2nd Joint IWRM-NET Call for Research on Integrated Water Resources Management

ESAWADI

Utilizing the **E**cosystem **S**ervices **A**pproach for **Wa**ter Framework **D**irective **I**mplementation

Synthesis Report

Work Package 5: Synthesis and policy recommendations

Final version
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The picture on the front page is a view of the Dordogne River from the Rocque-Gageac. EPIDOR© (French case study).

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Foreword

This synthesis report reflects the research study process and the results of three case studies carried out within the "Ecosystem Services Approach for Water Framework Directive Implementation" (ESAWADI) project funded through the 2nd call of the IWRM-Net Initiative[1]. The project was undertaken between July 2010 and December 2012 by a team of university researchers and private-sector consultants. The project was led by Asconit Consultants (France) in partnership with Instituto do Mar, Portugal (IMAR), seeconsult GmbH and InterSus (Germany) and Credoc (France).

The team is grateful for the support from the following funders: French Ministry of Environment, Sustainable Development and Energy, German Federal Ministry of Education and Research and Portuguese Foundation for Science and Technology.

The project methodology and findings were presented to a European Steering Committee formed of policy makers, academics from European universities, national ministry representatives and researchers from environmental institutes. We are thankful for their constructive inputs which challenged our thinking and enriched our approach. This report takes into consideration their wish to learn from the barriers and successes we encountered in implementing Ecosystem Service Assessments (ESA) and in making relevant links with the Water Framework Directive (WFD).

This report is aimed at people who are interested in applying the ecosystem services approach: scientists, policy makers, decision makers and environmental managers at national and local levels. Acknowledging the need for more aggregated information, specific conclusions and recommendations are presented for strategic policy makers and operational water managers.

One of the challenges of understanding the implementation of ESA is to find an adequate balance between the integration of all findings and the provision of detail. We have thus organized the report in such a way that the respective foci of ESAWADI on public participation and WFD on economic requirements are presented in separate chapters. Lessons learnt on ESA implementation and cross-cutting issues have been summarized in Chapter 4. We hope to minimize repetition while still allowing for a comprehensive understanding of our findings.

The report is divided into eights sections:

Executive summaries which focus on recommendations for the 1st revision of the River Basin Management Plans (RBMP), tailored to the relevant target groups, namely water managers and policy-makers.

Chapters 1 and 2 provide background information on the concept of Ecosystem Services and the methodology used.

Chapter 3 presents summaries of each case study (context, process, tools developed and conclusions).

Chapter 4 analyses the results of the case studies using the ESA's stepwise approach.

Chapters 5 and 6 focus on ESA's added value in the implementation of WFD and IWRM schemes, particularly economic analysis and participation.

Chapter 7 presents our conclusions and recommendations for the implementation of ESA in an operational context as well as proposals for further research.

Enjoy!

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[1] IWRM-net was funded by the European Commission and aimed to implement new collaborative research activities at the national and regional levels related to Integrated Water Resource Management (IWRM) with a focus on the Water Framework Directive

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The ESAWADI project team is grateful of the European Steering Committee members namely Evdokia Achilleos, Kevin Andrews, Simone Bastianoni, Melanie Bauer, Pieter W G Bots, Jos Brils, Ann-Kathrin Buchs, Marie Cugny-Seguin, Jacques Delsalle, Marie-Perrine Durot, Sarah Feuillette, Quentin Gauthier, Frédérique Martini, Claudia Pahl-Wostl, Dominique Richard, Stéphane Robichon, Robert Van der Veeren and Marcus Zisenis for the valued advice and contributions to the different versions of this final report.

We wish to acknowledge the contributions of the water managers and local stakeholders who participated in the French, German and Portuguese local case studies, as well as the many water economists who kindly provided valuable information and feedback on our approach.

The team also wishes to thank the French Ministry of Ecology, the German Federal Ministry of Education and Research and the Portuguese Foundation for Science and Technology for their financial support, without which the project could not have been undertaken.

We also extend our thanks to the OIEau for their overall coordination and support under the IWRM-net SCP project including support for disseminating and sharing our results with other IWRM-net project teams.

The Esawadi Project Team

Executive summaries

The ESAWADI project generated relevant information about the Ecosystem Services Approach (ESA) for future Water Framework Directive (WFD) implementations and revisions. Resulting recommendations for European and national policy makers, water managers and scientists are summarised in the following.

Executive Summary for European & national policy makers and water managers

Introduction

The ESAWADI project (Utilising the Ecosystem Services Approach for Water Framework Directive Implementation) has analysed the added-value of the Ecosystem Services Approach (ESA) for decision making and public participation processes supporting the implementation of the Water Framework Directive (WFD), and in particular its economic requirements. The project has built on the experiences of the first management cycle of the WFD.

The WFD is the major European policy instrument for achieving sustainable water resources management; however, at national and regional levels various other instruments exist and provide additional opportunities for implementing ESA. In the early stages of the project it was determined that it would be more fruitful to work from the perspective of sustainable integrated watershed management. Acknowledging these multi-level challenges, ESAWADI partners sought to develop their case studies to fit the local context, respond to expectations of water managers and to tap into the results of local scientific research and studies. A common analytical framework was applied for the three case studies. It allowed the development of a variety of tools and methods for implementing the ESA in order to adapt to local needs.

This executive summary is aimed at European and national policy makers, water managers and practitioners working in related fields. It summarizes the ESAWADI Synthesis Report emphasizing in particular those lessons learned that may be relevant for national and European policy as well as regional planning and management of natural resources.

At the heart of the research project was an investigation of the suitability of an approach for identifying ecosystem services and analysing their interaction with human activities in order to support the implementation of Integrated Water Resources Management (IWRM) programmes and the WFD. Furthermore, if the approach was judged to be appropriate, the study examined the types of additional benefits that ESA can contribute to (for decision-making and public participation processes as well as the economic requirements of WFD).

The synthesis report focuses on the purpose, the conditions and the means for successfully applying the ESA. The focal points are the analysis of the case study results, the ESA and economic aspects of the WFD, participation and decision-making and the main findings and recommendations. This summary reflects the structure of the synthesis report. After a brief overview of the case study approach, the main insights and lessons learned in the project are presented (thus summarising Chapter 7 of the synthesis report).

The Case Study Approach

Emphasizing the importance of "real life experience" the ESAWADI project took a case study approach with three real time but otherwise different case studies: the Dordogne River in France, the Mondego Estuary in Portugal and the Hase sub-basin in Germany. Based on a shared "Framework of Analysis" (Blancher et al., 2011), the case studies reveal differences related to scale, methodologies used and local issues focused on, summarized in Table 1.

Table 1: Summary of differences among the three case studies

	France	**Germany**	**Portugal**
Study scale	River Basin District : Adour-Garonne Sub-basin: Dordogne catchment Study focus: Middle stretch of the Dordogne River Study sub-area: 13 municipalities within that area	River Basin: Ems Sub-Basin: Hase Study sub-area: Oxbow in the Town of Bramsche, Lower Saxony	River Basin: Mondego Sub-basin: Mondego Estuary/Lower Mondego/ Mondego Study sub-area: Mondego Estuary
Local issues	Issue 1. Trade-offs between hydro-peaking and sustainable river management and effects on ES Issue 2. Effects of river mobility restoration on ES	Issue: Linear and lateral river continuity and ecological health	Issue: Sustainable integrated management of estuarine water resources

Summary of main findings and relevant lessons learned for policy makers/advisers

ESA as a concept: Integrative and not utilitarian

As a theoretical concept, the integrative character of the ESA has been acknowledged as being beneficial for supporting the WFD implementation. However, in practice, ESA should not adopt a fully utilitarian approach aiming at the maximisation of the provision of ecosystem services which this might imply. In contrast, and consistent with the WFD's stringent demands with respect to "Good Environmental State" (GES), it should feature a systemic approach to optimal ecosystem integrity protection and the sustainable provision of the various services in the long term.

During the implementation of ESAWADI, the project team promoted an ESA which was neither merely anthropocentric (focused on human benefits maximisation) nor ecosystem-centred (conservation without taking human needs into consideration). Rather it was oriented towards a sustainable co-evolution between nature and society (using a combination of scientific expertise and stakeholder consultations).

The experience of the ESAWADI team was that the principal strengths of the ESA lie in its structured and systematic approach to describing the way functioning ecosystems provide benefits to society. ESA may ensure that a comprehensive and consistent approach is used to highlight the linkages between uses and ecosystem functions, thereby identifying the full range of ES (potential or existing services), and thus facilitating the design of relevant policies. It can prevent the selection of measures with a narrow and short-term perspective (such as a measure which maximizes the benefits to one group at the expense of other stakeholders and a long-term perspective).

Characterization of ecosystem services and implementation of ESA

The comprehensiveness of the ESA approach (identification, characterisation, evaluation, etc.) has raised expectations. However, assessing all ES in a watershed presents a huge operational challenge: water managers expect that this is too complex and requires too much work. Institutional barriers such as discrepant reference scales for administration and ecosystems add to these challenges. As a consequence, it is expected that most of the ESA applications will make oversimplifications which will lead to disappointing or deceiving results. For instance, evaluations may be made at a scale which is not relevant and/or loses the river basin dimension. Given that water managers perceive their modus operandi as already being highly integrative, there is a reluctance to acknowledge the added value of ESA in comparison to other integrative management tools. From an operational perspective, the need for implementing ESA is therefore often considered to be limited.

Several water managers doubt that the quantification and even monetization of ecosystem services are feasible or would produce relevant results. Others, however, are of the opinion that ESA is not useful if it does not produce quantitative or monetary results. The ESAWADI European Steering Committee members further voiced a concern that the risks of adopting the ESA include the promotion of selected ecosystem services independently of the whole ecosystem in order to justify selective policies and land use choices. There is a lack of faith in the ability of the ESA to eventually contribute to the integration and acknowledgement of ecological values.

Although qualitative descriptions of ES bring new perspectives and acknowledgement of, for example, cultural values into stakeholder processes, actors with a financial stake were perceived in the case studies as only being open to benefits expressed in monetary terms. Still, the ESAWADI project has demonstrated in all case studies that a thorough quantification and valuation of ES, aiming at "full monetization,‟ is neither feasible nor desirable, and that if the ESA should be incorporated into WFD economic assessments, it has to be done in an alternative way, that is, in a qualitative or semi-qualitative way.

From an operational viewpoint, ESA should not be seen as a completely new approach compelling people to adopt an unfamiliar framework. The approach needs to build on existing local initiatives, plans and programmes. Any integrated planning approach has to be able to address different policies and regulations, as well as schemes originating from local to national and European bodies (WFD, Natura 2000, Flood Directive, etc.). The view of the ESWADI project team is that at a local level, ESA could create a bridge between these policies and regulations.

The implementation of ESA needs operational guidance, respecting the need for the site specificity of each social-ecological system and may thus only be a starting point. Being a process-based approach, part of the difficulties encountered while implementing the ESA may be due to typical process challenges such as a lack of clarity in the aims and objectives of the implementation of the ESA at the outset, as well as the need for adaptation of the approach to the actual context including the data situation. Since several options for simplifying the complex interactions between ecological and socio-economic river basin processes are possible, these choices need to be made with due consideration to the objectives (e.g., defining goals and priorities at a larger scale, assessing the effects of policy or measures on ES, discussing of the value of ES with the general population, etc.).

Relevance of ESA as an educational tool and means of supporting stakeholder participation in IWRM and the WFD

The potential role of ESA as a support for communication and environmental education is largely agreed upon. Water managers and other stakeholders involved in the project appreciated that ESA is a good educational and participatory tool, helping to create common ground with respect to the potential of a healthy ecosystem, benefits of ecosystems protection and restoration, awareness raising and discussions on ecological processes and the potential services that result from attaining GES.

The successful communication of ES involves building the capacity of stakeholders as well as researchers. Educational efforts have to be made to present the new approach and make the messages and concepts understandable to the general public. However, improving communication among stakeholders and with water managers requires time and a willingness of participants to talk to each other, with and without ESA. It requires thorough preparation.

The case studies have proven that ESA can be a valuable planning tool for systematically identifying all stakeholders and possible conflicts, as well as for illustrating the diverse benefits a measure could generate. In particular, water managers considered the representation of cultural ES as a true added value of the ESA. The positive essence of ESA – namely, that ecosystems provide benefits for human society – can be well communicated and discussed with stakeholders and the general public.

Relevance of ESA as a decision support tool for IWRM

As a decision support tool, water managers would expect ESA to generate "real numbers and facts" down as arguments for measures or water management objectives. This would require robust quantitative assessments, and even monetary valuation. The present perception is that ESA cannot deliver such robustness. ESA's main contribution to decision making is to provide a broad and comprehensive (ecological and socio-economic perspective) view of the issues at stake. In combination with traditional support tools (Cost-Benefit Analysis, Multi-criteria Analysis, etc.), ESA can support the production of qualitative, semi-quantitative and quantitative data through field investigations and discussions with stakeholders. Still, in most of the cases, a full and scientific quantification/monetization is not required or possible, but if attempted it should be based on sufficient technical/financial data to provide relevant results.

This adds to the scepticism that ESA is sufficiently valuable to "justify" the GES as a sustainable water management objective. In particular in human-shaped environments, the concern is that ES benefits will eventually not compete value-wise with benefits from activities such as hydroelectricity production or agriculture. Thus a significant barrier to the implementation of the ESA is that it "backfires" on the interests of water managers.

Our studies confirmed that the basic barriers for assessing the ecological/environmental benefits of policies/programmes are due to limited data availability and a lack of standardized methodologies. Uncertainty about the results generated by quantification and valuation methods is a significant barrier to the acceptance of such methods. Due to this uncertainty, the legitimacy of a decision needs to be the result of a participatory approach where stakeholders validate the options selected and trade-offs. As mentioned above, ESA is a powerful way to set the stage since it allows a systematic and thorough identification of concerned groups, and of synergies and trade-offs in terms of benefits and costs. From the perspective of WFD implementation, the harmonization of concepts and methods at a European level would be useful. But considering that the ESA concept is still more at a "storming" and "forming" stage than a "norming" one, it is more important right now to document the experimental processes.

Summarizing, it became clear that in practice from the perspective of a water management agency, the possibility of applying the ESA in a quantitative way faces a number of barriers, namely: (a) the large amount of work (and therefore the high costs) necessary for conducting ES assessments/evaluations on a larger scale; (b) limited knowledge and understanding of the concept by policy makers; and (c) limited robustness of most of the methodologies for quantifying ES, and therefore limited legitimacy of the results in supporting decision making.

Relevance of ESA for WFD economic requirements

The comprehensive economic approach of the WFD provides a particular challenge to most water managers. This is because it requires a basin wide application of economic methods which had only been applied in a select number of water management cases. At a European and national policy-making level, great expectations are placed on the ESA to better fulfil the WFD's economic requirements. For the implementation of WFD economic requirements, the ESA may act as a support tool providing qualitative insights on ES and trade-offs. ESA could play this role at the various stages of the economic analyses and at varying scales (a broad strategic approach at the river basin district level, or at the sub-basin or water body level). It is recommended by the ESAWADI project that the level of investigation and quantification be adjusted to the available resources.

In summary, the ESA can be included into the economic elements of the WFD in the following ways:

> a) Article 5 on the identification and characterisation of ecosystem services to illustrate particular socio-economic uses or specific characteristics of aquatic systems;
>
> b) Article 11 on cost-effectiveness: the ESA can be used as a kind of "second criterion" in selecting among measures in a semi-quantitative form to support cost-benefit assessments (e.g., a scoring system eliciting expert and stakeholder knowledge, or a semi-qualitative MCA for CEA or disproportionality assessments), and as purely qualitative descriptions of ecosystem services to form the framework under which analyses or surveys would be carried out;
>
> c) Article 4 on the disproportionality of costs: the ESA can be used as a second criterion to incorporate qualitative data for acquiring a broader understanding of impacts that measures would have.

To this end, it is necessary to develop tools (typology of services according the ecological and socio-economic context) and methodologies which do not aim at full monetization/quantification, but instead incorporate ES in a semi-quantitative way, or which combine quantitative and qualitative elements in one decision matrix, or improve on existing ones (such as the Leipzig Approach[2]).

EU-wide exchanges and agreement on a particular type of methodology would be highly beneficial. This should provide orientation and recommendations, as well as promote good practices, and at the same time, accommodate district level initiatives and experimentation to adjust the method to the local context.

The preparatory work to incorporate ES on a larger scale at a later stage in the implementation process should start immediately, even though it is too late for the 2nd implementation cycle. On the one hand, existing and/or new methodologies need to be adapted and improved; on the other, the knowledge base regarding ES and their linkage to human utilization of the water environment need to be strengthened. A first step could be to include a description of the ES and their importance for the water uses/services into the upcoming (2013) revision of the WFD Article 5 reports.

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[2] The "Leipzig Approach" was developed in 2008 by the University of Leipzig, the UFZ Leipzig and the Ecologic Institute, on behalf of the German federal states Northrhine-Westfalia, Thuringia and Rhineland-Palatinate. It has been applied in Rhineland-Palatinate to assess disproportionality of costs of measures.

Executive Summary for Scientists

Introduction

The ESAWADI project (Utilising the Ecosystem Services Approach for Water Framework Directive Implementation) has analysed the added-value of the Ecosystem Services Approach (ESA) for decision making and public participation processes supporting the implementation of the Water Framework Directive (WFD), and in particular its economic requirements. The project has built on the experiences of the first management cycle of the WFD.

The WFD is the major European policy instrument for achieving sustainable water resources management; however, at national and regional levels various other instruments exist and provide additional opportunities for implementing ESA. In the early stages of the project it was determined that it would be more fruitful to work from the perspective of sustainable integrated watershed management. Acknowledging these multi-level challenges, ESAWADI partners sought to develop their case studies to fit the local context, respond to expectations of water managers and to tap into the results of local scientific research and studies. A common analytical framework was applied for the three case studies. It allowed the development of a variety of tools and methods for implementing the ESA in order to adapt to local needs.

This summary is aimed in particular to those scientists who want to apply ESA in the context of water resources management.

At the heart of the research project was an investigation of the suitability of an approach for identifying ecosystem services and analysing their interaction with human activities in order to support the implementation of Integrated Water Resources Management (IWRM) programmes and the WFD. Furthermore, if the approach was judged to be appropriate, the study examined the types of additional benefits that ESA can contribute to (for decision-making and public participation processes as well as the economic requirements of WFD).

The synthesis report focuses on the purpose, the conditions and the means for successfully applying the ESA. The focal points are the analysis of the case study results, the ESA and economic aspects of the WFD, participation and decision-making and the main findings and recommendations; this summary reflecting the structure of the synthesis report. After a brief overview of the case study approach, the main insights and lessons learned in the project are presented.

The Case Study Approach

Emphasizing the importance of "real life experience" the ESAWADI project took a case study approach with three real time but otherwise different case studies: the Dordogne River in France, the Mondego Estuary in Portugal and the Hase sub-basin in Germany. Based on a shared "Framework of Analysis" (Blancher et al., 2011), the case studies revealed differences related to scale, methodologies used and local issues focused on, summarized in Table 1 below.

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Local issues	Issue 1. Trade-offs between hydro-peaking and sustainable river management and effects on ES Issue 2. Effects of river mobility restoration on ES	Issue: Linear and lateral river continuity and ecological health	Issue: Sustainable integrated management of estuarine water resources

Summary of main findings and lessons learned for scientists

ESA as a concept: Integrative and not utilitarian

Ongoing scientific debates and the continued development of the concept of ES and related concepts are a high priority within the scientific world. For the operational implementation of ESA in the context of IWRM schemes, it would be useful to translate these debates into topics for further experimentation. In this way, the richness of the concept will support fruitful local analysis and investigations whether through a detailed framework of analysis or simple educational documents that highlight the main elements of the concept.

During the implementation of ESAWADI, the project team promoted an ESA that was neither merely anthropocentric (focused on human benefits maximisation) nor ecosystem-centred (preservation/conservation without taking human needs into consideration). Rather it was oriented towards a sustainable co-evolution between nature and society (using a combination of scientific expertise and stakeholder consultations). This has been perceived as consistent with the WFD's stringent requirements for good ecological quality (GES).

The experience of the ESAWADI team was that the principal strengths of the ESA lie in its structured and systematic approach to describing the way functioning ecosystems provide benefits to society and its capacity to elicit expert and stakeholder knowledge to support planning processes and decision making in river basin management. Integrated, holistic approaches such as ESA are acknowledged as desirable approaches for an effective implementation of the WFD or other resource management objectives which include sustainability principles. ESA may ensure that a comprehensive and consistent approach is used to highlight the linkages between uses and ecosystem functions, thereby identifying the full range of ES (potential or existing services), and thus facilitating the design of relevant policies. It can prevent the selection of measures with a narrow and short-term perspective (such as a measure which maximizes the benefits to one group at the expense of other stakeholders and a long-term perspective).

Characterization of ecosystem services and implementation of ESA

As an interdisciplinary approach, it became clear that the ESA can be difficult to manage. Ecological sociological and economic methodologies are all needed, making communication of methodological requirements and common understanding challenging. When ecological processes have to be analysed at a basin scale, sociological and economic data can be better dealt with at administrative or other institutionally meaningful levels. Therefore ESA can be considered as both limiting and enabling the ES concept for the implementation of conservation and environmental measures.

Assessing all ES in a watershed presents a huge operational challenge: water managers expect that this is too complex and requires too much work. As a consequence, the assumption is that most ESA applications will make oversimplifications that will lead to disappointing or misleading results. For instance, evaluations may be made at a scale that is not relevant and/or loses the river basin dimension.

There is a lack of faith in the ability of the ESA to eventually contribute to the integration and acknowledgement of ecological values. Given that water managers perceive their modus operandi as already being highly integrative, there is a failure or reluctance to acknowledge the added value of ESA compared to other integrative management tools. From an operational perspective, the need to implement an ESA is therefore often considered to be limited.

To support ESA implementation at an operational level, there is a need for further research. This was addressed at the CIS-SPI Seminar 2011 during which "the links between geomorphological components, GES and ecosystem functioning, with both preservation and restoration perspectives" were stressed (Wallis et al, 2012, p. 12).

Relevance of ESA as an educational tool and means of supporting stakeholder participation in IWRM and the WFD

The potential role of ESA as a support for communication and environmental education is largely shared. Water managers and other stakeholders appreciated that ESA is a good educational and participatory tool, helping to create common ground with respect to the potential of a healthy ecosystem, benefits of ecosystems protection and restoration, awareness raising and discussions on ecological processes and the potential services that result from attaining GES.

According to the experience of the ESAWADI team, participatory ESA emphasizes the benefits of often unknown or unrepresented services, for instance, cultural ES. Several stakeholders stated explicitly that ES, such as heritage and quality of life, are often underestimated and could be taken into consideration. In particular, in local policy processes, stakeholders' involvement and political support can be sought by featuring these cultural ES. The case studies have proven that ESA can be a valuable planning tool for systematically identifying all stakeholders and possible conflicts, as well as for illustrating the diverse benefits a measure could generate. Combined with traditional stakeholder identification methods (e.g., who contributes to the problem? who is affected by it? who can contribute to solving it?), it allows a broader and more integrated approach. Also, due consideration has to be given to the scale issue. Namely, the number of stakeholders is contingent upon the scale of the analysis or upon the impact of a measure.

The positive essence of an ecosystem services approach – namely, that ecosystems provide benefits for human society – needs to be communicated in a way that is appreciated by stakeholders and the general public. Therefore, the primary purpose of an ESA should be to provide an accurate and comprehensive qualitative picture of the ES under consideration, supported by solid data. The relationship between benefits and ecological processes should be highlighted, as well as potential services arising from the improvement due to restoration measures. In all these analyses, the basin level dimension should not be lost.

The successful communication of ES involves building the capacity of stakeholders as well as researchers. This is also a result of a broad survey among (scientific) supporters of the ESA in the US on the barriers to a successful ESA implementation. Such efforts are fruitful and demonstrate that the ESA delivers clear added value.

Relevance of ESA as a decision support tool for IWRM

As a decision support tool, water managers would expect ESA to generate "real numbers and facts" down as arguments for measures or water management objectives. This would require robust quantitative assessments, and even monetary valuation. The present perception is that ESA cannot deliver such robustness. ESA's main contribution to decision making is to provide a broad and comprehensive (ecological and socio-economic perspective) view of the issues at stake. In combination with traditional support tools (Cost-Benefit Analysis, Multi-criteria Analysis, etc.), ESA can support the production of qualitative, semi-quantitative and quantitative data through field investigations and discussions with stakeholders. Still, in most of the cases, a full and scientific quantification/monetization is not required or possible, but if attempted it should be based on sufficient technical/financial data to provide relevant results.

With respect to ESA, the ESAWADI study has confirmed that the basic barriers to assessing the ecological/environmental benefits of policies/programmes can be attributed to limited data availability and a lack of standardized methodologies. Uncertainty surrounding the results generated by quantification and valuation methods is a significant barrier to the acceptance of such methods. As a result of this uncertainty, the legitimacy of a decision should be grounded in a participatory approach where stakeholders validate the options selected and the trade-offs.

To support ESA implementation, new valuation methods need to be developed or existing ones need to be improved (such as implementing value transfers). This also applies to tools and methodologies that allow fruitful policy-making discussions and negotiations with decision makers and other stakeholders.

In summary, it became clear in the project that in practice from the perspective of a water management agency, the possibility of applying the ESA in a quantitative way faces a number of barriers, namely: (a) the large amount of work (and therefore the high costs) necessary for conducting ES assessments/evaluations on a larger scale; (b) limited knowledge and understanding of the concept by policy makers; and (c) limited robustness of most of the methodologies for quantifying ES, and therefore limited legitimacy of the results in supporting decision making.

Relevance of ESA for WFD economic requirements

The ESA may act as a tool for supporting improvements in the implementation of the economic requirements of the WFD by providing qualitative insights on ES and identifying trade-offs. The ESA could play this role at the various stages of the economic analyses and at varying scales (a broad strategic approach at the river basin district level, or at the sub-basin or water body level). It is recommended by the ESAWADI project that the level of investigation and quantification be adjusted to the available resources.

In summary, the ESA can be included in the economic elements of the WFD in the following ways:

a) Article 5 on the identification and characterisation of ecosystem services to illustrate particular socio-economic uses or specific characteristics of aquatic systems;

b) Article 11 on cost-effectiveness: the ESA can be used as a kind of "second criterion" in selecting among measures in a semi-quantitative form to support cost-benefit assessments (e.g., a scoring system eliciting expert and stakeholder knowledge, or a semi-qualitative MCA for CEA or disproportionality assessments), and as purely qualitative descriptions of ecosystem services to form the framework under which analyses or surveys would be carried out;

c) Article 4 on the disproportionality of costs: the ESA can be used as a second criterion to incorporate qualitative data for acquiring a broader understanding of impacts that measures would have.

To this end, it is necessary to develop tools (typology of services according the ecological and socio-economic context) and methodologies that do not aim at full monetization/quantification, but instead incorporate ES in a semi-quantitative way, or which combine quantitative and qualitative elements in one decision matrix, or improve on existing ones (such as the Leipzig Approach[3]).

EU-wide exchanges and agreement on a particular type of methodology would be highly beneficial. This should provide orientation and recommendations, as well as promote good practices, and at the same time, accommodate district level initiatives and experimentation to adjust the method to the local context.

[3] The “Leipzig Approach” was developed in 2008 by the University of Leipzig, the UFZ Leipzig and the Ecologic Institute, on behalf of the German federal states Northrhine-Westfalia, Thuringia and Rhineland-Palatinate. It has been applied in Rhineland-Palatinate to assess disproportionality of costs of measures.

Abbreviations and acronyms

AWB	Artificial Water Bodies
CAP	Common Agricultural Policy
CBA	Cost Benefit Analysis
DPSIR	Driver, Pressure, State, Impact, Response
EC	European Commission
EEA	European Environment Agency
EPIDOR	French Dordogne River Basin Public Board
EQS	Ecological Quality Status
ERANET	European funding scheme for Research Activities carried out at National or Regional Level
ERC	Environmental and Resource Costs
ES	Ecosystem services
ESA	Ecosystem Services Approach
ESAWADI	Ecosystem Services Approach for Water Framework Directive Implementation
FoA	Framework of Analysis
FP6	6^{th} European Research Framework Programme
GWP	Global Water Partnership
HMWB	Heavily Modified Water Bodies
IWRM	Integrated Water Resources Management
MA	Millennium Ecosystem Assessment
MEDDTL	French Ministry of Environment
MNHN	Museum National d'Histoire Naturelle
MS	Member State
MSFD	Marine Strategy Framework Directive
ONEMA	French National Water Agency
PoM	Programme of Measures
PP	Public participation
RBM	River Basin Management
RBMP	River Basin Management Plan
SPI	Science Policy Interface
TEEB	The Economics of Ecosystems and Biodiversity study
WFD	Water Framework Directive
WISE	Water Information System for Europe

Glossary of terms

Ecological functions	Ecosystems are characterized by their biotic and abiotic components (i.e., their structure) which enable ecological functions to take place. Ecological functions are the biological processes which enable ecosystems to function and be sustained (Translated, from Bouvron et al., 2008).
Ecosystem dynamics	The processes and adjustments that take place within an ecosystem, including energy flow, nutrient cycling, and vegetation succession (Park, 2008).
Ecosystem health	The ability of an ecosystem to sustain its structure and function over time in the face of external stresses (Costanza, 1992).
Ecosystem integrity	The ability of an ecosystem to support and maintain a balanced, integrated, adaptive biologic system having the full range of elements and processes expected in the natural habitat of a region (Karr, 1996). According to Ulanowicz (2000), this concept has 4 attributes: 1) system health; 2) capacity to withstand stress; 3) undiminished 'optimal capacity'; and 4) continued ability for ongoing change and development, unconstrained by human interruptions.
Ecosystem restoration	The process of re-establishing, to as near as its natural condition as possible, the structure, function, and composition of an ecosystem (Park, 2008).
Ecosystem Services	Ecosystem Services (ES) are defined as "Ecosystem goods (e.g., food) and services (e.g., waste assimilation) that represent the benefits human populations derive, directly or indirectly, from ecosystem functions". (Costanza et al., 1997).
Ecosystem Services Approach	The Ecosystem Services Approach (ESA) explains societal dependence on nature while incorporating the assessment of the economic as well as other values of biodiversity, and supports participatory decision-making for sustainable development.
Ecosystem stability	A description of the dynamic properties of an ecosystem. An ecosystem is considered stable if it returns to its original state shortly after a perturbation (resilience), exhibits low temporal variability (constancy), or does not change dramatically in the face of a perturbation (resistance).
Ecosystem structure	The biotic and abiotic elements of an ecosystem, and the relationships between them, particularly in terms of trophic levels. (Park, 2008).
Ecological sustainability	The maintenance or restoration of the composition, structure and processes of ecosystems (Park, 2008).
Functional ecosystem	See Ecosystem integrity.
Good chemical status	Defined in terms of compliance with all the quality standards established for chemical substances at European level (WFD).)

Good quantitative status	There is only a certain amount of recharge into groundwater each year, and of this recharge, some is needed to support connected ecosystems (whether they be surface water bodies, or terrestrial systems such as wetlands). For good management, only that portion of the overall recharge not needed by the ecology can be abstracted - this is the sustainable resource, and the Water Framework Directive limits abstraction to that quantity. If this complies with Directive requirements, the status is good (WFD).
Public Participation	The WFD (Art. 14) requires the involvement of "all interested parties" during the implementation process. However, this involvement is specified only for information and consultation. Active involvement shall be encouraged but is not clearly defined.
Resilient ecosystem	A resilient ecosystem has the capacity to withstand shocks and surprises and, if damaged, to rebuild itself. In a resilient ecosystem, the process of rebuilding after disturbance promotes renewal and innovation. Without resilience, ecosystems become vulnerable to the effects of disturbance that previously could be absorbed.
Resource costs	The costs of foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g., linked to the over-abstraction of groundwater).
Social benefits	Economic and social advantages drawn by individuals, social organisations or society as a whole.
Stakeholder group	User groups or groups which have a particular interest in the river basin. Organized stakeholder groups are often considered as being more central to a successful implementation than the general public as they can potentially provide support or resistance to sustainable water resources management (e.g., for the implementation of measures.
Sustainability	A characteristic or state whereby the needs of the present and local population can be met without compromising the ability of future generations or populations in other locations to meet their needs. Strong sustainability states that human society must keep each type of capital (social, economic and natural) intact over time, and the whole stock of natural capital has to be preserved for present and future generations in the long run (Brand, 2009; Marques et al., 2009).

1 Project background

Ecosystems are used to satisfy all human needs: air, water, food, energy for warmth, materials for shelter, etc. In order to resolve conflicts between different users of the same natural resource (like a river basin) and to maintain healthy ecosystems, coordinated actions between operating and water management entities within a river basin are required. **Integrated Water Resource Management (IWRM)** offers a cross-sectional approach, a combination of bottom-up and top-down procedures for policy-making which includes knowledge from various disciplines. This participatory planning approach has, as its main goal, ensuring the sustainable management of water resources and of its protection for future generations. IWRM is one of the fundamental approaches set out by the 2000/60/EC Directive of the European parliament and the Council, referred to as the **Water Framework Directive (WFD)**. The WFD forms a common European policy framework in the water sector and seeks to define a complete mechanism for water protection in each of the Member States of the EC with the objective of achieving Good Ecological Status for surface and groundwater by 2015.

The **ESAWADI** project **(Utilising the Ecosystem Services Approach for Water Framework Directive Implementation)**, analyses and provides advice on the potential usefulness of the **Ecosystem Services Approach (ESA)** to support the implementation of the European WFD and in particular its economic requirements. It is funded through the 2nd call for research proposals of the IWRM-Net Initiative. The project started on 1st July 2010 and ended on the 31st December 2012 (2 years and 6 months).

Ecosystem Services (ES) are defined as follows:

> *"Ecosystem goods (e.g., food) and services (e.g., waste assimilation) represent the benefits human populations derive, directly or indirectly, from ecosystem functions". (Costanza, et al., 1997)*[4]

The ecosystem services concept is widely used and ecosystem services assessments have been carried out at various scales and for various purposes. The **Millennium Ecosystem Assessment (MA)** was the first global application of the ESA and was launched by the United Nations in 2001[5]. We consider the Ecosystem Services Approach a wider expression that includes Ecosystem Services Assessments (such as the MA) as well as initiatives which may identify and incorporate the existence of ES in their analysis and discussions without necessarily quantifying ES.

Ecosystem Services are basically understood as intrinsically anthropocentric. However, our perspective is neither merely anthropocentric (focused on human benefits maximization) nor ecosystem-centred (conservation without taking into consideration human needs), but oriented towards a sustainable co-evolution between nature and society. Conservation *per se* of ecosystems is an ESAWADI objective and implies taking into consideration complex, yet not well understood relationships between ecosystems and human activities. Figure 1 illustrates these complex interactions between different ecosystems/ecosystem functions and socio-economic uses, practices and values (e.g., the aesthetic value of a landscape). **Water resources policies and measures** can **regulate socio-economic uses, practices and values** so that ecosystem services and social services are optimized, and conflicts between different uses are resolved.

[4] Please refer to chapter 3 of the ESAWADI FoA for a detailed discussion of Ecosystem Services Concepts and definitions.

[5] See the ESAWADI Framework of Analysis Report for more details on ecosystem services definitions, categories and history.

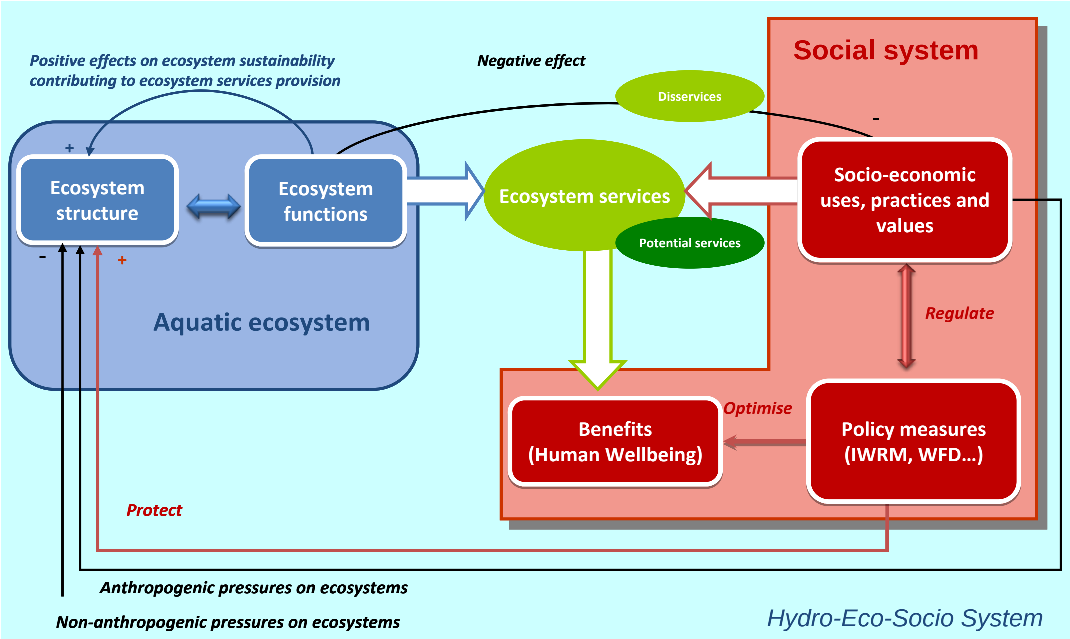

Figure 1: ESAWADI approach to Ecosystem Services

(Adapted from FoA 2011)

The project team's understanding was that in order to progress with the ESA, the project needed to experience practical as well as theoretical challenges through direct monitored implementation. Therefore, the research has been based on case studies. The following chapter presents the overall methodology while Chapter 3 presents a summary of the three case studies.

2 Methodology

2.1 Framework of Analysis

ESAWADI is based on the assumption that using ESA for policy design and implementation in the field of IWRM will allow a better integration of the ecological status of ecosystems and the impacts of healthy ecosystems on economic and social well-being, and therefore, familiarise stakeholders with the ecological issues at stake which, in turn, should improve biodiversity conservation. This is particularly relevant for WFD because of its complex objectives, concepts and methods.

The objective of the project is to assess the potential added value of the ESA for implementing WFD economic requirements, public participation and reaching good ecological status (GES). However, it became clear that the study would be better suited to a wider range of IWRM schemes.

The ESAWADI methodology included the elaboration of a common Framework of Analysis (FoA), the case study design and ESA application, and the drafting of the synthesis report including cross-site comparisons and lessons learnt for wider European application.

The key research questions elaborated in the FoA offer more insight into the way core issues were approached within the ESAWADI project (see Annex 1).

