Evaluating Economic Policy Instruments for Sustainable Water Management in Europe

Overall Assessment Framework

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1.0	30 June 2011	<u>Lead Authors</u>: David Zetland (WU) and Hans-Peter Weikard (WU) <u>Authors of the sections</u>: Gonzalo Delacámara (IMDEA - Section 2), Thomas Dworak (ECOLOGIC – Section 7), Carlos M. Gómez Gómez (IMDEA - Section 2), Benjamin Görlach (ECOLOGIC – Section 7) Colin Green (MU-FHRC – Section 4), Manuel Lago (ECOLOGIC – Section 7), Jennifer Möller-Gulland (ECOLOGIC – Section 7), Jaroslav Mysiak (FEEM – Section 8), Joanna Pardoe (MU-FHRC – Section 4), Meri Raggi (UNIBO – Section 5), Laura Sardonini (UNIBO – Section 5), Miguel Solanes (IMDEA – Section 2), Davide Viaggi (UNIBO – Section 5), Christophe Viavattene (MU-FHRC – Section 4), Hans-Peter Weikard (WU, Sections 1, 3 and 6), David Zetland (WU – Sections 1, 3 and 6). <u>Other contributors</u>: Margartha Breil (FEEM) <u>Reviewer</u>: Maggie Kossida (NTUA) <u>Layout and editing review</u>: Martina Gambaro (FEEM)
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Preface

Water is both a boon and a bane, the most essential life sustaining substance and one of the deadliest threats. It would take many pages to list all environmental functions provided or linked to water, including climate regulation, growth, photosynthetic processes, metabolism, energy generation, habitat provision and many others. On the other side, the ever increasing losses and death toll from extreme hydro-meteorological and climatologic events are a powerful reminder of our how vulnerable we are to water triggered disasters.

Water defies a simple classification as a public/private or economic/social good, although we believe that these views are reconcilable. The EPI-WATER project works towards this end. It sets to show that economic policy instruments (EPIs), if applied in a way which is sensible to the people's values and feelings, and properly rooted in the wider institutional contexts, can help to protect the resources and make their use more efficient and equitable.

Six month into the duration of the project, this report offers an initial specification the Assessment Framework (AF) that will guide the ex-post review of the existing EPIs in Europe and beyond. Based on the lessons drawn from the review (WP3 in figure 1), the AF will be thoughtfully revised and extended for the purpose of the ex-ante policy assessment. The final version of the AF will be produced in month 13 (deliverable D2.3).

The policy review in the WP3 will start with a selection of the EPIs to be analysed in depth, reviewed and approved by the Policy Think Tank (PTT). The thirty or so review reports will be completed until December 1st, 2011 (deliverables D3.1 and D6.1), and compared and synthesised in D3.2. In month 13 an international review workshop (MS4) will take place in Berlin. The PTT members will attend the meeting (MS5) and actively contribute to the review of the intermediate results.

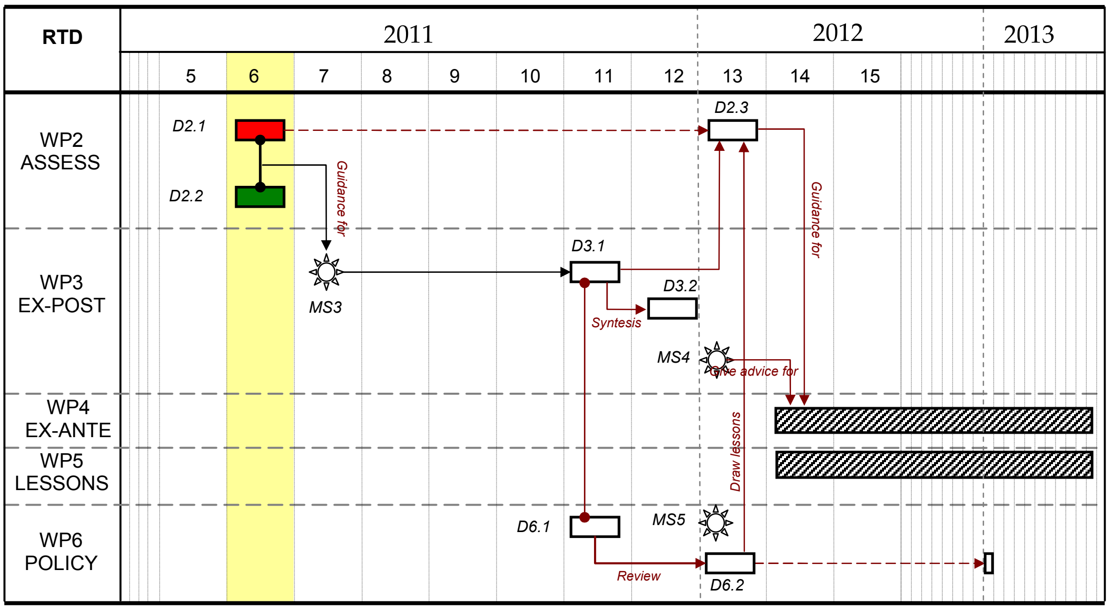

Figure 1. Road map of EPI-WATER *work packages*

Executive Summary

This assessment framework for EPI-WATER describes how participants in the research consortium will evaluate the effectiveness of Economic Policy Instruments (EPIs) that have been used or can be used to improve water management in Europe.

