale.

Households (sewerage services), agriculture and industry constitute pressures on water quality but for different criteria: domestic uses contribute through the stormwater runoff while industries are responsible for 90% of heavy metals emission; and certain agricultural practices contribute to the emission of oxidised nitrogen (nitrates) and pesticides (70% of phytosanitary product emissions).

One of the key challenges is controlling diffuse pollution, in particular nitrates and pesticides. For instance, 259 drinking water abstractions were abandoned because of their level of nitrate (exceeding the standards of 50 mg/l) between 1993 and 2001. Furthermore, nitrate of agricultural origin contributes to eutrophication of the coastline and excessive growth of algae (with the indirect consequences of toxicity for bathers, wildlife and consumers of shellfish). This phenomenon remains a contentious issue.

In relation to morphological issues, navigation and hydroelectricity are the main causes of the regression of species of migrating fish due to modification of riverbanks, locks, etc. (hydrological continuity of environments). The Aisne, Oise, Marne, Seine and Yonne rivers are the most concerned by the phenomena. And the sectors with good hydromorphological quality levels are rare in the Seine-Normandy river basin, while it is a decisive factor in achieving a good ecological status. In addition, large works such as those of the *Grands Lacs de Seine*[5] contribute to this degradation. But they also contribute to the regulation of the streamflow regime of rivers, to manage flooding hazards and to help meeting water demand of the Paris metropolitan area. The public institution was created in 1969 as a result of the floods of 1910 (damage estimated at EUR 60 million) and 1924 and the drought of the 1920s.

[5] The *Grands Lacs de Seine* refer both to the public institution created in 1969 to regulate the stream flow regime of the Seine and its principal tributaries and to the infrastructure it created to achieve this objective (artificial lakes located in the *Bourgogne* region and the *Champagne-Ardenne* region).

Today, flooding on the Seine is neither sudden nor powerful. It does cause major problems in the Paris region, however. With regards to the coastal water courses of the Normandy basin, in particular water courses in the Massif Armoricain are relatively sensitive to flooding (and droughts).

4.3.4 Economic policy instruments in place

There are different "traditional" economic instruments applied in the Seine-Normandy river basin (similar to other French river basins). These include:

- Tariffs for water services with different tariff structures depending on the municipality and the water service provider.
- Environmental charges (abstraction & pollution charges) of the Seine-Normandy water agency, whose levels vary according to regions and to the sensitivity of sub-basins.
- There is a limited role for voluntary agreements; although these are currently discussed by the city of Paris and the agriculture sector in the form of payments for environmental services (see above).
- There are specific subsidies for reducing the pressures by the agriculture sector on water resources (both point source and diffuse pollution sources). In the context of the first WFD related RBMP, subsidies for organic farming in drinking water protection zones are also considered as a means to reduce the diffuse pollution from agriculture and drinking water treatment costs.
- Recently, the *Caisse des Dépôts et Consignations (CDC)*, a semi-public financial body, has launched in 2008 a specific subsidiary (named CDC Biodiversity) for implementing the compensation rules established by the European Environmental Liability Directive.

4.3.5 institutional and organizational arrangements[6]

The Seine-Normandy water agency is the main institution on the Seine-Normandy basin for water-related issues. The role of the public institution is to finance actions contributing to the protection of the water resource and avoiding pollution. The Seine-Normandy water agency applies environmental charges to polluters aiming at reducing the pollution and generating revenue. Revenue are then used to subsidize local authorities, farmers, industries or association for reducing pressures on water and aquatic environments or restoring them.

[6] More details of the current system in place, particularly with existing evaluation of its performance will be referred to in defining the precise case studies and will be presented at a later stage.

The French Ministries of environment and agriculture are also involved in the research for adequate instruments to answer the water management issues the country is facing. They are especially involved in the Seine-Normandy basin because of its geographical proximity, Paris being in the middle of the basin.

In the between, the newly created *Office National de l'Eau et des Milieux Aquatiques (ONEMA)* has put economic instruments as a thematic area requiring further investigation, giving specific attention to innovative economic instruments such as tradable permits or payment for (aquatic) ecosystem services[7]. The seminar organized in 2009 by ONEMA provided an opportunity for economists, practitioners, policy makers and researchers to dialogue about the design and implementation of (new) economic instruments in the field of water. The level of complexity of the administrative processes associated to the payment for environmental services, as well as the effectiveness of information channels have been identified as a key factor to explain the success or failure of this Economic instrument.

The application of new economic instruments might thus require changes in the institutional and legal framework for ensuring (adequate) implementation of the instrument. For instance, new organizations or changes in the definition of water (use) rights might be required, be it in terms of administrative efforts needed, monitoring and enforcement capacities, etc.

The creation of *CDC biodiversité* to implement compensatory instruments may be one example of these institutional changes. CDC biodiversité is a subsidiary of *the Caisse des Dépôts et Consignations (CDC)*, a 190 year old French group made of a Public Institution and private subsidiaries, serving general interest and economic development of the country. One of its objectives is to use offset as a mean to target the «no net loss» principle and ecological neutrality, experimenting for instance habitat banking principles.

4.3.6 Performance of system in place

So far, morphological, ecological and biodiversity improvements and restoration have been driven by "engineering-driven investment", with limited role given to economic instruments (apart for subsidies in the agriculture sector, but that remains marginal when compared to the magnitude of the problem). Today, there are emerging discussions in France to apply more widely payments for ecosystem services (for the agriculture sector, for urban areas, for industry) in the field of water – as applications remain very limited although possible by law. In particular, the *Caisse des Dépôts et Consignations (CDC)*, a semi-public financial body, has launched in 2008 a specific subsidiary (named CDC Biodiversity) for implementing the compensation rules established by the European Environmental Liability Directive. Finally, the newly created *Office National de l'Eau et des Milieux Aquatiques (ONEMA)*

[7] Seminar on economic instruments to support water policy in Europe. 9th – 10th December 2009, Paris.

has put economic instruments as a thematic area requiring further investigation, giving specific attention to innovative economic instruments such as tradable permits or payment for (aquatic) ecosystem services[8].

4.3.7 Proposed research methodology

Advisory group

In view of starting the case study, initial efforts were undertaken since the start of EPI-Water to 1) assess the potential policy demand for research on payments for ecosystems goods and services[9] in France and 2) for building the stakeholder advisory board for the Seine-Normandy ex-ante case study (Task 4.3). Preliminary contacts have been made with experts from the Agence de l'Eau Seine-Normandie, the Office National de l'Eau et des Milieux Aquatiques (ONEMA) and the Commissariat Général du Développement Durable of the French Ministère de l'Ecologie. The issues discussed included: 1) the types of payments for ecosystem goods and services of priority interest; 2) the sectors/water users targeted by such payments; 3) given locations where research on payments for ecosystem services would have the higher interest (because of the characteristics of the area or because of current discussions among stakeholders and policy makers).

These contacts will be pursued in the coming weeks. They will support 1) the identification of the specific case study areas to be investigated in the context EPI-Water WP4 and 2) identifying the list of stakeholders to be considered as members of the stakeholder advisory board. With regards to the latter, particular attention is given to the potential links with the national advisory committee established under the parallel WATER CAP AND TRADE research project funded under IWRM.Net (research project focused on water markets and tradable permits) so that members sitting on both advisory groups see coherence in exchanges and discussions organised under both projects. These contacts provide the first elements towards the constitution of an effective and engaged (reference area) stakeholder advisory group. Negotiation is still in progress to define a proper advisory group composition. Furthermore, recent contacts have been made with Ifremer, the French national museum of natural history (MNHN), PIREN-Seine members and French researchers.

Identifying scenarios for economic instruments

Although it is too early to **specify** the economic instruments that will be investigated in detail in the Seine-Normandy river basin case study, as the final choice will build

[8] Seminar on economic instruments to support water policy in Europe. 9th – 10th December 2009, Paris.

[9] More traditional instruments such as charges will be reviewed, particularly with respect to performance when relevant to this basin. Their further exploration and potential development will be first discussed with the stakeholder group.

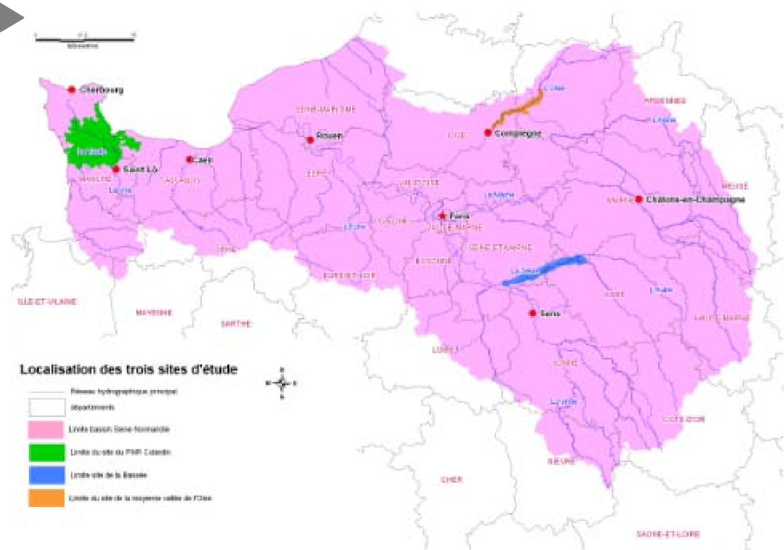
on the analysis of the current situation in the basin and discussions with local stakeholders (both at local and national scales), the first exchanges allowed identifying a few areas in the Seine-NormandyNormandy basin which offer a variety of opportunities for the development of EPIs. These are examples that will be confirmed at the beginning of March.

- The PNR Cotentin: The relation between agriculture, wetland protection and eutrophication could be analysed in the PNR Cotentin (Regional Natural Park) which is an agriculture based area of 148 000 ha influenced by the sea. As a Special Protection Area (Natura 2000), Hunting Reserve, Natural Reserve, *inter alia,* this extensive complex of marshes and associated floodplains is recognized as wetlands of international importance (Ramsar site). The area is extremely important for breeding and as resting and wintering grounds for numerous species of water birds, and provides habitat for a variety of passerines and various species of notable plants. Hunting, fishing, shellfish farming, water abstraction for human consumption are activities directly influenced by these wetlands. Extensive agriculture, as a landscape shaper, is enhancing biodiversity. Economic instruments could thus be considered either as financial compensation for agriculture services or as voluntary agreements. The PNR du Cotentin territory is a well protected area, but recent events (Ulva sea lettuce in August 2011 - macro algae) may be considered as warnings. Another territory (the *Seulles* river), also in Basse-Normandy has been considered as regards algal bloom issues.
- Hydromorphological and flood regulation issues have been mentioned for la Bassée. La Bassée is an internationally recognized floodplain upstream from Paris (Natura 2000, Natural Reserve). It acts as a natural dam participating to the protection of Paris from flooding. Furthermore, this wetland allows a natural treatment of water enhancing the quality of water consumed in Paris and reducing costly treatment. Threatened by urban sprawl, agricultural intensification and infrastructure projects, these natural services are reduced and lost in specific areas. Financial compensation, voluntary agreements, instruments for promoting river and wetland restoration and reversion could be combined in this area to protect its biodiversity and ecosystem services associated. Another area has been identified by the French Ministry of Ecology (*la moyenne vallée de l'Oise*) in a recent study on wetland valuation and could also be explored. It is linked to hydromorphological issues, wetlands, floods and land management (urbanisation vs. agriculture vs. nature protection).
- Payment for ecosystem services or other voluntary agreements have been developed (or are under development) in France. The cities of St-Etienne Auxerre (the Saulce plain), Lons-le-Saunier and Rennes developed voluntary agreements to protect drinking water quality on their catchment, following

the example of New-York city or Evian, Volvic and Vittel Natural Mineral Waters in France. Complementary work on one of these cases is considered.