2.2 Implementation of the ESA through local case studies

Three case studies have been carried out in Portugal, France, and Germany and which applied the ESA according to the common FoA developed in the initial phase of the project. In each country, the project team worked in cooperation with regional water authorities and with respect to the different ecosystems and local water management issues at stake. Stakeholder interactions were an important part of all case studies since they allowed an assessment of the potential of the ESA as a means of communicating the more abstract concepts and objectives of the WFD.

Each CS involved an in-depth **literature review** on ecosystem services and the current state of the WFD implementation processes in the study areas as well as a **stakeholder analysis**, which formed a sound footing for the next steps. The case study teams actively involved different stakeholders in the research areas. **Expert interviews** with water managers and water economists, the agricultural sector, municipalities, and tourism and environmental organisations revealed valuable information about the challenges of implementing measures according to the WFD. **Stakeholder workshops** in the French and German case studies included the identification of ES and their assessment/ranking. Additionally, different ES indicators were weighted through a multi-criteria analysis (MCA) in the Portuguese case study.

In France and Germany, through interviews, water managers and economists in charge of carrying out the WFD economic analyses discussed the integration of economic elements into the 1st WFD planning cycle, along with the main difficulties encountered; gained insight from the 1st management cycle, and current discussions, particularly in relation with the 2nd cycle; and discussed their knowledge and experience of ESA, and feasibility and added value of introducing ESA, in relation to what was done in the different case studies but also beyond.

The case studies focused on IWRM/WFD issues that were locally relevant. The detailed case study process and outputs are presented in Chapter 3 and are summarised in the table overleaf. Below is a short summary of the topic focus in each of the three countries.

- **The French case-study** dealt with the implementation of the Programme of Measures (PoM) on the middle stretch of the Dordogne River, particularly with issues related to the physical or hydromorphological status. It was thought that, with respect to these components of good status, ESA would be useful for enhancing meaningful interaction with stakeholders and for the better implementation of WFD. The case-study was implemented in collaboration with EPIDOR (Dordogne river Public Board) and Adour-Garonne Water Agency (the river basin authority).
- **The Portuguese case study** looked at the relationship between "good ecological status" and the provision of ecosystem services in the case of the Mondego river estuary, in collaboration with the Administração da Região Hidrográfica do Centro. The CS assessed the provision capacity regarding the current water quality status and the potential social impact of different policies/measures implementation on the estuarine system through a MCA.
- **The German case study** in the Ems basin has been limited to a sub-basin level, the Hase sub-basin (the largest tributary of the Ems River). Attention was focused on the assessment of the ecological connectivity of the Hase river launched by the River Basin Commission of the Ems basin, in order to contribute practically to the discussion on potential "disproportionality of costs" as an element for justifying exemptions according to the Article 4 of the WFD in Lower Saxony.

Table 1: Cross-comparison of case studies themes and methods used

	France	Germany	Portugal
Study Scale	River Basin (RB) : Adour-Garonne Sub-basin: Dordogne catchment Study focus: Middle stretch of the Dordogne river Study sub-area: 13 towns within that area	River Basin: Ems Sub-Basin: Hase Study sub-area: Oxbow in the City of Bramsche	River Basin: Mondego Sub-basin: Mondego Estuary /Lower Mondego/ Mondego Study sub-area: Mondego Estuary
Entry point/local issues	Issue 1. Trade-offs between hydro-peaking and sustainable river management and effects on ES Issue 2. Effects of river mobility restoration on ES	Issue: Linear and lateral river continuity and ecological health	Issue: Sustainable integrated management of estuarine water resources
CS Objectives	1. The role of ESA in **IWRM decision making** Issue 1. Analysing trade-offs between hydro-electricity production and conservation 2. The role of **ESA for awareness-raising of the value of ecosystem services** Issue 2. the benefits of restoring natural river flows	1. **Identify planning measures** to improve the linear and lateral connectivity in the Hase river catchment 2. How ESA can contribute to **improving communication** with and among stakeholders related to WFD implementation 3. How ESA can contribute to the **decision-making process** concerning policies and measures that promote river continuity in the Hase river sub-basin, and in particular justification for exemptions according to Article 4 of the WFD and the **"disproportionality of costs" criterion**	1. Selecting ideal **catchment management alternative** (to improve the quality of water) using an MCA 2. To measure the **links between ecosystem status and functioning** and its ability to provide services that are valued by human society 3. To provide an **alternative to valuing** estuarine ecosystems using ES

	France	Germany	Portugal
Work undertaken	1. Description of **linkages between ecosystem processes and ES, ES concept development** (potential/effective services, disservices…) 2. Theoretical **inventory of ES** in river ecosystems (functional compartments, habitats) 3. **Assessment of ES in a specific context** (identification of potential and effective ES and uses/characterisation of uses and quantification of some indicators) 4. Detailed analysis of ecosystem structure, ES and uses linked to Hydrological Regime and Sediment dynamic processes (natural and man-managed) 5. **Assessment of changes on ES provision** (increase/decrease)	1. Local **stakeholder identification** 2. **Qualitative assessment** of ES 3. **Characterisation of relationships** between the state of ecosystems, ES provision and land-use/water-use impacts on ES 4. **Quantification** of ES where possible (indicators) 5. Assessment of value addition of ESA for **WFD implementation,** focussing on WFD-economics 6. **Participatory Action Research**: Evaluation of familiarity and usefulness of ESA by local stakeholders 7. **Interviews** with Länder representatives and members of the LAWA Working Group on Economics	1. Assessment of the Mondego estuary **ecological quality status according to WFD** 2. **Inventory of ES** based on 2005 Portugal MA 3. Assessment of **interdependency within ES** 4. **2015 Trend analysis** using DPSIR (relation between natural and anthropogenic drivers, environmental pressures, its effects on the systems' status, economic impacts and responses to be given) 5. **Economic assessment of impacts** of ecosystem status changes on human well-being 6. Appraisal and **scenario building** : Baseline scenario for assessing GES ; appraising 4 policy measure scenarios through a **MCA**
Methods/ Tools	6. Data collection, interviews, literature review based on PhD research 7. Desk study assessment of ES 8. Workshop with water managers (Issue 1) on the usefulness of the ESA for policy trade-offs 9. Workshop with local inhabitants and river users (Issue 2) to get feedback on their interpretation of linkages between ES functions, ES and uses 10. Presentation of ES concept in simple terms	1. Literature review 2. Interviews with local and regional representatives from water authorities, experts and private sector 3. Interviews with water management experts from different "hotspots" on the RB 4. Consultation workshop with local stakeholders to test usefulness of ESA for selecting appropriate management options 5. Questionnaire to workshop participants (before/after the workshop)	1. Desk study, literature review based on PhD research 2. Statistical analysis (Pearson correlation) to correlate environmental pressures and ecological assets 3. Application of the DPSIR approach 4. Contingent Valuation / Willingness to Pay for improving water quality and developing an ecotourism centre 5. Multi-Criteria Analysis using the MULINO software (multi-sector integrated and operational decision support system for the sustainable use of water resources at catchment scale) 6. Interviews with water managers and local inhabitants

2.3 ESA and WFD implementation

The three case studies tested the usefulness of ESA in relation to participation and policy making, WFD good status and WFD economics.

2.3.1 WFD economics

The case studies looked at the usefulness of the ESA in complying with the following WFD Articles: 4 (exemptions/disproportionality of costs), 9 (cost recovery), 11 (cost-effectiveness). In addition, the case studies considered the link between ESA and payments for ES schemes. The ESAWADI project team considered WFD economics issues in the case studies in order to get a "feeling" for which issues the ESA is most promising in the future. Each case study reviewed the first WFD planning cycle in terms of economic analyses, main difficulties encountered by water economists and their insights for the following WFD planning cycle. Through detailed interviews with water economists in France and Germany, it was possible to assess the "appetite" for using ecosystem services approaches in economic analyses. The results are presented in Chapter 5 as well as the respective case study reports.

Table 2: Methodologies used and results produced in the case studies regarding ESA and WFD economics

Case study	France	Portugal	Germany
Methodology /tools	• Interviews with economists from the six Water Agencies (operating at River Basin District level), Ministry of Ecology and ONEMA	• Literature review • Interviews with Hydrographic Region administrations	• Literature and document survey • Interviews with relevant policy makers (federal and Länder levels) and researchers active in WFD economics • Adjusted Leipzig Approach to assess disproportionality of costs
Results	• Review of 1st WFD cycle implementation of Economic Requirements at national level • 2nd WFD cycle implementation perspectives • Value-addition of ES for WFD implementation	• Review of the RBMP process • Definition of economic tools or methods that were applied during the 1st RBMP cycle • Assessment and evaluation of the usefulness of ESA under current water conditions and stakes	• Integration of economic elements in the first WFD planning cycle and main difficulties encountered • Insights from 1st management cycle for possible future developments • 2nd WFD cycle implementation perspectives

2.3.2 Participation and decision making

WFD acknowledged the importance of public participation in the design of relevant and efficient public policies. Nevertheless, it is often difficult to convey to stakeholders and the general public the complexity of ecosystem functioning and the issues at stake, and to convince them of the benefits of some measures (e.g., letting the river erode its banks). We tested the adequacy of the ESA as a tool to describe complex processes in relation to benefits which are valued by stakeholders and/or the general public. Through interactions at the local level (workshops, interviews and meetings), the ESAWADI team looked at the insights that ESA brought to the table regarding decisions on proposed restoration measures (e.g., oxbow restoration in Germany) and measuring the impacts of policies (e.g., regulation of hydropower sector in France) on ecosystem services provision.

2.3.3 Good status and water body characterisation

The key requirement of the WFD is to achieve good water status by 2015. Under the WFD, water bodies are characterised in terms of type of water body and quality status, on the basis of structural indicators.

In order to investigate the relationship between water bodies' characterisation according to the WFD and ES, it was necessary to investigate the relationship between GES, biodiversity and ecosystem functions, the latter being the basis of the benefits provided by ES. The common approach in the three case studies was to collect the information available and to describe this relationship. At the time of writing the FoA, it was decided that the effort expended on the investigation of this issue would be similar to that expended on the two previous research themes (see Annex 1 Key Research Questions). However, the full analysis on the discrepancy between WFD characterisation metrics (determination of GES) and ecosystem integrity is beyond the scope of ESAWADI.

Therefore, considerations on this issue were instead incorporated within Chapter 4, "Case-Study experience of ESA Implementation", and Subsection 3.3, "Analyzing the link between ecological functions, ecological status and ecosystem service provision (Task 3)". This approach leads to a broader understanding of the role of GES in relation to socio-economic benefits.

3 Summary of the three case studies

This chapter present the summaries of the three case studies carried out within the ESAWADI project. Detailed reports are available for each of the case studies.[6] The summaries give insights into the rationale for the chosen study area, process and case study main outputs. The outputs are presented in terms of analytical frameworks, appraisal tools and other scientific approaches used in the case studies. They are meant to demonstrate in practical terms how each case study adopted the ESA in order to address their local research objectives.

3.1 France: Dordogne river basin

The French case study is located on the Dordogne River catchment, in the Adour-Garonne Basin in the South-West of France. More precisely, on the middle stretch of the Dordogne River, downstream of a series of important dams, between the towns of Argentat and Limeuil (area in red on the map below).

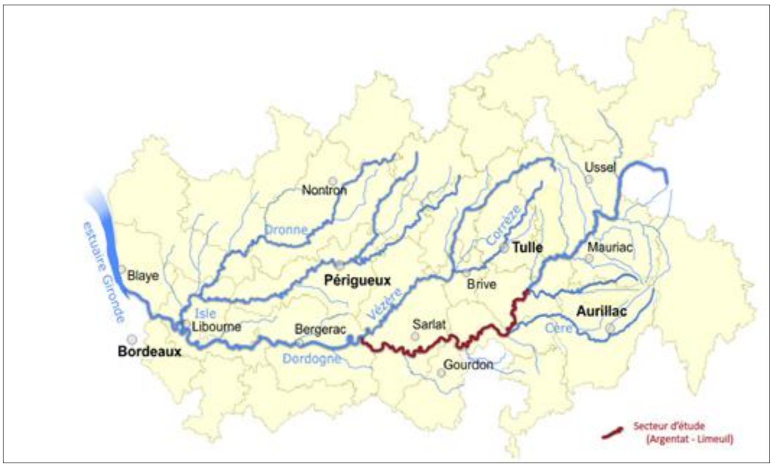

Figure 2: Map of the Dordogne River and case study scope
(Source: EPIDOR)

3.1.1 Context motivation and research questions

The choice of this site was motivated by two factors, a result of the long-time involvement of Asconit Consultants in this area: a good knowledge of the issues at stake and well established relations with local water managers. At 475km, the Dordogne River is the fifth longest river in France. The Dordogne basin cuts across five regions in the South West of France: Aquitaine, Auvergne, Limousin, Midi-Pyrénées and Poitou-Charentes and it has more than 1 million inhabitants.

The area is not densely urbanized; it is rural, agricultural and forested, and characterised by important hydro-electricity production[7] and tourism activities (water-based activities and fishing).

The natural heritage of this area is rich and conspicuous. Several Natura 2000 sites are protected under the EU Habitats and Birds Directives. An application for the recognition

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[6] Refer to www.esawadi.eu to download the case study reports.

[7] With 60 large dams barrages, 31 production units, a total power output of 1 500 MW, and able to deliver 3 100 GWh/year, the Dordogne River Basin's is one of the hydroelectric dam complexes able to fulfil peak demand.

of the Dordogne basin under the UNESCO's Man and the Biosphere (MAB) Programme has been made.

The WFD Programme of Measures fits under the 2010-2015 Adour-Garonne River Channel and Riparian Corridor Management Master Plan (known as SDAGE,[8] Schéma Directeur d'Aménagement et de Gestion des Eaux). SDAGE has a broader scope than the WFD and includes, for instance, flood risk management.

Hydro-electricity production and its hydro-peaking practices have affected the ecological and hydrological functioning of the Dordogne River. Under the WFD, hydromorphology criteria account for the ecological status assessment of water bodies (alongside biological and physico-chemical criteria); the WFD does not rate water bodies in terms of their physical status. In France, most water bodies are downgraded because of their poor physical status. Other issues include the lack of knowledge to date on understanding the science behind river dynamics and its physical evolution. Nonetheless, water managers are required to take hydromorphology into consideration in order to achieve good status.

The Regional Public Watershed Board, EPIDOR, is in charge of the assessment of the ecological, hydraulic and social impact of hydroelectric dam operations. EPIDOR is also in charge of developing a local operational "Programme of Measures" (PoM) for the Dordogne sub-basin. A number of agreements and policies have been signed between water authorities and hydropower operators in order to reduce the impact of dam operations practices on the environment and to identify trade-offs between electricity production, achieving WFD good status and the SDAGE objectives.

EPIDOR and the Adour-Garonne Water Agency, as well as field investigations, confirmed the relevance of the focus on hydromorphological issues. They expressed great expectations towards assessing the utility of ESA as a tool to link IWRM goals to local issues. Initial discussions resulted in changing the focus to current local issues related to hydro-electric dams operation and the restoration of river dynamics rather than to the way WFD had been implemented to date.

The case study aimed to test the operational contributions of the ESA in integrated water basin management as, (1) a tool for deciding on trade-offs between different policy scenarios; and (2) an educational tool to raise awareness amongst stakeholders, including residents and users, on the importance of ecosystem services and nature protection.

The case study focused on hydromorphological issues: ecological processes in undisturbed conditions, the effects of human intervention such as hydro-peaking practices and the effects of restoring sediment dynamics on ecosystem services. Although this part of the Dordogne is considered to be in GES according to WFD ecological quality criteria, it suffers from various disorders related to the impacts of hydroelectric dams. The case study was therefore an opportunity to look into the relation between ecological processes and good ecological status as per the WFD.

3.1.2 Case study process

The broad purpose of the case study was to assess the contributions of the ESA towards IWRM, both as a **decision-making tool** for elected representatives and water managers, and as an **educational tool to raise awareness** of the value of ecosystem conservation amongst stakeholders, including representatives from hydroelectric, agricultural and recreational sectors, and residents and users.

The work was organised as following:

- The identification and selection, in cooperation with EPIDOR and the Adour-Garonne Water Agency, of two current water management and protection issues, namely hydro-peaking practices and hydromorphology restoration.

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[8] The SDAGE is a public policy planning instrument introduced by the 1992 Water Act. WFD RBMP is now a component of the SDAGE which deals with other issues like floods.

- The selection and delimitation of the relevant aquatic ecosystems of the Dordogne River.
- The identification and characterization of the socio-economic uses associated with the ecosystems likely to be impacted by the measures at stake. Interviews and data collection work with the support of EPIDOR, the Water Agency and other stakeholders made it possible to conduct the study on the uses present in the area.
- Based on ongoing PhD research and previous studies, a description of the linkages between ecological processes, ecosystem services and socioeconomic uses was elaborated. A detailed inventory of ES in river ecosystems was undertaken according to functional compartments and habitats. A conceptual framework was built around the concepts of potential/effective ecosystem services, linkages between ecological processes, ecosystem structure, ES and socio-economic uses.
- The identification and characterisation of the potential and effective ES and their assessment (through physical/monetary indicators) using existing secondary data and through users or expert interviews for the following scenarios: undisturbed hydrological regime vs. hydro-peaking practices and undisturbed sediment dynamics vs. artificialisation of the river channel.
- The analysis of the effects (increase or decrease) on ES provision of a change in ecological processes and, consequently, the effects on socio-economic users, of current or planned measures in relation to the two selected issues.
- The organization of a first workshop with people living in the riparian zones along the Dordogne River to test their understanding of ES concepts and their interpretation of the linkages between structure, ES and uses to see whether it raises their awareness of environmental conservation issues.
- A second workshop for water authorities and private sector representatives to test the usefulness of the ESA for deciding on policy trade-offs.

The lessons drawn from these two workshops were used to elaborate proposals on the way the ESA could be used for the implementation of the economic analysis under WFD. These proposals were discussed with economists from the six Water Agencies, the Ministry of Ecology and ONEMA. Individual interviews (in person or by phone) were conducted with the economists in order to cover the following:

- Implementation of the WFD economic elements in the 1st cycle for each river basin district in France and in particular in the study area in the middle Dordogne.
- Discuss and compile their views on ecosystem services approaches and WFD economic elements.

3.1.3 French case study outputs

3.1.3.1 Ecosystem structure, processes, ES and uses

In order to better understand the drivers for ecosystem services provision, it is necessary to analyse ecological processes and therefore the ecosystem structure at stake. This analysis is a first step towards understanding the drivers and pressures that influence ES provision. Maps of a typical river ecosystem with different habitats and functional compartments was produced as well as detailed tables on ecosystem services and the ecological processes and habitats associated with them. Three categories of ecosystem services (regulation, provisioning and societal) were associated with three categories of components from which ES originate (respectively, ecological processes, natural resources and natural attributes, see Table 3). This work was undertaken as part of a PhD thesis on the Dordogne. See Annex 2 and 3 for a copy of the map and the detailed tables mentioned.

3.1.3.2 List of indicators for quantifying selected ecosystem services

Based on the selection of the six most relevant ecosystem services, a list of indicators was produced in order to provide an estimate of the importance of the ES in the study area. These indicators are a mix of physical and monetary indicators. As it turns out, few of these could be quantified mainly due to a lack of data relevant to the 13 towns where the study focused on.

See Annex 4 for a copy of the table on indicators.

Table 3: Linkages between ecosystem structure and processes and the categories of ES as defined in the Millennium Ecosystem Assessment 2003

Functions					ES categories (MA)
Components		**Definitions**			
Processes		Mechanisms in interaction with ecosystem characteristics and which constitute functioning ecosystem	**Categories**	Mechanical and hydrological	Regulation services
				Biogeochemical	
				Biological	
				climatic	
Structure	**Natural Resources**	Goods or products provided by ecosystems and exploitable by humans (peat, wood, aggregate, etc.)			Provisioning services
	Natural Attributes	Set of properties inherent to the structure and functioning of an ecosystem (landscape, heritage value, etc.)			Societal services

3.1.3.3 Flow charts of the causal links between policy measures and the impact on ecosystem services

The case study was designed to deal with conflicts and trade-offs in relation to two major issues for the mid-Dordogne. For each of the issues, flow charts were produced that show the links between present management or improved management scenarios and the provision of ecosystem services. Detailed flow charts were produced which explain in visual format the links between the pressures and/or policy measures and ecosystem structure, ecological processes, the provision of ecosystem services and socioeconomic uses. Tables were also produced with quantitative indicators to assess the impacts on ecosystem service provision (in physical terms mainly).

- **Issue 1: How to regulate hydropeaking in relation to ecological issues and socio-economic activities: managing water level and flow**

The "Défi Eclusée" (Hydropeaking Challenge) was signed on 28 April 2005, followed by a joint agreement between the Adour-Garonne Water Agency, EPIDOR and the French government (2008-2012). This new governance approach for hydropeaking management introduced measures for adapting to ecological constraints. Through the flow chart, the impacts of this new mode of operation on ecosystem services was assessed, along with further measures which are under consideration (increase/decrease of the corresponding ecosystem services). The assessment of the changes in the ES provision was done through expert assessment and interviews with local users. See Figure 3 on p. 15.

The flow chart was presented and discussed during a workshop attended by representatives of water managers, local authorities, local firms and other stakeholders. They discussed how the ESA concepts and flow charts led to a profound understanding of the conflict between hydropower production and ES provision and to the clarification of the choices to be made.

- **Issue 2: How to restore the river morphological dynamics**

The Master plan for the management of the mid-Dordogne river bed and banks, published in March 2012, aims to protect and restore the river dynamics. It proposes a set of recommendations for restoring the natural phenomenon of erosion and therefore sediment transport, along with the management of afforestation of alluvium and the banks, eco-morphological restoration operations and the reconstitution of morphogenic floods. The flow chart in Figure 4 (p.16) shows the effects of the suppression of morphogenic floods on the provision of ecosystem services. It was used as a presentation tool at a workshop attended by local inhabitants and river users to raise awareness of the importance of restoring natural river dynamics in support of the recent Master Plan measures.

3.1.3.4 Participatory qualitative assessment of the linkages between ecosystem services and ecological processes

In one of the workshops, the participants were asked to assess the linkages between ecosystem services and ecological processes. Four groups were formed and were tasked with assessing how ecological processes (top rows) influenced (0 not at all, * moderate, ** significant, *** very significant influence) services (in columns). The discussion within each group was documented and the results were presented and discussed in front of all the groups (see Table 4 below, when several marks appear it means that groups disagreed on the mark). More than the marks themselves, it was the discussions fostered through this process which were interesting and also the fact that each participant had to become active.

Table 4: Results from participatory assessment of the importance of given ecological processes in the provision of ecosystem services

Services	**Sediment dynamic conservation**		
	River course	**Existence of alluvium and riffle**	**Alternation of riffle and pool bars**
Landscape	***	***	**
Water for agricultural use	**	0	0
	*	*	*
Territory attractiveness	***		
Water quality conservation	***		
Favourable conditions for water sports practice	**		
	***		
Migratory fish species	***	***	***
Historical heritage, transport corridor, gastronomy	***	***	***
Biodiversity presence	**		
Water availability for drinking water supply	*		

3.1.4 French case study conclusions

With respect to the process of designing the case study, getting approval from the local water authority and securing their interest in testing the ESA was a feat in itself given that the concept was deemed difficult to explain.

The application of the ESA requires from stakeholders the understanding of the integration of complex ecological and socio-economic dimensions, thus making debates rather complicated. However, river inhabitants and users agreed that they gained a better understanding and knowledge of hydromorphological processes in the Dordogne river basin. This was largely due to the presentation efforts and the use of analogies.

During the second workshop, in which the whole process and quantification results were presented, water managers were rather confused by the approach. ESA is a new approach and further communication/presentation efforts are required, even to water management stakeholders who are intimate with the riverine area and its associated issues. Discussions with water managers showed that it was necessary to clarify the approach before they could decide whether it would be useful as a decision-making tool. The potential value-addition of ESA depends on the decision to be taken and its objectives.

The ESA is a good way to highlight and explain the GES objective. Its strengths is to make ecosystem services more visible and to put names on them, by describing them, but also by showing the complexity of ecological processes behind ecosystem services.

Quantification was perceived as a good way of providing information to decision makers; in particular on the impacts of policies/measures that can be assessed in terms of the positive or negative impacts of the provision (stock/flows) of ecosystem services. For instance, the benefits of using ESA for the protection of ecosystems occur at the cost of hydroelectricity production. Discussions with hydropower operators need to take place in order to find compromises between renewable electricity production and ecosystem protection, i.e., to find the acceptable threshold for electricity production reduction in order to reduce effects on ecosystems. It is important to highlight, however, that results from quantification should be used with caution since, depending on methods used, figures may change. It is therefore the magnitude which matters, rather than the precise number.

Upstream/downstream scale issues are very important in the river basin as they relate to different political agendas. Indeed, hydropower management relies on river flows from the upstream side, which makes the downstream areas vulnerable to the effects of management practices upstream. The choice of the study scale also had an effect on the extent of ecosystem services taken into consideration.

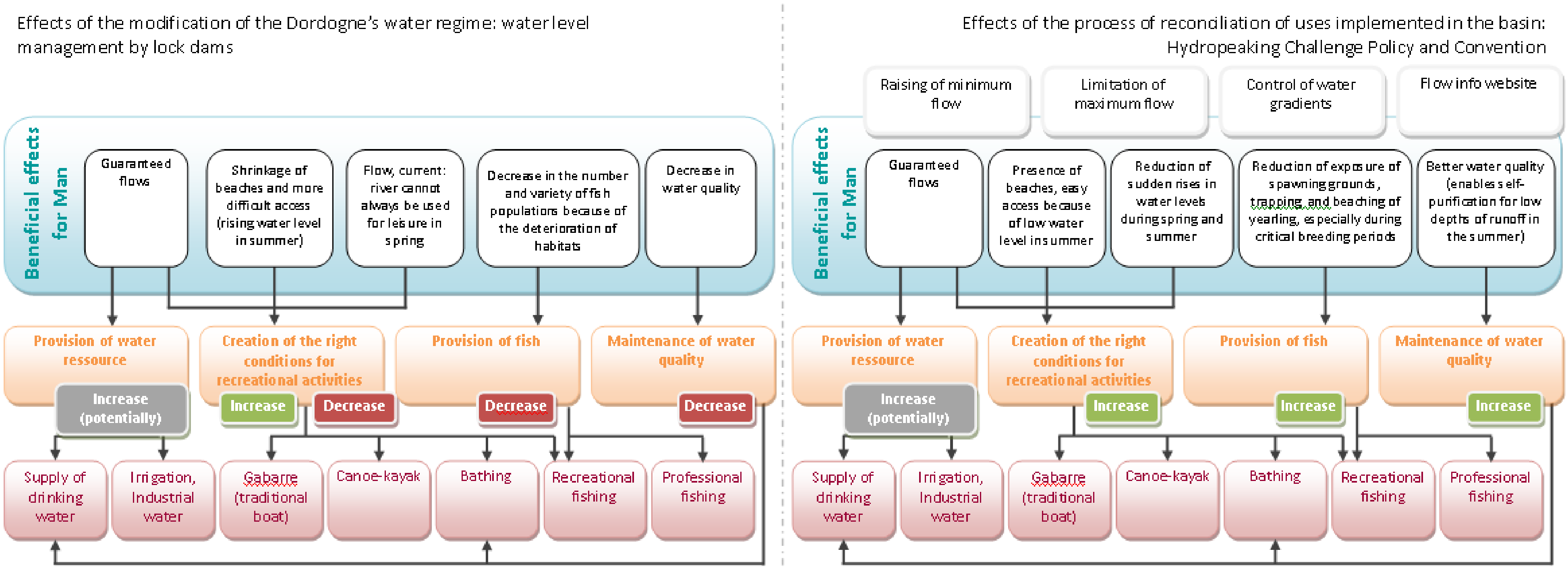

Figure 3: Impacts of modifications of hydropeaking management on ecosystem services provision

(Source: Blancher et al., 2013)

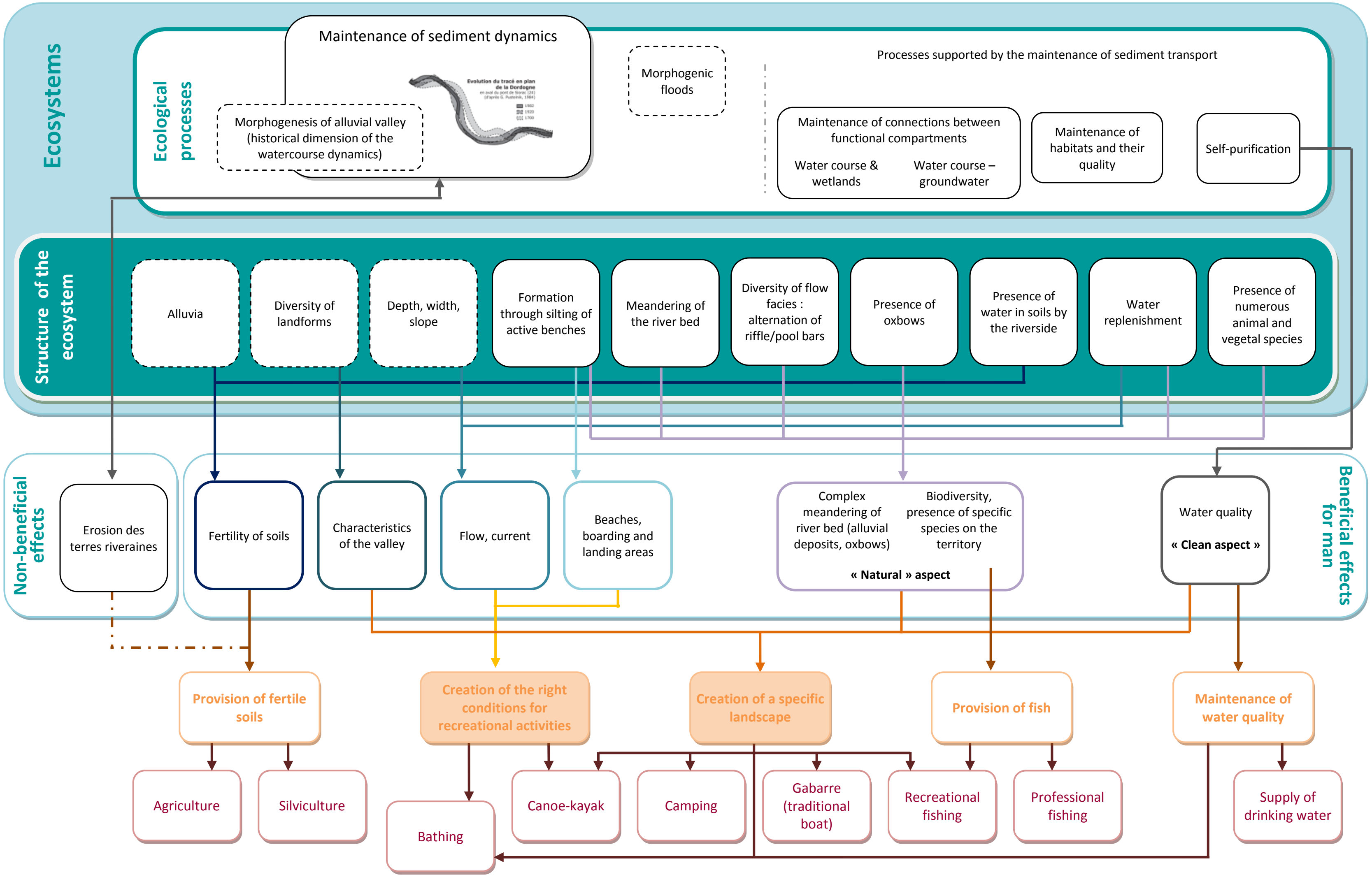

Figure 4: Impacts of modifications of sediment dynamics on ecosystem services provision

(Source: Blancher et al., 2013)

3.2 Portugal: Mondego Estuary

The main emphasis of this case study is on estuarine water quality improvements, as a crucial ecosystem service provided by the Mondego estuary. The case study focused on assessing the main pressures driving ecosystem status and the impacts on human well-being. It also estimated changes in ES provision under different responses scenarios.

3.2.1 Context motivation and research questions

The Mondego Basin is located in the centre of Portugal, representing a 6,670 km² catchment area, with an average discharge of 8.5×10^9 m³, and consisting of highly diverse characteristics in terms of hydrology, land-use and topography. The basin ranges from mountainous areas to a large alluvial plain discharging into the Atlantic Ocean (Marques et al., 2003) (Figure 5), with a population currently estimated at 885,561 inhabitants (2006 data). IMAR (Insituto do Mar, Portugal), leaders of the case study, have been working in this area for many years and have generated much scientific and socio-economic data on this ecosystem.

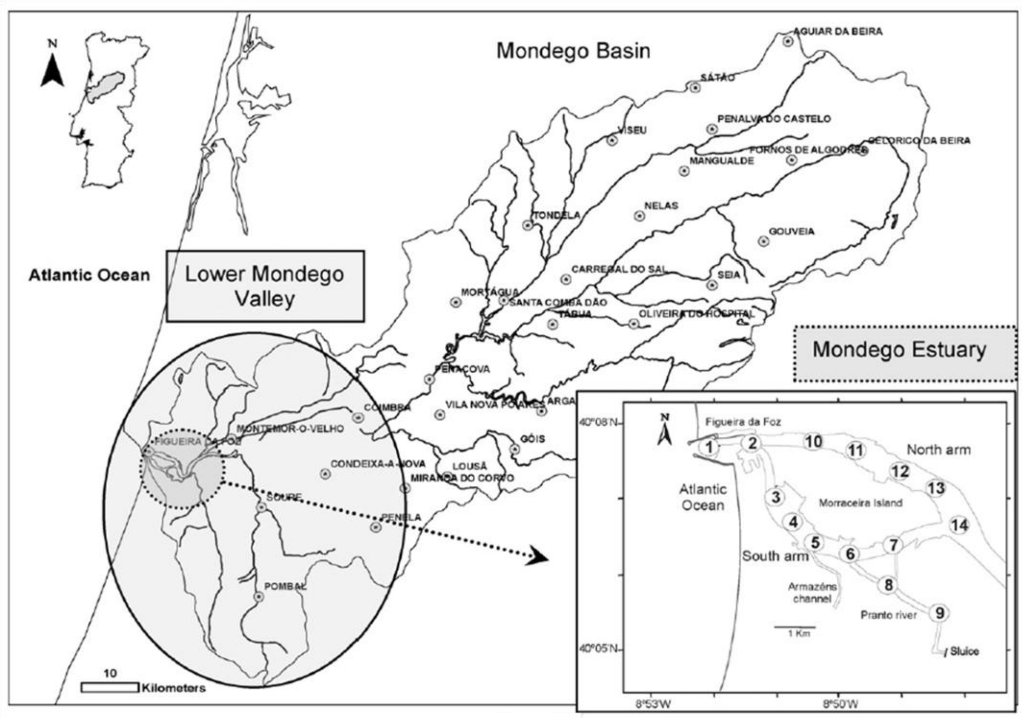

Figure 5: The Mondego Basin study area : Mondego Basin, Lower Mondego and Mondego Estuary

(Source: Pinto et al., 2010)

Overall, the whole basin is constantly under pressure. In addition to natural pressures, such as occasional flood events in winter (e.g., in 2000) or severe dry conditions during summer (e.g., in 2005), very strong anthropogenic pressures are also exerted on the system mainly due to extractive and industrial activities (wood extraction, glass, ornamental resources and beverage industries). More specifically, the fibre and leather industries dominate the economic activities in the Upper Mondego while in the Lower Mondego region (near the coastal area), the paper industry and aquaculture play the main economic role (Costa et al., 2001). Moreover, in the lower Basin of Mondego River strong pressures are evident from the agricultural sector and from the human activities in the Figueira da Foz harbour.

Based on the above, there is an urgent need to understand how the ecosystem may be better managed and which possible ecosystem services impacts should be taken into account when considering an integrated basin management. In this sense, the Mondego Estuary presented an ideal study situation with a broad scope for testing the use of the ESA while considering both ecological and economic valuation methods as part of the appraisal framework.

3.2.2 Case study process

The main objective of this case study was to evaluate the usefulness of the ESA as an operational tool to help WFD implementation. That is, to achieve good ecological status by 2015. To achieve this objective, and despite the inherent importance of the bundle of services provided by the Mondego ecosystem, water quality was considered a central element in the evaluation of the role of ESA in the WFD implementation. Therefore, the selected methodology was centred on this particular issue.

The case study focused on assessing the services provided by the Mondego estuary, in particular its capacity to provide good water quality. It analysed the links between ecosystem ecological status and functioning with its ability to provide services that are valued by human society.

The complex interactions between the socio-economic system and the ecosystem require generic but still 'tailor made' techniques to quantify all relevant variables and to provide an integrated view of the ecosystem's health status. One of the few techniques that can assist in structuring such complex data in an integrative way is the Drivers-Pressures-Status-Impacts-Responses (DPSIR) approach. In this case, the DPSIR framework was used as an analytical tool to trace changes in the transitional wetlands' structure and functions over time in relation to human uses. The main driving forces were identified and their impacts on the system functioning evaluated. The scale issue also was considered through a trend analysis of drivers and pressures carried out at successively higher geographic scales: Mondego Estuary, Lower Mondego, and Mondego Basin (Figure 5). This approach was used to assess water condition and status in the most seaward part of the Mondego River and to make inferences about the impacts of upstream activities on the estuarine region.

With this framework, some possible responses to improving the system status were formulated. In addition to those of the PoM, seven additional measures were proposed based on the available literature and expert knowledge. These measures were intended to function as a complement to the already proposed measures in the PoM and were analysed alone or in combination to see how they could work to optimize system improvement. To assess the potential social impact of these additional measures on the system, two sets of data were considered: (1) Interviews performed with local and national stakeholders; and (2) a Contingent Valuation Survey to estimate the population's awareness and Willingness to Pay (WTP) towards water quality improvements.

The knowledge generated on the system functioning was then used in a multi-criteria analysis (MCA) to select the best combination of management measures for improving ecological sustainability.

Due to delays in implementing the Directive requirements, and after preliminary discussions with water agencies responsible for the WFD implementation in Portugal (National Water Institute - INAG) and in the Mondego Basin (Hydrographic Region Administrations - HRA), it was decided that the case study would focus on the following aspects regarding the integration of the ESA into the economic elements of the WFD:

- the RBMP process in Portugal.
- the definition of economic tools or methods that could be applied given the non-exhaustive data set available.

- the assessment and evaluation of the usefulness of ESA under current water conditions and stakes.

Despite the delays in WFD implementation, a link was partly made through one measure of the PoM, namely the connectivity improvement measured in the MCA.

3.2.3 Portuguese case study outputs

This CS produced outputs relating to (1) the linkages between different ecosystem services; (2) the linkages between GES and ES provision; (3) forecasting impacts on ecosystem services and GES using the DPSIR approach; (4) valuing water quality through contingent valuation methods; and (5) selecting the best alternative between water management measures using a MCA.

3.2.3.1 Schematising linkages between ecosystem services

A preliminary **assessment of the ES** provided by the Mondego Basin was carried out in order to assess ecological quality and the WFD objective. The ecological, economic, and societal characteristics of the Mondego estuarine area were analysed, followed by an inventory of the main ecosystem services provided by the Mondego system. From this, three services were considered to be most important (food production, recreation and water quality maintenance). The next steps involved the **assessment of ES interdependency** (see Figure 6 below) and an **ecological assessment regarding water quality** and ecological conditions of the system.

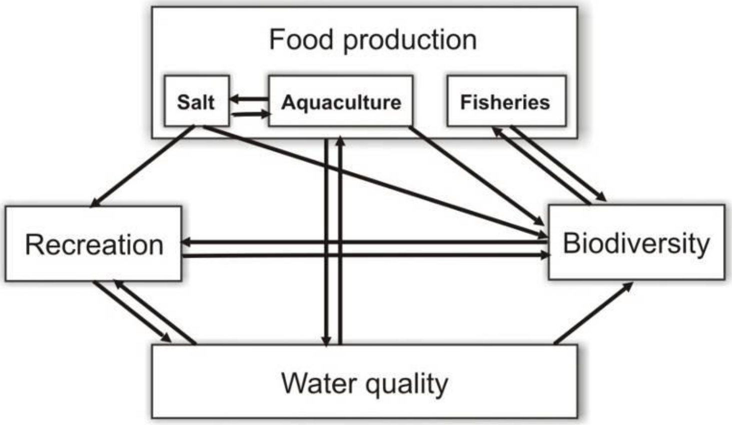

Figure 6: Inter-relations between different services in the Mondego Estuary

A trend analysis of the pressures (economic activities such as tourism, aquaculture, etc.) showed an increase in recreational activities and water uses and a simultaneous decrease in services such as food production as well as a strong interdependence among services. In light of these findings, ecological quality improvement is reflected in both local aquatic fauna/flora diversity and water quality.

3.2.3.2 Good Ecological Status and ESA

A conceptual framework was proposed for the Mondego Estuary to address the relative effects that biodiversity assets may have on the provision of ecosystem services in highly valued socio-economic and environmentally dynamic ecosystems, such as estuaries. Through the application of this framework, a quantitative and qualitative assessment of the relationships between ecological quality and ecosystem services provision was undertaken, aiming to achieve better guidelines for potential management actions in estuaries. A three-step approach was applied, trying to estimate the links that underpin the relationship between biodiversity, ecosystem functioning, ecosystem services and human well-being.

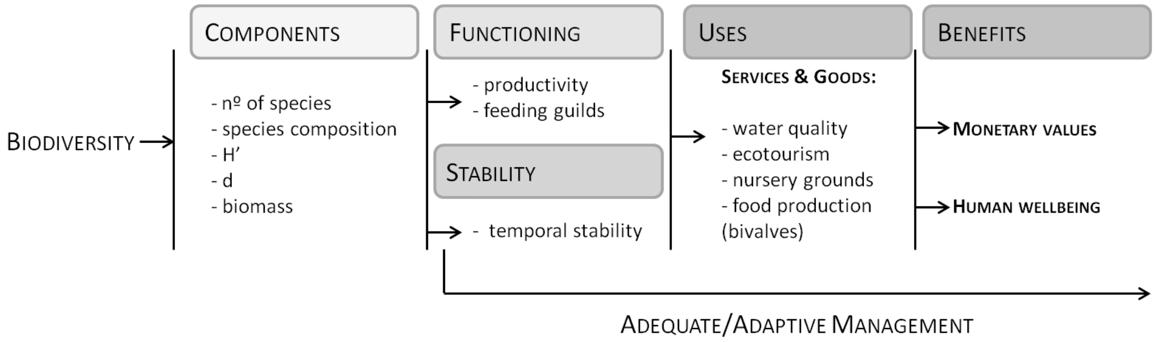

Figure 7: Conceptual framework : biodiversity assets and provision of ecosystem services

The results of the work show that linkages between biodiversity, ecosystem functioning and ecosystem services provision for human well-being are neither straightforward nor universal. Although the connections between ecosystem properties and ecosystem services are not always linear casual paths (Carpenter et al., 2009; Pinto et al., 2011), many changes in ecosystem services provision can be quantified by using variation in ecosystem properties recorded by routine measurements.

3.2.3.3 Using DPSIR to forecast impacts on ecosystem services provision and achieving good ecological status by 2015

Through the DPSIR application to the Mondego catchment area, the main environmental changes in ecosystem services provision in the Mondego estuary were outlined, and their causes and effects described. Within the Mondego Basin region the main water consumers are agriculture, industry and households. Baseline scenarios (i.e., "2015 scenario" if no changes are made to current management measures of the estuary) predict an increase in water usage, mainly by the tourism service sector. This analysis illustrates that pressures caused by human population growth and related activities have gradually increased over the studied period (1992 to 2006). Land-use patterns, diversion of freshwater flows, water pollution and morphological interventions directly resulted in physical, chemical, and biological modifications and degradation. Consequently, this led to negative ecological and socioeconomic impacts, such as eutrophication.

Table 5: Baseline 2015 scenario for the Mondego Estuary, following the 2006 observed data and posterior trends considering selected indicators of natural and anthropogenic drivers

Drivers		Selected indicator	1994 data	2006 data	Trends (%/year)	2015 scenario
Natural	Natural					
	Invasive species[3]					
	Extreme events[3]					
	Floods					
	Drought					
Anthropogenic	Social					
	Population	Area (ha)	661.7[c]	1773.9[d]	7.9	6110.4
		Total population (n°)	61 830	63 372	0.16	64 386
		Population density (hab/Km^2)	163	167	0.17	170.04
		Households number (n°)	22 976	42 685	0.48	44 734
		GDP per capita	95.2	99.3	1.10	110.2
	Economic					
	Agriculture	Area (ha)[a]	272 107.7[c]	124 917.2[d]	−5.2	12 491.7
		Employment (n°)[b]	330 955	114 528	−7.27	31 266
		Explorations (n°)[b]	128 119	96 253	−2.77	69 591
		Output (t)[b]	925 227	875 781	−0.59	824 110
	Industry	Enterprises (n°)	7625	6714	−1.32	5828
		Employment (n°)	11 500	19 895	8.1	36 009.9
		Output (1000 €)	1 029 000	2 041 247	10.9	4 266 206.2
	Salt-works	Area (ha)	137	33	−8.4	5.28
		Units (n°)	83	15	−9.1	1.35
		Production (t/year)	1511	870	−4.7	461.1
	Tourism	Lodging capacity (n°)	2339	1499	−3.6	959
		Output (1000 €)	3271	6 849 000	10.9	14 314 410
	Fisheries	Employment (n°)	737	560	−1.7	465
		Fishing boats (n°)	319	211	−2.4	160
	Commercial harbour	Traffic (entrance n°)	269	363	7.0	617
	Ecological					
	Water extraction	Water volume (Hm^3)	4910	4877	−0.1	4828
	Wastewater	Drainage (Hm^3)	1586	2620	7.2	4506
		Treated (Hm^3)	0.539	2474	39.9	12 345

[a] For the Mondego Estuary only.
[b] Trends for the Centre region.
[c] 1990 data.
[d] 2000 data.

The 2015 scenario ("do nothing approach", based on previous trend analysis) suggests an increased pressure based on an expected 8% annual population growth and an average annual decreased pressure of 5.2% due to the current reduction in agriculture. The results show that understanding the water use-related complex and intricate trade-offs among ecological, social, and economic goals is fundamental in designing and implementing management policies and ecosystems restoration schemes.

3.2.3.4 Valuing water quality through contingent valuation

From the stakeholder's consultation it was possible to see that concepts, such as the Polluter Payer Principle (PPP), are considered as fundamental by some stakeholders for achieving good environmental quality for the case study area. A WTP survey was carried out asking respondents how much they would be ready to pay to improve the ecosystem water quality in the Mondego Estuary. The results indicate a WTP of around 30€/year per household to achieve both a very good water quality status and to promote the development of an ecotourism centre that could enhance recreational activities in that region. Somewhat lower values were obtained to achieve a good water status (around 10€/year) or very good water quality levels (circa 20€/year) according to the WFD standards. Our findings show that both use and non-use values are reflected in respondents´ WTP, showing: (1) a strong relation between socio-economic respondents´ profile (e.g., income, education or number of household members) and WTP for environmental quality improvements; (2) the respondents residence distance to the surveyed the system being evaluate and usage of the system had a significant influence on respondents´ WTP; and (3) a substantial positive social awareness towards environmental improvements. This information was used in the MCA described below.

3.2.3.5 Using a Multi-criteria Analysis to select the best combination of water management measures

MCA is a stepwise process that allows the choice of decision alternatives with multiple and often complex impacts. The information used in this approach is often structured using a software tool, one which aims to record alternatives, while measuring and assessing the impacts of the proposed alternatives (Hermann et al., 2007). The MCA MULINO software[9] was developed within the European water policy context, specifically to address WFD requirements. In this case study, the MULINO tool was chosen mainly because it allows designing and implementing an operational decision support system for the management of water resources that is based on hydrologic modelling, multi-disciplinary (qualitative and quantitative) indicators and a multi-criteria evaluation procedure. Moreover, the MULINO tool relies on the DPSIR framework, which was the approach chosen to evaluate the main drivers and pressures acting on the Mondego Estuary case study. The objective was to test how the MULINO worked on different ecosystem services improvements scenarios. See Annex 5 for a detailed description of how MULINO works.

The case study identified 8 measures from the RBMP and from expert advice: (1) buffer zone creation; (2) changes in agricultural practices; (3) increasing of the connectivity between the two estuarine arms; (4) promotion of eco-tourism activities; (5). and (6) construction of waste water treatment plants with or without associated macrophytes buffer zones; (7) creation of a local trade-mark produce and; (8) pollution retention by bi-valves. Three types of criteria were adopted for these measures (investment costs, socio/ecological/economic effectiveness and risk exposure). By including cost, effectiveness and risks, the MULINO tool will provide a broader analysis than the usual cost-effectiveness calculations of the WFD. To assess the effectiveness of the measures, the case study team looked at the impacts on four different bundles of ecosystem services (water quality, selection of five ES, only indirect ES, and only direct ES).

Based on 2 decision rules selected in the software (SAW and TOPSIS), the software produced the following results:

Table 6: MCA results for the best combination of water management measures using the softwares SAW and TOPSIS

Alternatives		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
SAW	Water Quality	112	77	152	40	187	111	76	19	46	115
	5 services	187	152	115	112	231	80	210	188	77	151
	Indirect services	187	111	152	115	42	112	76	77	80	210
	Direct services	112	152	187	77	115	151	80	210	231	188
TOPSIS	Water Quality	247	242	246	235	240	215	233	194	241	216
	5 services	247	242	246	235	240	215	233	194	241	216
	Indirect services	247	242	246	235	240	215	233	194	241	216
	Direct services	247	242	246	235	240	215	233	194	241	216

- Alternative 112 (combination of buffer zones, eco-tourism enhancement, wastewater treatment plants development, and bivalves bio-control) was ranked as the most attractive option by the SAW method for the water quality and direct services enhancement.
- When considering the 5 services together or the indirect services, alternative 187 (previous measures plus the Murraceira trade-mark) maximize the services provision.
- With the TOPSIS calculation method, the optimal solution is the alternative 247 (combination of buffer zones, 'green agriculture', connectivity increase, eco-

9 Multi-sectoral, integrated and operational decision support system for the sustainable use of water resources at the catchment scale; http://siti.feem.it/mulino/mulino.htm

tourism enhancement, wastewater treatment plants development, wastewater treatment plants development with associated macrophytes, Murraceira trade-mark, and bivalves bio-control).

This analysis only used weights provided by one stakeholder group; however, the MCA could also be based on weights for the criteria chosen as part of a consensus between stakeholders. This could, indeed, be an important path to follow for future research. Based on the achieved outcomes, these could be presented to stakeholders and adjusted to the social, ecological and economic needs of the region, thus enhancing the multi-level governance of natural resources.

MCA is mainly used in situations where a broad range of ecological services in a multidimensional and community-based watershed approach has to be evaluated (Prato, 1999), which is essentially what is to be anticipated during the WFD implementation. In this sense, the MCA can be regarded as a complement to the economic approaches, explicitly dealing with multiple criteria but avoiding the need to attribute a monetary value to all environmental factors. Having said this, the outcomes from this study can provide some insights into the economic analysis when examining the possible trade-offs and synergies between the criteria/objectives aimed of each decision maker or stakeholders. This way, MCA, and more specifically the MULINO application to the Mondego Estuary, can be regarded as a helpful tool for water authorities to choose the more adequate programme of measures for a river basin.

3.2.4 Portuguese case study conclusions

The ES (e)valuation can be considered a useful tool to complement the water uses and services assessment of a basin in terms of economic importance and ecological role in a system' integrity. ESA can, therefore, improve our understanding of the connection between water bodies' status and pressures assessment. However, to accurately analyse and evaluate a system, it is important to consider integrative studies combining the complex interactions between the socioeconomic system and the ecosystem (as part of the 'integral system'), thus requiring generic but still 'tailor made' techniques to quantify all relevant variables and to provide an integral view of the system's status.

Therefore, the ecosystem services concept could be used to:

- Provide a qualitative and (ideally) quantitative assessment of the importance and value of water resources within a watershed to populations.
- To link the main uses present in the basin with the services they depend on.
- To drawn attention to specific uses and to the potential of other unexploited uses of these systems (e.g., eco-tourism development).

Although ESA does not constitute a novel concept (it has been in use for more than a decade), the present work proposed a way of making it operational regarding its use as an 'added-value' for environmental managers and decision makers. In the face of distinct ecological and socio-economic realities, the proposed approach aims at being used to provide guidelines regarding the sustainable use of estuarine ecosystems resources.

The integrative nature of the ESA allows the assessment of the benefits of ES, thus allowing the choice of measures that may be more costly, but that may have a more important global effect (see MCA) and which may or may not better integrate the users and local stakeholders' preferences reflected in the services assessment.

Six recommendations listed in this case study should be interpreted as suggestions for improving the management and conservation of coastal ecosystems. The emphasis is on estuaries (transitional waters in the WFD sense), using social and economic tools as an added value in optimising ecosystems' quality and functioning. Suggestions are generic, in order to facilitate their application to the management of a wide set of systems, and requiring adaptation when applied to specific sites:

1. *Explicit definition of the ecosystem services' assessment spatial scale:*

   Define clearly the system's ecological condition (e.g., biodiversity indicators or water quality parameters), provision capacity (e.g., thresholds) and catchment area uses (direct or indirect activities that may depend on or influence its condition), and assess the main drivers, pressures and impacts that are essential for measuring, valuing and managing natural resources.

2. *Use of spatial models and analytical tools:*

   Development of spatial models (e.g., catchment area models that integrate water environmental conditions, but also the activities and pressures occurring in the surroundings) may represent an additional advantage in the improvement of a systems' management.

3. *Take advantage of multi-disciplinary knowledge:*

   ESA involves the accurate and precise evaluation (qualitative, quantitative and monetary) of the ecological, economic and social potential of natural resources. A social-ecological framework, complemented by monetary valuations, should therefore be developed and applied to each case study ecosystem, capturing its monetary and non-monetary values.

4. *Understand how an ecosystem works and behaves under perturbation:*

   Research efforts are needed on more integrative studies, namely with regard to:

   - Measuring changes in biodiversity and in services provision.
   - Relating clearly a given ecological quality status to a specific level of services provision in an ecosystem, to serve as a basis for economic valuation.

5. *Be aware of the societal dependence on nature – giving special focus to the relationship between ecological rationality and biodiversity assets:*

   Accurate estimations are necessary to understand the intensity and amplitude of the links between biodiversity, ecosystem functioning and human well-being. This three-fold relation will finally determine the system condition, present uses, and its evenness for future generations. In this sense, it is necessary to adopt a clear methodology in order to guarantee an accurate e(valuation) of the system.

6. *Utilise the ESA as an 'added-value' for decision making:*

   Economic and social assessments can play a useful role in managing ecosystems since they allow the estimating of market and non-market values (benefits and costs) of natural resources. Such assessments may be combined with an efficient communication (stressing both the merits and shortcomings), and complemented by MCA (aiming at framing and systematising alternative outcomes), to assist decision making towards a more sustainable use of systems.

3.3 Germany: Ems river basin / Hase river sub-basin

The German case study focused on river continuity and ecological health in the Hase river sub-basin (the largest tributary of Ems river). It aimed to identify how the ESA could contribute to the decision-making process concerning policies and measures that promote river continuity in the Hase river sub-basin and, in particular, justification for exemptions according to Article 4 of the WFD and the "disproportionality of costs" criterion. The Ministry of Environment and Climate Protection of Lower Saxony and the regional water agency, NLWKN Meppen, were involved in the CS design and implementation.

3.3.1 Context motivation and research questions

The Ems River was chosen as the German case study in cooperation with the Ministry for Environment, Energy and Climate Protection of Lower Saxony. The selection was motivated by several factors, including the fact that the implementation of measures for meeting the environmental objectives of the WFD was lagging behind in the River Basin District (RBD), and new approaches for stakeholder communication were necessary. This was particularly the case at the local and regional scale. A further factor was the high amount of exemptions according to Art. 4 WFD reported in the Ems RBD. The Ems RBD therefore seemed well suited to analysing the possible connection between the ESA and the economic elements of the WFD, especially for the "disproportionality of cost" criterion to justify exemptions.

One of the central water management issues throughout Germany is the extensive changes in the hydromorphology of rivers, and the associated impacts on fish migration. The Ems RBMP identifies hydromorphological modifications as one of the main pressures on the aquatic ecosystems.[10] Therefore, the ESAWADI case study focused on hydromorphology, and more precisely on river continuity and ecological health.

The Ems river basin covers parts of North Rhine Westphalia, Lower Saxony and of the province of Groningen (Netherlands) and discharges into the Wadden Sea, part of the North Sea (see Figure 8).

Figure 8: Map of the Ems River

The river basin covers approximately 18.000 km², of which 13% is located on the Dutch side and 84% on the German side. The remaining 3% is the Ems-Dollard estuary, an international working area.

To test if the ESA is potentially useful for supporting the implementation of the WFD, the study area has been limited to a sub-basin level, the Hase sub-basin. The Hase river flows through western Lower Saxony, Germany. The longest tributary of the Ems river (168 km), it originates in Wellingholzhausen (see Figure 9) near the Teutoburg Forest. It then flows north-east through the city of Osnabrück, into the Ems river at Meppen (see figure 10).

[10] Flußgebietsgemeinschaft Ems 2009: Internationaler Bewirtschaftungsplan nach Artikel 13 Wasserrahmenrichtlinie für die Flussgebietseinheit Ems. www.ems-eems.de. Furthermore, ONEMA is currently doing a study on social and political bottlenecks of hydromorphological restoration: a comparison of several case studies in Europe, where the Ems is one of the case studies.

Figure 9: Headwaters of the Hase.

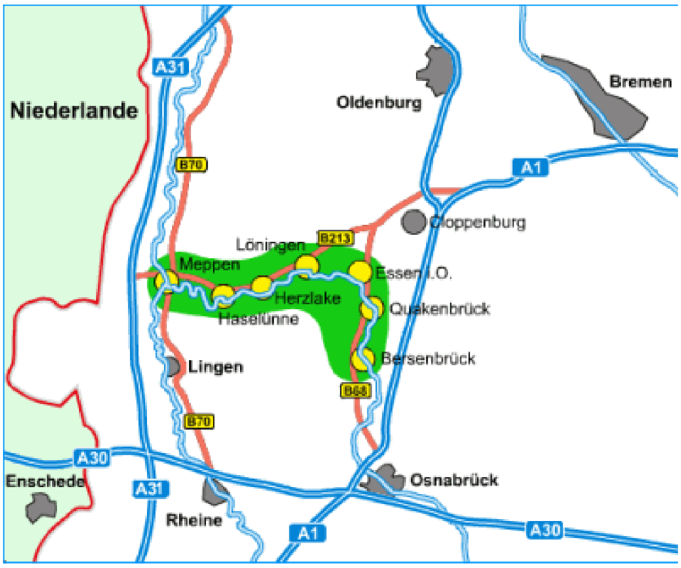

Figure 10: Map of the Hase River Basin

The surrounding landscape consists of alluvial pasture landscapes with a rich biodiversity (Stroh et. al., 2005). Ecologically, the river is home to about 30 species of fish, a few of which include eel, dace, roach, perch and brown trout. The restoration of the ecological connectivity in the Hase River is essential in order to establish an ecologically functioning waterway.

The German case study has been linked closely to the ongoing implementation processes of the WFD, in particular addressing the barriers to implementing river restoration measures in the area. In Annex 1, the research questions drawn from the ESAWADI FoA are listed according to the three major aspects of the case studies that have been investigated. The German CS mainly investigated how ESA can contribute to improving communication with and among stakeholders and in decision making related to WFD implementation. Furthermore, it assessed the extent to which the ESA can be helpful in implementing the economic elements of the WFD, using the "disproportionality of costs" criterion as an example for the analysis. To this end, an existing methodology incorporating the ESA has been adjusted and applied (for more details, see German CS report sections 3.2.3 and 7).

The following chapter describes how the research questions were approached.

3.3.2 Case study process

A qualitative assessment was carried out through a literature review and interviews with local and regional representatives from water authorities (municipalities, water associations) and other stakeholders (tourism, agriculture, nature protection), which assesses the usefulness of the ESA in implementing measures according to the WFD.

Through interviews with experts, mainly from the local water authorities (municipalities, water associations), relevant existing ecosystem services and potential services in the study area were identified. Starting with "hotspots", the diversity of ES within the sub-basin was identified. In other words, whether different locations provide different services was investigated. The existing services in the area were identified, including those services that could be restored and their manner of their restoration. Furthermore, the recipients of benefits of well-being (security, health, basic material, social relations, freedom of choice and action) were identified along with the drivers of change that might affect the provision or potential provision of services in the region.

Together with the experts, it was assessed (1) whether different kinds of measures would have an impact on the provision of ES; (2) which stakeholders are possibly affected by the measures and the anticipated change in ES provision; and, (3) what kind of conflicts can be foreseen. Conflicts refer to trade-offs which arise between the improvement of linear and lateral connectivity and extracted benefits from ES (e.g. cultural, industrial) or between different beneficiaries using the same ES (e.g. groundwater for industry and agriculture). Indicators were assigned to each ES and, where data was easily accessible, quantification was performed (e.g., for water provision services, tourism and recreation services).

The results of the interviews and the literature review were discussed with local stakeholders in a consultation workshop in Osnabrück at the beginning of June 2012. Results of the assessment of ES were presented, discussed and improved. It was tested whether the ESA facilitates the selection among various management options. The ESA was evaluated by the workshop participants for its potential for adding value to the WFD implementation on the regional or local level. In two questionnaires, one before and one after the workshop, participants were asked about their familiarity with the ESA (on a scale from 1, very much, to 4, not at all) and if they could imagine applying the approach in their daily work and, if so, how, and if not, why not.

For the analysis of the economic requirements, the main economic elements of the WFD as identified in the FoA were thoroughly examined. The focus here was on the principal questions listed in the FoA, as well as:

- The integration of economic elements into the 1st WFD planning cycle.
- The main difficulties encountered.
- Insights gained in the 1st management cycle, and current discussions.

These points were examined in a thorough literature and document survey, focusing on RBD planning documents, such as the RBMP, Programme of Measures (PoM) and attached documents. In addition, several interviews were conducted with the relevant policy makers (both of the federal as well as the "Länder"-level) and researchers active in the "WFD economics" field, to gain insights into the current status of the implementation of the economic elements as well as a sense of possible future developments.

3.3.3 German case study outputs

Implementing the ESA is resource intensive. As with all integrated approaches to water resources management, it is challenged by the unknown impacts of measures – in kind, magnitude and scale - and a lack of data. However, as a concept it provides an entry point for local data and stakeholder expertise. The German case study has shown how and where ESA may still provide support to protect and enhance healthy river ecosystems.

The German CS adopted a Participatory Action Research approach. The outputs presented below result from a workshop and discussions with experts and local stakeholders.

3.3.3.1 Qualitative assessment of ES through expert advice

Experts in the field of water management, education, agriculture and tourism assessed ES qualitatively through standardised interviews and a table listing the ES. Not only the existing relevance of each ES but also the *potential improvement* of ES in the Hase sub-basin were assessed. The questionnaire contained the following items, among others:

- How important is each ES on a scale from 1 (not important) to 4 (very important)?
- Which actor groups are affected by the respective ES?
- Which ES could perform better if the linear and lateral connectivity was improved by 100% in the Hase river? And how big would the effect be on these ES on a scale from 0 (no improvement) to 5 (significant improvement)?

The table below provides an example of the results.

Table 7: Selection of the results of the qualitative assessment of ES in the German case study

Description of relevance (according to experts)	Stakeholders	Indicators / Quantification	Rating of existing relevance (1-4)	Rating of potential improvement (0-5)
Provisioning Service: Fish (trout aquaculture)				
• Leisure activity • Vocational activity • benefits: economy and health	• trout breeder	• number of people doing trout aquaculture p.a., • Water for aquaculture (m^3 p.a.)	1,3	**5**
Regulating Service: Water runoff				
• retention areas / connected floodplains, reduced flood damage • Water regulation • benefits: safety, economy	• municipalities • people doing leisure activities, • NLWKN, agriculture, property owner, maintenance associations	• flood area (m^2), • costs of potential flood damage • (agriculture, buildings),(de-) watering costs	**3,9**	**4**
Cultural Service : Tourism				
• hotel industry, catering • benefits health, economy	• municipalities, tourism associations, angling association, • hotels / gastronomy, renting agencies (canoe, bicycles, boats)	• no of guest/nights (2006: 125 000)*, • business turnover (2006: 9,4 million)**, • no. of tourists (2006: 162 000)	**3,6**	2

*Härtling J. and Meyer I. (2006). Die wirtschaftliche Bedeutung im Erholungsgebiet Hasetal. Endbericht.

** Turnover generated by all businesses which are members of the Association for the Recreation Area of the Hase Valley (e.g., businesses that offer overnight stay, services like renting and gastronomy)

Experts had a similar assessment of the ES as presented. The exception was the importance of genetic resources, where opinions diverged considerably. For many stakeholders, it was difficult to imagine the importance of the present's biodiversity for the future and therefore the consideration of genetic resources is less important (on average: 2,5). Some interview partners saw a potentially significant improvement either in the ES fish (5) or genetic resources (5). Others were of the opinion that "the Hase River is not the Amazon", thus genetic resources were classified as not important (1).

With respect to the regulating ES, it was mentioned that floodplains are perceived as being highly relevant. However, conflicts arise when agricultural land needs to be purchased in order to restore wetlands and enhance lateral connectivity. Land availability is a common and fundamental source of conflict between farmers and authorities or environmental organisations when WFD measures are planned in the Hase sub-basin.

All experts perceived the existing cultural ES as being important and also saw options for improvement. A conflict was perceived in the trade-off between more tourists along the Hase river and their pressure on the ecosystems. Therefore, it is important to channel the stream of visitors and to install educational trails in order to make people aware of the diverse services healthy ecosystems provide for humans.

The results of the interviews and the literature analysis were discussed with local stakeholder in a consultation workshop in Osnabrück. In summary, the advantages of the ESA are perceived in the:

- Identification of involved stakeholders and communication partners. Identification of groups affected (positively or negatively) by the measure implemented, i.e., the groups depending on specific ES. Identification of more (e.g., cultural) benefits compared to common approach. Illustration of the complex system affected by the measure implemented.
- Communication with decision makers. Communication of the benefits other than the monetary (e.g., spiritual benefits, inspiration).

Scepticism was shown with regard to the applicability of the ESA:

- ESA is too abstract, and difficult to communicate to lay people.
- Quantification is important but difficult (also because of scale).
- Effects of measures difficult to assess (especially concerning the whole river basin).
- Negative outcome of measure assessment feared (benefits might not justify the costs of the measure implementation of the WFD).

Discussions during the workshop showed as well that EU-funding and communication between water management levels are experienced as hindrances in the implementation of the WFD.

3.3.3.2 Participatory Action Research for identifying trade-offs

At the case study workshop, an actual planned measure to improve the linear and lateral connectivity in the Hase sub-basin was discussed with regional stakeholders with respect to the ESA. The measure aims to reconnect an eutrophic oxbow to the Hase river and to restore the surrounding area as a floodplain. The preferred design of the measure is to develop a retention area / floodplain by relocating dykes in the southern part of the area. For this, it is necessary to purchase farmland. The land owner has not yet decided to make the land available.

In discussion with the stakeholders, it was explored how ESA could support the involved institutions in implementing measures to improve the river system with regard to the WFD. Furthermore, stakeholders were asked to identify the existent ES on the site. Only a fraction of the possible ES was perceived relevant for the planned project (i.e., the reconnection of an oxbow and floodplain development). Also, the expected effects on the ecosystem services through the planned measure were assessed. Because the measure is planned on a small scale, indicators for quantification (such as the number of residents provided with drinking water) are impossible to estimate.

Figure 11: Map of a planned measure to improve the linear and lateral connectivity in the Hase River

For the same reason, the small scale, the expected effects on ES are generally quite low (between 1 and 2 on a scale from 0 to 5, see table above). Furthermore, the magnitude of the expected effects depends highly on the specific design of the measure implemented.

In such a process, the ESA can help identify potential trade-offs as well as synergies between different stakeholders. Planning measures to improve the linear and lateral connectivity in the Hase river catchment revealed trade-offs with agriculture (land availability, nutrient input), land-use plan (land availability, sealing), industry (impoundment rights), tourism (old water mills), monument protection (change in water level), nature protection (crayfish, species regulation), sand transport, and hydro-power. Past engagements have shown that direct benefits for society are important in the decision- making process. Therefore, synergies with associations regarding recreation and tourism (e.g., canoeing, angling) are most important for municipalities. ESA can also help to generate arguments in favour of measures to restore rivers, which is especially appreciated for discussions with funding agencies.

3.3.3.3 Application of an adapted Leipzig Approach (LA)

Often, cost and benefit comparisons are based on monetized values for ES associated with the "tested" measure(s), which are then opposed to the costs of the measure(s) in a Cost-Benefit Analysis (CBA). The data needed for these analyses is rare and incorporates many uncertainties.

Therefore, instead of basing the methodology on quantitative, monetized values of benefits of measures (e.g., ES), the LA aims at including these in a semi-qualitative way, using expert judgment and simplified quantitative scales, in a 5-step process described in the figure below:

Step 1: Examination of potential disproportionality of costs on water body level.

Step 2: Comparison of the costs of measures with cost thresholds.

Step 3: Examination of the additional benefits of the measures.

Step 4: Adjustment of the thresholds according to the additional benefits.

Step 5: Comparison of the costs of the measures with the adapted thresholds.

Figure 12: The five steps of the Leipzig Approach

(Source: Ammermüller et al. 2008, adapted)

The aim of applying it here was to test whether a methodology incorporating the ESA can be potentially helpful in implementing the WFD´s economic requirements (the "added value"). The LA was adjusted slightly to take into account the data availability in the test area. See Annex 6 for detailed application of the Leipzig Approach.

The results of the LA show that the cost of the measures to achieve maximum linear and lateral connectivity in the Hase sub-basin is 34.200 Euro/km. As these costs are lower than the adjusted cost threshold (42.480 Euro/km), the costs in the Hase sub-basin to reach full connectivity have to be considered as being not disproportional.

Some general comments can be made regarding the changes done to the LA, namely the focus on a specific topic - linear and lateral connectivity - and the use of sub-basin data on costs of measures for calculating the median value and subsequently the cost thresholds.

First, both due to the focus on connectivity and the use of sub-basin cost data, it was easier to obtain data on costs of measures, as these are usually quite difficult to get, especially as average values. The narrowing of the focus can greatly increase the availability of reliable average cost data.

Second, the focus on a specific environmental problem - connectivity - increases the relevance of the comparison: in the original LA, the costs of all measures to reach a certain target in a given water body are compared to the costs of all measures in another water body, regardless of the predominant environmental problems that will be tackled with the measures. By focussing on a specific topic, only measures with the same aim will be compared (in this case achieving full linear and lateral connectivity).

3.3.4 German case study conclusions

Measures for improving the ecological status of rivers in the Hase sub-basin are mostly initiated and implemented at a local or regional level. In the survey and workshop, stakeholders as well as representatives from water authorities expressed their feeling that they were already obliged to integrate the different aspects of nature, tourism or agriculture. Nonetheless, the systematic approach in presenting the different impacts of measures was appreciated.

Close cooperation with the local stakeholders from the very beginning of the ESA application process is also central with regard to collecting data. Water management in the Hase basin is traditionally based on considerable expertise, and even more so with the WFD implementation. At the same time, the specific impacts of a single measure or a PoM can normally not be fully assessed. This is partly due to the inherent uncertainties of complex (eco)systems, partly due to lack of data and partly because of the inappropriateness of local indicators. The lack of quantification and generally accepted valuation methods need to be compensated for by transparency and good stakeholder cooperation.

As the Leipzig Ansatz application showed, once all relevant data has been collected, a methodology based on a semi-quantitative scoring system and the elicitation of expert knowledge for determining the importance and increase in ES provision is recommended for its relative simplicity and practicability. Additionally, the elicitation of expert knowledge via workshops or similar fora can be used to increase the general understanding of the necessity of measures to improve the ecological quality of water bodies.

In summary, the 'added value' of the ESA in the Hase case study has resulted in additional ecological, social and economic dimensions to assess and decide upon measures according to the WFD.

4 Analysis of Case Study Results

The use of the Ecosystem Services concept can be wide-ranging: for instance, assessing all ES in a given area (e.g., mapping of ES at European scale (Maes et al., 2011), National-level Millennium Ecosystem Assessments, etc.), valuing the costs of biodiversity loss (TEEB), promoting sustainable development and ecosystem/biodiversity conservation and increasing public awareness of ES contributions to human well-being and biodiversity. The three case studies were undertaken with the latter two objectives in mind: an assessment of ES was implemented at a local scale, with the hypothesis that using the ES concept would help decision making (highlighting synergies/trade-offs in terms of ES) and awareness raising. To do this, specific steps are needed and are discussed below.

This chapter provides an analysis of what worked or failed during our case studies and aims to present some guidelines and tools for ESA in the context of IWRM. Given the particular focus of ESAWADI on WFD economics, a separate chapter (Chapter 5) was deemed necessary.

What is presented below was implemented in at least one case study, but also our recommendation based on our experience of conducting these case studies, as well as other research and consultancy in the field of IWRM. Furthermore, this section includes the results of discussions and exchanges between the partners during various project meetings.

The outcomes of the comparison among the case studies are organised around six main tasks required for implementing ESA. These tasks relate to the step-wise approach described in the FoA report:

- Analyzing the context for setting objectives and methodology of ESA (Task 1).
- Identifying, characterizing and selecting relevant ecosystems services (Task 2).
- Analyzing the link between ecological functions, ecological status and ecosystem service provision (Task 3). This task could be considered as partly included in Task 2, partly in Task 4. However, since it involves very specific issues and difficulties, we thought it was important to highlight it as a specific task.
- Valuing ES in qualitative, quantitative or monetary terms (Task 4).
- Using ES assessment in decision making (Task 5).
- The 6^{th} Task, "organizing people/stakeholders participation" is for us a very important component of ESA in the context of IWRM. But it should be implemented all through the process and be considered a component of the other tasks. We have dedicated a specific chapter (6) to it.

Depending on the context and the goal of ESA, each task may be more or less developed, or even not included. But these 6 tasks constitute a full decision-making process.

4.1 Analyzing the context for setting ESA objectives and methodology (Task 1)

The ESA implementation is not always straightforward; it includes some methodological difficulties (e.g., uncertainty and limits to the scientific understanding of ecological processes and interactions, limited resources, lack of relevant data at the right scale, etc.), which can create some barriers to its wide acceptance, despite its potential for evaluating a system's ability to provide ecosystem services valued by human society. The literature review and ESAWADI partners' experience shows that there are different ways to implement ESA, depending on the local context, workforce and financial resources, skills of people in charge of the analysis, data available and scale at which the analysis is conducted.

More importantly, the ESA implementation method will vary depending on the goal of the assessment: that is, whether it is for the production of scientific knowledge, for general public awareness-raising, or for policy formulation or implementation, including participatory decision making (for conflict prevention between different stakeholder groups). Carrying out an ESA for the sake of listing all ES is feasible but has limited value for policymakers if it is not done in conjunction with a specific policy issue, be it to evaluate alternative policy measures, to assess the state of ecosystems or to assess the impacts of pressures, policies or trends on ecosystems.

A careful background analysis helps to set relevant objectives and methodology and should assist in making some difficult choices. This step includes the collection of basic data on the river basin (ecological, socio-economic, administrative), an analysis of issues at stake (particular drivers, pressures, trends), stakeholder analysis and incentives for stakeholder group, conflicts between different uses, the governance setup and expectations from water managers, and a first identification of some potential services. On this basis, the scope of ESA implementation and the components of the methodology can be defined, including biome, geographic area and temporal scale.

4.1.1 Context analysis in the three case studies

The Portuguese case study's main emphasis was on estuarine water quality improvement. Focusing on the main pressures driving the ecosystem status and impacts on human well-being, it aimed at comparing different response scenarios (e.g., possible measures to be implemented) according to the changes in ES provision they will induce at the level of the estuary. According to the aim of the case study, the following approach was implemented (see figure below).