- Other catchment areas combining several issues will be considered.

The PNR Cotentin is an agriculture based area of 148000 ha influenced by the sea (green on the map).



Source: ACTeon, EcoVia (2010). Evaluation économique des zones humides sur trios sites tests du basin Seine-Normandie. CGDD-MEEDDTL

Figure 5

The final choice will depend on discussion with the advisory group and with local stakeholders (including the geographical commissions of the Seine-Normandy river basin and representatives of regional administrations).

In relation to the EPI that will be applied in the Seine-Normandy basin, it is worth highlighting the exploratory nature of this prospective assessment in terms of the potential of innovative EPIs, in addition to the more traditional EPIs implemented and identified above.

- Today in France, there are emerging discussions to more apply widely payments for ecosystem services (for the agriculture sector, for urban areas, for industry) in the field of water – as applications remain very limited although possible under the law. A first family of options relating to the financial compensation for agriculture to restore and protect ecosystem services and biodiversity[10] is envisaged but still has to be confirmed at this stage. However, it should be kept in mind that these instruments should be considered in priority only in cases where legal possibilities to reach improvements are fully utilised or the limits of acceptability of other options are reached.

- Wetlands and nature restoration: this topic has also received attention from other partners and will be pursued.
- Premium to hydropower (including the incentive framework generated by how concessions are managed): the opportunities offered by this mechanism will be analysed, following the experiences of WP3. In addition to this, instruments potentially influencing ecological flows and aggregates extraction will be explored given their importance in the basin.
- Flood retention capacity: potential EPIs to manage the risk of floods are to be assessed in coordination with the main case study on floods and excess water (Task 4.1).

Support to and from consortium partners

The structure of the project allows and encourages collaboration between consortium partners. Although all partners can contribute, to take advantage of this opportunity, this part of the WP4 looks to develop upon the following specific exchanges:

- Substantive exchange with IMDEA in the analysis of cooperation instruments for water management. Although less support is to be expected on the water management issues, the core of the mutual support will focus in the understanding and analysis of negotiated arrangements between parties to promote good practices for the reduction of pressures on water resources often linked to subsidies or compensation schemes.
- Preliminary expressions of interest from others partners to contribute to the EPIs tackling the energy-water tension have been noted (IMDEA) and will be developed according to the actual opportunities and needs of the basin.
- Receive support from MU given the experience and interest of their researcher in the basin
- Define what this Seine-Seine Normandy case study can bring to the analysis developed on water accounts by NERI

[10] Although not yet clear, the question of invasive species and whether economic instruments can be used to limit their negative impact and promote their control will be discussed. Invasive species are increasingly called for in the debate on biodiversity.

- Review the opportunities based on the research project of REKK on floods as this water management issue is likely to be part of the challenges analysed in the Seine-Normandycase study. However, it will be taken into account that floods actually also have positive effects in certain cases, e.g. with regards to biodiversity and ecosystem structures.

These different approaches need to be more thoroughly discussed and formulated in the following weeks, mainly based on the final choice of the specific case studies agreed with stakeholders and the advisory group in the Seine-Normandy basin.

4.4 Macroeconomic perspective on water quality issues of relevance to the System of Environmental-Economic Accounting for Water (SEEAW)

4.4.1 Sub-task A: Water Quantity aspects

Overview of the task. For the purpose of water quantity aspects as related to the economy, task 4.4.a will focus on:

- Capturing the fragile balance between water availability and use and modeling it in terms of an accounting system, following the SEEAW methodology
- Evaluating the impacts of EPIs on hydrology
- Relating the contribution of water to the economy and the impact of the economy on water resources

Water Accounts and policy making. For policy-making and planning, taking an integrated water management (IWRM) approach requires that (Global Water Partnership, 2004):

a. policies and priorities take water resources implications into account, including the two-way relationship between macro-economic policies and water development, management and use;
b. there is cross-sectoral integration in policy development;
c. stakeholders are active in water planning and management;
d. water-related decisions made at local and river-basin levels are in-line with, or at least do not conflict with, the achievement of broad national objectives; and
e. water planning and strategies are integrated into broader social, economic and environmental goals.

The formulation and evaluation of water related policies, such as those aiming at efficient water allocation and cost recovery of the water services, are at the heart of water management. Policy makers taking decisions on water need to be aware of the likely consequences for the economy. Those determining the development of e.g.

industries making extensive use of water resources, either as inputs in the production process or as sinks for the discharge of wastewater, need to be aware of the long term consequences on water resources and the environment in general, and possess suitable tools for effectively and equitably formulating these decisions. Such tools are not adequately developed or readily available and in many cases need to be based on a uniform integrated system with common concepts, data definitions and classifications, which allows for derivation of consistent indicators across countries and over time.

How can Water Account assist policy-makers? Environmental accounting is one of the key tools for assessing environmental issues and their relation to the economy, and was claimed to be the "best option" for integrating social and environmental considerations into EU decision making in the long term" at the "beyond GDP" conference (Brussels, 19 November 2007 - ENDS Europe DAILY 2432, 20/11/07 http://www.endseurope.com/14171?referrer=search). A key advantage of the accounting framework is that it offers a platform for better integrating heterogeneous information, qualifying it and, to some extent, paving the way for accurately quantified scenario analysis. The "**System of Environmental-Economic Accounting for Water** (SEEAW)" developed by the United Nations Statistics Division (UNSD) aims at standardizing concepts and methods in water accounting. It provides a conceptual framework for organizing economic and hydrological information permitting a consistent analysis of the contribution of water to the economy and the impact of the economy on water resources. It is linked to a full range of economic activities with a comprehensive classification of environmental resources and includes information about all critical environmental stocks and flows that may affect water resources and that may be affected by water policies

The SEEAW is a useful tool in support of IWRM by providing the information system to feed knowledge into the decision-making process assisting policy makers in taking informed decisions on (SEEAW, 2006):

- **Allocating water resources efficiently**, as it presents the quantity of water used and who is using it, and provides information about the economic values added generated by different industries. It allows thus the derivation of water efficiency and productivity indicators, and helps water managers with developing policies for competing water uses.
- **Improving water efficiency**: SEEAW provides information on the fees paid for water supply and sewerage services, as well as payments for permits to access water resources, either for abstracting water or for using water resources as a sink. It also provides information on the quantity of water which is reused within the economy (water which, after having been used, is supplied to another user for further use) thus offering policymakers a

database that can be used to analyze the impact of the introduction of new regulations throughout the economy on water resources.

- **Understanding the impacts of water management on all users** and evaluating tradeoffs of different policy options on all users.
- **Getting the most value for money from investment in infrastructure**. Investment in infrastructure needs to be based on the evaluation of long-term costs and benefits. Policy makers need to have information on the economic implications of infrastructure maintenance, water services and potential cost-recovery. The water accounts provide the information of current costs to maintain existing infrastructure, the service charges paid by the users, as well as the cost structure of the water supply and sewerage industries. Therefore they can be used in economic models to evaluate potential costs and benefits of putting in place new infrastructure.
- **Linking water availability and use**. Improving efficiency in the use of water is particularly important in situations of water stress. For the management of water resources, it is important to link water use with water availability. The SEEAW provides information on the stocks of water resources as well as all changes in stocks due to natural causes (e.g. inflows, outflows, precipitation) and human activities (e.g. abstraction and returns). Further, water abstraction and returns are disaggregated by industry, thus facilitating its management.
- **Providing a standardized information system** which harmonizes information from different sources and is used for the derivation of indicators. Information on water is often generated, collected, and analysed by different agencies. The individual datasets might be collected for different purposes, use different definitions and classifications and show overlaps in data collection. A SEEAW based water account allows for disparate information to be integrated.

Water Accounts and Economic Policy Instruments. Water accounts provide the opportunity to show the supply and use of water in the economy, and the interaction with the environment. It is important to clarify to water policy and decision-makers how to use the water accounts and how to interpret the information supplied by these information systems. Even though the source and destination of the water flow (opening, closing stocks, change in stocks) can be traced with the help of the water accounts, the information still has to be interpreted with the necessary care in view of the fact that possible important indirect relationships are not included. Relating the water accounts to the Drivers-Pressure-State-Impact-Response (DPSIR) framework, the water accounts describe the driving forces and pressures related to the water system, such as specific economic activities and sectors. The impact of water policy and management responses on the water system and their effectiveness can be derived from the water accounts in principle through time series analysis of water use per economic sector. Thus, similarly, through time-series analysis, one could get information on the cost-effectiveness of different EPIs once implemented (this of course requires adequately long time-series and EPIs which are adequately framed by the SEEAW parameters). Yet, this kind of analysis usually requires also a more in-depth assessment of the various influencing factors that may have played a role in the observed trend (e.g. institutional set-up, external factors that re difficult to decouple etc). On the other hand, conclusions on whether water accounts could be used to vice-versa to help designing EPIs are really difficult to draw.

Objectives of the Case study. Although water accounts are beneficial to water policy providing an additional basis for the assessment of economic instruments, there are few examples nevertheless of implementation of accounts at the proper space and time scales to support the relevant assessment of water resources as part of hydrosystems' accounting. Yet, only by integrating information on the economy, hydrology, other natural resources and social aspects can integrated policies be designed in an informed and integrated manner.

The proposed case study focuses on capturing the fragile balance between water availability and use, and modeling it in terms of an accounting system, with the overall purpose of being able to identify the drivers of imbalances, assess the state of resources, and evaluate adequate response measures, while relating the contribution of water to the economy and the impact of the economy on water resources. It is based on the UNSD SEEAW methodological framework, and opts to produce a prototype application where the impact of selected EPIs will be simulated and evaluated on a physically based catchment model, following a robust modeling approach. Water accounts are by definition primarily carried out at watershed level and are fuelled by data from watershed and administrative levels. Depending on the aggregation or disaggregation scale they can be reported both at watershed or administrative levels. The proposed study will be implemented in **Segura River Basin** and **Pinios River Basin** in Spain and Greece respectively. These areas were selected due to the increased risk of water scarcity, competence of major water uses, and inadequacy of the existing water resources management schemes.

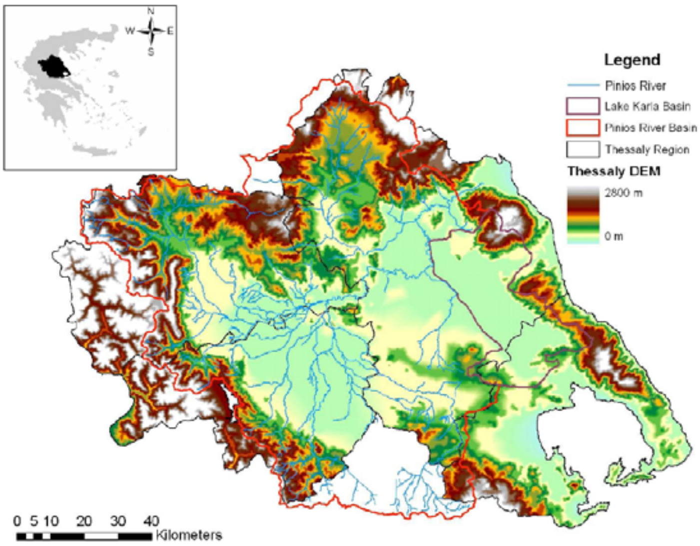
The main objectives of the case study are:

- Develop a generic hydro-economic model to assess the performance and impacts of EPIs on the hydrological system
- Provide a DSS tool for the optimal use of EPIs
- Link the hydro-economic model to the SEEAW
- Facilitate the communication of EPIs' performance to the policy-makers through the use of a quantifiable set of indicators built on the SEEAW parameters.