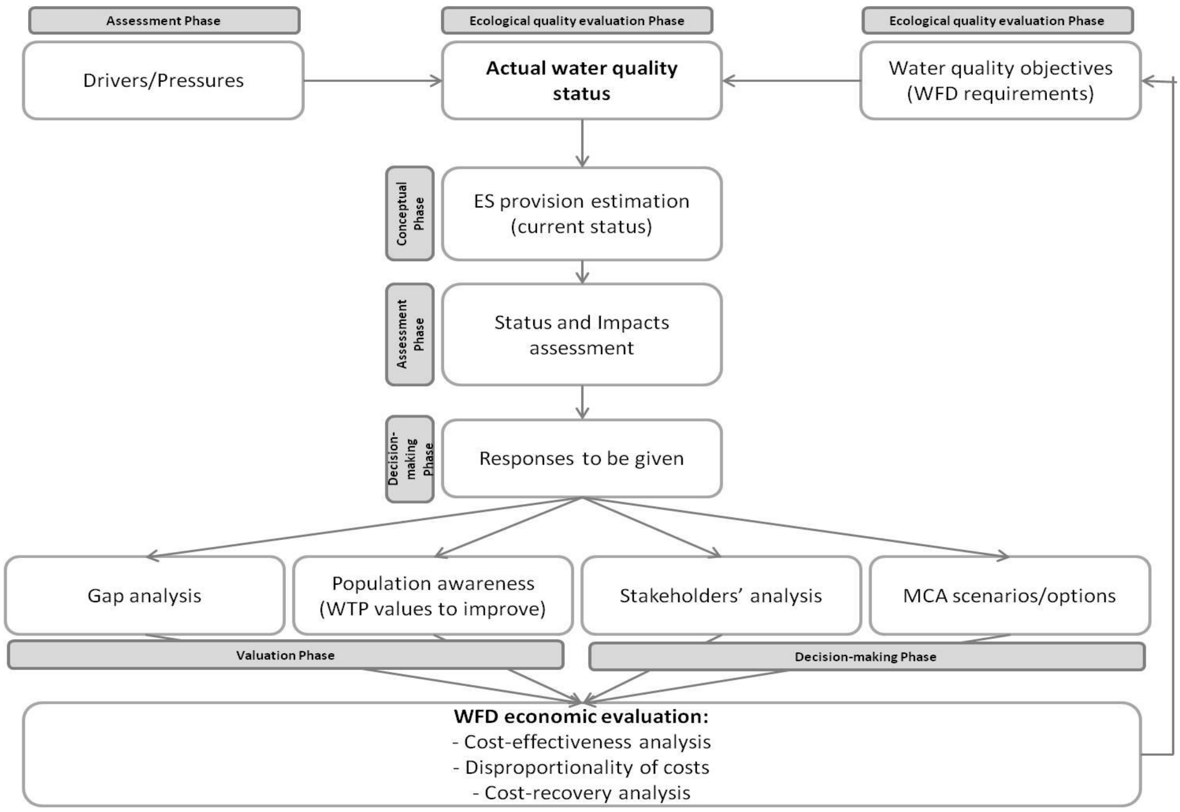

Figure 12: Ecosystem Services Approach (ESA) adopted in the ESAWADI project for the Mondego catchment area

A DPSIR analysis was used to structure the evaluation in the Portuguese case study. It included an analysis of the pressures from the upper part of the basin as well as a trend analysis of these pressures on the ecosystem. The analysis benefitted from the fact that IMAR has been producing scientific information on this area for many years and could correlate data on the evolutions for the last 20 years.

Through data from interviews with different stakeholder groups, the case study identified water quality as one of the main local concerns and therefore it focused on identifying the best mix of measures for achieving good status by 2015 as per the WFD requirements. The impacts of water management alternatives would be evaluated using a MCA software tool (Mulino).

The French and German case studies relate to the implementation of measures already envisaged by the water managers involved in the project. The purpose of using ESA was to assess the benefits/trade-offs of these measures as a way to support decision making and to support discussions with stakeholders, including the general public.

For instance, in Germany, hydromorphology and river continuity were the main issue. “Hot spots” were identified and covered different perspectives within the study area and experts from these different “hot spots” were targeted. These “hot spots” illustrate the variety of use patterns of the Hase river basin such as the parts of the river that are not heavily modified (close to the spring), urban environment, intensively used floodplain where the river is used mainly for drainage purposes and restored areas in which very different ecosystem services are expected.

In France, after the ESA was introduced to local water authorities, they mentioned two major water management issues of great interest to them: firstly, the management of hydroelectricity production by hydropeaking and its impacts on water levels, ecosystems and social uses; and secondly, the measures which allow the river to meander freely to improve sediment transport. These two issues are highly debated and have already led, in the case of the first one, to some major agreements between the water management authorities and hydropower operators.

The Portuguese and the German case studies chose to conduct an analysis based on the notion of pressure (DPSIR model in Portugal). They identified all the pressures which prevent water bodies from achieving good ecological status / good ecological potential (GES/GEP) and built their issues around these pressures.

In summary, the identification of basin management issues could be built on the identification of different kind of pressures on GES/GEP and/or on contested environmental issues, for which ESA can offer new and relevant perspectives in public discussion and decision-making.

4.1.2 Building on existing local policies and contribute to their integration

The ESAWADI experience is that ESA should not be encountered as a completely new approach compelling people to adopt an unfamiliar framework.

The approach should especially build on existing local initiatives, plans and programmes. Any integrated planning approach has to address different policies, rules and regulations, as well as schemes originating from local to national and European bodies (e.g., WFD, Natura 2000, Flood Directive, etc.). Our experience is that at a local level, ESA could create a bridge between these policies by highlighting trade-offs and synergies between different policies. The French case study demonstrated for instance the trade-offs between current hydro-peaking practices with ecologically-friendlier measures by highlighting the effects on the provision (increase or decrease in qualitative terms) of a set of ES and policies such as the Natura 2000 network, for the protection of vulnerable natural areas and the promotion of tourism activities. The Portuguese case study undertook a detailed analysis of the drivers influencing the status of the ecosystem under study and included the review of policies and institutional directives, both at a local scale, such as the municipal plans for development of the region that mostly aimed at urban development allied to the expansion of eco-tourism activities, and at a national/European scale, with, for example, the WFD requirements and RBMP. This analysis allowed the evaluation of the trade-offs among several services as well as the impacts that these policies may have under ES provision.

4.1.3 Setting the right spatial and temporal scale

The multi-level scale of river basins requires acknowledgement when applying ESA. Any ecosystem assessment should be bound by spatial and temporal scales that are appropriate to the objectives of local policy makers and natural resource managers. However, different types of ecosystem services are valued differently as the spatial scale of the analysis varies.[11]

The first temporal scale to be considered is the one of the policy under consideration (e.g., 6 year cycles up to 2027 for the WFD). But the temporal scale of natural and ecological processes has to be considered as well as the social and economic ones which determine pressures and potential benefits from ES. Retrospective (e.g., 20 years of data in Portugal and a policy launched 20 years ago in France for hydroelectricity operation) and prospective investigations are required.

Our recommendation is that data can be produced at a lower scale than the river basin, but data limitations should be stated and, particularly with issues such as hydromorphology, **one should never lose the broader systemic view at the basin level.** For instance, to result in a complete perspective, the Portuguese case study proposed correlations between pressures and service provisions at different scales (whole Mondego Basin, Lower Mondego, Mondego Estuary).

Although evaluations were made at a local scale in all case studies, upstream and downstream relations and issues were taken into consideration and mentioned.

As we shall see below (section 4.5.), the analysis of conflicts between ecological processes and the different uses may require a very precise identification of the places and periods of potential conflicts (to the level of detail of specific months or weeks in the year).

[11] Conclusions of CIS-SPI Brussels Seminar p13

4.2 Identifying, characterizing and selecting relevant ecosystems services (Task 2)

4.2.1 Understanding the links between ES and their corresponding uses

The notion of ES connects an offer of resources in a territory – here provided through the functioning of ecosystems – and the utility which is retrieved by humans. Even if they are connected by those concepts, the notion of ES is neither completely synonymous with ecosystem resources (e.g., good quality of water, fertile lands, etc.) nor with socio-economic uses and practices stemming from them (e.g., swimming and drinking water supply, forestry and agriculture, etc.). (For a similar challenge in the linkage of ecosystem functions and ecosystem services, see section 4.3.1 below)

Difficulties in defining ES hinder the description and the naming of ES, but also on the elaboration of indicators of measure of the ES.

The German and Portuguese case studies adopted the mainstream naming of ES. The risk of this approach is that at times, for services such as the supply of drinking water or leisure activities, people speak of ES without any added value to the traditional way of identifying river uses. Therefore, the French case study tried to make distinct and clarify the links between each ecosystem service and human uses at the specific case study scale, coining a specific name for the service (examples are mentioned below). Furthermore, the analysis shows the processes and habitats linked to water provision (the ES) which in turn create enabling conditions for recreational activities (the use).

As a consequence, it appeared that one ES can offer several socio-economic uses; conversely one socio-economic use can rely on several ES.

- ***A use is not necessarily linked to a single ecosystem service:***

A use can depend on several ecosystem services; thus, the impacts of ecosystem services on uses may be one of two types:

- An ES can be a determining factor in whether or not a socio-economic use exists.
- An ES may not be a determining factor in the existence of the use itself, but may have an important impact on the scale that is assumed by the socio-economic use in the area.

For example, canoeing and kayaking depend on both:

- The ES "creation of conditions favourable to recreational activities": that is, the existence of certain conditions (force of the water flow, level of water in the waterway, existence of banks for embarkation) that allow the recreational activity to be carried out.
- The ES "creation of a specific landscape": that is, the presence of a pleasant setting is one of the main attractions for canoeing and kayaking, as has been proved by its appeal to non-residents (French and other European tourists). This service positively affects the extent of the use (number of users).

- ***<u>Several uses may be associated with an ecosystem service</u>***

For example, four uses in the middle Dordogne region[12] can be associated with the "creation of a specific landscape" ES, namely: recreational fishing for tourism, canoeing and kayaking, swimming and camping.

Thus, the type and the degree of the relationship of dependence between uses and ES can differ markedly between two areas with ecosystems that are comparable in terms of functioning but with differing socio-economic contexts. Only a case study makes it possible to determine if the presence of ecosystems in the area actually gives rise to ES, and to identify the uses to which these are linked at a given time.

4.2.2 Different typologies of ES

The case studies explored the nature of ES. This led to discussions on direct and indirect and primary and secondary services, and the fact that regulation services need to be assessed through other services. As a result, the identification of ES has not been the same for all case studies.

<u>1. Potential versus Effective services</u>

The French CS adopted and developed the notion of *potential services*, i.e., services for which there currently is no socio-economic use (whether direct or indirect).

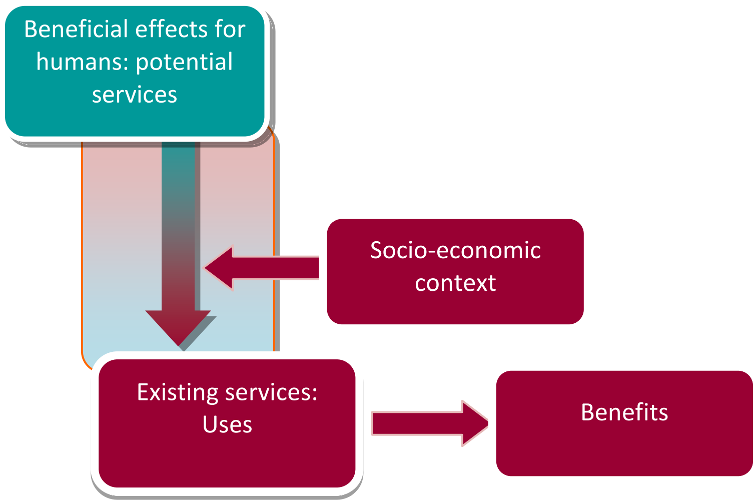

Figure 13: Process of transforming a potential service into an existing service

Source: Blancher et al., 2013

An ecosystem can offer optimal conditions for the emergence and/or the continuance of a socio-economic use without these being effectively exploited by humans. The ES thus remains at a **potential** stage. It is only when society takes advantage of the ecological processes in order to accomplish an activity that one can speak of an **existing service**. The development of a potential service into an existing service depends on the existence of a human use or activity, which is itself linked to the socio-economic context of an area: public policies, social norms, existing technologies, history, etc. The ecosystem can offer a river that is rich in fish and yet not give rise to any fishing activity. This can be explained in a number of ways: by the existence of other sources of supply of fish for eating (lower price of fish caught in other rivers, preference for saltwater fish), by the lack of appeal of the use as a leisure activity (due to the sociological profile of the

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[12] Note that this study deals with 10 uses, divided into four categories: recreational and tourist activities (canoeing-kayaking, swimming, boating, camping), fishing (for leisure and professional purposes), withdrawal of the water resource (for irrigation and drinking water supply) and the activities present on the waterfront lands (agriculture and forestry).

riverside residents and the existence of an alternative recreational possibility), by the lack of knowledge of the know-how or specific techniques for fishing relating to the fish found in that river, or by ethical concerns for the protection of the fish. Hence, the "fish supply" ES is not an existing service, and remains potential until it is transformed as a result of socio-economic changes.

On the other hand, an ecosystem service exists only if the integrity of the ecosystem processes, from which humans derives a benefit, is preserved or restored. In discussions with stakeholders at the level of a river basin on the need to maintain or achieve GES, the benefits from new potential services, and therefore the possibility to develop new activities, can be a persuasive argument.

2. Environmental/Ecological services:

The question of the different types of services – which services should be chosen and how that choice would be made - was very present in the discussions that took place with the different partners (particularly French and Portuguese).

Some authors (Amigues and Chevassus-au-Louis, 2001) make a distinction between environmental services and ecological services. The former includes services which originate from the physical structure (minerals, transportation) but are not dependent on biological processes; the latter implies that biological processes must be present. Another distinction can be made between ecological services – which accounts only as natural capital – and "benefits derived from ecosystems" – which include human investments – in order to benefit from these services (e.g., hydro-electric power) (see Figure 15).

Furthermore, some ES are similar for all case studies. The ES linked to human uses such as leisure activities, tourism, fishing or water extraction and those that are linked to natural processes such as water purification or erosion control are present in all case studies. Other ES are assessed differently in the case studies, especially immaterial human benefits such as aesthetic, heritage, cultural or spiritual. The French case study team prefers to use the term "landscape" as a palpable consequence of these benefits for humans.

Finally, regarding "Education" as an ES, there is no common agreement because it can be seen as a measure trying to prevent environmental degradation and to pass on societal values (French case study) or as a service delivered by ecosystems (German case study).

Figure 14: Distinction between ecological services and environmental services

(Source: Fischer et al., 2009)

4.2.3 How the case studies dealt with ES identification and characterisation

The level of detail for identifying and characterising ES is linked to the amount and availability of relevant data or scientific knowledge. In our three case studies for instance, two of them (France and Portugal) benefitted from long-term research and the involvement of our teams in the area, including ongoing PhD research theses. In the German study, however, this was not the case and so they relied on literature reviews, expert-knowledge and local stakeholders viewpoints for identifying and characterising the ES. In all case studies, only a selection of relevant ES was then used for further quantification (whether physical or monetary).

In Portugal, an ES inventory was performed based on a literature review of services provided by wetlands ecosystems (Costanza et al., 1997; Acharya, 2000; Atkins and Burdon, 2006).

On the basis of this list of ES, the information available for each service was estimated:

- Conditions and trends.
- Main drivers of change (natural, social, economic, morphological and ecological).
- Possible valuation methods of environmental pressures (pressures on water supply, water demand and water quality).
- Robustness of data.
- Uncertainty.
- Impacts on biodiversity.
- Institutions that manage local resources (e.g., water institutes, municipalities, etc.)

From this available set of services they identified two main factors that determine the Mondego Estuary services: the importance of its natural resources stock to local populations (i.e., estimation of their dependency upon the system) and the ecological importance of the system to the intrinsic biodiversity and human well-being. From this list, two critical ES/ecosystem features (Water Quality and Biodiversity assets) were identified as fundamental for sustainable natural resources use by society.

The French case study undertook an initial identification of ES in the study area. Based on a selection of six effective ES, it then described the ecosystem processes and structures which condition the provision of these ES. For each ES, the study then looked at the related uses attached to that particular ES. An historical account of the uses as well as trends and socio-economic importance of the use were presented.

In the German case study, existing ecosystem services and potential services in the study area were identified through interviews with experts mainly from the local water authorities (municipalities, water associations). Starting with “hotspots” (see section 4.1.1 in this report or in German CS section 3.2, p.16), the diversity of ecosystem services within the sub-basin was identified. In other words, the case study investigated whether different locations provide different services. It was identified which of these services still exist in the area, which could be restored and how, who receives which kind of benefit for well-being (security, health, basic material, social relations, freedom of choice and action) and which drivers of change might affect the provision or potential provision of services in the region. Together with the experts, it was assessed if and how different kinds of measures have an impact on the provision of ES.

The accurate identification and description of ecosystem services in a given water basin, on the basis of existing data and through interactions with water managers and other local stakeholders, even without quantification, can in itself offer substantial added value (e.g., the inventory of ES as a check-list of benefits stemming from a given ecosystem, benefits which may not have been noticed otherwise).

4.2.4 Dealing with spatial issues

When dealing with a complex ecosystem like a river basin, the very choice of a spatially delimited study area creates problems in the evaluation of ES. Indeed, ecological functions and corresponding ES and anthropogenic uses do not always take place at the same spatial or temporal scale; for instance, wetlands store water and protect downstream areas from floods and water scarcity.

Secondly, in order to explain the quality and the quantity of ES provided by a particular ES, it is important to identify the sources of pressures. In the case of aquatic ecosystems, pressures can be generated far upstream or beyond the study area.

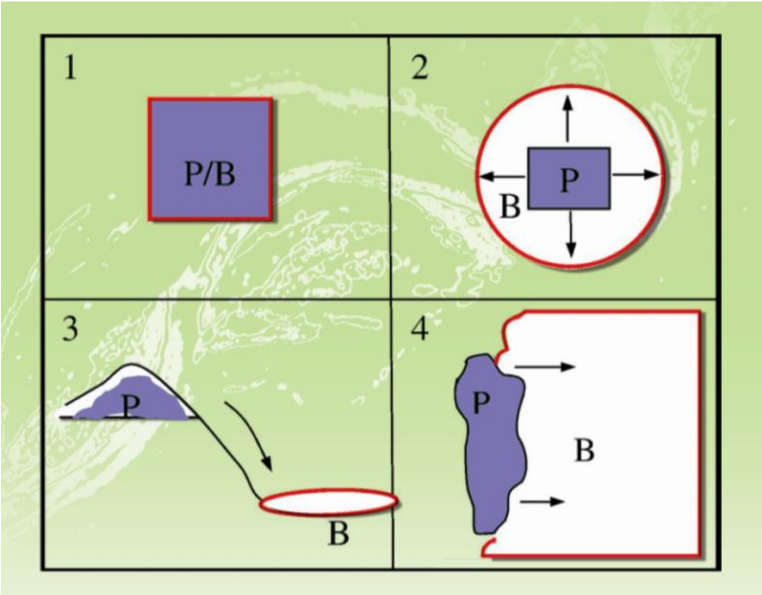

Figure 15: Typology of services depending on production and usage sites

(Source: Fischer et al., 2009, p.100)

Similarly, service provision can come from either large areas upstream or downstream, and the benefits themselves are dispersed over a large area. In order to take into account all the implications of ES degradation in the study area, it was important to identify all the beneficiaries, among which some are located further downstream. For example, water self-purification capacity can benefit swimmers in the study area, but also downstream.

Figure 16 illustrates the geographic scale issue where "production sites" of ES can have spillover effects (benefits) to areas outside the production area. There is a similar problem with ecological functions whose effects and magnitude can only be appreciated on the whole basin; for instance, those which allow the presence of migratory fish.

Thus some quantification might lead to the rejection of measures implemented on a small scale because the expected impacts and benefits are usually small (compared to the costs of the measure) and therefore might not justify the implementation. In a bigger context (the whole river basin) the measure might be justified, but the effects are difficult to assess. It should be made clear that several ecosystems in dispersed places may contribute to services in other dispersed places. In addition, and as noted before, a number of services may be required for a specific use and a specific service may contribute to several uses. This gives a clear idea of the complexity of an evaluation. This calls for a broad analysis at the water basin scale, so that local evaluations are always discussed within this broader perspective. This is particularly true when dealing with hydromorphology.

4.3 Analyzing the link between ecological functions, ecological status and ecosystem service provision (Task 3)

Once the identification and characterisation of ES has been accomplished, an accurate analysis of the link between ecological functions, ecological status and ES provision is required. This will allow verifying whether or not different measures will improve ES provision. The sections below account for the findings which stem from the thought processes that were used in our CS methodologies. Many of the difficulties faced while implementing ESA relate to this issue; therefore, it is worth spending time on. This was done in the French CS in relation with hydromorphology.

4.3.1 Understanding the links between Ecosystem functions and ES

The structure and functioning of an ecosystem is sustained by synergistic feedbacks between organisms and their environment thus determining ecosystem properties and setting limits to the types of processes occurring there (Mace and Bateman, 2011).

Sustaining ES provision requires a good understanding of how ecosystems function and provide services, and how they are likely to be affected by various pressures. Ecosystem responses to environmental change may quite commonly be non-linear, difficult to predict or even irreversible (de Jonge, 2007; Carpenter et al., 2009; de Jonge et al., 2012). Therefore, **it becomes essential to understand the basis of complexity in order to guarantee the effectiveness of response actions** and to ensure the continuation of important services provision. An illustrative example of this complexity (and how physical, chemical and biological assets underpin ecosystem functioning) is, for example, the reduction, or even disappearance, of macrophytes or seagrasses caused possibly by competition with green macroalgae, as illustrated in the Mondego Estuary (e.g., Marques et al., 1997, 2003; Patrício et al., 2009).

It was the experience of ESAWADI partners that the identification and characterization of ES is in itself a challenge. In a river socio-ecosystem, there are no linear relations, no direct cause-effect patterns among drivers, pressures, state, and impacts, but instead intricate and cumulative relations.

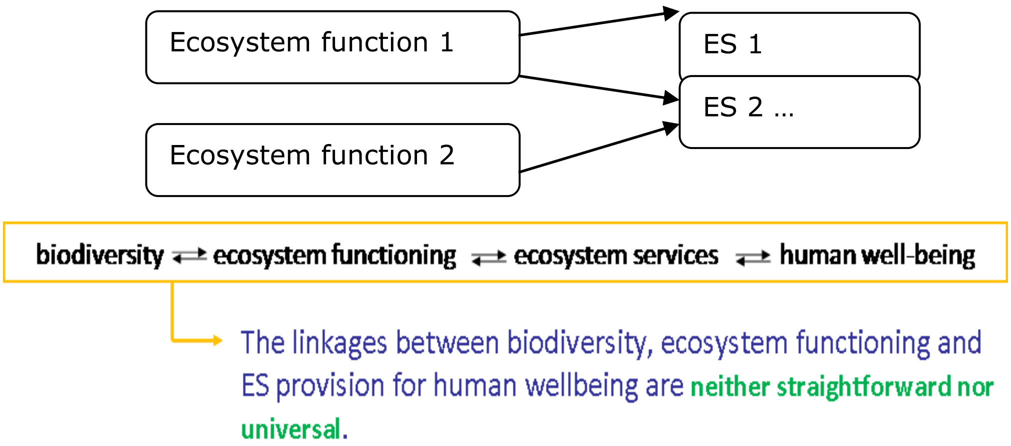

Figure 16: Relations between ecosystem function and ES

Although these linkages are not linear, it can be however useful to try and illustrate them by applying them to specific ES. The flow chart developed for hydropeaking impacts in the French case study (see case study outputs, chapter 3.1.3) shows how four ES (availability of water resources, enabling conditions for recreational activities, availability of fish, and maintenance of water quality) are conditioned or impacted by the hydrological regime under natural (undisturbed) conditions.

Given the ESA's holistic perspective, it can be seen that ES can act as the link between natural assets and human benefits. Regarding the ecological functioning and water quality evaluation of a system, it is necessary to include not only local conditions (including the surrounding human activities), but also the **conditions and pressures within its upstream** watershed (Pinto et al., 2011).

Furthermore, when one deals with measures related to hydromorphology, the physical and ecological impacts are hard to predict, not to mention the benefits in terms of ES provision. Nevertheless, a better understanding of this phenomenon among decision makers and stake holders is necessary.

More insights regarding biodiversity effects on ecosystem functions, which can be linked to ecosystem services provision, are needed.

4.3.2 ESA implementation in the context of WFD: Link between ecological status/GES and ecosystem service provision

One of the objectives of the case studies was to relate WFD objectives to local water management issues by showing the effects of GES achievement on a range of ecosystem services. The WFD is based on the assumption that restoring or maintaining the good status of water bodies will benefit biodiversity and water resources protection. However, this hypothesis has not yet been explicitly tested.

In the river bed for instance, there is a link between ecological status and ecological functions: if the ecological status is poor, some ecological functions will cease to work and consequently cease to support the existence of some ecosystem services. However, the presence of ES does not equate necessarily to GES. More work is needed to develop functional indicators to improve our understanding of ecological functions.

Water bodies with good ecological status according to WFD rules may include ecosystems where some major functions are disturbed (e.g., the middle stretch of the Dordogne where sediment dynamics and hydrological regimes have been modified due to hydro-peaking practices). For instance, water bodies which have been modified from a hydromorphological point of view can still score highly in terms of WFD ecological status. This is because the current WFD measurement of GES is based on a structural index (related to the structure of the ecosystem) and not on functional indicators (related to the integrity of the processes). Furthermore, even if hydromorphological criteria are part of the GES assessment[13], the fact is that they are only used (e.g., in France and some other countries) to distinguish between very good and good water bodies' GES. The WFD ecological criteria are based on the occurrence of type-specific communities. However, their presence is not necessarily linked to good hydromorphological conditions. The relationship between ecosystems and species is not linear but rather of a "catastrophic" type.

Furthermore, although ecosystem functions may be disturbed by external pressures (e.g., hydro-electricity operations), it does not necessarily mean that these will have impacts on either the ecological status of the water body or the provision of ES (the DPSIR model differentiates between drivers, pressures and impacts). One obvious impact of hydro-electricity barrages is the change in river continuity and therefore the effects on migratory species, something that is not accounted for in the WFD GES criteria.

In a further example, in France, the WFD only takes into account stream beds and does not consider fluvial annexes or wetlands even though these areas contribute to ecosystem functions.[14] The ecosystem approach on the other hand, takes into consideration all kinds of ecosystems. In this way, the ES approach can complement that of the WFD approach.

[13] Annex V of the WFD: hydrological regime, river continuity, morphological conditions

[14] In France, this choice was made because of another national programme which looks after the protection of fluvial annexes and wetlands.

The added value of the ESA is that it can highlight ecological functions which are the basis for the provision of ES. Improving our knowledge of these ecological functions, and the drivers and pressures that can impact them and ES, could greatly contribute to the WFD analysis of water uses and the formulation of the river basin management plans.

4.4 Valuing ecosystems services in qualitative, physical or monetary terms (Task 4)

A broad approach to this issue in relation to IWRM schemes is presented here. Chapter 5 deals specifically with the way of including ESA in WFD economic analysis; it offers further insights to this issue.

4.4.1 Mixed views on the usefulness and approach of measuring and ranking ES

For some water managers and policy makers, ESA is a convenient way to quantify and monetize benefits from ecosystems that is consistent with the MA and TEEB initiatives; therefore, for them, there is no ESA without these steps.

Our experience is that an accurate identification and description of ES (Task 2) in a given river basin is: (1) a difficult task; (2) a prerequisite for any further relevant and convincing quantification; and (3) an achievement in itself as it raises awareness of the need to protect ecosystems and contributes to decision making. Valuation with a qualitative scale is also a possibility as it has been done in Germany during the workshop in which participants were asked to value the relevance of different ES on a scale from 1 to 4 (see Table 7). In this case, a monetary valuation of ecosystem services was perceived as unnecessary.

Therefore, this task 4 included the measurement and ranking of ES through a combination of literature review, expert knowledge and, stakeholder-based judgments. This was accomplished in close connection with Task 3 which provided an identification of the interactions between environmental and socio-economic dynamics at multiple scales, inferring the effects of these interactions on ES and ecological stability.

The combination of expert knowledge and stakeholder-based judgments for measuring and ranking ES raised methodological issues, as well as epistemic and political questions such as whether we should give the same weight to both scientific **and** non-scientific knowledge. We shall analyse this below, particularly in the section on “Participation and ESA implementation”.

4.4.2 How the case studies undertook physical or monetary ES quantification

All the case studies identified methods and indicators for physical or monetary valuation of the services under consideration. The estimated value of the service was provided when it was easily available (see the table below for Portugal and an example for Germany in Table 7; physical indicators were identified for the French case study and are presented in Annex 4). None of the case studies achieved full quantification; it was, for Germany at least, a methodological choice.

Table 8: Inventory of ecosystem services in the Mondego estuary following the Millennium Ecosystem Assessment classification (2005)

Ecosystem service category	Ecosystem service	Valuation method	Estimated value (1000 €)	Value reliability	Results uncertainty	Impact on biodiversity
Provision services	Food production	MP*; PL	Fisheries: 7,078–14,831 Agriculture: 897–1,217	Underestimated	High	High
	Raw materials	MP	–	–	–	–
	Renewable energy	CVM	–	–	–	–
	Ornamental resources	MP	–	–	–	–
Cultural services	Aesthetic resources	CVM; BT; HP	Insufficient data	–	–	–
	Tourism	MP*; CVM; TC	8,102 – 12,821	Underestimated	Medium	High
	Recreation activities	CVM; MP*; TC	1.5–2.2	Underestimated	Very high	–
	Cognitive values	CVM	–	–	–	–
	Cultural heritage	CVM; HP	–	–	–	–
	Non-use values	CVM	–	–	–	–
Regulation services	Gas and climate control	PF	–	–	–	–
	Disturbance regulation	PF; AC; RRC; DC	–	–	–	–
	Carbon sequestration	PF	–	–	–	–
	Bioremediation	RRC; PF	–	–	–	–
	Soil erosion prevention	AC; RRC; DC	–	–	–	–
	Nurseries	PF; PL; AC; RRC; DC	–	–	–	–
	Habitat provision	PF; AC; RRC; DC	–	–	–	–
	Nutrient cycling	PF	Insufficient data	–	–	High
	Water supply	MP	Insufficient data	–	–	High
	Water quality	CVM; AC; RRC; DC	Insufficient data	–	–	High

Note: MP: market prices method; PL: productivity loss; AC: avoided cost; TC: travel cost; RRC: replacement and restoration costs; HP: hedonic pricing; CVM: contingent valuation method; DC: damage costs; PF: production function; *used in this study. The valuation method mostly used for each service, its estimated value and level of reliability, uncertainty of results and the level of its impact on biodiversity

4.4.3 Methodological difficulties

Although ESA is sometimes presented as a kind of "panacea", it does not solve any methodological difficulties or resolve any of the debates on the validity of results. One has to utilize a good part of traditional economic valuation methods (contingent valuation, hedonic pricing, willingness to pay, benefit transfers, etc.) and indicators, particularly for secondary services[15]. Therefore, all the typical difficulties faced by environmental economics are still encountered.

A lot of data necessary for measuring ES are missing, either data which relates to ecosystem functions and natural resources or data relating to socio-economic uses. The absence of data can be explained either by the lack of a data collection plan, or by

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[15] See definition in chapter 4.2.2.

methodological and technical difficulties in isolating and/or quantifying certain phenomena, in particular the benefit of some ecosystem functions. Furthermore, how does one deal with non-measurable values (e.g., aesthetics, spiritual ecosystem services)?

Existing data is generally not collected at the scale of the ecosystems which generates ES but at the scale of administrative entities or at the scale of an ecosystem management unit (catchment basin, public land). Therefore, the data which has been collected has to be processed using ratios and aggregations of figures to provide an indicator at the relevant scale. This treatment of data sometimes rests on strong hypotheses. Above all, this highlights the importance, when disputed issues are at stake, of organizing more precise data collection in order to replace data which has been built on the basis of disputable hypotheses.

Furthermore, it is complex, sometimes impossible, to establish indicators which would allow the measuring of an ES as such; that is, to distinguish within a socio-economic practice what is due to the functioning of ecosystems and what is produced by human intervention. Even if data is available (like the number of angling club members or the fish catchment), it may not reveal the benefit of the ES, particularly when a social practice is not very sensitive (or "elastic" in economic terms) to qualitative improvements or deterioration of, for instance, water quality. Another example is that the existence of landscapes might not, by themselves, influence some leisure activities which are determined by other factors like the presence of infrastructures and services.

The lack of data is an obstacle to evaluating the impact of ecosystem protection on socio-economic uses in the area, but it also makes it difficult to anticipate in a quantitative way the potential impacts of different options of river management. In spite of these methodological difficulties, a quantified monitoring of ES evolution, through broad trends evaluation, remains very useful for studying the degradation of the environment and its consequences (as was done in the Portuguese case study). In such cases, the quantification of ES is not interesting for the values it represents in an absolute way, but for the comparisons in time and space it allows.

Nevertheless, several water managers and other stakeholders voiced concerns that the ESA would induce too much work and would be very expensive. The risk is to launch ES quantification with too limited means. The French Seine Normandie Water Agency's experience was that the share of benefits in a CBA was correlated to the budget allocated to the evaluation and therefore to the extent of the investigations. Therefore, an evaluation with a limited budget will lead to an underestimation of ES benefits.

4.4.4 Scale issues

The scale (both spatial and temporal) at which ecosystem services evaluation is being undertaken is crucial to ensuring accurate ES evaluation. In water management, there are different spatial scales at play: spatial (local landscape unit or ecosystem, river basin, regional, European, etc.), administrative (municipalities, district, region and national authorities), and institutional (local water managers, regional and national water management authorities and ministries). We expected that the case studies would face particular challenges since these different scales and their levels do not necessarily complement each other, especially when boundaries are not well defined or when multiple institutions overlap on a given ecosystem unit (see, FoA, p. 14ff). Instead, stakeholders are more easily wedded to a process which responds to their local environment (Borowski et al., 2008) and references (e.g., their own management, policy and legal framework). This strong reference to the spatial area in which coordinating or decision-making bodies are located, provided a barrier during the 1st implementation cycle to approach water resource management at river basin scale for reaching a "good ecological river basin" (Junier et al., 2011). The French Ministry of Ecology stressed that in many CBA in the context of IWRM schemes, the evaluation of benefits are traditionally (and for practical reasons) limited to the scheme area without due consideration to upstream and downstream impacts. This leads to a clear underestimation of benefits. At the very least, this underestimation should be mentioned and the basin perspective should be always kept.

This was partly confirmed in the ESAWADI case studies: decision-making processes often referred to administrative units, whereas changes in ES such as flood retention may be more relevant at higher levels, for example the sub-basin or basin level. Biological or ecological processes may again have a different scale and level than the benefits of a specific ES. In the German case study this, among other factors, led to a basic dismissal of quantification efforts since ES were not considered to be impacted by single measures with local application. Thus the larger-scale idea of river basin management, suggesting the river basin as one ecosystem providing services for the complete basin, could not be improved upon in the case studies. Nonetheless, in France, on the two issues considered, there was strong demand by water managers for relating local issues to the broader river basin functioning, and some local stakeholders have integrated this approach. This may be related to the fact that there are well established basin-level institutions (EPIDOR and Water Agency) and procedures. The findings within the Portuguese CS showed also that the same ES (e.g., water quality improvements) can be valued differently depending on the geographic scale under consideration.

Therefore, it was difficult to assess for both the French and German stakeholders the benefits of a measure. Their concern was that the expected (ecological or socio-economic) benefits of a measure might not outweigh its costs. The inability to guarantee a positive result offers an opportunity not to spend money for river restoration or conservation.

Defining changes and benefits of ES in the case studies also became a monitoring problem. The French CS disclosed that existing data is generally not collected at the scale of ecosystems which generate ES but at the scale of administrative entities (municipalities) or at the scale of an ecosystem management unit (catchment area). Data from municipalities needs to be aggregated to fit the catchment area. In such cases, the quantification of ES is not useful in an absolute way but for comparisons in time and space. Above all, and in the interest of precision, it highlights the importance of organising data collection on ES. In order to explain the kinds of benefits of ES (and, if even possible, quantify them) which are provided by a particular ecosystem, it is important to identify the sources of human pressure. Similar, the Portuguese case study concluded that the lack of data is an obstacle to evaluating the impact of ecosystem protection on socio-economic uses on the territory. It also makes it difficult to anticipate in a quantitative way the potential impacts of different river management options. A quantified monitoring of ES evolutions remains essential for studying the degradation or restoration of the environment and its consequences.

Similar questions arise for temporal scale. While a river ecosystem may provide services for centuries, the land development project which modifies it may provide short term benefits. This is the very question of sustainability. Therefore, it may be useful to provide ES evaluations for different time frames. Several modifications can occur within an ecosystem along a period of time regarding changes in ecological quality status as well as the perception that people have of it.

Facing these manifold challenges, ESA may be successfully applied – including the quantification of benefits and their changes – if the scales are clearly defined and homogeneous in terms of decision-making processes, ecological processes and communication processes. However, concerns lay in the provision of a detailed analysis of the ES across the different spatial and temporal scales and their levels. Its particular systemic approach – along different sectors as well as different spatial levels – was considered very beneficial because it allowed for a better acknowledgement of the complexity of social-ecological ecosystems. It also improved stakeholder’s understanding of this complexity.

4.5 Using Ecosystem Services assessment in decision making (Task 5)

Decision-making processes applied to IWRM include the formulation of water resources management plans and policies, arbitration between different measures based on a separate appraisal (valuation exercise), regulation of hydropower operators, and selecting incentives mechanisms (policy, fiscal, regulatory, economic tools) to influence citizens and the private sector's behaviour, etc.

Decisions are made at different scales. For example, in France, River Basin Water Agencies are responsible for overall planning and therefore set the framework for SDAGE (Schéma Directeur d'Aménagement et de Gestion des Eaux)/WFD RBMPs. As well, the SDAGE technically and financially supports the different programmes for improvement. At the sub-basin level, local water boards (e.g., EPIDOR) or local authorities are responsible for the planning and implementation of measures for a specific river basin through schemes like the SAGE (Schéma d'Aménagement et de Gestion des Eaux) or River Contracts .

The ESA was tested as a tool to support decision making processes at different levels.

The presentation of the results of the previous tasks, particularly the valuation of ES in a qualitative or quantitative manner, to a group of stakeholders and/or decisions makers is a way of using ES assessment in decision-making processes (e.g., the table produced with stakeholders during the German workshop).

As well, ES identification and/or assessment can feed into different types of decision-making support tools (flow charts, CBA, AMC, Leipzig Approach, etc.).

4.5.1 Impacts of policy measures on ES: synergies and trade-offs

The Leipzig Approach (see Annex 6 and Chapter 5 on ESA and WFD economics), can be also used as a tool to assess the disproportionality of the cost of a measure: The German partners tested it to assess a measure for improving river continuity on a specific stretch of the Hase River.

The French team produced flow charts describing the ES cascade summing the various impacts of a measure and discussed them with sub-basin water managers. For instance, the diagram below shows the impacts of hydropeaking on: ecosystems structure ➔ ecological processes which benefit society ➔ ecological services ➔ social and economic uses.

Then the effects of measures to regulate hydropeaking - such as the one included in the agreement between hydroelectricity operators and public authorities, as well as new measures under consideration - can be assessed with, on the one hand, the negative effects on hydroelectricity production (loss of electricity production, especially when demand peaks arise and electricity is the most expensive, loss of flexibility, indirect effects such as increases in greenhouse gas emissions, etc.) and, on the other, positive as well as negative effects on uses. The physical or monetary valuation of these different impacts can be presented when data is available, or at least some qualitative estimation. The main contribution of such a diagram is that it **conveys a summary of the whole ESA production analysis, and stakeholders can debate the different links and impacts.**

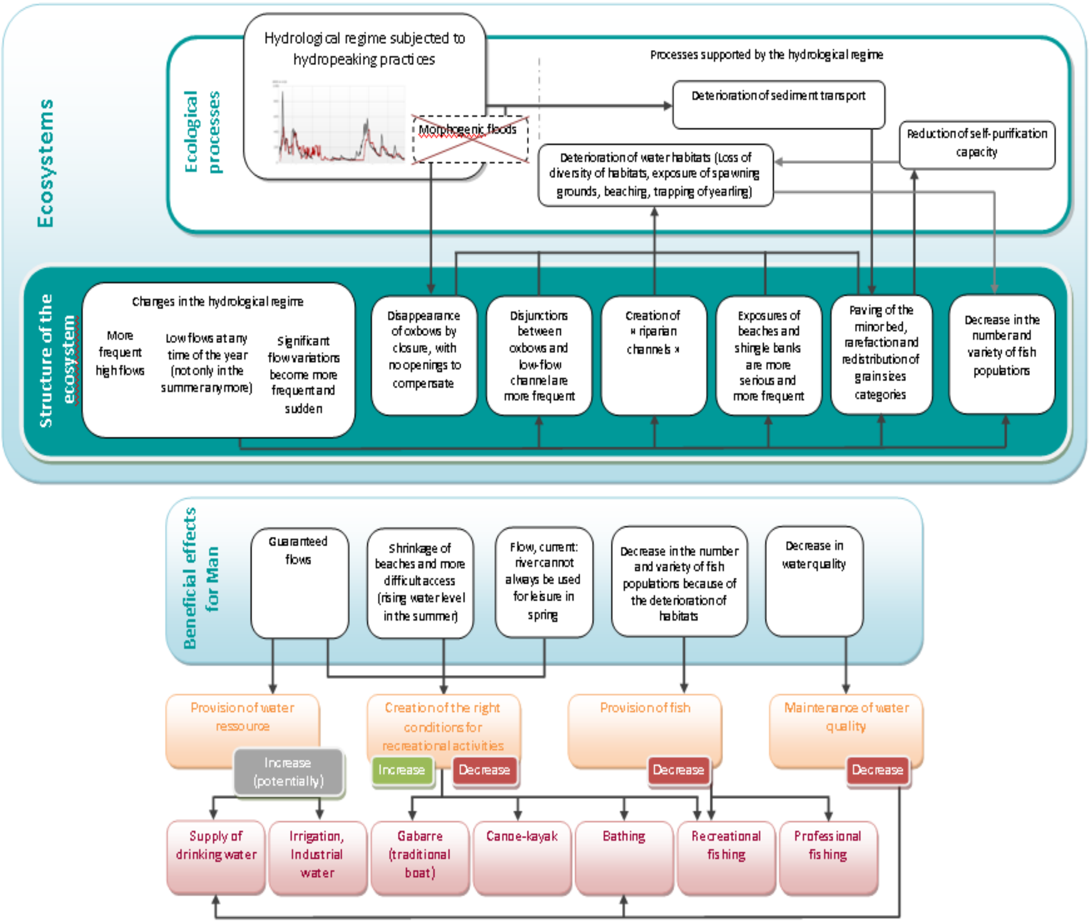

Figure 17: Impacts of hydropeaking on the ecosystem structure, ecological processes, ecological services as well as social and economic uses.

(Source: Blancher et al., 2013)

4.5.2 Selection of the best set of IWRM measures

The Portuguese partners used ESA to build alternative scenarios and compared them using a MCA tool (MULINO, see Annex 5).

Through the use of MULINO and depending on the objective under consideration, decision makers were presented with a choice of alternatives. In general, if the objective was only to improve water quality (as demanded by the WFD), fewer combinations of alternatives are required to achieve it. Moreover, and depending on if the objective is to improve direct services (e.g., food production or recreational activities) or to maximize indirect services (e.g., carbon sequestration), different sets of alternatives are recommended. For example, there was clear evidence for the significant relationship between carbon sequestration maximization and the buffer zones creation, especially for the SAW technique.

4.5.3 Arbitration between stakeholders

When water managers or stakeholders with concern with the maximisation of investment ask for "hard" economic data, the difficulty lies in monetizing the benefits. The Dordogne case study and the agreement which was reached with the hydroelectricity operator showed that the monetization of benefits was not compulsory. Should the hydropower operations be modified in favour of greater ecosystem protection, the main challenge was to reconcile the direct economic and financial benefits from electricity production with the large range of highly valued but difficult to quantify indirect benefits for large sections of the populations. With the aid of representatives of these sections of the population, pressure can be applied to stakeholders who are mainly concerned with the direct economic benefits.

To foster such a process, a very precise analysis of ecosystem services benefits in time and place is required so as to identify precisely where and when conflicts arise. The Figure 18 (used for Dordogne CS) gives a good example of such a tool. It relates to measures taken to monitor hydropeaking according to the different user requirements (the different pictograms). Columns represent months while rows represent stretches of the river.

Therefore, the main difficulty is to assess the ecological and physical impact of measures and to locate the benefits from the restoration of a given ecosystem (see Section 4.3). The notion of *potential services* proved to be very attractive and was able to foster positive decisions, provided these potential services could be assessed.

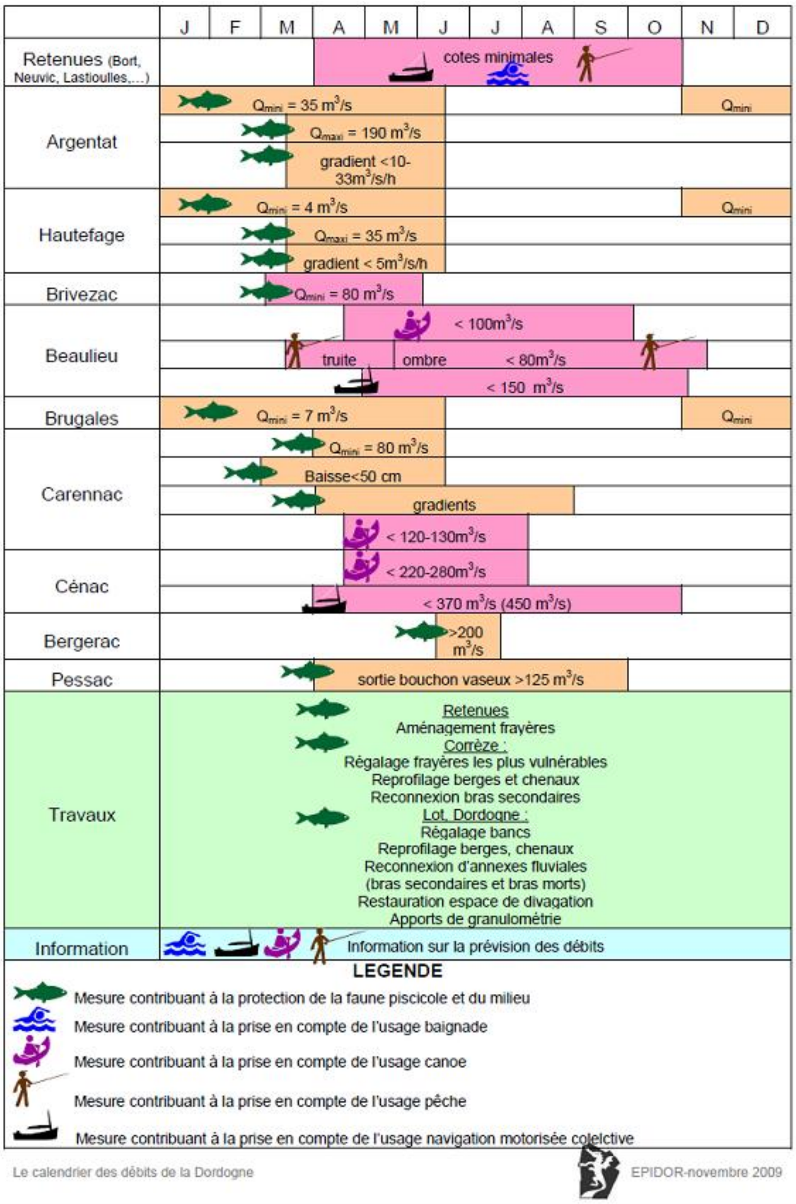

Figure 18: Location in time and space of conflicts and mitigation measures

(Source: EPIDOR, 2009)

4.5.4 Setting the right spatial and temporal scale

The spatial and temporal scale considered at the time of decision making will always tend to be the administrative and political one in relation to the scheme under consideration and the authority in charge of its implementation. Fortunately, IWRM is progressing and, particularly in France, authorities are entitled to plan and act at river basin level. Therefore, it is important to always keep the perspective of the river basin and to qualitatively describe the complex interrelations between the different components of the river ecosystem.

When quantification is introduced, risks of underestimation because of downstream (positive) impacts are not considered. In a larger context (the whole river basin) the measure might be justified, but the effects are difficult to assess. This holds particularly true for hydromorphology, or for services like flood prevention or those related to biodiversity where, for instance, the benefits of the protection of one single wetland may be few, but the protection of a "network" of wetlands may have many benefits. That is why, to assess the benefits of WFD PoM, the Seine Normandy Water Agency conducted a CBA at the basin scale which mainly concerned groundwater, to show the benefits of a more ambitious PoM. This is of course a key step for participation in that it will be more fruitful if decision makers and stakeholders have been involved all through the process (the "co-construction" approaches). Decision-support tools as those presented above are very important for fostering fruitful debate and positive decisions. ESA is a powerful way to set the stage since it allows a systematic and thorough identification of concerned groups, and of synergies and trade-offs in terms of benefits and costs, even if valuation is a tricky exercise for the reasons identified above.

5 Analysis of ESA and WFD Economics

5.1 Introduction

One principle aim of ESAWADI is to analyze and provide advice on the potential usefulness of the ESA to support the implementation of the WFD and its economic requirements, namely the assessment of cost recovery levels including environmental and resource costs, of the cost-effectiveness of the PoM, and of exemptions due to disproportionately high costs. Additionally, as an initial step, an examination of the analysis of existing water uses, impacts and pressures was performed in the French CS.

The project was aimed at examining whether incorporating the ESA into the existing methodologies to address the economic elements (e.g., as elaborated in the WATECO guidelines[16] and other national guidelines) can be potentially helpful in WFD implementation, and how such an inclusion could happen. It has to be noted, however, that it was not the goal of the project to perform (another) monetary assessment of the ES in the case studies given that such an approach would not generate new insights into determining the possible helpfulness of the ESA, and would have exceeded the scope of the project. Nor was it envisaged that ESA would be the sole approach to the implementation of WFD economic requirements. Instead, the project team aimed at examining the existing approaches - on all relevant implementation levels, i.e., local to national - and illustrating the feasibility and added value of incorporating the ESA into these approaches.

It turned out, however, that there is only a very limited number of coherent and/or transparent methodologies for assessing the economic requirements, or that methods exists but have not been thoroughly applied. Therefore, the results of the ESAWADI analysis of the links between ESA and economic requirements are inherently limited due to the information available for examination and comparison.

The "Payments for Ecosystem Services" (PES) schemes were included as a separate set of questions into the ESAWADI project at a later stage due to the high interest and topicality of the issue. As the case studies were initially not planned to incorporate this topic, the results on PES schemes should be understood as being a first screening exercise.

5.2 Methodology

To assess the questions regarding the use of the ESA in the implementation of WFD economic requirements, as a first step all case study teams performed a thorough literature and document survey, focusing on RBD planning documents, such as the RBMPs, PoMs, and attached documents.

Based on the information garnered, it was determined whether existing methodologies to address WFD economic requirements could be adapted to incorporate ES, or whether methodologies already existed which did this.

In the German case study, a practical experiment to apply the ESA in the context of WFD implementation was then performed: an existing methodology to assess the disproportionality of costs - the Leipzig Approach (LA) - was adjusted and employed in the Hase sub-RBD (see Chapter 3 Case Studies, Annex 6 and below; for more details on methodology, see the case study report, section 7.4).

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[16] Common Implementation Strategy for the Water Framework Directive (2000/60/EC), Guidance document no.1, *Economics and the environment, The implementation challenge of the Water Framework*, Produced by Working Group 2.6 – WATECO, European Communities, 2003, 270 p.

In the Portuguese case study, a MCA incorporating ES was performed, but with more of a focus on the links between "ESA and participation" (see 6.3) than on analysing the usefulness of ESA in the implementation of WFD economic requirements (see Chapter 3 Case Studies and Annex 5). Since a number of economists argue that a MCA should be incorporated in the WFD economic analyses (see below), this approach may offer some important insights.

Additionally, several interviews were performed in the German and French case studies with policy makers and water economists (from French Water Agencies[17] and national ministries, German "Länder"-representatives, members of the LAWA Working Group "Economics"), with an explicit focus on the WFD economic elements, that is, the principal questions outlined in the ESAWADI FoA. The interviews were aimed at gaining insights into the following points:

- The integration of economic elements into the first WFD planning cycle. Main difficulties encountered.
- Insights gained in the 1st management cycle, and current discussions, particularly with regard to the 2nd cycle.
- Their knowledge and experience of using the ESA, and their opinion of feasibility issues and the potential added value.

[17] Acronyms of French Water Agencies (Agences de l'Eau) used in the following paragraphs:

AEAG : Adour-Garonne
AEAP : Artois-Picardie
AELB : Loire-BretagneAERM : Rhin-Meuse
AERM&C : Rhône-Méditerranée & Corse
AESN : Seine-Normandie

5.3 Results and insights gained

As already outlined in the ESAWADI FoA, the implementation of the economic elements of the WFD posed (and poses) a significant challenge for the water administrations of the Member States. This concerns both the policy integration of economics in decision making and the requirements concerning the use of economic methods and tools in this work. The following section describes the present status of the "handling" of WFD economic elements and the ESA in the case study, given the information available, and the manner in which the interviewed policy makers and economists evaluated the future potential of utilizing the ESA. For better readability, it is structured around the main economic elements analysed: cost-effectiveness, exemptions due to disproportionately high costs, environmental and resource costs, and PES. The section begins with a short overview of the French results regarding Article 5.

5.3.1 Analysis of existing water uses, impacts and pressures (only French Case Study)

> ESAWADI findings:
>
> The assessment of water uses can be complemented by an analysis in terms of ES at the basin scale which can improve the connection between water bodies' status and pressure assessment, thus improving the characterisation of the River Basin District and providing the data on ES required for further analysis.

a) How was socio-economic data integrated in the analysis of existing water uses, impacts and pressures?

In all French basins, household, industrial and agricultural uses were studied, gathering statistical data and information from existing studies, particularly regarding the main water services and uses (e.g., water supply, waste water treatment, industrial uses, hydroelectricity, irrigation, etc.). Some basin studies went further by covering all the types of water uses or conducting studies on specific uses (e.g., navigation, leisure activities, etc.). AELB and AERM&C produced information at the level of river basin or even water body scale. Some specific efforts were devoted to characterising leisure activities in a few basins.

b) How the approach will evolve in the 2nd implementation cycle?

For the implementation of the first steps of the 2nd cycle, a national guide book was produced by the French Ministry of Ecology (Ministère de l'écologie, du développement durable et de l'énergie, Direction de l'Eau et de la Biodiversité, 2012. Guide pour la mise à jour des états des lieux DCE, 124p.). The guide book includes the analysis of water uses. For all the French Water Agencies, it was very important that the methodology remained consistent with the 1st cycle in order to be able to follow the changes in water quality in relation to the evolution of uses and pressures. Furthermore, it was very important that the information produced could be used not only for WFD implementation but for the other plans and programs implemented at River Basin District level or at the level of the different river basins, as well as for routine work.

c) How ESA could be implemented in this analysis?

ESA was not used for the 1st cycle and it is too late to use it for the 2nd cycle. Furthermore, some respondents were concerned that this will mean too much work and additional financial resources that will not be available. Nevertheless, for the AELB economist, it is at this stage that ESA should be used since it is a more qualitative step where descriptions and physical data are welcome. More importantly, it would allow relevant information regarding ES to be made available; information useful for the steps to follow and providing a basis for future ESA. It is a very encouraging position. However, one difficulty may be that the level of precision required to deal with a specific issue, the derogation of a specific water body for example, will be too exacting to be accomplished at this stage (analysis of water uses) given that all the River Basin District must be covered.

A compromise could be to undertake a broad analysis which could serve as a basis for a more precise analysis and to investigate in greater detail the river basins where problems are anticipated. The AERM&C economist suggested that some sort of typology linking water body characteristics, water uses and services could be produced to facilitate further value transfers, or even to consider potential services.

Most of the French economists agreed that the ESA can be very useful at this stage to bring more consistency between what is done for the evaluation of pressures and what is done for water uses; at present, it is not the same people who conduct the two analyses, and often their work is somehow disconnected.

5.3.2 Identifying potential measures and Programmes of Measures

ESAWADI findings:

The ESA can be a useful tool to include in cost-effectiveness analyses, on the condition that effectiveness is not only limited to achieving GES, but that additional benefits created through water protection measures are also taken into account. Through the integration of ESA into such assessments, these additional benefits could be illustrated and integrated into a more comprehensive analysis of the costs and benefits of measures.

a) How was the cost-effectiveness of sets of measures dealt with in the 1st RBMP?

Through the literature survey and interviews, quite similar information could be gained across the case studies concerning the use of cost-effectiveness assessments in the 1st management cycle. The findings suggested that cost-effectiveness analyses have not been performed in a systematic way or on a broad scale, neither in the case studies areas nor at the national level. Instead, if used at all, cost-effectiveness considerations were utilized selectively, for individual, selected measures or bundles of measures (sometimes in an exploratory way; examples include the German federal states of Bavaria, where the cost of hydromorphological measures per kilometres were used as one criterion, among others, and in Thuringia, where the cost per tonne of reductions in ammonium emissions was calculated, and costs of 40 000 €/t were set as a cost threshold to determine cost-effectiveness).

The reasons for this rather limited use of cost-effectiveness assessments were manifold: in Germany, for example, it was stated that all measures that will be implemented (or have been implemented) are by definition cost-effective, as the German local, regional and federal budgetary regulations only allow for the implementation of the most cost-effective combination of measures.

In France, a combination of cost-efficiency analysis and technical analysis was implemented by so called "Local Technical Secretariats" composed of water managers and experts, and at times other players.

Several factors were mentioned in the interviews to explain why cost-efficiency analyses were not systematically used. Most of the time there was only a single relevant measure under consideration, rendering a cost-effectiveness analysis unnecessary (similar information from Germany). It is quite easy to make a list of measures to be implemented, but much more difficult, at this planning stage, to assess their actual efficiency in a given situation, to scale them to achieve the desired targets and to assess their cost with enough precision. In Portugal, specific methodological difficulties were identified, namely assessing how different effectiveness indicators for a given measure influence its overall score, and assessing how the effectiveness of a measure with regard to reaching GES could be determined ("the dimension of the measure").

Additionally, the determination of the costs of measures on a general scale is as difficult as the determination of the benefits; thus, the necessary amount of work to conduct cost-effectiveness analyses is deemed too high. In Germany, it was even stated that performing a CEA for every single measure or measure bundle would be disproportionate with respect to the induced cost for the analysis.

The French AEAG performed an ex-ante economic assessment of the SDAGE/RBMP impacts. The purpose of this analysis was to demonstrate that if funds had to be mobilized to implement the PoM, the achievement of good status would generate welfare and positive economic impacts. In the same spirit, AESN conducted a CBA at the river basin scale, which mainly concerned groundwater, to show the benefits of a more ambitious PoM. This approach at the basin scale could be useful for gaining a more balanced and comprehensive view of the results and the benefits, than the one suggested by a sum of analyses at the local scale.

Overall, however, it was quite clear that cost-effectiveness is recognized as an important topic by policy makers and other experts and will be given further consideration in the 2nd implementation cycle, although it is not the sole decisive criterion upon which a decision to implement a certain measure will be based.

b) When looking at the ES identified for the case study, can the cost-effectiveness of measures be judged in a better or more transparent way if considered from the perspective of ESA?

There is no practical experience regarding this point in any of the case studies, as the ESA has not been used at all in the few cost-effectiveness analyses performed in the 1st management cycle so far. The reasons stated for this were a general lack of understanding of and knowledge about the ESA by policy and decision makers, as well as the large amount of work necessary for such analyses (especially if the routine in performing CEA is lacking - see above).

However, across the case studies, most interviewees agreed that the ESA could potentially be beneficial in judging the cost-effectiveness of measures, under special conditions and circumstances: (1) ES could be included in such analyses in a qualitative way, as a kind of second criterion (for example through a "score system", attributing semi-quantitative score points for high/low or more important/less important ES); (2) it could be used to prioritize between different measures, especially regarding measures that create additional benefits (e.g., on biodiversity or employment); (3) the ESA could be used to prioritize between different water bodies (e.g., which water body should be restored first based on the greatest “ecological potential” improvement, i.e., the greatest improvements in ES flows and/or ecological processes); and (4) the ESA could be used to make the diverse impacts of measures more transparent. Therefore, ESA could play a role in relation to the acceptability of ambitious measures since it creates arguments that can be used for negotiation and it favours dialogue.

In the Portuguese CS, a MCA was performed using the MULINO software tool. In the MCA, several options to improve the status of water bodies were examined and compared with regard to effectiveness, cost and risk criteria, and using a semi-qualitative approach and including impacts on ecosystem services provision (for more details, see Portuguese CS report, Annex 1). The Portuguese CS team concluded that an MCA using the MULINO tool enables a broader view of proposed measures than the usual cost-effectiveness calculations that are part of the economic analysis required by the WFD. In this sense, such an analysis can be regarded as a complement to the more "classic" economic approaches by explicitly dealing with multiple criteria, but avoiding the need to attribute a monetary value to all environmental factors and ES.

5.3.3 Designation of Heavily Modified Water Bodies (HWMB), definition of less stringent objectives and justification of time derogation

ESAWADI findings:

The ESA can be used in the costs-benefits assessments which analyse "disproportionality of costs" for the declaration of WFD exemptions. Through the integration of ESA into such assessments (for example in a CBA), "additional benefits" stemming from ES provision (while reaching GES) could be highlighted and integrated into a more comprehensive analysis of the costs and benefits of measures. As well, ESA could be used to check that the full range of benefits and stakeholders concerned are identified and integrated in the analysis. In addition, ESA can be used as a second criterion to incorporate qualitative data for acquiring a broader understanding of impacts that measures would have.

a) How were the exemptions selected in the 1st RBMP? What was the importance of "disproportionality of costs" in this selection?

Across the case studies, disproportionality of costs was only used sparingly to justify exemptions from WFD obligations.

In the Portuguese CS, there are three exemptions beyond 2027 noted in the RBMP (2% of surface water bodies), but there is no reference to the cost of these, only that they are natural water bodies that will be transformed by dam building and therefore will be changing status. The time derogations (to 2021 or 2027) are justified on grounds of technical feasibility, not cost.

In France, for the justification of exemptions, the Ministry of Ecology proposed a very precise procedure (MEEDM-D4E, 2009) and published guides and assessment tools to support its implementation. In this method, the first filters were related to technical feasibility and natural conditions. If, through these filters, exemptions were not justified, the possibility of disproportionate costs had to be studied using a three-step procedure. Most of the time, this included a *simplified* CBA based on the Ministry database which lists representative costs and benefits. A *specific* CBA was implemented only for a limited number of water bodies where significant environmental and economic issues were at stake. In total, 1 634 exemptions were declared in France on the basis of disproportionate costs (29% of the causes of exemptions are due to disproportionate costs, the majority of exemptions are due to technical feasibility (ONEMA-DAST, 2011)).

In the German CS, exemptions (extension of deadlines) were solely justified on the grounds of "technical feasibility" and "natural conditions". The argument of "disproportionality of costs" was not raised (this is mostly true also for the rest of Germany: disproportionality of costs was only used in very few RBDs).

Furthermore, it was obvious from the literature survey and the interviews that there is a general lack of clear and transparent methodologies regarding the determination of disproportionality of costs. The following difficulties were found:

- Uncertainty in relation to the effectiveness of the planned measures.
- Significant need for funds in a relatively short period of time (and with regard to the financial capabilities of the implementing authority), making extensions of deadlines necessary.
- Limiting factors such as availability of area to implement measures and expertise.

One exception is the German federal state of Rhineland-Palatine, where the Leipzig-Approach was tested (see question 2c for more details). This approach employs a clear and transparent methodology, and generated results that were used in conjunction with the argument of substantial budgetary burden to declare disproportionality of costs.

In the three countries, as reasons for not using the disproportionality of costs as an argument to justify exemptions, the large amount of work and the difficulties in determining the costs of measures on a general level were again stated.

b) Can cost-benefit assessments play a bigger role in the 2nd implementation cycle?

In the interviews of the German CS, it was stated that the "Economics" working group of the LAWA is currently working on guidance documents for economic assessments in the 2nd management cycle. Therefore, it can be expected that the economic elements of the WFD, including potential cost-benefit assessments, will be at least based on more consistent methodologies. Regarding a wider usage, the information gained in the interviews suggests the contrary; economic assessments will probably be used in the 2nd management cycle again in a selective way because of the large amount of work and the absence of knowledge about such approaches. One interviewee even stated that both cost-effectiveness analyses and additional checks for the disproportionality of costs for each measure or water body are extremely unrealistic and will in future not take place in Germany (the same arguments regarding a large amount of work were raised here). The interviewee also stated that the cost-side of measures is extremely difficult to assess on a broader or general scale - with implications for all sorts of cost-benefit assessments.

The Portuguese CS team concluded from the survey of RBD documents that the topic of the "disproportionality of costs" will not play a significant role in the upcoming management cycle.

In France, the methodology used in the 2nd management cycle has not yet been defined, but there is general demand that the so-called “simplified CBA” should not be used as often (using the Ministry of Ecology tool) and to include the results of the CBA in a MCA. While the "classic" CBA will deal with benefits which can be easily monetised, non-market benefits (which are hard to evaluate and for which the results are very much disputable) will be directly integrated in the MCA.

c) If cost-benefit assessment could play a bigger role, what would the role for the ESA be in this context (monetary assessment, qualitative-MCA)?

Because of the negligible role that the ESA has played so far in the economic assessments performed in the 1st management cycle across the case studies, it may be difficult to imagine that the ESA will play a much bigger role in any form of cost-benefit assessments in the near future. This view was also expressed in the interviews, explicitly in the German case study, and implicitly in the Portuguese case study.

In France, most economists interviewed consider that ESA could play a role in the argument for the importance of the benefits at different steps of the screening process for HMWB. In this respect, the concept of *potential services* (i.e., services which could become effective provided good status is reached) is considered of utter importance; some economists refer to the notions of “ecological value” and “ecological potential” of rivers. ESA could characterise and illustrate the benefits in very convincing terms. Those who systematically implemented the quantitative approach, such as AERM, fear that an overly qualitative approach will not find its place in the process easily, and feel that it should come as a final filter when more precise and detailed analysis are required.

Most interviewees also agreed that the ESA could be potentially useful under conditions similar to that of the cost-efficiency assessments. That is, as a kind of second qualitative criterion (e.g., through a "score system", attributing semi-quantitative score points for high/low or more important/less important ecosystem services, or another form of semi-quantitative MCA), and for generally acquiring a broader understanding of the diverse impacts that implemented measures would have. It should be stressed that the ESAWADI European Steering Committee fears that integrating ESA at the end of the process will not take advantage of its primary added value; that is, a comprehensive view of benefits based on ecosystem functionality. Therefore, ESA should come at the beginning of the analysis, and may also be included later on as a criterion to deepen the analysis.

Overall, it was widely agreed that the full monetization of ES is not feasible for WFD implementation. This was also confirmed by the above mentioned adaptation of the Leipzig Approach - a methodology which aims to include the benefits of measures (i.e., the improvement in ES provision) in a semi-qualitative way, using expert judgement and simplified quantitative scales. It has to be noted here that the aim of applying the LA was not to test its general applicability - as was done before - but to be able to draw conclusion regarding the possibilities and difficulties of utilizing the ESA in economic assessments. While the "testing" performed in the German case study should be understood as a first, tentative testing of such a methodology, it affirmed that ecosystem services (i.e., the ESA) can be included in cost-benefit assessments without an unrealistic amount of work. This could be done by using a semi-quantitative score system and by eliciting expert knowledge.

The French Water Agencies' economists expressed the need for a clearly defined methodology which quickly gets to the most important points and is able to communicate clearly and efficiently the results with convincing figures. Otherwise, ESA will never really be influential. It would also be useful to provide a typology of river basins and water bodies with their associated services. A similar approach could be developed in relation to different types of measures.

d) What are imperative services to maintain? What trade-offs are possible?

The water bodies in the German RBD Ems are characterized by a high degree of technological development. Therefore, the focus of implementing the WFD in the Ems RBD lies more on restoring lost ES than in maintaining the existing ones (e.g., guaranteeing transportation), at least from an environmental perspective. In this respect, hydromorphology and the eutrophication/immissions of nutrients are considered the most pressing issues to be addressed by WFD measures. Therefore, the restoration of the ES associated with these environmental problems (i.e., the ES that are the most impacted) could be considered as being imperative. These ES include the provision of clean water for various purposes, of fish, and cultural and aesthetic services, including the value of ecosystems for recreation and tourism. No clear answers on this issue were obtained from either the literature survey or the interviews in the French and Portuguese CS, but a remark was made in the French CS to the effect that "*this could be part of the methodology asked for by economists interviewed, in relation with the type of river basin/water body considered*".

5.3.4 Assessment of levels of cost recovery for water services (including environmental and resource costs)

ESAWADI findings:

The ESA can be used as support for environmental and resource costs assessments, or at least for the identification and characterization of these costs. At the same time, since the consideration of cost recovery is restricted to water services, this excludes some of the activities that strongly impact ES provision (if, however, the definition of water services is widened, this will change, and the concept of ES could be of more significance for ERC).

a) What approach has been taken so far in the CS for estimating Environmental and Resource costs (ERC)?

The WFD obliges Member States to include ERC into assessments of cost recovery levels.

In France, the cost recovery levels analysis was initiated in 2004 on the basis of broad-scale statistical and financial data. For water supply and sewerage utilities, Ernst & Young undertook a study at the national level which produced data at the regional administrative scale. A similar study was produced in 2012 for the 2nd cycle. It showed in particular, that at that time, water pricing did not cover infrastructure renewal. This study remained confidential for some basins.

Some basins integrated other costs, including compensation costs such as the purchase of bottled water or the necessity to dig deeper wells, resulting in much lower recovery ratios compared to those that only relied on the Ernst &Young study (but both financial and also overall cost-recovery rates including environmental and resource costs should be reported to the EU). Furthermore, the methodology provided by the French Ecology Ministry was not precise enough, for instance for the evaluation of compensation costs, and results between different agencies were not comparable. Therefore, whatever the approach, it is very important to apply the same criteria in all the basins. Resource costs were not really taken into account. The Water Agencies which engaged in the assessment of environmental costs based it on restoration costs alone and not on the loss of benefits. AEAP went farthest in the analysis of the cost recovery levels depending on the user categories.

In the Portuguese CS area, environmental costs were not assessed and not included in the basic water tariff (which aims only at recovering financial costs). However, the Water Resource Charge (issued in 2008) has a broader focus, and should actually reflect ERC, benefits from private use of the public domain and administrative costs. There was no information available on the methodologies employed to measure ERC other than the fact that specific coefficients were used for each RBD.

In the German CS, in Lower Saxony, and in the other federal states as well, ERC are not yet identified and quantified according to a specific methodology. Instead, it is widely assumed that the charges levied for extracting water for all kinds of purposes (on the Länder level), as well as levies for discharging sewage and wastewater (also on the Länder level) and for navigation (on the federal level) represent these costs, which are internalized through the charges. The rationale is that through the process of licensing, in which all possible negative impacts of water-utilizing activities are thoroughly analyzed, these negative impacts are minimized (and, by implication, ERC as well). The remaining negative impacts are then compensated for through extraction and effluent charges. Methodologies for assessing ERC independently of such assumptions are being developed in research projects (several in Lower Saxony, including one aiming at assessing ERC comprehensively in a test area), for potential use in the 2nd WFD-implementation cycle.

b) Are there plans to estimate the environmental and resource costs in more detail for the 2nd cycle?

The research projects mentioned in 3a aimed at developing additional – and practical – methodologies for assessing ERC, to be eventually used in the 2nd management cycle. The relevant parts of the RBD documents are very vague regarding this topic, however; as such, it can be assumed that some work might be done for the 2nd cycle, but up to now no specific plans exist on how to include ERC in more detail or in another way in the 2nd management cycle.

In France, the approach used in the 1st management cycle will be improved (ONEMA, 2011, produced a guide which included a list of compensation costs as well as data to assess them), but not altered significantly, meaning that most likely the (costs of the) measures required to reach the goals defined up to 2027 (GES, GEP or less stringent objectives) will be considered as the environmental costs, and resource costs will not be assessed. But debates are still continuing on this issue. For instance, some economists interviewed thought that health costs should be considered since they can be a powerful incentive.

In several French interviews, it was reported that the quantification of ERC is such an important topic that it was better to stick to hard financial data which already allows persuasive arguments about the lack of full cost recovery. Introducing disputable evaluations of environmental costs (through ESA or otherwise) would blur the message and weaken the argument for a better level of recovery. Not all economists, in the French context, share this position. However, all agree that it is a very important issue and precise analyses have to be provided.

In the case of Portugal, there is no information available regarding a planned improvement or alteration of the 2008 Water Resource Charge, which, supposedly, already incorporates ERC.

c) How could the ESA contribute to such better assessments?

The information gathered regarding the potential use of the ESA in evaluating ERC varies greatly across the case studies, and also across the interviewees within the same CS. In the German CS, the argument was made that the ESA is very suitable for determining ERC, even more than for assessing the cost-effectiveness or disproportionality of costs, as (the loss/destruction of) ES more or less equals environmental costs. It was further suggested that ESA be used as a form of "confirmation instrument", that is, (1) to compare the price level for water services with the ES affected by the provision of the water services, in order to get insights into a proper pricing policy; or (2) as a tool to check whether any relevant environmental impacts were not considered appropriately in the analysis of the impacts of water service provision and usage. This notion was also more or less confirmed by the Portuguese CS.

On the other hand, both in the French and German CS, more practical arguments were raised against the usage of the ESA in assessing ERC. Mostly methodological difficulties were stated as the reason for this - the existing methodology for calculating ERC is based primarily on substance loads and thresholds, instead on an ecosystem-wide analysis, making an assessment of affected ES difficult, and an inclusion into the calculation of ERC impossible. Also, the rather qualitative approach of the ESA was not considered adequate for delivering results for calculating very concrete costs. Additionally, the arguments stated in the above paragraphs are also applicable here (and were in fact also repeated by some interviewees). That is, a large amount of work is required and a limited availability of knowledge.

5.3.5 Implementing PoM and incentive pricing (only French Case Study)

ESAWADI findings:

The ESA can help show the PoM measures' benefits and convince local operators and stakeholders to get it implemented. It can help to conceive and give the main orientations to local operational PoM (choice and prioritization of actions, for example). The preservation or increase of services can be included in the assessment of the PoM.

a) What approach has been taken so far in the CS for implementing the PoM?

To implement the PoM, French Water Agencies and Public Authorities have to, in many cases, convince public or private operators to act accordingly. The participation of local players in the definition of the measures beforehand greatly facilitates this process. In Adour-Garonne, AEAG commissioned the local administration, or organisations such as EPIDOR, to prepare "local operational PoM". In several basins in France, schemes like River Contracts or Water Management and Development Schemes (SAGE) integrate PoM in their own programme of measures and they allow or facilitate its implementation.

Incentive pricing is hardly used since several constraints operate on the different components of water price. One of the greatest constraints is the fiscal one and any extra taxes will face strong opposition unless they are defined at a national level.

b) How could the ESA contribute to such improved implementation of the PoM?

It is agreed that ESA can play a role in convincing stakeholders of the importance and benefits of the measures proposed, thus facilitating PoM implementation. Though some economists consider that at this stage local players are more concerned with pure financial considerations (e.g., the availability of funds to implement the measures), a good ESA can also be a way of gathering new funds or be convincing of the need to invest more funding. In this perspective, the capacity of ESA to relate WFD to other environmental and development policies can be a useful way of enlarging the perspective of decision makers.

5.3.6 A discussed but controversial measure: Payment for Ecosystem Services (PES)

ESAWADI findings:

PES are controversial. In the ESAWADI project, the consensus is, recognizing the basic idea of the ESA, that PES should not be implemented in a way contrary to the "polluter pays principle". For instance, a farmer could receive money only if she contributes to the reduction of a negative impact on water bodies she has not herself generated.

Furthermore, from the perspective of ESAWADI, the objective of applying the ESA is not necessarily a maximization of ES provision, but a sort of optimization of the interaction between human well-being and natural environments. For instance, a greater amount of a given service may not call for a higher payment; a greater variety of services in relation to various stakeholders and a better protection of the ecosystem per se may be considered a better goal.

a) Is there a case in the respective case studies for integrating payments for ecosystem services (PES)?

In the French CS, the issue of PES was not considered for the 1st cycle. It is at present being discussed and studied at the national level and on some river basins (Loire-Bretagne or Adour-Garonne, for instance), in relation to agriculture or to promote organic agriculture.

In Germany, PES have been discussed for several years in the context of services provided by forestry and with regard to the provision of clean drinking water. The background to this discussion concerns the rising levels of charges for water extraction and the maintenance of water infrastructure, and the failure to consider that these services are provided by forest owners. Therefore, the principal advocate for PES schemes in Lower Saxony is the Federation of Forest Owners (WBV). Presently, forest owners are only being compensated for the additional costs that they have to bear with regard to forest conversion and afforestation beneficial to water provision. The WBV argues that the services provided by forests should be additionally recognized and rewarded. On the federal level, the thoughts and ideas seem to be more focused on the "greening" of the EU´s Common Agricultural Policy (CAP) – the coupling of payments with certain ecological services are regarded as a form of PES scheme. There was no information available from Portugal on the issue of PES.

b) What would need to be done in order to estimate ES for integration into a PES?