Overview of the river basin[11]

The Pinios River Basin is located in Thessaly, in central-eastern Greece. Thessaly is considered to be the principal agricultural region of Greece, as its plain is the most intensely cultivated and productive agricultural area in the country (Loukas and Vasiliades, 2004). In total, 36% of its areas (about 13,700 km^2) is covered by cultivated land (European Commission, 2002). The economy of the Thessaly region depends mainly on agriculture and a relatively high percentage of its population (38.7%) is partly or fully employed in this sector. Moreover, the primary sector contributes 35.5% to the total Gross Domestic Product produced in Thessaly, while the corresponding percentage is 15% for the whole of Greece (Hellenic Ministry for the Environment, Physical Planning and Public Works, 2003).

The climate of the study area is continental at the western and central parts of the Pinios river basin and Mediterranean at the eastern part. Winters are cold and wet and summers are hot and dry with large temperature variation between the two seasons. Mean annual precipitation is about 700 mm and it is distributed unevenly in space and time. The mean annual precipitation varies from about 400 mm at the central plain area to more than 1850 mm at the western mountainous areas. Generally, rainfall is rare from June to August, while the area has experienced many drought episodes. Mountainous areas receive significant amounts of snow during the winter months and transient snowpacks are developed (Loukas, 2010).



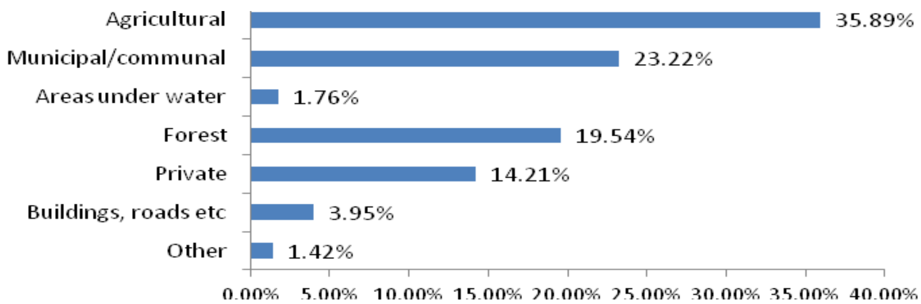
Source: Loukas 2010.

Figure 6 Thessaly basin in central Greece with its major watersheds.

[11] For the description of the Segura River Basin please refer to section 4.2 above.

Main water uses in the reference basin

Land use of Thessaly is presented in Figure 7 about 1/3 of the area is occupied by agricultural land, 23.22 % is municipal or communal land, 14.21% is private land and 19.54% is forest. In the Thessaly Plain roughly 500 000 ha are cultivated; of these, 252 500 ha are irrigated (18,7% of the total irrigated land in Greece). Main crops cultivated in the area include 160 000 ha cotton (63% of the irrigated land), maize, sugar beets and vegetables (Mahleras et al., 2007). The two major basins of the region are the Pinios River Basin and Lake Karla Basin.

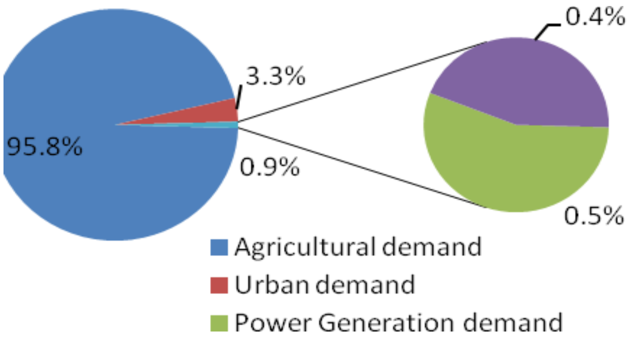


Source: Mahleras et al., 2007.

Figure 7 Land uses of the Thessaly Plain

The Pinios River Basin is located in the center of the Thessaly plain and drains about 9500 km^2. Pinios river originates from the Pindos mountains and outflows, after 216 km, in the Aegean Sea. The region is surrounded to the north by the mountains 'Olympus' and 'Chasia', to the west by the Pindos Range, to the south by the mountain Othrys and to the east by the mountain Ossa. The basin of Pinios is divided in the sub-basins of Enippeas, Farsaliotis, Sofaditis, Kalentzis, Pamisos, Portaikos, Mourgkani, Lithaios, Neochoritis and Titarisios. The main part of the basin includes a mountainous terrain with altitudes greater than 2000m (Pindos and Olympus), agricultural plains (the Thessaly plain) and urban areas. The mean elevation of the catchment is 285 m. The alluvial basin of the Pinios estuary is a sensitive and complex hydrogeological environment. Surface and groundwater resources are jointly used to cover rural, urban and industrial needs, whilst on the same time they are essential to the preservation of the wetland developed in the area. Pinios River Basin experiences significant water scarcity due to the imbalance between water availability and demand. The waters of Pinios are used primarily for irrigation and for hydroelectric power generation located in the Smokovo plan. Water used for irrigation and water supply amount 96% and 3.3% of the total water consumption respectively (Figure 8). The total water availability is about 3.209

million m³ and consists of 2.596 million m³ surface water and 613 million m³ groundwater.



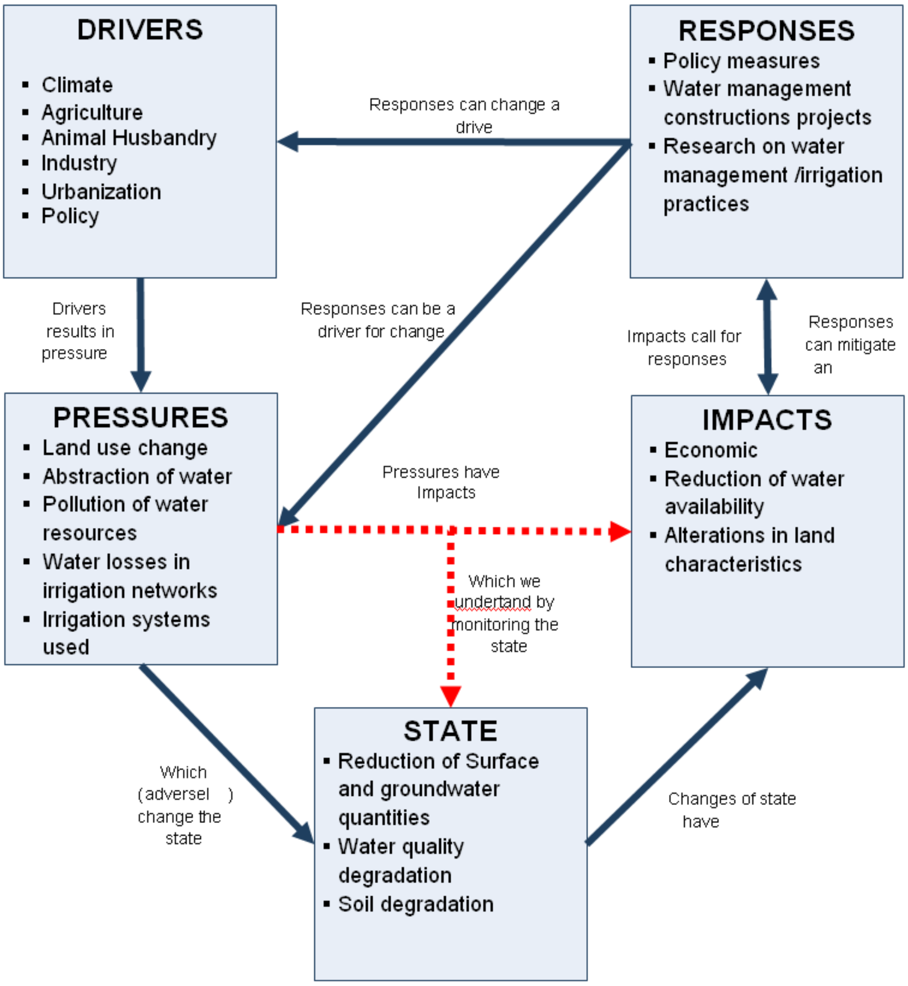
Source: Mahleras et al., 2007.

Figure 8 Water demand per sector at Pinios River Basin

Analysis of Drivers-Pressures-State-Impact-Response

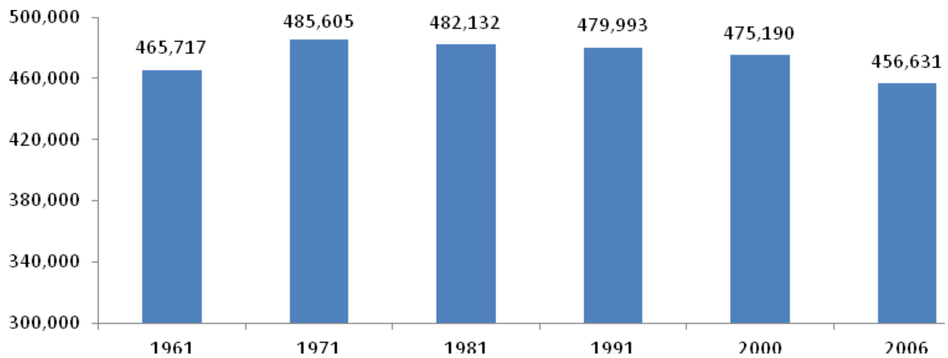
The DPSIR framework has been used in order to detect the main driving forces and their pressures on the water resources of the Pinios river basin, assess their state and identify the associated impacts and responses for the sustainable management of the water resources of the basin (Figure 9).

In terms of natural drivers, drought is an important climatic characteristics of the region. During the past 50 years Thessaly has experienced the more intense drought events in Greece, with duration up to 4 years in some cases. Rainfall patterns demonstrate a decreasing trend, and there is evidence that in the near future Thessaly will face major problems with drought, which will have major effects on the ecosystems and human environments and will lead to intense water scarcity problems (Tigkas, 2008). Agriculture on the other hand is the most important anthoropogenic factor (driver) affecting the water resources in the Pinios River Basin. Cotton production in Thessaly corresponds to 40% of the total cotton production in Greece. The cultivated area of Thessaly is about 450.000 ha from which, about 252.000 ha are irrigated (of which more than 210.000 are irrigated with groundwater). The expansion of the irrigated areas began in the middle 1950s when the main drainage and irrigation projects were accomplished. Evolution of the cultivated area of Thessaly is shown in Figure 10.