In the German case study, the interviewees were of the opinion that the methodologies for the qualitative and quantitative estimations of ES are presently not sufficiently developed to serves as a base for PES schemes. Therefore, the further development of reliable and transparent methodologies would be needed to comprehensively include ES into payment schemes of any sort. In the interviews, however, not much hope was expressed regarding the future inclusion of ES into such payment schemes.

In the French CS, water agency economists agreed in principal with the general links and similarities between PES and ESA, but did not think that the concrete payments for PES schemes could be based on the quantification of ES, as the methodologies were too weak. Furthermore, considerations on the level at which the price will be an incentive, on the basis of socio-economic data, is more important[18]. Instead, ESA could be used as a flanking instrument, to qualitatively monitor potential ES. It may also help to discard practices too easily considered as "good practices" but which do not result in significant change.

5.4 Conclusions and recommendations for the 2nd management cycle

Regarding the implementation of the economic requirements of the WFD, the quantitative aspects of the economic assessments - be it CEA, CBA, or the identification of ERC - are often very much the focus of discussions, scientific debates and other contemplations. This means that when the utilization of the ESA in WFD economic requirements is considered, often the only way to include it is thought to be "monetization", that is, a full quantification and valuation of ES. The ESAWADI project has demonstrated across all case studies that an approach aimed at "full monetization" is not feasible, and that if the ESA should be incorporated into WFD economic assessments, it has to be in an alternative way.

From the practical side, from the viewpoint of an implementing agency, the non-feasibility of including the ESA in a purely quantitative way is due to:

a) The large amount of work (and therefore the high costs) necessary for conducting ES assessments/evaluations on a bigger scale.

b) Limited knowledge and understanding of the concept on the part of policy makers.

c) Limited validity of most of the methodologies for quantifying ES, and therefore limited use of the results in supporting decision making.

If one expects ESA to be useful at this stage, ground work will have to be done so that meaningful information and data can be easily provided; otherwise the process is already so cumbersome that water managers will not accept extra constraints and work loads.

ESAWADI has shown also, however, that besides "full monetization", there are alternative ways of including the ESA into WFD economic elements, and these are widely supported and agreed upon by policy makers and water economists interviewed in ESAWADI. These alternatives are:

a) As a kind of "second criterion" for choosing between measures.

b) In a semi-quantitative form in support of cost-benefit assessments (e.g., in the form of a scoring system eliciting experts and stakeholders' knowledge, or through a semi-qualitative MCA) for CEA or disproportionality assessments.

c) Through purely qualitative descriptions of ES, to form the framework for following analyses or surveys.

In France, Water Agencies' economists call for tools which allow for fruitful discussions and negotiations with decision makers and other stakeholders. These tools should not only allow the integration of their own visions but also produce understandable and convincing evidence-based information.

It is difficult and may often not be relevant to apply ESA at the level of a single water body given that the provision of ES is very systemic. Therefore, the ESA could be implemented first at the level of a River Basin District as part of a preliminary screening to identify potential HMWB and derogations, as well as benefits to be considered and properly assessed.

ESAWADI originally aimed at analyzing and applying methodologies that were used in the 1st management cycle with regard to the implementation of WFD economic elements,

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[18] For a discussion of this issue see Massarutto (2012).

and to test whether and how the ESA could be incorporated into these existing "classic" economic appraisal methodologies. However, it turned out that very few methodologies were actually utilized in the 1st management cycle, and those that were used were not used on a broad scale. Therefore, ESAWADI cannot offer a complete answer to the question: "In which way can the ESA be used in WFD economic assessments?" Nevertheless, the "testing" of the Leipzig Approach (LA) in the German CS and the MCA in the Portuguese CS clearly demonstrated the possibilities of using ESA-based methodologies which do not aim at full quantification, but instead elicit experts and stakeholders' knowledge to be included in a semi-quantitative decision matrix.

Furthermore, beginning with the "analysis of existing water uses, impacts and pressures" and at each step, the ESA can yield consistency to the whole process by illustrating the link between GES goals and benefits for society (including potential services). This therefore helps in the development of a broad analysis of the issues and priorities required to properly use the qualitative and quantitative information provided by the economic analysis in the decision-making process. Consistently, it was widely recognized by the interviewees and stakeholders that the ESA is extremely valuable as a tool for communication and stakeholder participation, for improving discussions and finding solutions, as well as in the implementation processes that deal with "economics" in the first place (as was also demonstrated by the testing of the LA).

With regard to the upcoming 2nd management cycle, the following conclusions and recommendations regarding the inclusion of the ESA into economic assessments can be made:

a) There are plenty of feasible possibilities for incorporating the ESA into WFD economic elements and decision making in the various steps of the economic analyses and at different scales (e.g., a broad strategic approach at River Basin District or river-basin level, precise analysis at sub-basin or water body level without losing the view of the complex interactions at various scales in the river ecosystem).

b) To this end, it is necessary to develop tools (typology of services according the ecological and socio-economic context) and methodologies which do not aim at full monetization or quantification, but instead incorporate ES in a semi-quantitative way, combine quantitative and qualitative elements in one decision matrix, or improve on existing ones (such as the Leipzig Approach). For this to occur, EU-wide exchanges and agreements on a certain type of methodology would be very beneficial. This should provide orientation and recommendations and promote good practices, but at the same time, leaves room for River Basin District level initiatives and experimentation to adjust the method to the local context.

c) Although it is too late for a large-scale, comprehensive utilization of the ESA in the 2nd management cycle, initial steps in this direction can still be taken.

d) The preparatory work to incorporate ES on a larger scale at a later stage in the implementation process should start immediately. On the one hand, existing and/or new methodologies need to be adapted and improved; on the other hand, the knowledge base regarding ES and their relation to the human use of aquatic ecosystems needs to be strengthened. A first step would be to include a description of the ES and their importance for the water uses and services into the upcoming (2013) revision of the Article 5 reports.

6 ESA, participation and decision making

The WFD encourages (Art. 14) the active involvement and contribution of various stakeholders such as local authorities, the farming industry, environmental organisations and consumers in order to reach its objectives. Stakeholder participation aims to improve decision-making processes in water resource management by including the knowledge and experiences of people who are affected by the same decisions. The ESAWADI case studies in France, Germany and Portugal actively involved relevant stakeholders to test the ESA for the improvement of the transparency of RBM processes and to facilitate the development of cost-effective and broadly supported measures and their implementation.

The three case studies analysed ESA to determine if it was a supportive tool for improving stakeholder communication and decision making in order to enhance the implementation of IWRM and the WFD. In France and Germany this was conducted through expert interviews and stakeholder workshops, where relevant stakeholders of the respective river basins discussed and evaluated the advantages and shortcomings of the approach for stakeholder communication and decision making. In Portugal, the main interests of the stakeholders were elicited so that they could be compared with the results of a quantification of the changes of ES. Furthermore, the ESA approach was used as part of a MCA.

In the following section, insights into the research questions as presented in the FoA will be grouped along three central aspects: ESA as an educational tool; ESA as a support tool for decision making; conclusions and recommendations for the 2nd cycle.

6.1 ESA as an educational tool

This section addresses the following research questions (FoA 2011, p. 40):

- Can the ESA be implemented (i.e., can ES provision be described and assessed) to give a better illustration of the objectives of an integrated and sustainable watershed management plan such as WFD?
- Can the ESA improve the stakeholders and/or public's understanding of the WFD terms, such as GES, provided relevant indicators and communication tools are used according to the various target groups?
- How to avoid over simplifying the analysis and losing a good part of the pedagogical benefit?

The workshop discussions in France and Germany strongly suggested that the ESA could serve as an information and educational tool. Workshop participants – including water authorities and other stakeholders – appreciated the utility of the assessment of ES in order to protect ecosystems and to improve the understanding of the relationship between socio-economic activities and services. One major benefit of the ESA is that it illustrates the richness of linkages between ecosystems and their uses. The illustration of the complex system which is affected by the measure implemented, as presented in the Dordogne workshop devoted to the educational role of ESA, creates a common understanding and makes communication easier.

ESA also offers the option of considering and discussing issues beyond a certain discipline and to include different perspectives in the planning process. ESA can make stakeholders more conscious of the complexity of the system in which the implementation of a measure is planned. Awareness can also be increased with regard to what an ecosystem can provide to people (ES), starting with the uses familiar to them and illustrating the ecological processes which sustain them. Stakeholders from both countries highlighted the usefulness of ESA for bolstering arguments in discussions with funding bodies regarding the benefits of a measure. For example, for leisure activities and tourism as well the maintenance of biodiversity.

The German workshop fostered a common understanding on the part of the stakeholders. There was a discussion that the ESA might generate a common language for them. Therefore, a mutual understanding for each perspective might be enhanced and a consensus regarding the implementation of WFD might be more easily reached by means of the ESA. While authorities and other stakeholders are familiar with ESA topics and concept, there was a concern that the ESA might be too abstract to be understood by laypeople. However, simple analogies could be used to introduce the concept of ES. For instance, in the French case study, participants were first asked to indicate the positive and negative impacts of living near the Dordogne River. Then, taking pollination by bees as a paradigm of ES, the group was invited to identify the ES at the roots of the benefits. As the results of the Portuguese CS showed, if the essence of the ESA is communicated in clear terms, improvements in ecosystems are strongly valued.

Educational efforts have to be made to present the new approach and to make the messages and concepts understandable to the public. These efforts should not only be aimed at the public but also at researchers to improve their communications skills. In addition, the obstacles mentioned regarding the WFD implementation (financing, bureaucracy) should not be neglected.

ESA can be used as a tool for educational activities, but also to raise the understanding of socio-ecological issues among stakeholders involved in a decision-making process.

6.2 ESA as a support tool for decision making

This section addresses the following research questions (see FoA 2011, p. 40):

- Can the ESA provide a good basis for making decisions related to the implementation of an integrated and sustainable watershed management plan such as WFD (selecting measures, assessing exemptions, etc.)?
- What type of decision-making tools could be implemented in the context of the ESA?
- What are the actual benefits of using ESA: clearer discussion, clearer trade-offs, higher level of understanding among stakeholders, better integration of ecological and socio-economic dimension?

Stakeholders involved in the case studies in France and Germany perceive benefits from ESA foremost in terms of providing a systemic approach. More specifically, in planning processes, the ESA ensures a complete identification of groups that might be affected by the measure implemented, positively (e.g., canoeing clubs by the removal of a barrier) as well as negatively (e.g., cultural heritage or tourism as the result of a change in water flow). Therefore, even though integrated planning procedures already require the involvement of all relevant stakeholder groups, German stakeholders perceive the ESA as a valuable supporting tool for identifying relevant and affected interest groups in a river basin. It was acknowledged by French and German stakeholders that the following could be appraised in advance through ESA: the possible conflicts between stakeholders (e.g., between up- and downstream users or between land owners/farmers and environmental organisations) and different political ambitions (e.g., between renewable energy production and ecosystem protection) as well as the synergy effects resulting from the potential cooperation between local or regional water authorities (e.g., tourist and water sports associations, riverside residents) and other stakeholders.

As more of an approach for generating more information for decision makers than a tool for the direct communication with stakeholders, ESA, in combination with appropriate tools such as an MCA analysis (e.g., the Leipzig Approach or the Portuguese MCA) can illustrate the benefits of a healthy ecosystem. As illustrated by the Portuguese CS this perspective, being a more positive approach, cultivates the support of the general public for good water quality. In the French and the German case studies, however, concerns were voiced that an assessment of changes in ES (i.e., of costs and benefits due to measures) – in particular at the regional or local scale – is rather challenging. For example, German water managers did not consider the approach useful for making decisions at the regional level. This was because the changes in ES due to measures (e.g., concerning species regulation or leisure activities) at the regional scale were perceived as being too small to base decisions on.

6.2.1 Involve stakeholders at each stage of ESA implementation for a relevant decision-making process

In the various steps involved in implementing the ecosystems services approach as defined in chapter 4, attention should be given to stakeholder participation. For the **1st Task (*Analyzing the context for setting objectives and methodology of ESA*)**, participants should include at least water managers and other policy or decision makers. It may involve some major stakeholders whose agreement on the whole decision-making process is required. As mentioned before, a stakeholder analysis has to be done at this stage. Finally, the setting of objectives and methodology includes the design of the participation process to be implemented.

For **the 2nd Task (*Identifying, characterizing and selecting relevant ES*)**, involving stakeholders in the identification of ES in their territory can be a great exercise for increasing their understanding of the different values attached to the area in which they live. This was tested during workshops in France and Germany.

The educational dimension is central to the **3rd Task (*Analyzing the link between ecological functions, ecological status and ecosystem service provision*)**. Therefore, the implementation of this task may include the production of educational materials to communicate this analysis in terms adapted to the different stakeholders. There is also the understanding that some of the stakeholders can contribute to these presentations as a result of their own daily practical knowledge of the river.

Water managers and stakeholder representatives have to play a very important role in the **4th Task (*Valuating ecosystems services in qualitative, physical or monetary terms*)** thus the organisation of participation is very important. A fair representation of the different parties is required.

If stakeholders are asked to make a qualitative assessment of the relative importance of ES, as in Germany, the justification of this ranking is much more important than the ranking itself. Furthermore, the differences between the rankings by different stakeholders, water managers and scientists have to be explained and discussed. A difference may result from the fact that one of the players (even a scientist) has forgotten or underestimated some phenomena, or that, perspectives and interests are different. The goal of ESA is to raise awareness of the unknown or underestimated benefits from ecosystems. Therefore, it may be interesting to ask a given stakeholder group for their (qualitative) valuation of a service without any scientific input, and then to ask them again after presenting a proper ES identification and characterisation based on scientific work and stakeholders' knowledge and experience of the area, and to compare rankings. For instance, during one of the Dordogne workshops, the presence of fish as a benefit from oxbow lakes restoration was presented on the basis of scientific work. The benefits and value of their presence was better assessed through the contribution of different stakeholders; for example, a famous restaurant preparing a specific dish with a specific fish was mentioned.

Even for quantitative valuation, stakeholder participation is very important. Due to the uncertainties and difficulties inherent in quantification, the scientific legitimacy of the evaluation may be too weak, and some sort of agreement between scientists and stakeholders may be achieved on the main methodological choices (indicators used and ways to quantify them).

For the **5th Task, when the decision has to be made,** the process will be more fruitful if decision makers and stakeholders have been involved throughout the process ("co-

construction" approaches). The decision-support tools presented above are very important for fostering fruitful debate and positive decisions. ESA is a powerful way to set the stage since it allows a systematic and thorough identification of concerned groups, and of synergies and trade-offs in terms of benefits and costs, even if valuation is a tricky exercise for the various reasons already cited.

6.2.2 Which types of benefits are relevant for a wide range of stakeholder interests and can outweigh individual private costs?

Through discussion with the broader public, it was confirmed that cultural ES such as heritage and improved quality of life are rather difficult to quantify but, at the same time, highly valued. This might be because of a lack of experience but also because of their strong context dependency: What makes a landscape appealing for tourists beyond accessibility? Reluctance to express such a value in numbers emphasizes the need for local processes and actors' involvement: if unambiguous numbers are not available to express ecosystem services' importance, then discourse on what is valued and what needs to be protected or enhanced is vital.

6.2.3 How to deal with stakeholders with major economic interests, such as the agricultural industry?

Agricultural stakeholders were often perceived as rather rational economic actors. In relation to the costs and benefits of relevance to farmers, direct linkages to monetary values were considered mandatory.

Agriculture is seen as the most involved industry regarding measures implemented according to the WFD in the Hase sub-basin (in the county of Osnabrück, Lower-Saxony, Germany). If ESA demonstrates for farmers the benefits of a healthy ecosystem, it would be a true added value of the approach. The establishment of links between agriculture and ES may benefit farmers or it may constrain land use. It is necessary that indicators for such services are agreed upon so that their changes can be quantified. If a way of valuation is linked to a regular adaptation of the (existing) payments, this needs to be built on a sound participatory approach since it might also lead to a curtailing of existing incentives for farmers. Furthermore, stakeholders in France agree that ESA favours dialogue, and it creates a rationale useful for negotiations, especially with farmers in relation to river bank erosion.

In Portugal, the concerns of the main stakeholder regarding the proposed measures to improve the Mondego Basin quality and the WFD requirements had to do with agricultural usages (nitrate contamination, excessive use of herbicides) and (eco-)tourism. Many stakeholders consider the Polluter-Payer-Principle (PPP) fundamental to achieving good environmental quality. Therefore, it is suggested that PPP be addressed in future public participation actions.

In the Hase basin – as in many other river basins in Germany – the natural landscape has been thoroughly transformed into a cultural landscape. As a consequence, ES such as food provision were either enabled or much improved. While restoration of a more natural river system provides other benefits, this is still perceived as a threat to already existing ES such as food provision. Such perceptions are strengthened by the fact that it remains difficult to quantify or valuate benefits from the restoration of ecosystems.

6.2.4 Potential ES and cultural ES

Potential ES and cultural ES can be seen as drivers for a credible and accepted adaptation of activities for maintaining the good ecological state of the ecosystem. The analyses of cultural ES are seen as an advantage because they promote a discussion about values that are often not possible to monetize. Some French and German stakeholders regard the approach useful (for consultation and persuasion of decision makers) or more comprehensible, only if indicators and quantification become more concrete.

Some water managers in France are sceptical about the applicability of the ESA. The approach, if it is to be applied accurately, is regarded as being too difficult and costly. It is also feared that results might not be well understood by decision makers and stakeholders. At the same time, German stakeholders fear that through ESA, the value assigned to ecological benefits might be too low relative to the costs of the measure implementation. Moreover, more emphasis is put on difficulties such as the bureaucracy associated with EU funding to implement the WFD.

In all the case studies, the identification of ***potential*** ecosystem services created by a measure to enhance the ecological state of the river (or to reach GES) is valued highly by stakeholders. In France, potential ecosystem services are considered of great importance, especially for local measures acceptability. In Germany, stakeholders are of the opinion that cultural ecosystem services need to be included in planning and decision-making processes. Since barriers for implementing WFD measures are often linked to the lack of availability of land, or the lack of influence on land management practices, direct benefits of ES for land use management are crucial in WFD implementation activities so that measures are credible and accepted. Leisure activities and tourist attractions (e.g., canoeing, biking, hiking, gastronomy) as well as educational activities (e.g., nature trail) along a river acknowledge human benefits. Although viewing a river as a cultural heritage and source of inspiration are valued ES, they are at risk of being taken for granted and are not explicitly appreciated. With more emphasis on these arguments in discussions with stakeholders, a common ground can be found and perspectives can be shifted in favour of the implementation of measures according to the WFD.

6.3 Experience from 1st WFD management cycle and recommendations for the 2nd

A lot of demands were initiated by the WFD implementation process, and the focus of the water authorities implementing WFD was on complying with WFD requirements, especially in terms of timeliness. This resulted in a barrier for stakeholders (Junier et al. 2010).

ESAWADI partner were aware that by linking scale to ecological indicators it would be difficult to communicate indicators of GES to the public and even for stakeholders with different professional expertise. There was a call for a more diversified selection of indicators (and thus data); for example, for reporting to Brussels, for monitoring the RBMP at the district level, or for explaining local measures to the public (FoA, p. 23). This was confirmed in the case studies. In Germany, for example, it was felt that the scale of the indicators for the reports to Brussels does not match the need for local decision making. On the other hand, a local stakeholder voiced a concern about generating extra data for the local level. In the German case study, stakeholders hesitated to suggest new indicators which might be better applicable to the local or regional level. This might have been due to a (felt) knowledge gap among the stakeholders on what was already available and which indicators were commonly used, and on how to improve the monitoring of changes or benefits in the ES. For example, it is difficult to assess the impacts of a single (often costly) measure in favour of hydromorphology or river continuity (large scale) on fish habitats. To what extent does the measure improve the ecological status of the river basin? What are the ecological and socio-economic benefits of such a measure? If, as in the German case study, some water bodies would not reach good ecological status due to hydromorphological pressures despite this measure, but which conform to the definition of a HWMB, it is easily accepted that the costs and constraints are perceived to be larger than the benefits expected and that not implementing measures is easily justified. Furthermore, local scale does not always deliver a good overview of regional issues (e.g. up- and downstream issues) such as migrating fish and salmon stocking. Regional issues such as the transboundary characteristics of a river like the Hase River or Ems River and its influence on its management level need to be taken into account. Thus, in order to get a general overview of ES in a river basin, a higher scale might be more appropriate. To detect specific and local impacts and to gather data, a lower scale, more along the administrative (local) units, may be chosen. This would also facilitate stakeholder involvement and communication at the local scale.

The strengths of the ESA lie in its structured approach to a systemic description of ecosystems and their benefits and its ability to elicit expert's and stakeholder's knowledge to support planning processes and decision making in river basin management. The ESA has been perceived by stakeholders as a good educational tool, helping to create common ground with respect to the potential of a healthy ecosystem, and to increase awareness, particularly in professional stakeholders. As a tool for the general public, concern was expressed as to whether the concept might be too abstract. Educational efforts have to be made to present the new approach and to make the messages and concepts understandable to the general public. These efforts should also address researchers in order to improve their communications skills. This is also a confirmation of the result of a broad survey among (scientific) supporters of the ESA in the USA on the barriers towards successful ESA implementation (ResourceMedia, 2012).

To make better use of ESA, the positive essence of it - namely, that healthy ecosystems provide benefits - needs to be communicated in a way that's more understandable to stakeholders and the general public. For the German context, this could mean, for example, that in management processes less effort may need to be spent on categorizing and identifying ES in scientific terms and more on the benefits appreciated by stakeholders. This would require specifying how these benefits are generated by the ecosystem. For example, if stakeholders appreciate foremost the scenery and the view over a flat landscape, growing forest in a wetland area might be met with resistance.

In summary, ESA is a valuable planning tool for identifying stakeholders and possible conflicts as well as for illustrating the diverse benefits a measure could generate. Therefore, ESA can support decision making, but it is not a decision-making tool in itself. This is particularly true if a full quantification and valuation of the impacts of measures is challenging, if not unsuitable, at the regional or local level. This is often the case. The assessment of specific impacts (by a single measure or a programme of measures) cannot generate convincing data for stakeholders and decision makers due to the inappropriateness of local indicators and the inherent uncertainties of complex (eco)systems. The lack of quantification and the generally accepted valuation methods need to be compensated for by a transparency in river basin management and good stakeholder cooperation.

7 Main findings and recommendations

ESAWADI aimed at analyzing the added-value of the ESA for decision making and public participation processes with regard to the implementation of the WFD, particularly its economic requirements, building on the experiences of the 1st management cycle of the WFD. The WFD is the major European policy instrument for achieving sustainable water resources management; however, at national and regional levels various other instruments exist and provide further opportunities to implement ESA. Additionally, it soon became apparent that it would be more fruitful to work from the perspective of sustainable integrated watershed management. Acknowledging these multi-level challenges, ESAWADI partners sought to develop their case studies to fit the local context, respond to water managers' expectations and to benefit from existing local scientific research and studies. A common analytical framework was applied for the three case studies and which developed various tools and methods in order to adapt to local needs.

ESAWADI's case study focus is operational with a strong scientific component and is aware of the policy-making needs at the European level. The analysis and recommendations are mainly targeted at water managers and other stakeholders who aim to implement IWRM schemes and/or WFD and who want to assess the suitability of ESA as a supportive tool.

In this context, we have taken water managers' expectations of ESA as a starting point, as well as their concerns with barriers to implementation. Some of these expectations and concerns are conceptual and even ideological, others are more technical or institutional (e.g., lack of methodology or means to implement ESA in current institutional structures). More importantly, if the perception of some barriers to implementation were a result of the very nature of ESA, others were related to a lack of knowledge, experience and misconceptions of ESA. In this chapter we respond to those concerns by summarizing the central findings of ESAWADI, followed by major lessons learnt and, where appropriate, to recommendations for future implementation of the ESA.

Reflecting the structure of this report, we first conclude with an overview of the expectations and perceptions of the ESA concept. In section 7.2, our insights in terms of implementing ESA are collected. Sections 7.3-7.5 reflect the thematic foci of the project: ESA with regards to communication, education, decision making and ESA for supporting WFD economic requirements.

The sections are structured as follows:

- Initial water managers' expectations and concerns regarding ESA (including barriers to the application of ESA) which appeared in our case studies and beyond.
- The team's findings in response to the above.
- Major lessons and, if appropriate, recommendations to water managers, as well as to national and European policy makers so that they can support water managers in their use of ESA.

While we will not enter into the debate as to whether or not ESA should be used, based on our experience we shall elaborate on the following questions: for what purpose, under which conditions, and in which way may the ESA be applied?

7.1 ESA as a concept: expectations, barriers and insights

7.1.1 Water Managers' expectations and barriers regarding the concept of ESA

Appreciated as a promising approach for supporting IWRM, feedback from water managers emphasizes that ESA is in particular expected to ensure that the value of natural assets is not forgotten. ESA thereby should contribute to the better protection of ecosystems. Nevertheless, particularly in France, ESA faces ideological criticism related to its anthropocentric and utilitarian approach and because of the perception that it commodifies nature, that is, the denial of nature an intrinsic value. Thus there are concerns that implementing ESA would not support the environmental objectives of the WFD, that is, the GES. Some see the risk of it can becoming a tool for seeking the maximisation of some highly valued services at the expense of others and the integrity of ecosystems (Wallis et. al., 2012). In addition, the concept is seen as complex, not clear enough, and consisting of a melange of issues.

7.1.2 Summary of ESAWADI findings on ESA as a concept

- Scientific debates are still continuing on the exact nature of ES and on their relation to ecological functions, etc. While considerable work has already been done, the concept of ES is still new and people are still learning about it. The ESAWADI project implemented and **promoted an ESA** which was neither merely anthropocentric (focused on human benefits maximisation) nor ecosystem-centred (conservation without taking human needs into consideration), but **oriented towards a sustainable co-evolution between nature and society (using a combination of scientific expertise and stakeholder consultations)**. This has been perceived as consistent with the WFD's stringent requirements in terms of ecological quality (GES).
- The ESAWADI team's experience was that the principal strengths of the ESA lie in its structured and systematic approach to describing the way functioning ecosystems provide benefits to society and its capacity to elicit expert and stakeholder knowledge to support planning processes and decision making in river basin management. Integrated, holistic approaches such as ESA are acknowledged as desirable approaches for an effective implementation of the WFD or other resource management objectives which include sustainability principles. ESA may ensure that a comprehensive and consistent approach is used to highlight the linkages between uses and ecosystem functions, thereby identifying the full range of ES (potential or existing services), and thus facilitating the design of relevant policies. It can prevent the selection of measures with a narrow and short-term perspective (such as a measure which maximizes the benefits to one group at the expense of other stakeholders and of a long-term perspective).

7.1.3 Major lessons on the ESA as a concept

- As a theoretical concept, the integrative character of the ESA has been acknowledged as being beneficial for supporting the WFD implementation. However, in practice, ESA cannot (fortunately) adopt a fully utilitarian approach and thereby the maximisation of the provision of ecosystem services which that might imply. In contrast, and consistent with the WFD's stringent demands with respect to GES, it features a systemic approach to optimal ecosystem integrity protection and the sustainable provision of the different services in the long term.
- On-going scientific debates and the continued development of the concept of ES and other related concepts is still very important. For the operational

implementation of ESA in relation to IWRM schemes, it would be useful to translate these debates into further research issues. In this way, the richness of the concept will support fruitful local analysis and investigations whether through a detailed framework of analysis or simple educational documents which highlight the main elements of the concept.

7.2 Characterization of ecosystem services and implementation of ESA

7.2.1 Water managers' expectations and concerns with respect to the characterization of ES and the implementation of ESA

- Most water managers involved in the project or interviewed consider that ESA accords more consistency and sense to the whole IWRM/WFD approach, particularly between technical (natural science/engineering) and socio-economic components, thus providing people in charge of these components with a common language.
- The comprehensiveness of the approach (identification, characterisation, evaluation, etc.) has raised expectations. Assessing all ES in a watershed presents a huge operational challenge: water managers expect that this is too complex and requires too much work. Institutional barriers such as discrepant reference scales for administration and ecosystems add to these challenges. As a consequence, it is expected that most of the ESA applications will make oversimplifications which will lead to disappointing or deceiving results. For instance, evaluations may be made at a scale which is not relevant and/or loses the river basin dimension. Several water managers doubt that the quantification and even monetization of ecosystem services are feasible or would produce relevant results. Others, however, are of the opinion that ESA is not useful if it does not produce quantitative or monetary results. The ESAWADI European Steering Committee members further voiced a concern that the risks of adopting the ESA include the promotion of select ecosystem services independently of the whole ecosystem in order to justify selective policies and land use choices. There is a lack of faith in the ability of the ESA to eventually contribute to the integration and acknowledgement of ecological values. Given that water managers perceive their modus operandi as already being highly integrative, there is a failure or reluctance to acknowledge the added value of ESA in comparison to other integrative management tools. From an operational perspective, the need for implementing ESA is therefore often considered to be limited.

7.2.2 Summary of ESAWADI findings on characterization of ES and implementation of ESA

- In addressing the water managers' concerns, our case studies placed a great emphasis on the more qualitative descriptions and characterisations of ES provision. The challenge was to reconcile (a) very conspicuous and at times financial benefits with (b) a large range of indirect benefits for large sections of the populations, which although difficult to quantify are very valuable and significant.
- Being a process-based approach, part of the difficulties encountered while implementing the ESA may be due to typical process challenges such as a lack of clarity in the objectives and aims for this implementation from the outset, as well as a need for an adaptation to the actual context including the data situation. Although several options for simplifying the complex interactions between ecological and socio-economic river basin processes are possible, these choices need to be made with due consideration of objectives (e.g., defining goals and priorities at a larger scale, assessing the effects of policy or measures on ES, discussing of the value of ES with

the general population, etc.). In our case studies, the ESA contributed to a variety of water management objectives, and its implementation needed to target all of them.

- Although qualitative descriptions of ES bring new perspectives and acknowledgements (e.g., of cultural values) into stakeholder processes, actors with a financial stake were perceived in the case studies as only being open to benefits expressed in monetary terms. The ESAWADI project has demonstrated in all case studies that a thorough quantification and valuation of ES, aiming at "full monetization", is neither feasible nor desirable, and that if the ESA should be incorporated into WFD economic assessments, it has to be done in an alternative way, that is, in a qualitative or semi-qualitative way.
- The experience of ESAWADI partners was that the identification and characterization of ES is in itself a challenge. In a river socio-ecosystem, there are no linear relations and no direct cause-effect patterns among drivers, pressures and state/impacts, but instead intricate and cumulative relations. As mentioned during the 2011 2nd CIS-SPI seminar in Brussels (Wallis et al., 2012, p.10): "Sustaining ecosystem services flows requires a good understanding of how ecosystems function and provide services, and how they are likely to be affected by various pressures. Aquatic ecosystems support a number of key regulatory functions."
- However, if characterising ES in qualitative terms offers a good account of the complexity of ecosystems, ecological functions and processes, the ESA may lose a good part of its utility and accuracy when it comes to quantifying the value of ES (in physical terms, and even more in monetary terms). This is due to the necessary simplifications required and the methodological and data availability challenges faced when quantifying.
- ESA is often presented as a panacea which will solve biodiversity valuation issues. Our experience is that when it comes to the quantification and monetization of services, one has to utilize a good part of traditional methods (contingent valuation, hedonic pricing, willingness to pay, benefit transfers, etc.) and indicators, particularly for indirect ecosystem services (e.g., regulation services). Therefore, all the difficulties encountered by environmental economics rear their heads. In other words, the numerous gaps in data and knowledge on the linkages between ecosystem functions, pressures, and ES.
- Literature reviews and exchanges with practitioners confirmed that a thorough valuation is expensive and should only be undertaken with adequate means. Nevertheless, specific quantification may be useful to capture the dynamics of evolution of the ecosystem and related services provision and therefore trade-offs. These analyses can be supported by diagrammatic maps, rather than precise GIS maps, showing the location of specific services over a general area.
- As an interdisciplinary approach, it became clear that the ESA can be difficult to manage. The interaction of ecology with sociological and economic methodologies makes the basic communication of methodological requirements challenging. Thus, when ecological processes have to be analysed at basin-scale, sociological and economics data can be better dealt with at administrative or other socially meaningful levels. As well, it is necessary to be aware of the importance of the socio-economic context in order to understand why potential services are not exploited by human uses. The term "potential services" is a good example of the duality resulting from the use of a concept by several disciplines. Indeed, as noted above, a potential service can be due to a cultural or economic lack or it could be due to the inability of an ecosystem to deliver the service due to bad ecological status but which, in future, may be able to deliver if the status improves. If an interdisciplinary approach can be seen as limiting, it can also be considered an enabler of the ES concept for conservation and environmental measures implementation.

7.2.3 Major lessons and recommendations for implementing ESA and the characterization of ES

- The implementation of ESA needs operational guidance. However, general guidelines need to acknowledge the site specificity of each social-ecological system and may thus only be a starting point. It is possible to give broad guidelines, but there is no method relevant for each situation.
- From an operational viewpoint, ESA should not be encountered as a completely new approach compelling people to adopt an unfamiliar framework. The approach needs to build on existing local initiatives, plans and programmes. Any integrated planning approach has to address different policies, rules and regulations, as well as schemes originating from local to national and European bodies (WFD, Natura 2000, Flood Directive, etc.). Our experience is that at a local level, ESA could create a bridge between these policies.
- Quantification and monetization may bring some added value, but it should be considered with care. In most of the situations, it is neither possible nor desirable to quantify/monetize everything. In fact, only the Portuguese case study attempted to monetise ES through a WTP survey.
- Several water managers are of the opinion that the additional value of a full quantification and monetary valuation of the policy/programme measures is too low for the investment required for a thorough assessment/valuation of ES and the related trade-offs/synergies.
- However, the concise identification and characterisation of ES in a given water basin, on the basis of existing data and through interactions with water managers and local stakeholders, even without quantification, can in itself result in significant added value. The qualitative description of ES is a prerequisite should an economic valuation of ecosystem services be planned.
- To support ESA implementation at an operational level, there is a need for further research. This was addressed at the CIS-SPI Seminar 2011which stressed "the links between geomorphological components, good ecological status and ecosystem functioning, with both preservation and restoration perspectives" (Wallis et al., 2012, p. 12).

7.3 Relevance of ESA as an educational tool and a means for supporting stakeholder participation in relation to IWRM and WFD

7.3.1 Water managers' expectations and concerns with regard to ESA as an educational tool and means for supporting stakeholder participation

- Water managers accept that ESA is a good educational tool for supporting and promoting local water policies. In particular, the representation of cultural ES was considered a true added value of the ESA. However, water management experts are concerned that the concept and its methods might be too abstract for a lot of stakeholders and the general public because of its complexity.
- The ESAWADI team's experience was that participatory ESA emphasizes the benefits of often unknown or unrepresented services of, for instance, cultural ES. Several stakeholders stated explicitly that ES, such as heritage and quality of life, are often underestimated and could be taken into consideration; their inputs into qualitatively describing and valuing such services were very useful. Even though these services may be difficult to quantify they are highly valued. In particular, in local policy

processes, stakeholders' involvement and political support can be sought by featuring these cultural ES. The preservation of cultural ES was perceived as a driver for accepting changes of activities to maintain GES.

7.3.2 Major lessons and recommendations with regard to ESA as an educational tool and for supporting stakeholder participation

- The potential role of ESA as a support for communication and environmental education is largely shared. Water managers and other stakeholders appreciated that ESA is a good educational and participatory tool, helping to create common ground with respect to the potential of a healthy ecosystem, benefits of ecosystems protection and restoration, awareness raising and discussions on ecological processes and the potential services that result from attaining GES.
- The positive essence of an ecosystem services approach – namely, that ecosystems provide benefits for human society – needs to be communicated in a way that is appreciated by stakeholders and the general public. Therefore, the first purpose of an ESA should be to provide an accurate and comprehensive qualitative picture of the ES under consideration, supported by data such as trends and background figures (i.e., importance of activities relying on ES provision) and diagrammatic maps. The relationship between benefits and ecological processes should be highlighted, as well as potential services arising from the of improvement measures. In all these analyses, the basin level dimension should not be lost.
- The successful communication of ES involves building the capacity of stakeholders as well as researchers. Educational efforts have to be made to present the new approach and make the messages and concepts understandable to the general public. These efforts should not only be directed at the public but also to researchers to improve their communications skills. This is also a result of a broad survey among (scientific) supporters of the ESA in USA on the barriers to a successful ESA implementation. Such efforts are fruitful and allow the demonstration that ESA delivers clear added value.
- For this purpose, a qualitative approach and a participatory evaluation of ES are very useful since they allow taking into consideration underestimated ecosystem benefits. Even without the provision of detailed data and a quantification or even monetisation of ES, ESA can support communication and serve to cultivate awareness of the purpose of specific water resource management measures.
- ESA is a valuable planning tool for identifying stakeholders and possible conflicts as well as for illustrating the diverse benefits a measure could generate. Combined with traditional stakeholder identification methods (e.g., who contributes to the problem? who is affected by it? who can solve it?), it allows a broader and more integrated approach. Also, due consideration has to be given to the scale issue. Namely, the number of stakeholders is contingent upon the scale of the analysis or of a measure's impact.
- However, improving communication among stakeholders and with water managers requires time and a willingness of participants to talk to each other, with and without ESA. It requires thorough preparation. This is supported by the results of the 2011 Brussels CIS-SPI Seminar which states that "ecosystem services help us recognise all stakeholders likely to be affected by decisions, and therefore those who should be included in the deliberative process. This in turn can facilitate more effective communication and engagement with people in socially meaningful terms."

7.4 Relevance of ESA as a decision-making support tool in relation to IWRM

7.4.1 Water managers' expectations of and concerns about ESA as a decision making support tool

Within the context of the prevailing public discourse on financial and economic constraints, ESA has often been expected to provide additional support to decision making through the option of valuing the benefits of ecosystems, or even monetizing the value of hitherto unvalued benefits of ecosystems and their services. In order for this to occur, water managers would expect to put "real numbers and facts" down as arguments for measures or water management objectives. This would require robust quantitative assessments, and even monetary valuation. The present perception is that ESA cannot deliver such robustness. This adds to the scepticism that ES can be documented by the ESA as sufficiently valuable to "justify" the GES as a sustainable water management objective (see 7.1). In particular in human-shaped environments, the concern is that ES benefits will eventually not compete value-wise with benefits from activities such as hydroelectricity production or agriculture. Thus a significant barrier to the implementation of the ESA is that it "backfires" on the interest of water managers.

7.4.2 Summary of ESAWADI findings on ESA as a decision-making tool

With respect to ESA, our studies confirmed that the basic barriers for assessing the ecological/environmental benefits of policies/programmes are limited data availability and a lack of standardized methodologies. Uncertainty about the results generated by quantification and valuation methods is a significant barrier to the acceptance of such methods. Uncertainty exists with respect to impacts, on how to generate data, and on the methods for assessing data, in particular on the benefits of policy measures. Thus, the numbers produced during an ESA are not considered beneficial. The French Seine-Normandie Water Agency's experience was that the importance of benefits in different CBA was correlated to the budget allocated to the evaluation and therefore to the extent of the investigations. As well, the French Ministry of Ecology stressed that in many CBA in the context of IWRM schemes, the evaluation of benefits are limited to the scheme area without due consideration to upstream and downstream impacts.

7.4.3 Major lessons and recommendations for applying ESA in decision making

- ESA's main contribution to decision making is to provide a broad and comprehensive (ecological and socio-economic perspective) view of the issues at stake.
- In combination with traditional support tools (CBA, MCA, etc), ESA can support the production of qualitative, semi-quantitative and quantitative data through field investigations and discussions with stakeholders.
- Due to the existent uncertainty, the legitimacy of a decision needs to be the result of a participatory approach where stakeholders validate the options selected and trade-offs. As mentioned above, ESA is a powerful way to set the stage since it allows a systematic and thorough identification of concerned groups, and of synergies and trade-offs in terms of benefits and costs.
- In most of the cases, a full and scientific quantification/monetization is not required/possible, but if attempted it should be based on sufficient technical/financial data to provide relevant results.
- To support this ESA implementation, there has to be the development of new valuation methods or the improvement of existing ones (such has the way to

implement value transfers), as well as tools and methodologies that allow fruitful policy-making discussions and negotiations with decision makers and other stakeholders.

- From the perspective of WFD implementation, the harmonization of concepts and methods at a European level would be useful. But considering that the ESA concept is still more at a "storming" and "forming" stage than a "norming" one, it is more important right now to document the experimental processes.

7.5 Relevance of ESA in relation to WFD economic requirements

7.5.1 Water managers' expectations and concerns in relation to WFD economic requirements

The comprehensive economic approach of the WFD provides a particular challenge to most of the water managers. This is because it requires a basin wide application of economic methods which had only been applied in a select number of water management cases. At a European and national policy-making level, great expectations are placed on ESA to better fulfil the WFD economic requirements since methodological standardization of their implementation is one of the core challenges throughout Europe. That being said, awareness exists of the methodological uncertainties and the need for local adaptation, raising questions about the particular benefits of ESA in comparison to other economic methods.

7.5.2 ESAWADI findings on ESA in relation to WFD economic requirements

- In Germany and France, the ESAWADI team discussed this issue with the persons in charge of implementing economic requirements in different River Basin Districts. It turned out, however, that although significant "new" work had been carried out on WFD economic analyses, there was only a very limited number of systematic and transparent methodologies which fulfil the economic requirements in Europe. Therefore, ESAWADI's analysis of the links between ESA and WFD economic requirements are inherently limited to what was available for examination and comparison.
- Nevertheless, this situation led us to make additional observations. One is that the implementation of WFD economic requirements requires much work and brings its own methodological constraints; therefore, people are reluctant to introduce new methods which possibly include additional work and constraints. The second one is that in the different cases, water managers adjusted the method to the local situation by combining economic analyses, natural and technical constraints, political constraints and negotiation results.
- In this context, the possibility of applying the ESA in a quantitative way encounters a number of barriers: (a) the large amount of work (and therefore the high costs) necessary for conducting ecosystem services assessments/evaluations on a larger scale; (b) limited knowledge and understanding of the concept by policy makers; and (c) limited robustness of most of the methodologies to quantify ecosystem services, and therefore limited legitimacy of the results in supporting decision making.
- Nevertheless, by discussing with them the approach developed within ESAWADI, it appeared that there are possibilities for incorporating the ESA into WFD economic elements and decision making other than "full quantification and monetization".
- At a first glance, ESA would appear to be very convenient for assessing cost recovery in relation to environmental and resource costs. However, in practice, water managers are reluctant to include a methodology requiring a large amount of work and which

produces results with high uncertainties. The extent of the distrust of ESA for this purpose was evident in some of the French case study interviews when it was reported that cost recovery is such an important topic that it is better to stick with hard financial data which already demonstrates the lack of full cost recovery. Therefore, at this stage, the use of ESA for ERC assessment remains an issue for research, as in Lower Saxony for instance.

- Across the case studies, most interviewees agreed that the ESA could potentially be beneficial in judging the cost effectiveness of measures under specific conditions and circumstances: first, ES could be included in such analyses in a qualitative way, as a kind of second criterion (for example through a "score system", attributing semi-quantitative score points for high/low or more important/less important ES); second, it could be used to prioritize between different measures, especially regarding measures that create additional benefits (e.g., on biodiversity or employment); third, the ESA could be used to prioritize between different water bodies (i.e., the question of which water body should be restored first); and fourth, the ESA could be used to make the diverse impacts of measures more transparent. Therefore, ESA could play a role in relation to the acceptability of ambitious measures since it creates arguments that can be used for negotiation.
- As far the disproportionality of costs assessment is concerned, most interviewees agreed that the ESA could be potentially useful under conditions similar to those for the cost-efficiency assessments: for selected cases, as a kind of second criterion mainly in a qualitative way (for example through a "score system", attributing semi-quantitative score points for high/low or more important/less important ecosystem services), and for generally acquiring a broader understanding of the diverse impacts that implemented measures would have. ESA may be integrated into other tools such as the MCA or the German Leipzig Approach to generate valuable - even more qualitative – information for decision makers. The suggestion was to combine CBA and a MCA. While the "classic" CBA will deal with benefits which can be easily monetized, non-market benefits (which are hard to evaluate and for which the results are very much disputable) will be assessed in a qualitative or quantitative manner integrated in the MCA with CBA results. ESAWADI proposes that ESA should instead be used for a systematic identification of benefits to be included in a CBA (if relevant) or in a MCA.
- Payments for ES are currently popular at the European level and in different countries. Some economists agree that the ESA methodology is so far too weak to base financial schemes on; moreover, several economists agree that payment levels should be related to incentive capacity and not on a disputable monetary valuation of the service. Nevertheless, ESA could be used to identify the services for which a payment is relevant and the practices which will justify this payment due to their capacity to restore some valuable services.

7.5.3 Major lessons and recommendations on ESA in relation to WFD economics

- For the improved implementation of WFD economic requirements, the ESA may at least act as a support tool providing qualitative insights on ES and trade-offs. ESA could play this role at the various steps of the economic analyses and at varying scales (a broad strategic approach at river basin district level, or at sub-basin or water body level).
- The argument was expressed that ESA is not feasible on a very large scale given the available means. However, we recommend that the level of investigation and quantification could be adjusted to the available resources.
- In summary, ESA can be included into WFD economic elements in the following ways:

a) For Article 5 on the identification and characterisation of ecosystem services: ESA illustrate particular socio-economic uses or specific aquatic systems.

b) For Article 11 on cost-effectiveness: ecosystem services provision/the ESA can be used as a kind of "second criterion" in choosing between measures; in a semi-quantitative form to support cost-benefit assessments (e.g., in the form of a scoring system eliciting expert and stakeholder knowledge, or through a semi-qualitative MCA for CEA or disproportionality assessments); and as a purely qualitative descriptions of ecosystem services to form the framework under which analyses or surveys would be carried out.

c) Article 4 on the disproportionality of costs: ESA can be used as a second criterion to incorporate qualitative data for acquiring a broader understanding of impacts that measures would have.

- To this end, it is necessary to develop tools (typology of services according the ecological and socio-economic context) and methodologies which do not aim at full monetization/quantification, but instead incorporate ES in a semi-quantitative way, or which combine quantitative and qualitative elements in one decision matrix, or which improve on existing ones (such as the Leipzig Approach).
- This is consistent with the expectations of operational economists, for instance in the French Water Agencies, who acknowledge the need to have tools and methodologies which allow fruitful discussions and negotiations with decision-makers and other stakeholders; that is, which produces data understandable and convincing for them using tools and methodologies which can integrate their own visions.
- Towards this end, EU-wide exchanges and agreement on a certain type of methodology would be very beneficial. This should provide orientation and recommendations and promote good practices, but at the same time, accommodate district level initiative and experimentation to adjust the method to the local context.
- It is at present too late for a large-scale, comprehensive utilization of the ESA in the 2nd management cycle, but initial steps in this direction can still be taken.
- The preparatory work to incorporate ES on a larger scale at a later stage in the implementation process should start immediately. On the one hand, existing and/or new methodologies need to be adapted and improved; on the other hand, the knowledge base regarding ES and their linkage to human utilization of the water environment needs to be strengthened.
- A first step would be to include a description of the ES and their importance for the water uses/services into the upcoming (2013) revision of the Article-5 reports.

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ANNEXES

Annex 1 Key Research Questions

The three case studies tested the usefulness of ESA in relation to participation and policy making, good status and water body characterisation as well as to WFD economics. The respective research questions are listed in the following.

1. Participation and decision making

The hypothesis in ESAWADI was that the ecosystem approach for environmental policy decision making has to be sufficiently understood by all involved in order to discuss, negotiate and finally reach a solution/programme of measures that is acceptable and supports reaching the objectives of the WFD. The objectives of the WFD as defined in Article 4 and specified in Annexes II and V of the WFD are difficult to understand by non-experts. Thus, a more illustrative vehicle for transmitting the current situation of water bodies as well as the different options for improvement is needed. ESAWADI examined whether the ESA could serve as such a vehicle by answering the following main research questions:

Research questions on participation and decision -making	Covered by case study
How can ESA be applied (i.e., ES provision should be described and assessed) to give a better illustration of the objectives of an integrated and sustainable watershed management plan such as WFD? Can the ESA improve the stakeholder's/public's understanding of the WFD terms, such as good ecological status, by suggesting that relevant indicators and communication tools are used according to the various target groups?	**DE/FR/PT**
How can the ESA provide a good discussion basis for taking decisions related to the implementation of an integrated and sustainable watershed management plan such as WFD (selecting measures, assessing exemptions etc.)?	**DE/FR**
In the participatory decision process requested by the WFD, which types of benefits are relevant for a wide range of stakeholder interests and can outweigh individual private costs?	**DE/FR**
How can the identification of potential ecosystem services be a driver towards a credible and accepted adaptation of activities to maintain the good ecological state of the ecosystem (products of better quality…)?	**DE/FR/PT**
How to integrate upstream/downstream issues to provide a good understanding of river functioning and at the same time assess services provision at a manageable scale?	**FR/PT**
What type of decision-making tools could be implemented in the context of the ESA? How to avoid over-simplifying the analyses and losing a good part of the pedagogical benefit?	**DE/FR/ PT**
What are the actual benefits of using ESA: clearer discussion, clearer trade-offs, higher level of understanding among stakeholders, better integration of ecological and socio-economic dimension?	**DE/FR**

2. Good status and water body characterisation

In order to investigate the relationship between water bodies characterisation according to the WFD and ES, it was necessary to investigate the relationship between GES, biodiversity and ecosystem functions, which are the basis of the benefits provided by ES. The common approach in the three case studies was to collect the information available and to describe the situation with respect to this issue. However, the full analysis on the discrepancy between WFD characterisation metrics and ecosystem functions is beyond the scope of ESAWADI. Key Research Questions related to Good Status and water bodies characterisation were:

Research questions on Good status and water body characterisation	Covered by case study
What can we say about the links between GES as it is defined in WFD (Annex V - 1.2. Normative definitions of ecological status classifications) and its implementation in the given case study area and the different facets of biodiversity (taxonomy, functionalities, genetic aspects…)?	**FR/PT**
What are the relations between the services provided (from a qualitative and quantitative perspective) and the water bodies' characterisation according to the WFD? What are the pressures and impacts on the ecosystem which this characterisation considers and those it doesn't? How should/could the characterisation be improved?	**FR/PT**
How can we estimate the potential service provision associated with ecosystem integrity and the different levels of water quality status?	**FR/PT**
How can we estimate the potential impact of ecosystem functions restoration, ecological status and changes in ecosystem services provision?	**FR/PT**
What added benefits would a good status of the river deliver to each stakeholder group and what are the costs of the adaptation of river basin activities and objectives?	**FR/PT**
At which spatial scale are ecologists able to characterize ES; is it consistent with management scales (water bodies, basin, district, etc.)?	**DE/FR/PT**

This approach leads to a broader understanding of the role of good ecological status in relation to socio-economic benefits.

3. WFD economics

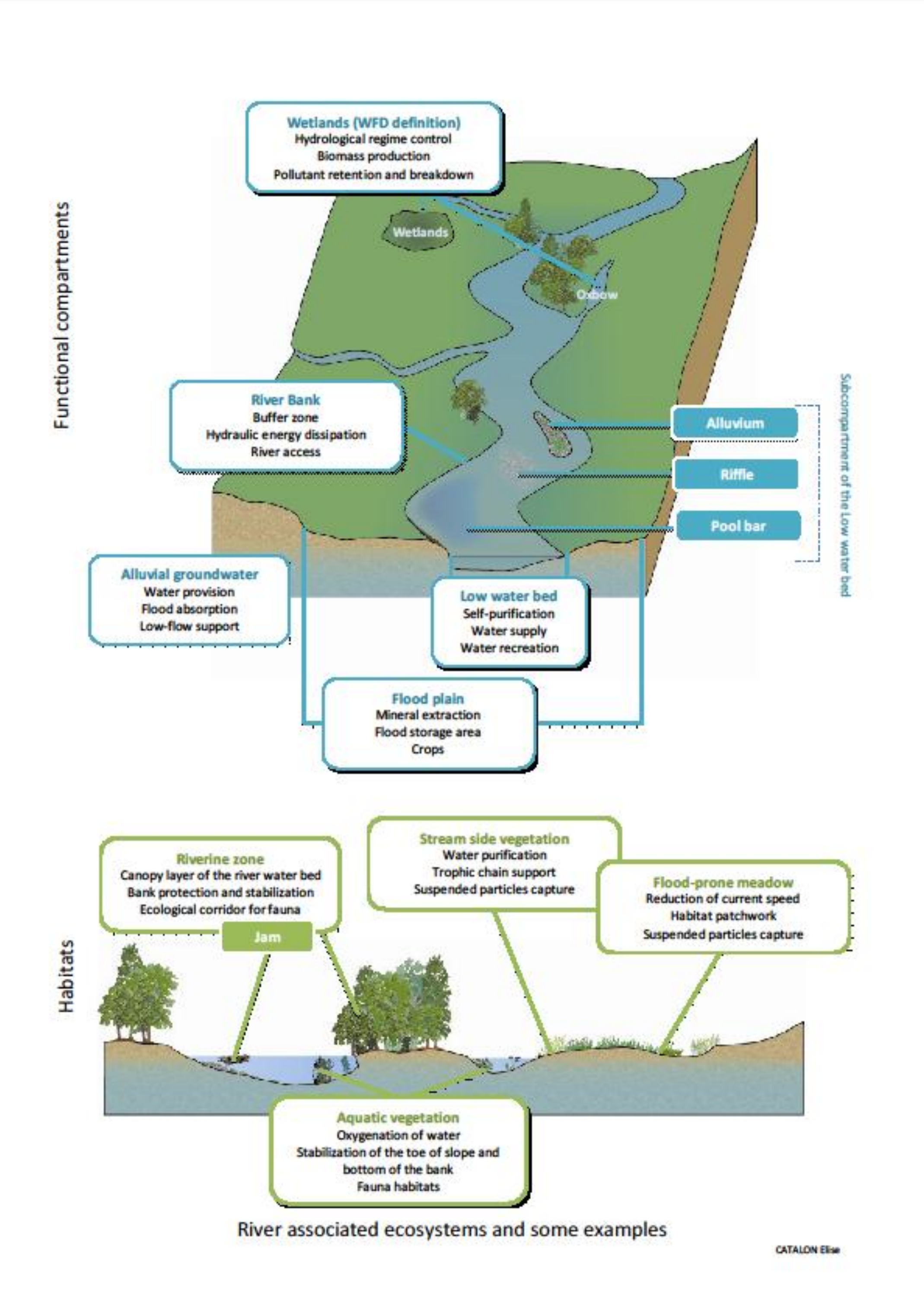
The case studies looked at the usefulness of the ESA in complying with the WFD Articles 4 (exemptions/disproportionality of costs), 9 (cost recovery), 11 (cost-effectiveness) and, additionally, the link between ESA and payments for ES schemes. In the French CS, the analysis of existing water uses, impacts and pressures was also examined. The aim here was not to develop another, "better" approach to WFD implementation, but to demonstrate the added-value of the ESA for the implementation of the WFD economic requirements and for the design and implementation of any sustainable watershed management plan. The ESAWADI project team considered all above mentioned WFD economics issues in the case studies in order to get a "feeling" for which issues the ESA is most promising for in the future. Nevertheless, the CS were very diverse in the sense that they had different starting points. Furthermore, water managers involved in the case studies might have had their own expectations. Considering these constraints, the project team used a limited number of specific questions as far as case study implementation and interactions with stakeholders was concerned:

Research questions on WFD Economics	Covered by case study
Analysing existing water uses, impacts and pressures: • How socio-economic data were integrated in the analysis of existing water uses, impacts and pressures? • How the approach will evolve in the 2nd implementation cycle? • How ESA could be implemented in this analysis?	FR
Selection of measures/Cost-effectiveness (Art.11) • How was the cost-effectiveness of sets of measures dealt with in the 1st RBMP? • When looking at the ecosystem services identified for the case study, can the effectiveness of measures be judged in a better/more transparent way if looking at it from the perspective of ESA? Which are insights gained for the 2nd management cycle?	**DE/FR/PT**
Disproportionality of costs (Art.4) • How were the exemptions selected in the 1st RBMP? What was the importance of "disproportionality of costs" in this selection? • Can cost-benefit assessments play a bigger role in the 2nd implementation cycle? • If so, what could the role for the ESA be in this context (monetary assessment, qualitative-MCA)?	**FR/DE/PT**

• What are imperative services to maintain? What trade-offs are possible?	
Cost recovery / Environmental and resource costs (ERC) • What approach has been taken so far in the CS for estimating ERC costs? • Are there plans to estimate the ERC in more detail for the 2nd cycle? • How could the ESA contribute to such better assessments?	**DE/FR/PT**
Implementing Programmes of Measures and incentive pricing • What approach has been taken so far in the CS for implementing the PoM? • How could the ESA contribute to such better implementation of the PoM?	**FR**
Payments for ecosystem services • Is there an issue in the specific CS for integrating the payments for ES given? • If so, what would need to be done in order to estimate these ES (quantitative, or qualitative)?	**DE/FR**

Each case study adjusted all research questions listed in this chapter to its specific circumstances.

Annex 2 River ecosystem compartments and habitats which condition ecosystem services



Annex 3 Ecosystem services linked to ecological processes, natural resources, natural attributes and habitats

Regulation Processes and Services (direct)

Service	Zone	Processes		Low water bed	riffle	Pool bar	alluvium	River banks	Floodplain	Oxbows/ Wetlands	Alluvial groundwater	Hyporheic zone	Aquatic Vegetation	Alluvial forests covers	Timber debris	Stream Side vegetation	Flood prone meadows	Effectiveness on the Dordogne Basin
				Functional Compartments								Habitats						
Conservation of water resource quality – Conservation of water and aquatic habitat quality	Self-purification process	Dilution of pollutants (volume)		■														✓
		Suspended matters deposit	Currents slowdown			■												✓
			Water mechanical filtration in the gravel interstices		■		■					■	■			■		
		Water oxygenation	Water mechanical mixing		■								■			■		✓
			Photosynthesis (diurnal activity)															
		Meanders' formation⇨ Creation of a turbulence area extrados of meanders	Favour water mixing and gaseous exchange between hydrosphere and atmosphere	■														✓
		Biochemical degradation (bacteria, UV rays, etc.) of organic matter and of certain micropollutants that can be metabolized		■	■							■						✓
		Micropollutants capture (in mineralized organic matters) and bioaccumulation by transformed or not living organisms		■								■						✓
		Absorption and transformation by living organism of organic matters and of certains pollutants that are under different forms		■								■	■			■		✓
	Buffer zone	Capture, transformation and degradation (form or state change) of organic matter and pollutants in seepage water	Biochemical degradation in soils, assimilation by living organisms, sedimentation						■	■								✓
		Mechanical filtration of seepage water	Slower flow speeds in the ground					■	■	■								✓
		Absorption of nutritive elements by vegetation (runoff and seepage water)												■		■	■	✓
		Mechanical filtration of runoff water	Capture of organic and mineral particles							■				■		■	■	✓
		Thermic regulation of surface water	Avoid important increases in temperatures (which has an influence on the oxygen rate) and aquatic plants development control⇨ limitation of eutrophication problems									■		■				
		Shade of the low water bed												■				✓
Conservation of soil quality		Flooding	River overflowing ⇨ silt deposit	■														±
		Mobilisation of rivers external sediments	Avoid the incision of the water bed ⇨ lowering of groundwater level	■														
Conservation of alluvial lands and terraces		Mobilisation of rivers external sediments	Avoid river banks erosion	■														
		Energy dissipation because of roughness, slowing of hydraulic flows	Dissipation of erosive flows					■		■								✓
			Stabilisation of river bed and river banks bases										■			■		
		Capture of organic and mineral particles carried by runoff water												■		■	■	✓
Stability of infrastructures (bridges, roads, etc.)		Mobilisation of rivers external sediments	Avoid river banks erosion	■														
Reduction of floods impacts		Flood expansion area							■	■								±
		Flow slow down during flooding events	Hydraulic flows energy dissipation by increasing of roughness						■	■								✓
			Flood capping : flooding peak mitigation						■	■		■						✓
			Flooding peaks desynchronization							■								✓
Availability of water resource – Conservation of water levels		Groundwater recharge		■						■		■						✓
		Atmospheric water catching and return to the river	Seepage influenced by runoff water slow down due to present vegetation						■	■								✓
			Runoff						■									✓
		Water storage		■						■	■							✓
		Support for low water regimes	Water return to rivers in case of hydric deficit							■	■	■						✓

Regulation Processes and Services (indirect)

Service	Dynamics	Processes		Low water bed	riffle	Pool bar	alluvium	River banks	Floodplain	Oxbows/Wetlands	Alluvial groundwater	Hyporheic zone	Aquatic Vegetation	Alluvial forests cover	Timber debris	Stream Side vegetation	Flood prone meadows	Effectiveness on the Dordogne Basin
				Functional Compartments									**Habitats**					
Favour Biodiversity's determinism and expression	Ecological dynamics	Edge effect, ecotone	Particularly favourable to biodiversity											■		■	■	✓
		Ecological continuity	Favour transfers and exchanges between communities	■														
		Ecological corridor												■				✓
		Interspecific relations (competition, etc.)	Populations regulation, notably for invasive species										■	■		■	■	✓
		Shade of the low water bed	Aquatic plants' development control											■				✓
	Dynamics linked to the river's functioning and to certain habitats' particularisms	Hydraulic flows' energy dissipation and thus slow down of currents' speed	Hydraulics regimes' diversification in the low water bed (branches, roots, etc., in contact with the low water bed) ⇨ habitats' diversity										■	■	■	■		✓
		Flow microfacies' creation by sediments' deposit (flow obstruction, etc.).	Substratum's micro structuration ⇨ habitats' diversity										■		■	■		✓
		Floods	Habitats' regeneration (disturbances)	■														±
			Oxbows' creation and conservation (limit their closure)	■														
		Solid and liquid transport	A river shifting its course as well as alluvium's movement create constant disturbances for the environments that settle in.	■			■	■		■								✓
		Mobilisation of sediments which are external to the river ⇨ limits the river bed incision phenomenon	Limits oxbows' disjunction	■														
			Limits the alluvium groundwater level lowering which generates vegetation losses	■														
		The shifting of the river course and its meandering generate the creation of second river branches (different flow conditions) and oxbows		■														
		The diversity of flow facies (meso habitats) creates a diversity of hydrological conditions and thus of aquatic habitats (the more reophil species like the riffles strong currents, whereas the species which are more adapted to lentic environments are rather located in pool bars)			■	■												✓
		Sediment transport creates alluvium (intrados of the meanders) which constitute very specific environments					■											✓
		Oxbows constitute very calm areas (which are important in white water rivers), rest areas for reophil fauna or in case of important flows (floods, etc.) and habitats for fauna and flora living in freshwater								■								✓
		Very rich environment (ecotone, concentration in plant nutrient, etc.) according to the type of oxbow, to their geographical situation								■								✓
		Shelter area for macro invertebrates in case of hydric deficit										■						✓
	Habitats' diversity	Basis for the creation of diverse habitats for piscicultural fauna : shelter, hide areas for hunting, etc.				■		■		■			■		■	■		✓
		Reproduction area for piscicultural fauna: for species laying on plants				■		■		■			■		■	■	■	✓
		Reproduction area for piscicultural fauna: for species laying on the water bed, where currents is important			■		■					■						✓
		Habitats that are particularly important for algae, bacteria, micro fauna, etc.											■			■		✓
		Environments that are particularly interesting for wild fauna : avifauna, amphibian (on gentle slope), odonate species (dragonflies), etc.					■	■		■			■	■		■	■	✓
		Habitats for many macro invertebrates										■	■			■		✓
River's dynamic balance conservation		Floods		■														±
		Solid transport	External water course sediments' removal	■														
			Water course sediments' removal	■														±
		Comment : the things related to liquid transport are mentioned with the service "Water levels conservation"																
Biocenosis' conservation		Mineral and organic matters cycle (food chain)	Longitudinal and vertical (spiral) flows of organic and mineral matters	■														✓
			Organic matter removal by leaching, re-suspension, desorption or dissolution					■		■		■						
		Organic matter allochthonous supply	Comment: Primary production is relatively important for oxbows						■	■				■	■		■	✓
		Indigenous organic matter supply											■		■	■		✓
		Comment: also contribute to biocenosis' conservation, water levels conservation and to water quality conservation																
Local climate regulation		Influence on temperatures, precipitations and other climate processes	Albedo/reflexion effects	■						■								✓
			Gaseous exchanges between the atmosphere and the hydrosphere	■						■								
			Contributes to energy and flow transfers between important reservoirs (liquid, solid, gaseous)	■						■								
Global climate change's effects mitigation		Organic carbon sequestration	Assimilation by living organisms, transformation by biodegradation, carbon storage	■						■								✓
			Gaseous exchanges with the atmosphere, photosynthesis	■						■								
			Removal, sedimentation, release of carbon in mineral form	■						■								
		Carbon export towards oceans		■														

Resources and provisioning services

	Resources	Low water bed	River banks	Floodplains	Wetlands/Oxbows	Alluvial groundwater	Aquatic vegetation	Alluvial forest cover	Stream side vegetation	Flood prone meadows	Effectiveness on the Dordogne Basin
		Functional compartments					Habitats				
Drinking water supply	Water (hydraulic stock)	■			■	■					✓
Irrigation practice		■			■	■					✓
Industrial water supply		■			■	■					✓
Cattle watering		■			■						✓
Bottled water production						■					
Aquaculture	Water (Aquatic habitats for fishes)	■									✓
Hydroelectric production	Water (energy resource)	■									✓
River transport	Water (support)	■									
Waste water treatment plant discharge	Water (spillway)	■			■						✓
Professional fishing	Piscicultural populations	■	■		■		■	■	■	■	✓
Aggregate extraction	Bed load	■			■						✓
	Alluvial terraces			■							
Farm production (crops, fodder)	soils (substrate)			■	■						✓
Grazing	Vegetation			■	■					■	✓
Forest productions	soils (substrate)			■	■						✓
Fuel wood harvesting	Timber							■			✓
Peat exploitation	Peat									■	?
Picking	Berries, mushrooms, plants, etc.						■	■	■	■	✓
Pharmacopoeia, biotechnology	Genetic resources						■	■	■	■	✓

Attributes and sociocultural services

		Effectiveness on the Dordogne Basin	Attributes: Properties	Attributes: Types of associated values
	Artistic and creative inspiration (stories narration, etc.)	✓		Aesthetic value
	Feeling of belonging to a specific territory	✓	Landscape, olfactory and noise environments	Olfactory value
	Aesthetic pleasure	✓		Noise value (quietness, etc.)
Leisure activities' practice	Water leisure activities (canoeing, boating, etc.)	✓	Cultural heritage (stories, old fishing practices, non-movable heritage linked to water, etc.)	Personal attachment or territorial identity value
Leisure activities' practice	Bathing	✓		Historical and cultural value
Leisure activities' practice	Leisure fishing	✓	Heritage and remarkable species presence, biodiversity	Existence Intrinsic value (current and future ones)
Leisure activities' practice	Walking/ Hiking	✓	Ordinary species presence	
Leisure activities' practice	Hunting	✓	Environment properties enabling leisure activities practice (access to the river, flows, water quality, presence of piscicultural species for leisure fishing, etc.)	Recreational value
Leisure activities' practice	Naturalism	✓	Properties of a quality environment (clear waters, etc.)	Value associated to health
	Territory attractiveness for tourism (economic rewards) : both linked to the attributes and to the supply present on the territory	✓	Wild aspect	Value linked to what is different from anthropogenic areas

Concerning attributes, sociocultural services that result from these attributes can only be allocated to each of the functional compartments or habitats they are associated to, because they result from their combination. Likewise, there is no direct link between an attribute and a resulting service, indeed, the resulting service often results from the combination of several attributes.

Annex 4 Indicators for quantifying selected ES on the middle stretch of the Dordogne

ES and hydro-electricity	Indicators
Water resource availability	Volume of water drawn for irrigation (low water level and/or annual)
	Number of farmers/farms involved
	Area of irrigated land
	Number of days when drawing of water is banned
	Production on irrigated land (quantity)
	Types of crops on irrigated land (diversity)
	Turnover of irrigated crops
	Volume of water drawn for drinking water supply
	Number of people who receive drinking water supply
	Amount of water available in the river that can be drawn without damaging its good status. Data based on different times of the year
	Charge for domestic use
	Irrigating charge
Provision of fertile soil	Turnover of agricultural crops on the banks of the river
	Quantity, quality and diversity of harvests
	Production quality (labels, controlled appellations, etc.)
	Types of crops (diversity)
	Number of farmers/farms involved
	Number of hectares on the banks of the river
Provision of fish	Annual catch from professional fishing
	Number of professional fishermen
	Socio-demographic profiles of professional fishermen
	Annual turnover of professional fishing
	Transportation of fish for consumption (number of km travelled between catching and consumption)
	Local gastronomy
	Number of leisure fishing permits
	Presence and characteristics of oxbow lakes
	Number of potential spawning sites
	Number of fish strandings
	Number of dewatered spawning grounds
	Charge for fishermen (RMA)
Creation of a specific landscape	Contribution of the landscape quality in the construction of a territorial identity
	Landscape quality (wild/natural appearance) - perceptions
	Diversity of landscapes - landscape atlas
	Contribution of the landscape quality to tourist attractiveness
	Presence and abundance of invasive species (Ash-leaf maple) - loss of endemic species and homogenisation of the landscape
	Presence of oxbow lakes, animal and plant biodiversity
Creation of conditions favourable to leisure activities	Use of canoeing sites
	Numbers of participants in clubs
	Number of clubs
	Presence of a race course
	Number of bathing areas developed
	Popularity of beaches
	Number of camp sites with beaches
	Number of locations
	Turnover of camp sites
	Socio-demographic profiles of the users
	Number and socio-demographic profiles of employees
	Number of recovery points
	Water level (flow)
	Water quality
Maintenance of water quality	Number of days when bathing, canoeing and fishing is banned
	Water quality at the withdrawal points
	Strength of the water treatment for drinking water supply
	Price of water
	Cost of water treatment
	Quality of the bathing water
	Self-purifying capacity
	Presence and number of riffles

Caption:
Benefit derived from ES by man
Effective ecosystem service
Potential ecosystem service
Cost of preserving resources supported by the users
(Source: Blancher et al., 2013)

Annex 5 Using the Mulino Software as part of a Multi-Criteria Analysis

Abstract
Ecosystems' sustainable management, and, therefore, the underlying decision-making process, generally requires the analysis of ecological, social and economic information, integrating both value judgement and policy goals. Once this process can be regarded as complex and tricky, natural resources management requires a well-structured and transparent decision-making process.

Based on the assumption that decisions concerning the management of watersheds may imply trade-offs between their different functions, the intent was to test if software tools, like the MCA MULINO, could be used to enhance multi-level governance of ecosystems. To achieve this, the DPSIR and multi criteria analysis were incorporated, to analyze and quantify the explicit trade-offs between several types of services provided by estuarine ecosystems and stakeholders' objectives.

The Mondego estuary was used as case-study. This system is constantly under pressure, from both natural (e.g., extreme events) and anthropogenic drivers (e.g., land use). Urban expansion and tourism activities were identified as having a strong impact on the system development, while agriculture activities, although declining, had a determinant role in the systems' status. Based on this, different measures were considered as alternative measures to improve the system capacity to provide the several associated services.

The study showed that depending on the services considered to be improved different alternatives were considered as the most suitable, although there seems to be a close connection between the improvement of water quality and the direct services provided (food production and eco-tourism). This analysis allowed simplifying and explaining several management objectives; nonetheless, further tests are still required to understand the real connection between these outcomes and decision-makers.

1. Introduction

Sustainable development is regarded as a complex issue, involving strongly interconnected ecological, social, and economic aspects of an ecosystem, now and in the future (de Jonge et al., 2012). Decision-making in environmental projects can be complex and seemingly intractable, principally because of the inherent trade-offs between socio-political, environmental, ecological, and economic factors (Kiker et al., 2005). Depending on the decisions approved, different stakeholders' groups are affected in different ways, leading to inevitable tradeoffs between them, while also between present and future generations. Stakes are high, decisions urgent, facts uncertain, and values in dispute (Farley et al., 2005). Decision-making involving such complex systems requires a logical well-structured decision-making process.

In this sense, multi-criteria analyses (MCA) have been recommended as useful tools to ensure an integrated management of an ecosystem, allowing to incorporate different sets of data (e.g., Villa et al., 2002; de Jonge et al., 2012). MCA is a stepwise process that allows to choose decision alternatives with multiple and often complex impacts (Hermann et al., 2007). The information used in this approach is often structured using a software tool, which aims to record alternatives, while measuring and assessing the impacts of the proposed alternatives (Hermann et al., 2007).

Ecosystems are seen as suppliers of a wide range of ecosystem services through which humans benefit in terms of welfare or wellbeing. Most of the studies conducted so far, tried where meaningful to place monetary values on the benefits provided by 'healthy' ecosystems (e.g., Turner et al., 2010). However, the problem arises when it is recognised that some services are not suitable candidates for monetisation e.g., so-called cultural services such as among others heritage landscapes and seascapes (e.g., de Jonge et al., 2012). Therefore, in terms of political economy of nature conservation, it becomes essential to include socio-economic analysis within the decision support system

(DSS) to supplement scientific and ethical arguments in favour of environmental protection. This kind of analysis can be achieved through MCA tools application. In fact, this kind of tools become even more important when higher institutions approve compulsory frameworks for EU Community action in the field of water policy (e.g., Antunes et al., 2009), such as the European Union Water Framework Directive (WFD; EC, 2000). The key objective is to achieve by 2015 'Good Ecological Status' (GES) for all European surface water and groundwater. One of the instruments recommended to assess its feasibility was through the DPSIR (Driver, Pressure, State, Impact, Response) approach (OECD, 1993; Elliott, 2002; EC, 2002) implementation, as a possible analytical framework for determining pressures and impacts under the WFD (IMPRESS, 2002; Borja et al., 2006; Pinto et al., 2011).

In this work, aiming to mainstream decision support systems tools to address the sustainable management of ecosystems, the MCA MULINO software (Multi-sectoral, integrated and operational decision support system for the sustainable use of water resources at the catchment scale; http://siti.feem.it/mulino/mulino.htm) was evaluated (Giupponi and Cogna, 2000; Giupponi et al., 2004; Giupponi, 2007). The software incorporates integrated analysis modelling (IAM), multi-criteria analysis, and the DPSIR (Drivers-Pressure-Status-Impacts-Responses) framework of environmental cause-effect relationships (La Jeunesse et al., 2003). This software has been implemented in several European River Basins, like the Bahlui river catchment in Romania, the Caia river catchment in Portugal, the Yare river catchment in UK, the Nethen catchment in Belgium, or even the Vela river catchment in Italy (Giupponi and Cogan, 2000), being regarded as a tool that aims to facilitate the WFD objectives achievement. The MULINO software was developed within the European water policy context, more specifically to answer to the WFD requirements. In this case study, the MULINO tool was chosen mainly because it allows designing and implementing an operational decision support system for the management of water resources that is based on hydrologic modelling, multi-disciplinary (qualitative and quantitative) indicators and a multi-criteria evaluation procedure. Moreover, the MULINO tool relies on the DPSIR framework, which was the chosen approach to evaluate the main drivers and pressures acting on the Mondego Estuary case-study. However, some criticisms have been pointed to the DPSIR framework, such as the absence of an explicit stakeholder role on the process, they may participate but the engagement cannot be described satisfactorily (e.g., Bruins and Heberling, 2005), where linear and direct links are difficult to establish (Pinto et al., 2011). When integrated into the MULINO tool it presents an evolution from a static reporting framework to a dynamic multi-disciplinary modelling environment (Linkov et al., 2006).

2. Objectives

The overall objective of the MULINO tool application to the Mondego Estuary case-study was to ensure multi-disciplinary integration of information. This intended to facilitate decision-making processes of multi-level environmental governance, aiming at a sustainable management of the system.

Specific research objectives were:

- To assess how the DPSIR framework could be enhanced to facilitate decision-making processes;
- To test how the MULINO worked on different ecosystem services improvements scenarios;
- To evaluate the relation between MULINO outcomes and possible links with the WFD economic requirements; and
- To enhance multi-level governance of natural resources.

3. Methodology

3.1The Ecosystem Approach: How does the MULINO software work?

This MCA tool relies on the assumption that stakeholders (measured through the contingent valuation surveys undertaken and through the public participation results, please see section 5.1 of the Mondego case study report) identified water quality improvement as a key-issue for local, regional, basin, and even national development. In this sense, scientific and technocratic expertise (e.g., in the valuation of ecosystem services) were used to complement stakeholders' inputs. Scenarios were evaluated according to how well they achieve the proposed objectives. Figure 1 shows conceptually how MULINO handles with both quantitative and qualitative data.