Source: Evangelou L. et al., 2011

Figure 9 DPSIR conceptual framework for assessing water scarcity in the Pinios River Basin



Source: Hellenic Statistical Authority, 2011

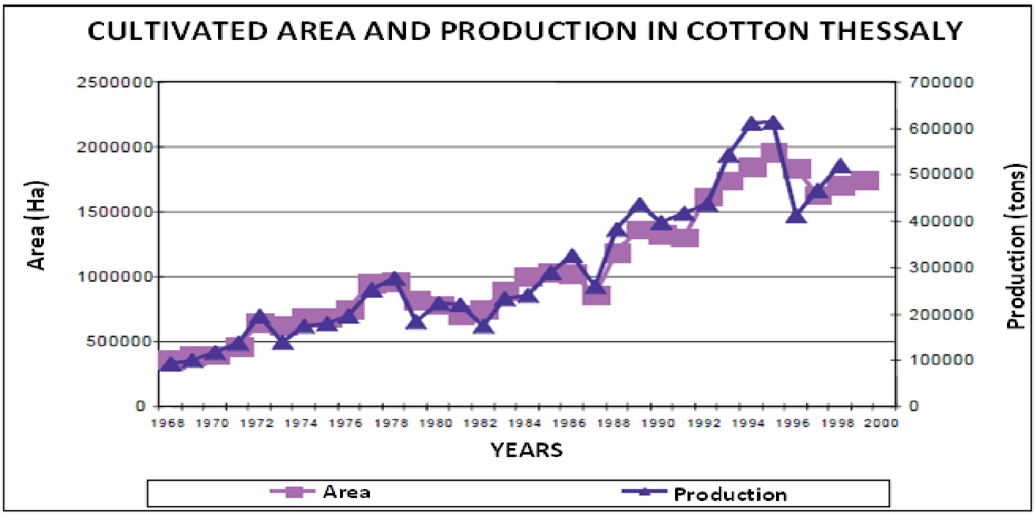
Figure 10 Cultivated area in Thessaly

The total amount of irrigation water used is estimated to 750 million m^3 from which 200-250 million m^3 are surface and the rest ground water_(Goumas, 2006). It is estimated that water needs for various uses in Thessaly are increasing. More specifically, the water demands for irrigation will continue to increase irrespectively of the policy on subsides in agriculture adopted with the new common agricultural policy (Polizos et al., 2006). Cotton cultivation has significantly expanded in the last fifteen years covering more than 0.4 Mha today. Price security and state investments in irrigation infrastructure resulted in private investment in irrigation and mechanization. As a consequence, traditional rotation schemes were abandoned and cotton mono-culture has dominated arable land farming, with all the resulting negative effects on the environment stemming from increased input use, namely fertilizers, water and pesticides. Today the cultivation of cotton is the most important consumer of irrigation water in the region.

The increased needs of irrigation water in Pinios RB were met by over-exploiting the groundwater resources. Groundwater overexploitation, especially during extended dry periods, led to the deterioration of the already disturbed water balance and the degradation of water resources. From 1970 up to 1996 about 30,000 permissions for bore constructions were approved from which about 23,000 were executed (Goumas 2006). Moreover, an undefined number of illegal bores contribute in the overexploitation of ground waters. The amount of water pumped annually from the aquifers in the Thessaly plain is much more than the naturally recharged water within a hydrological year. The total amount of water that was over consumed in Thessaly during 1974-1994 period, has been approximately calculated equal to 1 billion m3 (Goumas 2006) and is responsible for the decline in the groundwater level. The available quantity of surface water of Thessaly Water District is estimated at 1,220 million m3 although practically only 623 millions m3 are available for use (Mahleras et al., 2007). The hydrographic network in the area has been strongly modified including channelization, diversion, and straightening of the river channels and construction of embankments or levees. Considering that an environmental flow of about 5 m3/s or 100 million m^3 is essential for the conservation of Pinios river ecosystem (Petalas et al., 2005), there were many cases in the past that this minimum ecological condition was not met. The resulting impacts, do not only affect the water quantity and quality of water resources (salinization, pollution etc.), but also the land resources (soil degradation, desertification) and the economy. One of the main economic impacts due to water scarcity in the past was the reduction of yields. In the period of 2000-2001 the yield of an area of about 40 km^2 was destroyed due to the lack of irrigation water (Proias et al., 2010). The yield losses caused by drought events during the last 50 years were more than 40% compared with the yield potential of the area of Thessaly (Tsakiris et al., 2010). Taking into account predictions for future drought events (Tigkas, 2008), severe economic impacts in the agricultural economy of Pinios river basin are expected unless appropriate measures are taken.

Key policy/management issues

Among the most important changes in agriculture was the spectacular increase of cotton cultivation due to the subsidies provided to the farmers since 1981. The acreage cultivated with cotton in Greece almost doubled during the 1980s reaching 240.000 ha in 1991, from only 120.000 ha in 1981 and continued to expand during the 1990s reaching 430.000 ha in 1996. The volume of cotton production swelled according to the Greek Cotton Board from only 290.000 tons in 1981 to about 1 million tons in 1996. Within the EU, Greece has thus become the largest cotton producer, accounting for about 70% of the total EU cotton production. As a result of the initial favorable CAP measures (very strong incentives were provided to replace traditional non-irrigated crops like wheat with irrigated crops like sugar beet, cotton, tomatos, etc.), cotton cultivation became gradually the primary farm activity (and source of income) for a growing number of agricultural households. Farmers diverted even land of marginal productivity to cotton cultivation; invested in equipment (such as cotton harvesters, irrigation systems, and water drillings) and in general, they largely expanded their scale of operation (Pantzios et al., 2006).



Source: C.M.D., 2001.

Figure 11 Cultivated area and cotton production in Thessaly

Furthermore, the adopted policy by the Ministry of Agriculture to subsidize the improvement of cultivation conditions including water management such as boring, construction of irrigation canals etc. resulted in the water resources exploitation in

Thessaly (Polizos et al., 2006). During this period a dramatic increase of surface and groundwater exploitation was observed from both public and private sector. More specifically, from the 1980s to 1990s a huge number of bores were constructed legally or illegally. In parallel, a very big number of individual irrigation equipment systems such as high pressurized mobile rain gun systems and center pivot sprinkler systems with low pressure sprays were obtained by the farmers. Another reason contributed substantially to water overexploitation was the replacement of non irrigated crops such as wheat, barley and oats with water demanding crops such as corn, alfalfa, tobacco and cotton, while the area under fallow was reduced significantly (Ministry of Environment and Climate Change, 2006).

Institutional and organizational arrangements

Within the framework of the Directive 2000/60/EE a central authority in the Ministry of Environment and Regional Services of Water Resources has been established. The Pinios River Basin has been defined as a pilot watershed for the WFD. The transposition of the WFD into the national law came in force in 2003 (3199/2003 (Official Gazette of the Hellenic Republic No 280 P.A./9-12-2003) and along with the Presidential Decrees and the various Common Ministerial Decisions, progressively replaced the legislation framework for water management. The new legislation framework (Law 3199/2003 on the "Protection and Management of Waters" - Harmonization to the Directive 2000/60/EC of European Parliament and the Council of 23th October 2000) aims at tackling the past disjointed and opportunistic approach of the problems related to water resources management and safety and suggest multiple sharing of responsibilities and economic sources. In the last decade multiple Regulations, Decisions, Laws, Circulars, Common Ministerial Decisions have been edited concerning the implementation of agricultural activities in the framework of the CAP of the EE and National Agricultural Policy. This legislative framework was not satisfactory implemented in the Pinios River Basin. An example of the results of the above legislations in the water consumption can be illustrated by the pricing of irrigation water: In most cases of irrigation, the volume of water consumed is not measured, while the charge is based on the irrigated area regardless of the type of crop, season, and method of irrigation. This pricing policy provides minimal motivation for water conservation, in contrast to the volumetric methods, where pricing is based on the volume of water consumed or another correlated metrics (e.g. energy consumption for pumping). This traditional way of irrigation water pricing in Greece, which does not take into account the actual water used from each farmer, but only the irrigated area, does not conform to the law 3199/2003, which harmonizes the national legislation with the Directive 2000/60/EC,.

Moreover there is a different "pricing policy" for most of the Local Organizations of Land Reclamation, which are responsible for the management of water resources at the local level. As regards to different billing methods, a strong differentiation between regions with different characteristics has been indicated with dominant types of charging, being the cost per cultivated area and crop types while billing based on accurate metering (meters, value of electricity consumption etc.) only existing in the deficit areas. In the Pinios river basin the average prices for irrigation water are presented in the following Table 7.

Table 7 Irrigation water price in Pinios river basin

Prefecture	Average Price (€ / ha)
Larisa	289.8
Karditsa	197.8
Trikala	137.3

Source: Ministry of Environment and Climate Change, 2008

In December 1991 the Directive 91/676/EC for water protection from pollution of nitrates of agricultural origin was adopted aiming at taking measures to reduce water pollution by nitrates. Greek legislation was harmonized with this Directive through the Common Ministerial Decision No. 16190/1335/1997/ (Official Gazette Government 519/B/25.6.1997). Responsible for the implementation of this directive were the Ministry of Environment and Climate Change and the Ministry of Rural Development and Food. In the frame of the implementation of this Directive measurements were done in the groundwater bodies of almost the whole country (especially phosphates and nitrates concentrations). The Common Ministerial Decision No 19652/1906/1999 was edited entitled "Determination of waters undergone pollution from nitrates of agricultural origin – List of vulnerable zones". Among the areas characterized as vulnerable to pollution from nitrates of agricultural pollution was the Thessaly plain. According to relevant studies the following subareas of Thessaly were included in the vulnerable Greek areas group: a) the watersheds of Pinios river, b) Titarisios, c) Almiros, d) Enipeas, and e) the drained Lake of Xinias. This area is the biggest in the country characterized as vulnerable to nitrate pollution. A relevant agro-environmental project is applied for several years providing the necessary information and initiatives to the farmers for adaptation of their practices to the rules of the nitrate directive.

Performance system in place

Due to the loose enforcement of the legislation on water resources management (National low for water resources management 3199/2003 and EC 2000/60 directive), numerous uncontrolled groundwater abstractions have occurred (Goumas, 2006). Among the reasons for the non-satisfactory enforcement of the legislative framework are the poor monitoring due to the inadequate and inappropriate staff, the lack of public understanding of the environmental concerns and cause-effect relationships, the high monitoring costs, as well as the lack of incentives to comply with legislation (Petalas et al., 2005).

The total amount of money approved for water management in Thessaly through the 3rd Community Support Framework amounts to about 1 billion €. For projects of water resources exploitation 88,450,000 € were allocated (approximately 9% of the total support). It was however estimated by local authorities that this amount was not adequate compared to the significance and the severity of the water problem of Thessaly (Souflias, 2006). The effects of the actions taken through the 3rd Community Support Framework on the utilization of water resources were significant. More specifically: about 221 km of subsurface irrigation network were constructed; improved irrigation methods were implemented in 26,000 ha; storage works of about 8 million m^3 water were accomplished. The water supply management measures target to increase the availability of surface water in Thessaly by managing the surface water resources of the region through the development of dams and reservoirs (they accumulate a mean volume of $320x10^6m^3$ per year that is used for irrigation, energy production and water supply) and by diverting water from the nearby Acheloos River basin to Thessaly that has been criticized for environmental and political reasons and thus not effectuated.

The water resources management in Pinios River Basin was not integrated and sustainable so far. The enforcement of relevant legislation has to be coupled with the modernization of the bodies responsible for the water management. Policy measures in the near future have to include the environmental rehabilitation of the ground water bodies with artificial recharge actions in sites where this is technically and economically feasible, and the gradual reduction of ground water resources used for irrigation purposes. The political desire coupled with a comprehensive planning are among the most important parameters in achieving the sustainable use of water resources in Pinios river basin. The implementation of EPIs in the areas has not been investigated so far. The option of transferring water from the nearby Acheloos River Basin is a highly debatable proposal, at the same time a very challenging issue to explore in terms of establishing a relevant water markets and auction schema for the Pinios farmers.

Proposed research methodology

The core of the task evolves around the development of a hydro-economic model by linking a hydrological to an economic model which simulates the selected EPIs, in order to assess their performance on a physical based reality under different scenarios, and define optimal key parameters under specific context. The output of the model will be fueling the standard SEEAW tables. The activities to be implemented are summarized in table 7 below:

Table 8 Overview of the activities of task 4.4.a

#	Activity	Actions
1.	**Hydro**logical Model Development	Generic Hydrologic model for Integrated Water Resources Planning Water Evaluation And Planning System (WEAP21) http://www.weap21.org/
2.	**Economic** Module Development	Customization of the selected EPI(s) and coding
3.	Coupling **(Hydro-economic** Model**)**	Scripting within WEAP21 to simulate EPIs and link the economic to the hydrological model Development of hydro-economic model
4.	**SEEAW** Export function	Scripting within WEAP21 to generate standard SEEAW export tables (asset accounts, physical supply and use accounts, elements of hybrid accounts)
5.	**Assessing** EPIs	Application of various EPIs under different scenarios to assess their impact - SEEAW tables output
6.	**Optimization**	Development of a multi-objective GA (in Matlab) as a DSS Tool
7.	**Indicators compilation**	Compilation of policy-relevant indicators based on the SEEAW parameters

For the Segura River Basin, a hydrological model is already in place. A robust Water Resources Management Model will be developed for the Pinios RB. The model will have a node-based architecture and will develop water balances as well as additional functionalities in order to run simulations and scenarios for optimal water allocation representing the physical system. The modeling platform proposed for this work is the Water Evaluation and Panning (WEAP) system (http://www.weap21.org/), developed by the Stockholm Environment Institute's U.S. Centre. WEAP is a generic, integrated water resource planning software tool that provides a comprehensive, flexible and user-friendly framework for planning and policy analysis. The detailed water balance model will represent the salient feature of the river basin in its actual spatial orientation. The applications will include all major surface water and groundwater resources, distributed representations of demand, return, losses, transfers etc. and objects to represent the major water management infrastructure (reservoirs, WWTPs, desalination plants, etc.).

Box 2: The WEAP system

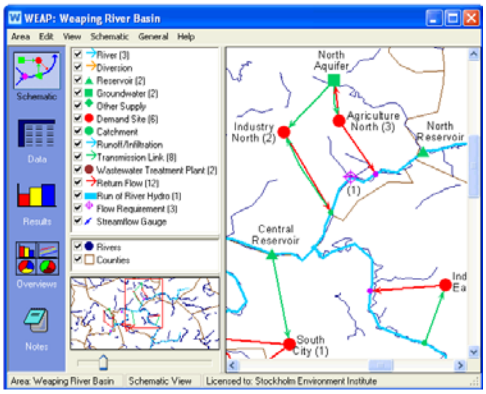


Figure 12 An example of the WEAP model

WEAP functionalities support:

- Water balance: WEAP provides a system for maintaining water demand and supply information.
- Scenario generation: WEAP simulates water demand, supply, runoff, streamflows, storage, pollution generation, treatment and discharge and instream water quality under various assumptions about the future
- Policy analysis: WEAP evaluates a full range of water development and management options, and takes account of multiple and competing uses of water system
- Model Integration: Dynamic links to other models and software such as water resources models (QUAL2K, MODFLOW, MODPATH, PEST etc), economic models (GAMS), Databases (Excel and other software)

Regarding the development of the economic model, collaboration with task 4.2 (Tagus and Segura interconnected river basins) is foreseen. The model developed in task 4.2 to simulate the “water use right markets” in Segura River Basin will be customized and adopted for the Pinios River Basin. The necessary coding will be implemented. Further, the hydrological model and the economic model will be coupled to develop a hydro-economic model. The necessary scripting within WEAP to simulate the EPI and link the economic to the hydrological model, as well as coding in Matlab to serve coupling purposes will be undertaken. The potential of linking an additional economic model which simulates “cap and trade” will also be investigated. The hydro-economic model will be able to function as an integrated model and different scenarios (on top of the baseline) will be run to forecast the behavior of the EPI under different alternative futures (e.g. climate, land use). Additional scripting will be implemented in WEAP to enable a SEEAW export function, which will allow the generation of standard SEEAW export tables (asset accounts, physical supply and use accounts, elements of hybrid accounts). The same tables will be generated for Segura RB. The results prior to and after the implementation of the EPI will be reflected in the SEEAW tables and expert judgment will be made on whether the tables can easily communicate a change in performance to the policy makers. For this purpose, policy-relevant indicator (e.g. water productivity per sector) will be compiled based on the SEEAW parameters, to assess whether they can reflect changes in the baseline scenario. Finally, a multi-objective GA will be developed, most probably in Matlab, as a DSS Tool linked to the hydro-economic model, in order to define optimal key parameters of the model under specific context. This algorithm will also run in the Segura River Basin (task 4.2) (with the necessary parameter customization). The algorithm will seek to maximize a utility function, testing the result on the physical basis, and identifying the best set of solutions which satisfy the design constraints while maximizing the defined objective function. A schematic representation of the case study is illustrated in Figure 12.

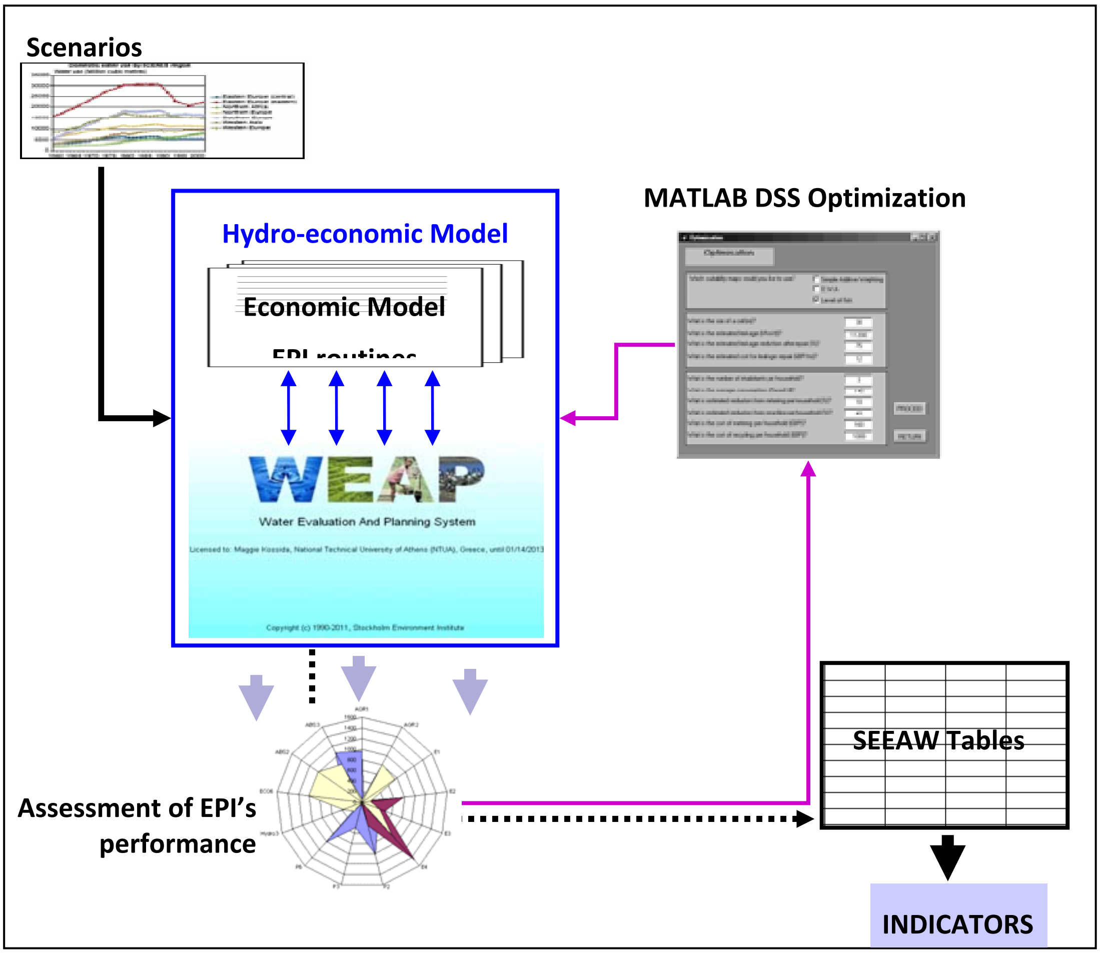


Figure 13 Schematic representation of the case study

4.4.2 Sub-task B: Water Quality aspects

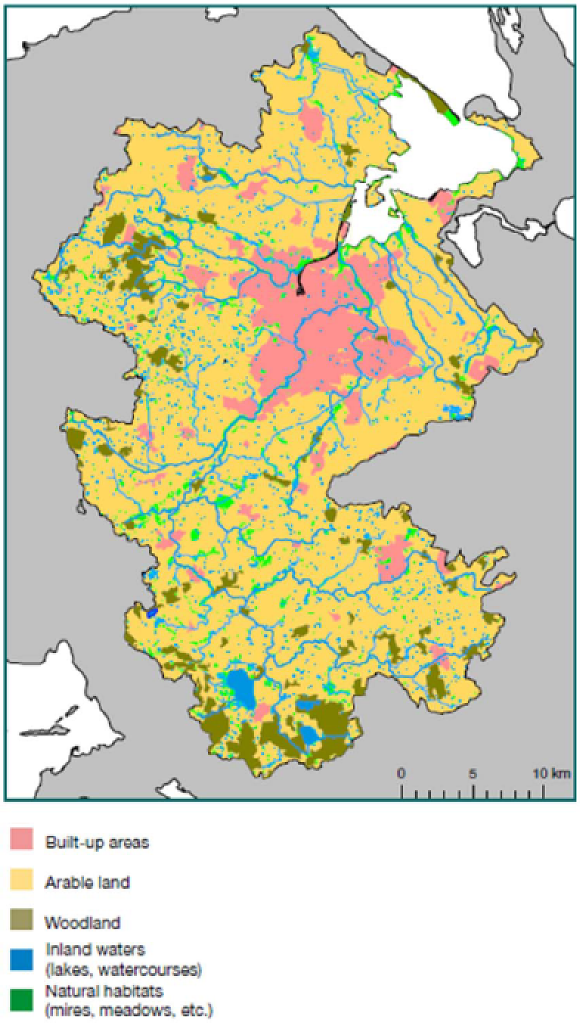
Overview of the river basin

The essential information about the Odense River Basin (ORB, or Odense catchment) is described in this section in order to understand the key issues in terms of water management that will be used for the ex-ante assessment within the EPI-water project. The information presented in section 1 is mostly taken and adapted from the *"Pilot project for river basin management planning"* (Env. Centre Odense, 2007). The report contains more detailed information about the natural environment of the catchment as well. It is available freely (and in English) at http://odenseprb.naturstyrelsen.dk/english/.

The Odense River Basin is located in the Funen region of Denmark. The basin includes the Odense River, numerous small lakes, and the shallow Odense Fjord. The clay and sandy soils covering the area are well suited for cultivation of agricultural crops and favour agriculture and farming as main activities in the catchment. Cereal crops (approx. 2/3 winter cereals) are in fact cultivated on 63% of the arable land, while 10% is permanent grassland. Pig farming increased in the last decade compared to cattle farming and is presently the main farming activity (Figure 14).