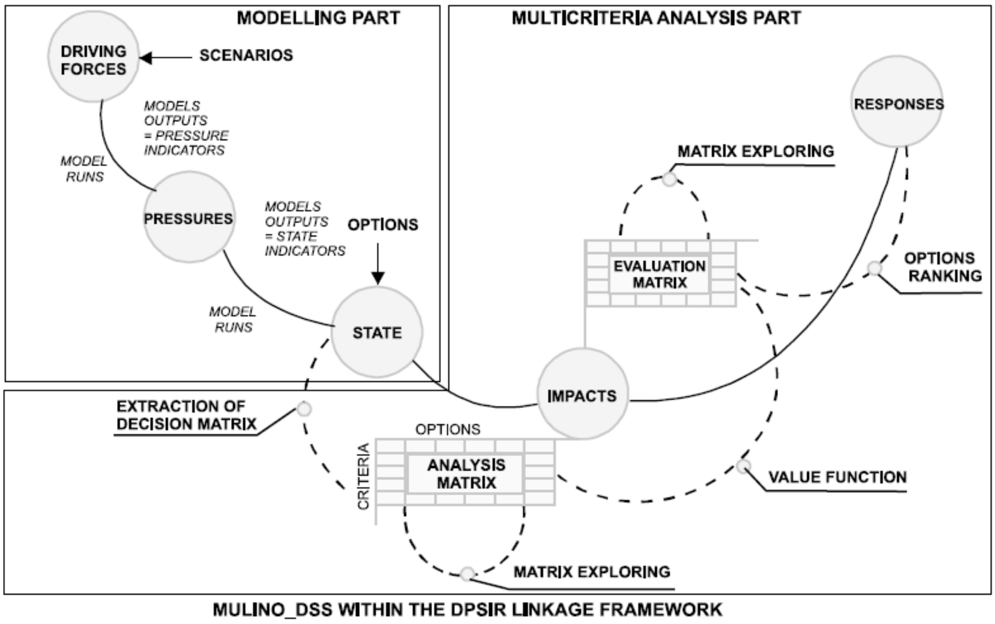


Figure 1: The MULINO tool structure and conceptual links (after La Jeunesse et al., 2003).

The MULINO decision support tool is composed by three phases of analysis (Giupponi and Cogna, 2000):

1) The 'Conceptual Phase': where the user of mDSS investigates and identifies causal links between human activities (D), the pressures they exert (P), and the state of the environment (S) (Figure 1). This phase produces a formal description of activities and issues relevant to catchment management and makes relationships between these factors explicit in the form of 'DPS chains'. It is in this first phase that mathematical modelling and local network analyses can be used to explore the problem in different ways;

2) The 'Design Phase': where the identification of alternative options for possible responses to be given, such as specific water management projects are undertaken. Using the MULINO system, the user constructs a matrix with n rows of decisional indicators or criteria and m columns of options. This formalises the structure of the 'analysis matrix', which represents the interface between the IAM and the MCA parts (Figure 1). The analysis matrix cells can be filled with values derived from indicator monitoring, model outputs and/or expert judgements. The pairwise comparison approach (Saaty; 1980; Malczewski, 1999) is adopted to structure the inclusion of expert opinions when quantitative data are not available or when subjective choices have to be

made, such as for the weighting of criteria. Value functions and normalisation procedures allow the user to produce an 'evaluation matrix' which can be used to compare the expected impacts (I) of the alternative decisional options (Figure 1). A hierarchical weighting procedure is included to facilitate the elicitation of the decision maker's preferences and to support the interface between them and their technical staff;

3) The 'Decision Phase': where the user elaborates a concise presentation of decisional criteria, using one or all of three alternative decision rules which can be applied as simple additive weighting (SAW); ordered weighted averages (OWA); a technique for order preference by similarity to ideal solution (TOPSIS); or ELECTRE. In this case study only the SAW and TOPSIS methods were applied and tested. The application of any of these methods to solve the decision problem will elicit the user's preferences with reference to the alternative options to arrive at a response (R). Results obtained can be further investigated and re-assessed by means of sensitivity analysis procedures (Figure 1). These various procedures encourage the user to increase his/her awareness of the effects of subjective judgements such as criteria selection, weighting, and value function on the final result.

3.2Alternatives, Criteria, and services-bundles improvement

Taking into account the work developed concerning ecosystem services evaluation and the programmes of measures included in the RBMP, a multi-criteria analysis framework was set up.

Usually, the alternatives represent the different choices of action available to the decision-maker. Usually, the set of alternatives is assumed to be finite, ranging from several to hundreds. They are supposed to be screened, prioritized and eventually ranked. In this case-study the alternative measures proposed were developed relying on the River Basin Plans developed for the Mondego catchment area and based on expert knowledge of the system functioning. From this integration a list of 8 measures/options were considered in the analysis:

- Buffer zones creation: This measure relies on the construction of a vegetated buffer zone for water pollution reduction coming from agriculture fields, through the retention of nutrients and pesticides in these macrophytes areas, avoiding their introduction in the water cycle.
- Changes in agriculture practices, aiming to improve water use efficiency and control of nutrients: This measure intends to test the effect that agriculture practices changes may have on the water resources, through not only a more efficient use of irrigation water, but also to stimulate a 'quality', instead of a 'quantity', production.
- Increasing of the connectivity between the two estuarine arms: This measure intends to guarantee the accurate connection between the estuarine South Arm and the main river course, ensuring an efficient water circulation in this sub-system (in order to reduce the eutrophication symptoms already felt). This was in fact one of the main proposed measure in the RBMP for this system.
- Promotion of eco-tourism activities: This measure has as goal the implementation of an ecotourism centre in the Murraceira Island, with bird-watching and pedestrian activities.
- Construction of waste water treatment plants: This measure intends to evaluate the impacts that waste water treatment plants, located upstream the estuarine area, might have to determine the system' good status.
- Construction of waste water treatment plants with associated macrophytes buffer zones: This measure is an extension of the previous one, in which is

considered the creation of buffer zones around the point sources of the waste water treatment centrals, in order to reduce the nutrients that are released to the water course.

- Creation of a Murraceira trade-mark: Production of local products, such as bivalves, aquaculture fishes or salt, as 'image-product' of the good quality of the system, relying on sustainable practices.
- Pollution retention on biological resources: This measure intends to explore the potential capacity of using the estuarine natural biological resources, e.g., bivalves, as possible nutrient storage.

Here only the 8 basic alternatives descriptions are presented, however different alternatives were also considered resulting from the combination of these measures. This would allow to optimize the possible responses to be given to improve the system quality.

Furthermore, to each MCA problem is usually associated multiple criteria (also referred to as 'goals' or 'attributes'). Criteria represent the different dimensions from which the alternatives can be viewed, being at the basis for a decision that can be measured and evaluated, i.e. a standard of judgement to test the desirability of the options (Mysiak et al., 2002). In this analysis, three types of criteria were considered:

- Investment: This criterion considers the initial investment necessary to implement each of the considered measures. In order to achieve this, the NPV (Net Present Value) was used for each measure (at a 3% rate), allowing to compare the effectiveness among measures. The values were achieved based on literature review. The 2027 year was used as reference, since it the year that the ARH Centro, Portugal, predicts that the basin will achieve the Good Ecological Status.
- Performance (social, ecological and economic): Each measure performance is evaluated in a semi-qualitative way, combining the (social, economic and ecological) importance of the services and their status evolution through time (final scale will be given by 'Low', 'Medium' and 'High' scores). It translates the performances of options for every decisional criterion into value scores, which represent the degree to which a decision objective is matched. This parameter will allow, afterwards, to evaluate the several options of services bundles (see next section).
- Risk exposure (social, ecological and economic): This criterion will be evaluated using the 'Vulnerability Assessment Method' (Figure 2).

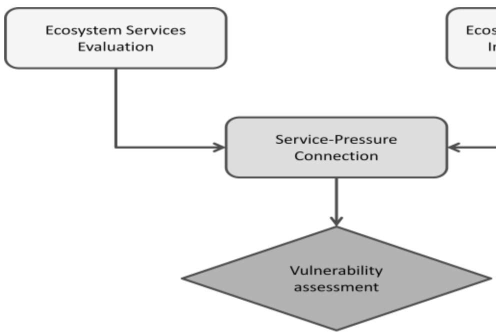


Figure 2: Vulnerability Assessment Method used.

To evaluate the services risk potential, the score achieved in the importance of services (from the previous criterion) was combined with its resilience value. The modelling of criteria weights is proposed to be based on the surveys described and on expert judgments.

By including cost, effectiveness, and risk criteria in the analysis, the MULINO MCA tool will allow us to have a broader view of the proposed measures than the usual cost-effectiveness calculations that are part of the economic analysis required by the WFD.

To test the measures effectiveness, relying on the ecosystem services inventory previously done (Pinto et al., 2010), and on the performance and risk evaluations, 4 different options for performance evaluation, considering several services potentially affected by these measures implementation, were considered (see Table 1):

- Water quality: The first set only took into account the water quality improvement of the system, considering which measures would maximize this service, regardless the others;
- 5 services: The second set of services integrated the 5 more important services for local population, both direct and indirect services (food production, water quality, recreation, C sequestration and nursery grounds);
- Indirect services: The third set considered only the indirect services optimization (water quality, C sequestration and nursery grounds); and finally,
- Direct services: The fourth set considered the water quality and direct services provision (food production, water quality, recreation).

Focusing on these four different options for performance evaluation was possible to rank economic, ecological and social objectives for each.

Table 1: Sets of services-bundles potentially affected by the selected measures implementation on the system.

Services category	Services	Options for performance			
		1	2	3	4
Provision	Food production		x		x
Cultural	Eco-tourism		x		x
Regulation	Water Quality	x	x	x	x
	C sequestration		x	x	
	Nursery grounds		x	x	

The intent was to test the influence of measures on water quality improvements (as requested by WFD), but also look at it in an integrative manner considering the other services provided to the local populations (integrating also the social and economic benefits in addition to the ecological ones). This approach allowed to accomplish two objectives:

a) to evaluate the measures that will be more effective to improve water quality conditions (as required by the WFD) and optimize ecosystem services provision;

b) to estimate how the ESA can be integrated and how useful it will be to communicate the effectiveness of measures implementation on a system.

3.3Weightings and analysis

In this study, we evaluated the results achieved through the application of two methods available in MULINO regarding decision-making processes: SAW and TOPSIS. A short explanation of both approaches is needed to understand the differences in the achieved results. The intent was to aggregate partial preferences describing individual criteria in a global preference and then ranks the options (Mysiak et al., 2010):

- **SAW**: is the most popular decision method mostly due to its simplicity. It assumes additive aggregation of decision outcomes, which is controlled by weights expressing the importance of criteria. This method is a simple additive weighting, where it uses the additive aggregation of the criteria outcomes, given by:

$$\Phi_{SAW}(a_i) = \sum_{j=1}^{n} w_j \times u_{ij} \qquad w_j \text{ .. criterion weights}$$

- **TOPSIS:** this method orders a set of options on the basis of their separation from the ideal solutions. The option that is closest to the ideal positive solution and furthest from the negative (anti-)ideal solution is the best one (Rodrigues, 2002). The measurement of separation requires distance metrics, usually Euclidean distances. The ideal point methods order a set of options on the basis of their separation from the ideal solution:

$$s_{i+} = \left[\sum_{j=1}^{n} w_j^p \left(u_{ij} - u_{+j}\right)^p \right]^{1/p}$$

s_{i+} … separation of the *ith* option from the ideal point
w_j … weight assigned to the criterion j
u_{+j} … ideal value for the *jth* criterion
p … power parameter ranking from 1 to ∞

Therefore, the ideal solution represents an (not achievable and thus only hypothetical) option that consists in the most desirable level of each criterion across the options under consideration. Similarly, for the ideal negative solution, the best option may be defined/ characterised by the maximum distance from it:

$$s_{i-} = \left[\sum_{j=1}^{n} w_j^p \left(u_{ij} - u_{-j}\right)^p \right]^{1/p}$$

s_{i-} … separation of the *ith* option from the negative ideal point
u_{-j} … negative ideal value for the *jth* criterion

4 Results

The ranking order of the alternatives are presented and discussed for the Mondego Estuary case study. Table 2 presents the investments considered for the several alternatives of measures to be implemented.

Table 2: Total investments considered for the several alternatives, from 2012 to 2027. Alternatives: 1-buffer zones; 2-'green agriculture'; 3-connectivity improvement; 4-eco-tourism enhancement; 5-wastewater treatment plants development; 6- wastewater treatment plants development with associated macrophytes; 7-Murraceira trade-mark; 8-bivalves bio-control.

Alternative considered	Total Investment value [10^3 €]
1	4446.03
2	54403.69
3	38340.36
4	1020.91
5	457.68
6	20615.45
7	11663.83
8	5281.06

Based on the performance and risk reduction (social, ecological and economic) values considered for the several services and alternatives of improvements, Table 3 presents the final outcomes results of the MULINO alternatives ranking, illustrating the appraisal outcomes using two different mathematical techniques, therefore, providing the ranking of the best alternatives to be considered.

Alternatives		#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
SAW	Water Quality	112	77	152	40	187	111	76	19	46	115
	5 services	187	152	115	112	231	80	210	188	77	151
	Indirect services	187	111	152	115	42	112	76	77	80	210
	Direct services	112	152	187	77	115	151	80	210	231	188
TOPSIS	Water Quality	247	242	246	235	240	215	233	194	241	216
	5 services	247	242	246	235	240	215	233	194	241	216
	Indirect services	247	242	246	235	240	215	233	194	241	216
	Direct services	247	242	246	235	240	215	233	194	241	216

Table 3: Final outcomes from the MULINO tool, where, depending on the services-bundles scenarios, different alternatives implementation should be conducted, using the two techniques (SAW and TOPSIS).

The alternative combining measures 1 (buffer zones), 4 (eco-tourism enhancement), 5 (wastewater treatment plants development), and 8 (bivalves bio-control) was ranked as the most attractive option by the SAW method for the water quality and direct services enhancement (Table 14). When considering the 5 services altogether or the indirect services, to the previous measures should be added the alternative 7 (Murraceira trade-mark) to obtain the alternative that would maximize the services provision. Considering the TOPSIS method, the optimal solution would be the alternative that included all the considered measures.

Table 4. Combination of alternatives of possible measures given by MULINO.

Alternative	Measures included	Description	Alternative	Measures included
1	1	Buffer zones creation	115	1,4,7,8
2	2	green agriculture'	151	4,5,6,8
3	3	connectivity improvement betw een estuarine arms	152	4,5,7,8
4	4	eco-tourism enhancement	187	1,4,5,7,8
5	5	w astew ater treatment plants development	188	1,4,6,7,8
6	6	w astew ater treatment plants development w ith associated macrophytes	194	2,3,4,6,8
7	7	Murraceira trade-mark	210	4,5,6,7,8
8	8	bivalves bio-control	215	1,2,3,4,7,8
19	4,5		216	1,4,5,6,7,8
40	1,4,5		231	2,3,4,5,6,8
42	1,4,7		233	2,3,4,6,7,8
46	1,5,8		235	1,2,3,4,5,6,8
76	4,5,7		240	1,2,3,4,6,7,8
77	4,5,8		241	1,2,3,4,6,7,8
80	4,7,8		242	1,2,3,4,6,7,8
111	1,4,5,7		246	2,3,4,5,6,7,8
112	1,4,5,8		247	1,2,3,4,5,6,7,8

5 Discussion

The MULINO software intents to provide a DSS that supports decision-making in the integrated management of water resources at the catchment scale. In the Mondego Estuary, the good knowledge regarding the system structure and functioning allowed to maximize the MULINO outputs, permitting (1) to deal with integrated management alternatives; (2) to help the implementation of the participatory approach, as well as the economic requirements, within the WFD context, and (3) to contribute to a more sustainable use of water-related ecosystems within an catchment area.

MULINO and DPSIR: which links?

The DPSIR framework can be used during discussions among stakeholders but does not necessarily provide detailed enough information on the magnitude and significance of the 'state change'. For management purposes we additionally need more specific quantified information. A next step then may be that the indicated DPSIR-factors are quantified and put together in a model describing the cause-effect relationship (including all the known feedbacks) between the ecological and the socio-economic system (de Jonge et al., 2012). The MULINO software tries to answer to this need, using the DPSIR framework to accomplish the water resource planning and decision process set by the WFD. In this context, the DPSIR framework was designed and adapted to support the decision-making processes, through the introduction of a structural system of the catchment in which cause–effect chains are formalised and later modelled to simulate the anticipated effects of the proposed courses of action (responses to water management issues) (Mysiak et al., 2010). This adaption aims to overcome the inherent problems of the DPSIR framework (e.g., absence of an explicit stakeholder role during the assessment process) (Bruins and Heberling, 2005; Pinto et al., 2011).

Despite all the efforts, it is not always clear to follow the DPSIR framework during the process of the WFD implementation. Estimating cause–effect relations means constructing a simplified representation of the complex and overlapping relationships occurring at the catchment level (both temporal and spatial), which can significantly influence the final decisions (de Jonge, 2007; Mysiak et al., 2010; Pinto et al., 2011; de Jonge et al., 2012). In fact, there are no linear relationships or direct cause-and-effect patterns among drivers, impacts, and status; the interactions among them are complex and at least cumulative (Pinto et al., 2011). In addition, the identification of the driving forces, pressure and state indicators is not always straightforward, once the same indicator may be considered as a driving force or a pressure, or even confounded between a pressure or a state characteristic. For example, nutrients concentrations due to agriculture activities may be considered as a pressure (emissions to the water column), difficult to estimate (diffuse pollution), while also are used to establish the current water condition (following, e.g., EEA guidelines; EEA, 1999).

Can MULINO be used to enhance ecosystem services provision?

From the alternatives achieved through the MULINO, was possible to see that depending on the objective under consideration, different measures could be selected. In general, if the objective was only to improve water quality (as demanded by the WFD) fewer measures were required to achieve it in comparison with the optimization of other services. Moreover, depending if the objective is to improve direct services (e.g., food production or recreational activities) or to maximize indirect services (e.g., C sequestration) different alternatives were recommended. For example, there was clear evidence of the link between C sequestration maximizations and the buffer zones creation, especially for the SAW technique.

The analyses among ecosystem services optimization revealed a promising scope for aligning objectives, in particular regarding biodiversity and water quality improvements. In fact, biodiversity and water quality were highlighted in previous studies as key-factors to improve services provision; however, those studies merely analyzed the overlap between biodiversity and ecosystem services derived for each objective independently (e.g., Pinto et al., 2010, 2011, 2013). Nevertheless, more analysis and further testing are necessary to have an accurate revealing of important synergies and trade-offs among services and environmental quality.

Although this analysis relied on the weights input from a stakeholder, it can, however, support social interaction between stakeholders within the context of dialogue if the chosen weights for the criteria reflect a consensus between stakeholders (La Jeunesse et al., 2003). This could, indeed, be an important path to follow for future research. Based on the achieved outcomes, these could be presented to stakeholders and adjusted to the social, ecological and economic needs of the region, enhancing this way the multi-level governance of natural resources.

MULINO and the WFD economic requirements: which links?

The resource system policy issues will be composed of a complex mixture of environmental and socio-political driving processes, consequent environmental state changes which then impact on the provision of ecosystem services and their effects on human welfare/wellbeing (Pinto et al., 2011; de Jonge et al., 2012).

The distribution of the welfare gains/ losses in society, together with existing policy measures and networks will influence policy responses (de Jonge et al., 2012). Through MCA processes implementation, it becomes possible to estimate the nature of decisions arising in the process of the WFD implementation and facilitates the choice of an appropriate decision support methodology for a specific decision (Mysiak et al., 2010). In particular, the MULINO tool allows for the economic decision methods, such as cost effectiveness analysis and cost benefit analysis, which are foreseen by the WFD for specific situations (e.g., Brouwer et al., 2009). These economic analyses seek to evaluate the social welfare gains/losses from an economic efficiency perspective, tempered by any distributional equity considerations, other precautionary environmental standards and regional economic constraints (most often focussed on local employment and economic multiplier impacts which can result in cultural and community losses or gains, e.g., closure or restrictions on fisheries) (de Jonge et al., 2012).

Cost-effectiveness analysis (CEA) is a decision-oriented tool designed to compare the costs and effectiveness of alternative measures (Levin and McEwan, 2000). The aim of using the method is to choose the least expensive alternative which guarantees the given goal is fulfilled (Mysiak et al., 2010). When assessing alternatives, CEA of each alternative (in achieving a given goal) is obtained by dividing the cost of each alternative (C) by its effectiveness (E) (Levin and McEwan, 2000). The benefits need not be expressed monetarily. In a different situation when the expected costs of measures are disproportionately high, the WFD provides for the application of CBA (Mysiak et al., 2010). Unlike CEA, CBA requires the benefits or positive impacts of measures to be expressed in monetary terms as well (Levin and McEwan, 2000).

Both CEA and CBA methods have been widely used in water management, even though their application may be overwhelmed by difficulties whenever a broad range of ecosystem services have to be taken into consideration and where a number of stakeholders with different interests are involved or affected by the decision (Brouwer et al., 2009; Mysiak et al., 2010).

MCA is mainly used in situations where a broad range of ecological services in a multidimensional and community-based watershed approach has to be evaluated (Prato, 1999), which is essentially what is to be anticipated during the WFD implementation. In this sense, the MCA can be regarded as a complement to the economic approaches, explicitly dealing with multiple criteria but avoiding the need to attribute a monetary value to all environmental factors. In this sense, the outcomes from this study can provide some insights to the economic analysis when examining the possible trade-offs and synergies between criteria/objectives aimed by each decision-makers or stakeholders. This way, MCA, and more specifically the MULINO application to the Mondego Estuary, can be regarded as a helpful tool for water authorities to choose the more adequate programme of measures for a river basin.

Moreover, the inclusion of the ecosystem services approach (ESA) should be useful to make the diverse impacts of measures more transparent, since the RBMP approach was quite opaque. It should be noted that, in spite of WFD recommendations for the inclusion of economic instruments in the programme of measures, those listed here do not include such instruments because there is insufficient data on water demand for the different sectors, which means that it would be hard to evaluate the cost (in terms of welfare burden) and the effectiveness of possible economic measures such as tariff increases, changes in the Water Resource Charge or other charges.

6 Conclusion

This work shows that multi-criteria analysis tools, in this specific case the MULINO software, may offer a scientifically sound decision analytical framework for environmental management, in general, and specifically for selecting ideal catchment management alternatives. Nevertheless, the integration of these outcomes into the WFD public participation and economics requirements may still require further research and analysis.

The main advantages resulting from the MULINO application to the Mondego Estuary case-study were:

- to allow the use all the available data, both quantitative and qualitative, integrating different kinds of information;
- to simplify and explain the several objectives elements inherent to a decision (data, criteria, and alternatives), placing the entire decision process into a single matrix;
- to provide a tool to organize complex decisions, making them more accessible to a rational decision process;
- to produce results that are reproducible and organized.

The next steps should be:

- to discuss the possibility to integrate the MULINO outcomes with the economic articles covered by the WFD; and
- to discuss the outcomes with decision-makers (e.g., inclusion on the RBMP).

In conclusion, the MULINO software can be an effective tool to evaluate several improvements alternatives during a decision-making process, while promoting the effective participation of stakeholders during the planning process.

Annex 6 Leipzig approach methodology

1 Introduction

To analyze the "added value" of the ESA in implementing the economic elements of the WFD, an experiment was conducted, adjusting and applying an existing methodology to assess disproportionality of costs, the so-called "Leipzig Approach" (LA).

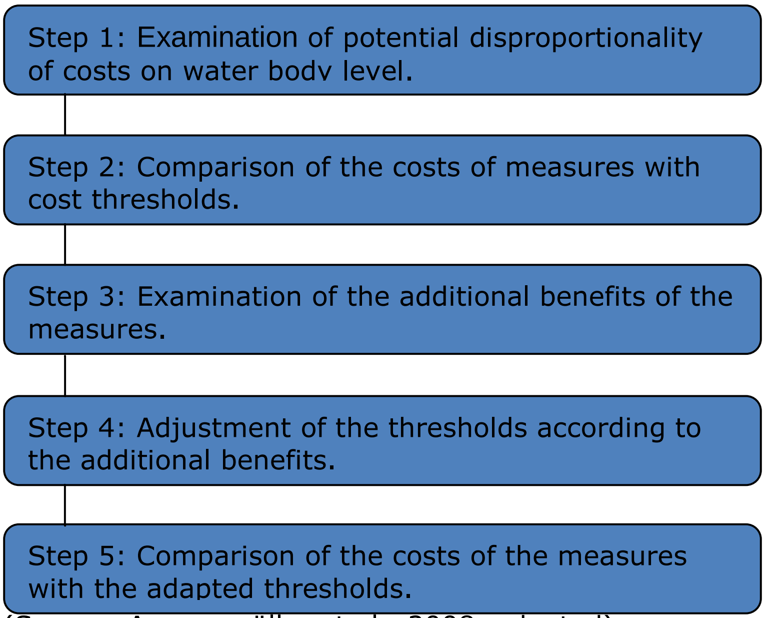
The LA has been applied in Rhineland-Palatine, but evaluated as not being practically applicable, as the determination of average costs of measures (the median value) for a whole federal state "contradicted the planning practice, which is based on individual, case-by-case planning and execution of measures" (LAWA 2011). It was, however, judged to be a scientifically sound methodology.

In the ESAWADI project´s case study "Ems", the Leipzig Approach was therefore not be tested for its general applicability. Instead, the aim of applying it here was to test whether a methodology incorporating the ESA can be potentially helpful in implementing the WFD´s economic requirements (the "added value"). The LA was adjusted slightly to take into account the data availability in the test area (see below) – therefore, it´s application here may nevertheless lead to secondary conclusions regarding the general applicability of the (adjusted) methodology.

2 Description of the Leipzig Approach

The "Leipzig Approach" was developed in 2008 by the University of Leipzig, the UFZ Leipzig and the Ecologic Institute, on behalf of the German federal states Northrhine-Westfalia, Thuringia and Rhineland-Palatinate. In was published in two consecutive papers, the first laying the theoretical foundations (Ammermüller et al., 2008a: "Entwicklung einer Methodik zur nicht-monetären Kosten-Nutzen-Abwägung im Umsetzungsprozess der EG-Wasserrahmenrichtlinie"), and the second transferring these into a short and more practical handbook for the application by public authorities (Ammermüller et al. 2008b: "Kosten-Nutzen-Abwägung zur Feststellung von Ausnahmen aufgrund unverhältnismäßiger Kosten").

Ammermüller et al. (2008a) developed a methodology to assess the (dis-)proportionality of costs of proposed measures in order to justify potential exemptions from the WFD-environmental objective of good surface water status by 2015 (Art.4), as the WFD does not advocate a certain approach or methodology for such assessments. Often, however, cost and benefit comparisons are based on monetized values for ecosystem services associated with the "tested" measure(s), which are then opposed to the costs of the measure(s) in a Cost-Benefit Analysis (CBA). The data needed for these analyses is rare and incorporates many uncertainties. So, instead of basing the methodology on quantitative, monetized values of benefits of measures (e.g. ecosystem services), the LA aims at including these in a semi-qualitative way, using expert judgment and simplified quantitative scales, in a 5-step process described in figure 6:



(Source: Ammermüller et al., 2008, adapted)

Figure 1: The five steps of the Leipzig Approach.

Below, the steps are described in more detail:

Step 1: Examination of potential disproportionality of costs on water body level.

This step actually consists of a kind of pre-examination: the costs of all WFD measures in the "tested" water body (per square km or km of length or per inhabitant of the respective area) are compared to the median value of all WFD measures (again per square km/km of length or per inhabitant of the respective area) in the given federal state. If the costs of the measures in the "tested" water body are higher than the median value, the possibility that the costs are disproportionate is given, and the analysis proceeds with Step 2.

Step 2: Comparison of the costs of measures with cost thresholds.

This step accommodates for the variabilities in the "distance to target" covered by the measures in the tested water body, i.e. higher-than-average costs may be justified with a greater level of improvement of the status of the water body. According to this, the median value of all measures identified in Step 1 is adapted through multiplying it by 1 (slight improvement of status), 1.5 (medium improvement of status) or 2 (great improvement of status). Then, the costs of the measures in the tested water body are compared to the new, adapted median value ("cost threshold") – if they are still higher than the cost threshold (i. e. the possibility of disproportionality is still given), the analysis proceeds with Step 3.

Step 3: Examination of the additional benefits of the measures.

In this step, the additional benefits of the examined measures - in addition to achieving the legally binding goals (which was taken into account in Step 2) - are accommodated for. These additional benefits can be roughly translated as ecosystem services, and are categorized for the purpose of the LA into five "benefits categories": ecology, provision and cleaning of water, protection against floods, soil protection and tourism/cultural heritage.

In a first sub-step, the person in charge determines whether positive effects in the five benefit categories are to be expected by the tested measures, or not (either for the bundle of measures, or for each measure individually). In a second sub-step, the importance and relevance of the effects is estimated, using indicators and expert knowledge, and evaluated on a scale ranging from 0 (no additional benefit) to 5 (great additional benefit). These values are weighted and summarized, to arrive at a semi-quantitative "benefit value", ranging from 0 to 100 (for details see the respective documents).

Step 4: Adjustment of the thresholds according to the additional benefits.

The "benefit value" determined in Step 3 is in this step translated into another adjustment of the cost threshold, again raising the "bar" with which the costs of the measures in the tested water body are compared.

Step 5: Comparison of the costs of the measures with the adapted thresholds.

In this final step, the costs of the measures in the tested water body are compared to the final, adjusted threshold value that now accounts for both the "distance to target" in reaching the environmental goals, as well as the "additional benefits" derived from the measures. If cost of the tested measures is still higher than the threshold value, the measures have to be considered disproportionally expensive.

3 Adjustments and application of the LA

Due to data restrictions and practical considerations, the following methodological adjustments to the original LA have been done:

- Adjustment 1: instead of focusing on all measures in a given water body/area, the focus here lied exclusively on measures to improve lateral and linear connectivity.
- Adjustment 2: instead of comparing a single water body with all water bodies in a federal state, in this case the measures (to achieve linear and lateral connectivity) in a sub-RBD (the Hase) were compared with the measures (again to achieve linear and lateral connectivity) in a second sub-RBD (the Nordradde).
- Because of the comparison taking place on the basis of costs of measures in a single water body (instead of average costs for the whole federal state), and because the conditions and ecological improvements of the Nordradde are well known before and after implementing the measures, the ecological improvements achieved through measures in the Nordradde river were considered in the application of the LA (see step 2 below).

Step 1: Examination of potential disproportionality of costs on sub-RBD level.

In the following application of the (adjusted) LA, the costs of measures to achieve maximum linear and lateral connectivity in the Hase sub-RBD (the "policy site") are compared to the costs of measures to achieve "good environmental potential" (GEP), meaning maximum linear and lateral connectivity in the Nordradde sub-RBD (the "test site").

The general measures to achieve linear and lateral connectivity considered here are as follows:

- Dismantling/deconstruction of transverse structures.
- Creation of bypasses for fish/ small invertebrate animals.
- Construction of structuring elements and pebbly banks.
- Integration of deadwood/deadwood stumps.
- Widening of the water body and creation of scours.
- To a limited extent, establishment of flooded areas through widening of the water bodies´ profile.
- Construction of berms to improve passage under throughflow structures.
- Creation of grit chambers or settling basins for coarse sediments.

The costs for a similar bundle of measures to achieve "good environmental potential" (GEP), meaning in this case full linear and lateral connectivity (as far as possible in a Heavily Modified Water Body) in a 22 km stretch of the river Nordradde sum up to around 520.000 Euro, or, per km length of water body, 23.600 Euro/km(including dismantling of transverse structures). This cost level will be the “median value” (see description of Step 1 above), which will be further modified in the following steps.

According to a pilot project planned in a small tributary to the Hase, the “Löninger Mühlenbach”, the costs for measures to achieve linear and lateral connectivity in the Hase sub-RBD sum up to 10.000 Euro/km, excluding the dismantling of transverse structures. Including these, the costs raise to 34.200 Euro/km.

Therefore, the first screening of the costs of measures to achieve linear and lateral connectivity in the Hase sub-RBD confirms the possibility of disproportionality. According to the original LA, the analysis proceeds with Step 2.

Step 2: Comparison of the costs of measures with cost thresholds.

This step accommodates for the variabilities in the “distance to target” covered by the measures in the tested water body, i. e. higher-than-average costs may be justified with a greater level of improvement of the status of the water body. The median value - 23.600 Euro/km water body length - is adapted through multiplying it according to the relative improvement achieved through the measures (by 1 for slight improvement of status, 1,5 for medium improvement of status or 2 for significant improvement of status).

Status of the Hase and expected improvement through measures: The Hase is considered a Heavily Modified Water Body throughout its length; the river´s condition with regard to linear and lateral connectivity is therefore considered to be of deficit status. The estimation was confirmed also by expert interviews. The implementation of the above listed measures would achieve "good environmental potential" with regard to hydromorphology, i.e. maximum linear and lateral connectivity. In the context of the LA, such an improvement (from "poor status" to reaching GEP) is considered a "significant improvement", which was also confirmed by expert interviews. Hence, the median value of 23.600 Euro/km would be raised to a new cost threshold of 47.200 Euro/km.

The potential measures in the Hase, with a cost of 34.200 Euro/km, would therefore be lower that the adapted cost threshold. The disproportionality assessment would be finished, with the result that the cost for reaching GEP for hydromorphology in the Hase sub-basin would not be considered disproportionate, because of the high level of improvement achieved.

In this case, however, the conditions in the test site (the Nordradde) are well known: as a HMWB, it is similar to the Hase in terms of initial condition with regard to hydromorphology. Therefore, the improvements achieved in the Nordradde with measures costing 23.600 Euro/km can be considered "significant" as well. Or, differently put, the costs of measures in the Nordradde already reflect costs for a significant improvement. Adapting this cost level according to the LA would distort the results, as reaching a significant improvement would be considered doubly in the analysis.

Hence, the median value is not raised in this step, and the cost threshold is kept at 23.600 Euro/km.

Therefore, after taking the relative improvement reached by measures to achieve maximum connectivity in the Hase sub-basin into account, the possibility for disproportional high costs is still existent. According to the original LA, the analysis proceeds with Step 3.

Step 3: Examination of the additional benefits of the measures.

In this step, the additional benefits achieved through the examined measures - in addition to achieving GEP (which was taken into account in Step 2) - are accommodated for. These additional benefits can be roughly translated as ecosystem services, and are categorized for the purpose of the LA into five “benefit categories”:

- ecology (habitat and nursery functions, contribution to reaching targets of other directives),

- provision and cleaning of water,
- protection against floods,
- soil protection and
- tourism/cultural heritage.

In a first sub-step, it was determined if positive effects on the five benefit categories are to be expected by the tested measures, or not. This was done at the ESAWADI Stakeholder-Workshop (see section 5). The participants were asked about which changes to expect in ecosystem services provision by reaching maximum linear and lateral connectivity. As table 2 shows, changes were expected by experts to take place in all five benefits categories.

In a second sub-step, the importance and relevance of the effects were estimated, again using expert knowledge elicited in the Stakeholder-Workshop, and evaluated on a scale ranging from 0 (no additional benefit) to 5 (great additional benefit). As table 1 demonstrates, the effects were estimated to be highest for ecology (4,6 on the scale ranging from 0-5), followed by flood protection (3,7), tourism/cultural heritage (3,5), soil protection (3,2) and provision and cleaning of water (2).

To complete the estimation of the effects of measures to achieve maximum linear and lateral connectivity, in a third sub-step the benefit categories were weighted according to their relative importance for the region. As table 2 shows, "ecology" was ranked as having the highest importance, and "soil protection" the lowest. This ranking will be "translated" into a weighting coefficient (ranging from 1 to 10), which will be combined with the expected effects of measures on the benefit category (sub step 2), to generate a factor ("total benefit value") with which the cost threshold will be raised to accommodate for "additional benefits" reached through the assessed measures.

Table 1: Effects of measures on ES categories and weighting of ES - results from the ESAWADI Stakeholder-Workshop

Ecosystem Service Category	Improvement achieved Y/N	Relative level of improvement (0-5)	Importance of category
Ecology	Y	4,6	High
Provision and cleaning of water	Y	2	Medium
Flood protection	Y	3,7	Medium
Soil protection	Y	3,2	Low
Tourism and cultural heritage	Y	3,5	Medium

In the original LA, a ranking of the importance of the ES categories is proposed: 8 for ecology, and 3 for the four others, meaning that ecology accounts for 40% of potentially achieved additional benefits (or of the calculated "total benefit value"), and the other categories for 15% each. In this case, however, soil protection was ranked much lower than the other categories.

Therefore, the following weighting coefficients were applied:

- Ecology: 8,25.
- Provision and cleaning of water: 3,25.
- Protection against floods: 3,25.
- Soil protection: 2.
- Tourism/cultural heritage: 3,25.

The weighting coefficient is now multiplied with the figure representing the relative level of improvement, to generate a final value for each benefit category called "benefit value". The five individual benefit values are summed up to generate the "total benefit value" (ranging from 0 to 100), which is used in step 4 to raise the cost threshold accordingly.

The results are summarized in the following table 2:

Table 2: Summary and results of sub-steps 2 and 3

Ecosystem Service Category	**Relative level of improvement (0-5)**	**Weighting coefficient**	**Percentage of Total Benefit Value**	**Benefit Value**
Ecology	4,6	8,25	41,25	38
Provision and cleaning of water	2	3,25	16,25	6,5
Flood protection	3,7	3,25	16,25	12
Soil protection	3,2	2	10	6,4
Tourism and cultural heritage	3,5	3,25	16,25	11,4
Total Benefit Value				**74,3**

The total benefit value of 74,3 is translated in the following step 4 to a percentage value used to raise the cost threshold to a new level, to accommodate for the additional benefits reached through the measures.

Step 4: Adjustment of the thresholds according to the additional benefits.

The "total benefit value" determined in Step 3 is in this step translated into another adjustment of the cost threshold, again raising the "bar" with which the costs of the measures in the "policy site" (the Hase) are compared.

According to the LA, the "translation" is done via the following table 3:

Table 3: Adjustment of the cost threshold according to the total benefit value.

Total Benefit Value	**Adjustment of the cost threshold**
0 to 10	no adjustment
11 to 29	20%
30 to 49	40%
50 to 69	60%
70 to 89	80%
90 to 100	100%

Accordingly, with a total benefit value of 74,3, the cost threshold determining whether the tested measures are disproportionate or not, is raised by 80%, to a new value of 42.480 Euro/km.

Step 5: Comparison of the costs of the measures with the adapted thresholds.

In this final step, the costs of the measures in the tested water body are compared to the final, adjusted threshold value that now accounts for both the "distance to target" in reaching the environmental goals (step 2 above), as well as the "additional benefits" derived from the measures (steps 3 and 4 above).

4 Results

The cost of the measures to reach maximum linear and lateral connectivity in the Hase sub-basin amount to 34.200 Euro/km. As these costs are lower than the adjusted cost threshold (42.480 Euro/km), the costs in the Hase sub-basin to reach full connectivity have to be considered not disproportional.