The establishment of artificial drainage on a large part of the arable land in ORB modified considerably the aquatic environment in the catchment during the last century. Small water bodies like mires, meadows, watercourses and shallow lakes, and fjord sections have disappeared or been converted to arable land. In the ORB we see a physical water environment that is strongly modified by humans. Many watercourses have been channelized and regulated and are under controlled maintenance. As a consequence, some of the natural properties of the aquatic system have been lost, like the self-cleansing ability of the Odense Fjord and of the river basin. This loss has severe implication for the maintenance of good water quality. This is more difficult to achieve in conditions of reduced natural remediation capacity.

The River Odense and the Odense Fjord are among the most well studied water bodies in Denmark. The ORB was designated as one of the pilot catchments for the testing of the new principles of river basin management planning introduced by the EU Water Framework Directive (WFD). Pilot projects were in fact carried in different Member States prior to actual implementation of the Directive. The main reason behind this choice is that the basin "*encompasses a broad spectrum of Danish aquatic and terrestrial habitat types, as well as major sources of environmental pressure*" (Env. Centre Odense, 2007). The project started in 2002 on the initiative of the Danish Environmental Protection Agency - DEPA (*Miljøstyrelsen*) and of the Funen County. The Odense Pilot River Basin project was therefore a contribution to the implementation of the WFD and resulted in the organization of stakeholder meetings and lectures, and in the production of articles and reports on the status and on the critical issues of the ORB.



Odense River Basin Key figures	
Catchment area (km2)	1050
Population	
Total (thousands)	246
Density (inhab./km2)	234
Land use (percentage)	
Built-up areas	16
Farmland	68
Woodland	10
Natural/seminatural countryside	6
Crops (percentage)	
Winter cereals	45
Spring cereals	23
Seed crops	8
Pulses	2
Grass/green fodder	10
Permanent grassland	4
Root crops	5
Market gardens	3
Fertilizer consumption, nitrogen (tonnes N)	
Manure	5000
Commercial fertilizer	6400
Total	11400
Fertilizer consumption, phosphorus (tonnes P)	
Manure	1370
Commercial fertilizer	530
Total	1900
Climate and hydrology (annual means)	
Precipitation (mm)	825
Freshwater runoff (mm)	305
Temperature (ºC)	8.4

Source: Env. Centre Odense, 2007

Figure 14 ORB, land use and key figures

A quantitative study on the Odense catchment was performed within the EUROHARP EU-project. The project 's objective was to explore quantitative tools for the assessment of diffuse nutrient losses in order to facilitate the implementation of the WFD and of the Nitrates Directive. The project assessed the performance of individual models and their applicability in catchments throughout Europe with different data availability and environmental condition. This was done via compilation of a harmonised GIS/database for all catchment data and via a large scale comparison and evaluation of nutrient pollution models in estimating the consequences of diffuse pollution on river water quality. EUROHARP focused in particular on the agricultural load of Nitrogen and Phosphorous to arable land and to water bodies within the Odense catchment. Modelling scenarios and results were produced. These constitute a pool of useful background data for the present ex-ante analysis of water quality issues. Relevant data provided by the EUROHARP project include: estimates of nutrient transport and source apportionment, trend analysis, and calculations of nutrient retention (Andersen, 2011).

More recently, the Odense catchment was chosen as case study area within the EU funded project AQUAMONEY, whose objective is to *"develop and test practical guidelines for the assessment of environmental and resource costs and benefits in the European Water Framework Directive"*. The study linked ecological aspects with economic estimates in the Odense catchment and estimated the benefits related to the improvements of the ecological status of Odense River according to the WFD. The study performed a survey focused on households' recreational use of water bodies and on their willingness to pay for improvements of the ecological status of Odense River. The study observed that the households' willingness to pay is sensitive to the magnitude of the improvement, with higher WTP for improving the water quality of a segment of the river than of the whole river. Based on the results of the Contingent Valuation, the study compared the benefits of achieving good ecological status in the river basin with the cost for obtaining such change, and a cost-benefit assessment was also performed (results not published yet).

Main water uses in the reference basin

The river basin management involves different economic sectors and actors ranging from agriculture to fisheries, and encompassing urban mobility, shipping, and water abstraction, drinking water supply, and wastewater treatment. As in the rest of Denmark, in the study area of the ORB the water abstracted is essentially groundwater. Users of groundwater are households, market gardens, industry, and agriculture.

Groundwater is extracted in large amounts because of its higher quality compared to surface water, which abstraction has undesirable effects on the inland waters. However, the refilling rate of the groundwater reservoirs in Odense Catchment by precipitation has been estimated to be lower than the abstraction rate in the long term perspective. One reason is the reduced soil-infiltration of precipitation water. Rainwater is channelled by paved surfaces and sewers. It doesn't penetrate into the soil but is led to watercourses either directly or via the wastewater treatment plant. Therefore, rainwater doesn't refill the groundwater reservoir and instead affects the quality of surface waters.

Table 9shows the consumption of drinking and raw water by sector for the all Funen Region, from 1997 to 2004. The data are taken from the website of the "Statistic

Denmark" Organization[12] of these data by the organization stopped in 2007, and updated statistics on water abstraction aggregated per sector are not directly available. However, disaggregated but detailed data on water abstraction by each single activity/supplier in the municipalities in the area may still be accessed from the GEUS- Geological Survey of Denmark and Greenland[13].

Table 9 Consumption of drinking and raw water in the Funen region, usage and time (1997-2004)

	Millions of m3	1997	1998	1999	2000	2001	2002	2003	2004
1	*City water, households*	*22.9*	*22.2*	*22.6*	*21.4*	*20.9*	*20.5*	*20.9*	*21.2*
2	*City water, industrial*	*14.2*	*12.8*	*12*	*13.8*	*12.6*	*12.1*	*12.8*	*11.6*
3	*City water, loss, etc.*	*3.9*	*3.3*	*2.9*	*2.5*	*2.6*	*2.5*	*2.8*	*2.8*
4	Water supply TOTAL (1+2+3)	41	38.2	37.5	37.7	36.1	35.1	36.5	35.6
5	*Filter flushing etc.*	*0.8*	*0.8*	*0.8*	*0.8*	*0.8*	*0.7*	*0.5*	*0.7*
6	City water TOTAL (4+5)	41.8	39	38.3	38.4	36.9	35.8	37	36.3
7	*Private Collection, industrial*	*5.7*	*1.7*	*1.9*	*2.7*	*6.3*	*5.7*	*3.3*	*4.9*
8	*Private Collection, irrigation*	*6.1*	*3.4*	*3.5*	*3.2*	*3.7*	*0.4*	*3.3*	*0.4*
9	OWN QUARRYING TOTAL (7+8)	11.8	5.1	5.4	5.9	10	6.1	6.6	5.2
10	**DRINKING WATER TOTAL (6+9)**	**53.6**	**44.1**	**43.7**	**44.3**	**46.8**	**41.9**	**43.6**	**41.5**

Source: Statistic Denmark

In order to extrapolate the ORB-specific consumption, a scaling based on population or based on area can be performed. Approximately half of the Funen region population lives in the Odense Fjord (246,000 inhabitants out of 454,000). Roughly 50% of the consumption of groundwater of the Funen Region can therefore be attributed to the ORB if scaled according to population. The surface covered by the Basin is approximately one third of the total Funen area (1050 km^2 out of 2984). If scaled according to the area, approx 35% of the consumption can be attributed to the ORB.Given that the major water-consumer is the household sector, and that Odense - the biggest city in Funen- is located within ORB, the first scaling (50%) appears more accurate.

The abstraction of water is divided between public and private. The agricultural sector doesn't use public water supplies, and all the water abstraction in this sector is private. This water use shows a variable trend with minimums in years 2002 and 2004. The reasons for such minimums are not clear at present (it may also be due to reporting gaps) and should be further investigated. In general, the variability may be in part attributable to differences in climatic conditions. The (inverse) correlation

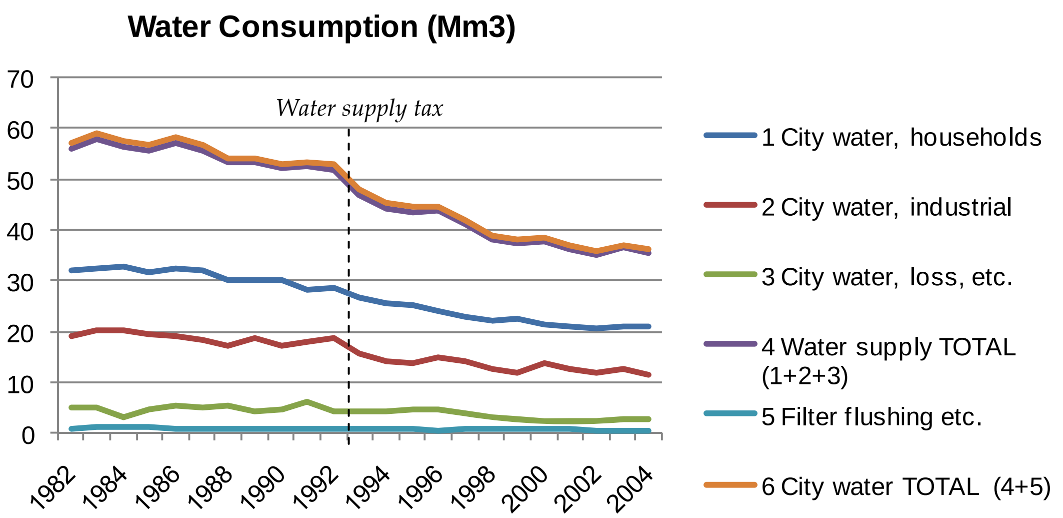
[12] http://www.statistikbanken.dk

[13] http://www.geus.dk/

between the data on water consumption by agriculture [Mm³] and data on average precipitation rates [mm/y] for the same period results in an *R-squared* value of 0.335. Regarding industry, the variable trend in water abstraction may be attributable either to the starting of new activities or closure of old ones, or to the shift from public to private supply and vice-versa for certain industrial activities.

Figure 15 complements the public supply data Table 9 with data since 1983 and shows the decrement in consumption observed for the last three decades, with focus on the time of the introduction of the Danish *water supply* tax in the early nineties. The tax applies mainly to households and contributes to the already decreasing trend observed for water consumption for the household sector. ECOTEC (2001) provided a rough estimate of such contribution, and concluded that a 13% reduction in water consumption for the period 1994-1999 is attributable to the tax. A 23 % reduction in leakage from waterworks in the years after implementation (from 4.3 Mm³ in 1993 to 3.3 Mm³ in 1998) has also been estimated as an effect of the *water supply tax*. A significant decreasing trend is observable also for the use of water from industry, that can't be due to the *water supply tax* (the tax applies only to households) and the reasons are therefore not clear at present and should be further investigated. Figure 15 shows, however, that the combination of water savings in the private and public sector lead to a significant decrease in the total water consumption from public supply.

Figure 15 Decrease in consumption of drinking and raw water in the Funen region, usage and time (1982-2004)



Source: Statistic Denmark

Key policy/management issues

There are different water management–related issues in the Odense catchment, ranging from water pollution to overexploitation of groundwater. It is in particular interesting to see how issues of water quantity and quality are strictly interlinked. The most remarkable issue is the failure of the various types of water bodies to meet their environmental objectives. This is attributable to pollutant pressure due to loading with nutrients and hazardous substances, and due to physical pressures associated with interventions such as watercourse maintenance, land reclamation, etc.. Three key issues can be identified:

a) In terms of surface water quality, the most relevant management challenges regard point and diffuse sources of nutrient load: extensive diffuse nitrate and phosphorus pollution originating from agriculture and point source pollution originating from sewage. The management of fertilizers and of discharges from wastewater treatment plants into water bodies are therefore the main focus in this EPI-water task.

b) There are two sub-issues related to groundwater management: b.1) controlling the alteration of the natural transport pathways for storm water; b.2) regulate the excess abstraction of groundwater. These measures should be taken to avoid overexploitation of the resource, and to avoid changes in its chemical composition due to e.g. infiltration of contaminants from the surface or infiltration of seawater in the reservoirs.

c) In addition, the water management should be synchronized and integrated with the Natura 2000 planning such that the programme of measures for water bodies also contributes to the achievement of the environmental objectives of the Habitats Directive for both aquatic and terrestrial habitats.

Economic policy instruments in place

At national level, there are three economic instruments presently operating that have an effect on water quality and quantity-related issues: the *Phosphorous tax*, the W*ater Supply tax*, and the *Wastewater tax*.

The *Phosphorous tax* operates on agriculture and aims at reducing the excess phosphorous. This reduction target is of 25% by 2009 via a tax of DKK 4 per kg of mineral phosphorous in feed and through general improvement of the phosphorous balance. In the period from 2009 to 2015 a further 25% reduction is expected. Revenues from the *Phosphorous tax* are returned to agriculture through a reduction in land taxes in accordance with the principles of the Government's tax freeze (DME, 2004).

The *Water supply tax* was introduced in 1993 as part of a broader "green tax reform" and with the objective of protecting groundwater via reduced water consumption

(ECOTEC, 2001). In 2001 the rate was of EUR 0.67 per cubic metre of water supply of piped water. The tax was imposed on metered water delivered to customers and applies to households either connected to the public supplier or using individual wells (common in rural areas), but not to the agricultural sector. The agricultural sector does not normally use the water supply infrastructure but directly abstracts groundwater. Industry is exempted from the tax, and only certain business activities are liable for it (e.g. lawyers, accountants, architects, etc.). If metered water amounts to less than 90% of the quantity abstracted by the water work, this will be subject to the remaining tax. The Danish *water supply tax* contributed to additional water savings in the magnitude of about 13 per cent of residential use over the period 1994-1999 (UN, 2001). The tax deals directly with water quantity issues, but has an indirect effect on water quality too; however, this has not been precisely quantified yet (ECOTEC, 2001).

The *Wastewater tax* was also introduced in 1993 as part of the "green tax reform" and became fully effective in 1998 (ECOTEC, 2001). The tax applies to discharges of organic material (BOD - biological oxygen demand), nitrogen and phosphorous from direct discharges. The main subjects are waste water treatment plants, industries, and dwellings not connected to the sewerage network, whereas some significantly pollutant activities are exempt and pay only a minor percentage of the tax (3% for fish processing, cellulose and sugar beet industries). Therefore, the *Wastewater tax* mainly affects public sewage plants. The tax was introduced to reach very low emission levels, and to incentive a decrease in use and discharge of water in general. Providing an incentive to introduce rainwater separation and to seal sewer networks was also an objective of the tax. The standard rate of the tax is of 1.48 Euro/kg of BOD; 2.69 Euro/kg of N; 14.78 Euro/kg of P). A substantial part of the revenues was devoted to an independent Water Fund, to finance projects of groundwater protection.

A number of potential measures for the integrated improvement of water quality within the ORB have been proposed in the *Pilot River Basin Management Plan*; these are reported in Table 10 as extracted from the document by Env. Centre Odense (2007). None of them is explicitly described as an economic measure, but some of them have a potential to be implemented with an EPI. This is e.g. the case of the optimization of crop production via reduced N fertilization, which could be performed by introducing a tax on nitrogen similar to the Phosphorous tax. Environment Centre Odense (2007) provides also a cost-effectiveness analysis for the preliminary inventory of possible measures which is mostly based on operative costs.

Table 10 Measure proposed for the reduction of existing environmental pressures within the Odense River Basin

Pressures and measures to reduce them	Target / Effect
Diffuse nutrient and pesticide loading – agriculture	
1) Environmental optimization of crop production – upland and lowland/river valleys	
Nitrogen: Additional 5% higher utilization of the N content of manure; Catch crops: Increased area; Reduced N fertilization norm (-10%)	Nitrogen(N) leaching
Phosphorus: P fertilization regulation: Balance between applied and removed phosphorus at field level ; P fertilization regulation: Reduced P fertilization of soil with a high P index (Pi>4)	Phosphorus (P) leaching
2) Set-aside of farmland – upland and lowland river valleys	
Land for afforestation (broadleaf); Permanent grassland; Restrictions on cultivation of land potentially subject to erosion; 5-m buffer zone alongside watercourses in lake catchments; 10-m buffer zone around ponds in lake catchments	Nitrogen(N) and Phosphorus (P) leaching; Sediment loss Re-establish the dry grassland habitat types and reduce/reverse the decline in species diversity in these habitats
3) Groundwater protection measures	
Set-aside of arable land: Permanent grassland kept unfertilized; Afforestation Environmental	Nitrogen(N) and Phosphorus (P) leaching
Environmental effectivization of arable land: Pesticide-free cultivation of arable land; Increased area of spring cereals, fertilization with 60% N norm and increased use of catch crops	Nitrogen(N) and Phosphorus (P) leaching
Reduction of pressure from point sources	
Sparsely built-up areas – improved wastewater treatment; Storm water outfalls – detention volume; Wastewater treatment plants – improved wastewater treatment (UV and ozone treatment); Contaminated sites; Enterprises	BOD, nitrogen and phosphorus; Hazardous substances; Improved water quality

Source: Env. Centre Odense, 2007.

Institutional and organizational arrangements

There are two different institutional levels regarding the management of the ORB via the water plan. At the regional level, an overall River Basin Management Plan and a Programme of Measures are defined, according to the specific requirements of the Environmental Objectives Act (main piece of Danish legislation on Environment).

Presently, the "River Basin Management Plan" for the ORB (*"Hovedvandopland 1.13 Odense Fjord")* is prepared in accordance with the Danish environmental law implementing the EU-Water Framework Directive (WFD) in Denmark. The water plan must by law ensure that rivers, lakes, coastal waters, and groundwater meet the environmental objective of "good status" by the end of 2015. It should also be ensured that any deterioration in the status of water bodies will be prevented (*Miljøministeriet*, 2011).

Furthermore, many Natura 2000-areas are present in the ORB. The Natura 2000-plans should promote the efforts necessary to ensure a natural state in the areas. The WFD and Natura 2000 efforts are in many cases aiming at the same objective of a good ecological status of water bodies. Therefore, the water plan soughs to utilize this synergy in order to minimize the costs.

The present River Basin Management Plan was drafted by the former Regional Authorities (*Fyn amt.*), which have been reformed in Denmark after 2007 and are not in place anymore. The task is now under the Ministry of Environment, Danish Nature Agency (*Naturestyrelsen*).

At municipal level, the municipal councils within the basin develop both a "Municipal Action Plan" and a municipality-related "Programme of Measures". In these documents the municipalities must specify how the "Regional River Basin Management Plan and Programme of Measures" will be implemented within the boundaries of the municipality. The management of the river basin water environment has therefore to be practically implemented at municipal level. Yet, the Environmental Objectives Act doesn't specify any guidelines or requirement regarding the geographical subdivision of the programmed measures according to municipal boundaries.

The ORB touches seven municipalities (*Nordfyns Kommune, Odense Kommune, Kerteminde Kommune, Faaborg-Midtfyn Kommune, Assens Kommune, Svendborg Kommune, Nyborg Kommune*) and covers a different a proportion of each of them. For each municipality, the municipal action plan for river basin management is therefore developed based on calculations and extrapolation at municipal-level from the measures planned at regional level.

Criteria for this extrapolation are e.g. dividing the River Basin in smaller catchments and then calculating the necessary measures for each of the municipalities within the catchment. Common practices include taking into account area-related issues like e.g. the municipality's lowland/farmland/upland areas that need groundwater protection; or specific physical conditions in rivers within the individual municipality (obstructions, storm water discharges, sparsely built-up areas, contaminated sites, etc.).

There are therefore different key actors in the catchment, with a mix of responsibilities:

- Municipalities. They issue extraction permits for small abstractions and operate the system of water quality regulation. They monitor and enforce compliance with all laws and regulations with regards to water and wastewater provision. They define the local (Municipal) water plans and programmes linked to the regional plan.
- Regional authorities like the Environmental Centres (*Miljøcenter*), basically regional sections of the Danish Environmental Protection Agency -DEPA (*Miljøstyrelsen*). They control emissions from agriculture and industry, and soil protection. Most notably, DEPA carries the activities related to the nitrates directive in Denmark: i.e. preventing nitrates from agricultural sources polluting ground and surface waters and by promoting the use of good farming practices.
- Danish Nature Agency (*Naturstyrelsen*). It issues the regional water plan according to the WFD. Such institution has then different tasks like: Natura 2000 planning, groundwater mapping, monitoring of natural and marine environment, administration of beach protection lines, supervision of municipal planning, environmental impact assessment (assessment of environmental effects).

Performance of the system in place

Eutrophication can be considered as the main environmental problem in the ORB. Agriculture is the main contributor to pollution of both the river and the river basin. Water quality issues are therefore central in ORB.

The monitoring performed by the Environmental centre of Odense in the context of the WFD, and Hasler et al. (2009), report that:

- Rivers: 96% are classified as at risk of not obtaining the WFD's objective of good ecological status in 2015. Watercourses undergone major physical changes in the last decades and the natural appearance of most watercourses was changed via major physical interventions; many streams disappeared. These pressures seem to be the most significant in affecting the quality of rivers: the short water-retention period makes rivers less vulnerable than lakes to phosphorous- and nitrate pollution. On the other hand, watercourses are major pollution pathways from the source of pollution to the fjord, and further to the sea.
- Lakes: in general they score below the requirements of good ecological status stated in the WFD; the quality of most of the lakes is poor; 86% classified as at risk (15% because they are not monitored). Most lakes show both nitrate and phosphorous content higher than the requirement for good ecological status. Long retention periods for water present in lakes worsen the effect of the

extensive diffuse nitrate and phosphorus pollution from agriculture and point source pollution originating from sewage

- Coastal areas: 100% classified as at risk, including the fjord area. They are the terminal recipient of most waterborne un-remediated pollution. The pollutant load generated from agriculture, major industries, shipping activities, waste dumps, and other minor activities ultimately reaches the fjord.

The maximum concentration level for both nitrate and phosphorous in lakes within the ORB that is acceptable to preserve their good ecological status has been previously estimated by studies at AU-NERI (Søndergård et al. 2003). NERI estimated the upper limit of 1 mg/L nitrate concentration for Danish lakes to hold good ecological status, whereas the phosphorous content should not exceed 0.05 mg/L in shallow lakes and 0.025 mg/L in deep lakes.

The condition of water bodies within ORD appears to be below the standards for good quality. It is therefore doubtful whether the introduction of the different EPIs has been effective. The EPIs operating in the area focus on water quantity and on discharges, and are not specifically target for water quality. They are therefore supposed to have an indirect effect on the water quality, which is not straightforward to quantify. The analysis of time series on water quality for different water bodies in ORB may help both in the ex-post valuation of the EPI in place, and in the ex-ante assessment of new EPIs to test. Both the gathering of existing data on water quality and their production via modelling will be therefore prioritized in the ex-ante assessment.

Proposed research methodology

There is as yet no developed approach for how to integrate quality issues in environmental accounts, for this reason the present sub-task will take a methodological orientation and explore feasibility of progressing from monetary appraisal of water quality attributes to evaluation of economic policy instruments. The method applied for monetary valuation is catchment-specific and has been developed in a previous EU FP6 project, EXIOPOL. EPI-Water will allow us to apply the method to more catchments as well as for the first time explore implications of applying economic policy instruments. This can be done within a welfare economic framework informed by the benefit estimates arrived at.

The valuation of environmental benefits related to water quality has up to now largely been undertaken separately from the valuation of water as a natural resource. While water quality has been viewed mainly as a recreational issue, water quantity valuation on the other hand has been approached as a natural resource issue related to water supply and irrigation purposes. Various approaches and methods can be found in the valuation literature to deal with these two different sides of water management. The literature and practice is especially fragmented when it comes to valuation of water quality. Hypothetical approaches to valuation have been explored to test the willingness-to-pay for water quality that improves, for instance, from boatable to fishable to swimmable, while hedonic studies have revealed the use value of proximity to surface waters, e.g. for lakefront properties. As such water quality has become to some extent a testing ground for the basic method development in the monetary valuation literature, resulting in many different estimates and some confusion as to their validity. When it comes to drinking water it is the resource availability per se that is valued, disregarding its possible quality attributes which can be affected by the same pollutants that also may affect recreational water quality. Hence, in the area of water management the economic analysis lacks a uniform framework for monetary valuation of the benefits associated with changes in management practices affecting several water bodies through the hydrological cycle.

In EXIOPOL it was explored how the impact-pathway methodology, initially developed to establish a framework for valuation of air pollution effects (cf. Rabl and Peuportier, 1996; Friedrich and Bickel, 2001), can be extended and developed to establish a coherent framework for valuation of water pollution effects. The starting point of the impact-pathway methodology is with emissions that affect environmental quality, not the water resources per se. Nitrogen is known to leach from agricultural activities and is a classical non-source pollutants confronting most water managers. Nitrogen transforms to nitrate which is believed to affect the quality of water as a healthy source for drinking water supply, while also known for its ability to cause eutrophication that leads to increased algal growth, which decrease the recreational and aesthetic benefits of water bodies. While phosphorus is pivotal for eutrophication in fresh waters, nitrogen is the controlling nutrient in coastal and marine waters (Redfield, 1934). As such the nutrient may cause important changes in the attributes of the good 'water'.

From the valuation literature we combine two different strands of studies for the purpose of connecting the effect end-points with monetary estimates. Health effect end-points relating to the use of water resources for human consumption purposes can be valued according to implications for mortality and morbidity, to the extent that these have been identified with risk ratios in the relevant literature. Evidence for the effects of nitrate in drinking water is not conclusive, but some key studies nevertheless can be used as a basis for quantification to explore the scale of the possible health costs at stake based on the conventional approach to health cost valuation in Europe. The eutrophication effect end-points, which are well understood, can be valued according to the implications of emissions for summer Secchi depth (sight depth), a parameter which in several valuation studies have been shown to affect house prices.

A modelling framework for the relationships between field nutrient application, the leakage to surface waters and ultimately the implications for Secchi depth which depend on site-specific properties of the aquatic recipients, has been established by linking a set of leakage models with water quality models for lakes and coastal waters respectively. Leakage models are also applied to establish a dose-response relationship for the nutrient pulse to groundwater reserves.

The impact-pathway method is a site-specific bottom-up method for estimation of external costs. EXIOPOL addressed six different catchments across Europe. These catchments were among a wider set of catchments subject to analysis and calibration of environmental models in the previous EUROHARP project. The data required for modelling the processes of nutrient leakage per se are available and have been carefully checked, providing a good basis for our estimates of the external costs involved when changing agricultural practices. Table 11 shows some results for external costs. These figures represent the monetary benefits from changes in nitrogen application

Table 11 Illustrative figures for external costs related to potable water nitrate health risk costs in EU-27

	Potable water from surface (%)	Surface water above 25 $mgNO_3/l$ (%)	External costs (€/kgN applied)		Potable water from surface (%)	Surface water above 25 $mgNO_3/l$ (%)	External costs (€/kgN applied)
AT	72	1	0.03	IT	13	2	0.05
BE	35	30	1.29	LT	0	2	0.00
BG	66	0	0.01	LU	25	31	0.39
CY	42	8	0.07	LV	43	1	0.00
CZ	53	18	0.30	MT	0	86	0.39
DE	26	4	0.15	NL	39	7	0.34
DK	0	12	0.15	PL	38	4	0.05
EE	53	8	0.03	PT	60	1	0.07
ES	85	4	0.08	RO	60	2	0.03
FI	39	1	0.00	SE	51	0	0.00
FR	40	19	0.23	SI	19	1	0.03
GR	59	1	0.02	SK	19	0	0.07
HU	5	5	0.02	UK	65	34	1.34
IE	84	2	0.02	EU27			0.29

Source: EXIOPOL.

As noted in the inception report, barriers (language, distance, etc.) exist for the study of the same basin by different consortium members. Therefore, a "*mirror approach*" is recommended. This can be done in a simple way for the case of water quality. In parallel to the main case study (CS) of ORB, one or more mirror basins will be chosen, where to test the same EPI consistently. Alternatively, the EPI will be tested on the main CS, whereas a similar (mirror) basin will be used as counterfactual. The same theoretical methodology as used in the main CS basin will be applied to the mirror basin, whereas practical aspects (type of models, level of detail) may change. The ex-ante assessment for water quality will be therefore performed in four different steps:

1. Scoping of the data and modelling capacity available for both the CS catchment and the mirror ones to ensure that a similar approach can be performed for each basin consistently.
2. Choice and definition of the EPI and of the criteria for its consistent modelling both in the CS basin and in the mirror basins. This phase will also imply the participation of basin-specific stakeholders.
3. Modelling of water management scenarios inside the main CS basin and for the mirror basins. Two scenarios will be considered for each basin: business as usual (baseline) scenarios and EPI scenarios, with focus on water quality. Alternatively, the mirror basin will be chosen as baseline scenario (counterfactual) and the EPI will be modelled on the CS only.
4. Evaluation of the EPI performance in terms of impact on water quality according to common criteria.

Task 4.4.b focuses on the SEEAW - System for Environmental-Economic Accounts for Water (UN, 2003) and its relation with EPIs concerning water quality. The SEEAW is a methodology to harmonize both physical and monetary flows into the same hybrid accounting system. It can be used successfully in producing new insights regarding the potential effects of EPIs on the aquatic system/economy of ORB (and of the mirror basins within the consortium) only if both water quantity and water quality issues are dealt together and consistently. However, the water quality-related section of the methodology is still experimental and there is less scientific consensus on it compared to the water quantity-related section. The research on the ex-ante EPI assessment will therefore develop in a context where scientific gaps exist. Two approaches are proposed in detail on following.

Indirect effects: using the SEEAW to determine whether water quantity-oriented EPIs can improve water quality

A first approach is proposed to consortium partners that have limited possibilities regarding the modelling of the fate/dispersion of nutrients within a catchment.

The idea is to investigate the complex relationship between surface water quality and quantity of water abstracted by households/agriculture. It is doubtful whether an improvement of the surface water quality would allow using (part of) this water in replacement to groundwater, thus leading to reduced groundwater abstraction. Similarly, it is unclear whether a reduction in groundwater abstraction by households and agriculture -achievable by e.g. using more efficient water-extraction technologies- would improve the water quality of either surface or groundwater.

This investigation will be performed by designing and modelling the effect of a tax on drinking water supply similar to the Danish *water supply tax*. The effectiveness of this EPI has been described in detail and reported previously at EU level (ECOTEC, 2001). The EPI was developed in a context of both water quantity and quality issues. It is therefore interesting to determine how this same tax could be applied in other member states, and if it would lead to improvements in water quality as an indirect effect. This was e.g. not observed in the case of Netherlands (See EPI case study on groundwater tax).
The Danish *water supply tax* has some weaknesses and limitations, the main being that it has too many exemptions to promote a water-use reduction in industry. An appealing approach is to design and model –e.g. for both the CS basin and a mirror catchment- a similar tax but improved by taking environmental issued more explicitly into account.

A simplified approach to the SEEAW will be implemented requiring the calculation of hybrid water accounts for water quantity partially accounting for water quality. In particular, the assessment of water quality will be limited to one specific hazardous substance or nutrient (N, P). Data on time series for pollutant concentration and emission (load) will be retrieved and scenarios modelled based on past and expected trends. The data will be coupled with the water-quantity account according to the SEEAW methodology. This should avoid the necessity for advanced and pollutant-specific dispersion/fate modelling techniques. The implementation of an EPI designed as an "improved" Danish *water supply* tax, i.e. having a direct effect on water quantity, will be modelled. The SEEAW-based hybrid account will be used to investigate whether the defined EPI can have an indirect effect also on water quality.

Direct effects: addressing quality issues related to nutrients inside the SEEAW context

The second proposal is about modelling the implementation of an EPI that addresses nutrient load, in particular in the form of a tax on nitrogen/nitrogen loss from diffuse sources and according to the methodology previously used in Andersen et al. (2011). For the ORB, we will use the modelling data available for the ORB to estimate the benefits achievable with this EPI in terms of improved water quality via reduced concentration of nitrates. The impact-pathway approach will be used to estimate the economic value of such benefits, as previously done in Andersen et al. (2011). The modelling will consider different scenarios: the baseline scenario will be defined comprising business-as-usual activities and existing policy instruments. A reference scenario will be defined for the EPI to be explored, which may eventually include adjustments in existing national level policy instruments as a policy-maker would see fit. Emitters' adjustment to modulations in EPI's will be gauged from elasticity estimates available in literature. A sector-based input-output model will be selected to estimate how the impacts of the EPI's will come through. On basis of these results it will be possible to outline an extension of the UN framework for environmental accounts which addresses the quality aspects.

The main modelling framework will be calibrated for the Odense catchment by AU, while a mirror approach is suggested for other catchments within the consortium, where similar modelling possibilities can be found (in terms of e.g. linking water quality to nutrient emissions from human sources), or where a counterfactual basin could be identified. On the basis of preliminary expressions of interest by consortium partners at the kick-off meeting the Seine-Normandie (Acteon) catchment is a likely candidate for participation in the sub-task. *(Such interest has to be confirmed and other catchments can still be individuated based on interest expressed from the consortium members.)*

Because of problems of surface water quality at regional level in Italy, UK, Germany and Netherlands/ Belgium it would be interesting to see whether any interest and capacity exist among partners to address catchments from a water quality perspective. EXIOPOL results are based on the previous FP5 project EUROHARP where nutrient modelling results are available, which would allow to tap on existing dose-response relations for several case studies (more specifically Enza catchment in Italy, Ouse in UK and Attert in Belgium for instance).

The extension activities could include checking whether data on nutrient load from agriculture are available. These should be used in the nutrient loss modelling. For additional non-EUROHARP catchments availability of leaching models with the Consortium partners need therefore be checked for the application of the mirror approach. The extension activities would result in updated estimates for the external costs of nutrients in the mirror basins.

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