EPI-WATER was launched in January 2011; it will run until December 2013. The project has two core goals: to make ex-post evaluations of existing EPIs that have been operating in Europe and abroad and to make ex-ante evaluations of potential EPIs that may be implemented within Europe.

The EPI-WATER project will analyse EPIs that use different means to reach objectives. EPIs can spur behavioural change through incentives or disincentives; change conditions to enable economic transactions, or reduce risk. The variety of EPIs means that the AF needs to be flexible enough to accommodate particular EPIs but specific enough to allow side-by-side comparisons of these EPIs. EPIs can be used as complements or substitutes to existing regulatory or voluntary methods of managing water quality and water flows. EPIs often use price or market mechanisms to change incentives and/or increase the range of potential actions. An EPI aimed at groundwater depletion, for example, might impose a tax on extractions. An EPI aimed at reducing the potential harm from floods may require insurance against flood damage.

It is difficult to find an objective and widely-accepted measure of EPI performance. Some people may be interested in an environmental outcome (e.g., water quality); others will be interested in social impacts (e.g., the incidence of higher prices for domestic water use); still others will care more about economic efficiency (e.g., the value of crops grown with a water market). The assessment framework described in this document will be used to clarify (and where possible, quantify) the effectiveness of each EPI according to seven criteria: institutional background, environmental outcomes, economic outcomes, transaction costs, distribution effects, uncertainty, and policy implementation. Each of these criteria will be described in terms of one or more indicators appropriate to the EPI under consideration. (The methodological toolbox in Deliverable 2.2 describes indicators and their assessment.)

Participants in EPI-WATER will deliver a series of reports and case studies that will facilitate the discussion and implementation of EPIs targeted at improving water management in Europe. This assessment framework will make it possible to describe the impacts of EPIs in a thorough and rigorous manner. Decision makers and stakeholders can then debate and implement EPIs appropriate to their local situations and needs.

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D 2.1 - Overall Assessment Framework

Overview

Clean, fresh water is essential to life, but EU governments have struggled to reverse habits and rules dating from the Industrial Revolution in which water diversions and pollution were acceptable as a means of promoting economic growth. Rivers that transported waste to the sea affected biodiversity, harmed human health, and polluted coastal and marine waters. Depleted and polluted groundwater reduced the quantity of water available in droughts and the quality of water we use for drinking and food production. Reduced river flows lower hydroelectric power generation, harm ecosystems and increase risk among agricultural producers. Channelization increases flood risk, reduces land fertility, and threatens biodiversity. These impacts vary from place to place but they directly and indirectly reduce our quality of life.

In addition, climate-change induced alteration of rainfall patterns (form, intensity and timing of rainfall) will have significant effects on water availability and frequency of extreme events such as floods and droughts. The knock-on effects of these changes will affect almost all communities throughout the EU, and most economic sectors. It is not surprising thus that water becomes a centrepiece of climate adaptation initiatives. The European Union has taken several policy actions, namely:

- The European Water Framework Directive (WFD) aims to protect EU ground- and surface waters and its depending ecosystems following natural geographical and hydrological units - instead of according to administrative or political boundaries.
- The European Marine Strategy Framework Directive (MSFD) expands the ideas of the WFD to Europe's marine waters
- Directive 2007/60/EC on the assessment and management of flood risks entered into force on 26 November 2007. This Directive now requires Member States to assess if all water courses and coast lines are at risk from flooding, to map the flood extent and assets and humans at risk in these areas and to take adequate and coordinated measures to reduce this flood risk.
- In order to address the issue of water scarcity and droughts the Commission presented an initial set of policy options to increase water efficiency and water savings in a Communication from the Commission to the European Parliament and the Council - Addressing the challenge of water scarcity and droughts in the European Union (COM/2007/0414 final) - published in July 2007.

EPIs for managing water resources

Economic Policy Instruments (EPIs) can make water allocation more efficient, water supply more reliable, and water-related risks easier to manage. EPIs can include environmental constraints and objectives with these human uses, and they can do so in a cost-effective manner. These "magical results" do not just happen – they are the result of careful planning, customization and implementation of EPIs best suited to local circumstances, culture and objectives.

Article 9 of the WFD discusses water pricing and cost-recovery EPIs. The water scarcity and droughts initiative emphasises EPIs in its recognition of the importance of incentive pricing for adapting water demands and ensuring sustainable water management. These promising mentions have not, however, resulted in widespread use of EPIs in reaching the environmental objectives of the WFD or water pricing. Furthermore, EPI other than water tariffs, water charges and taxes have rarely been considered so far in designing the WFD programmes of measures. Very recently, because of the very high costs of the WFD programmes of measures, some Member States have however shown renewed interest in EPIs that may be used to generate revenue, reduce water scacity, improve water quality, manage risk and so on.

EPIs can play an important role in complementing regulatory and voluntary instruments designed to reach environmental objectives in a cost-effective and efficient manner (according to the cultural and social dimensions of the different regions and basins).

Water as an economic good

Water is an economic asset that might be managed efficiently and sustainably (Hanemann, 2006; Rogers, et al., 2002; Serageldin, 1995; Winpenny, 1994, Young and Haveman, 1993), but water allocation has not often been determined by economic criteria. Policies for managing water have aimed at services that are either essential for life or strategic for the economy. Water policy has been almost exclusively oriented to guarantee the public provision of water services at subsidized prices. This is why water agencies and water users have been insulated from the influence of market forces (Dinar, 2000; Young, 2005). In such a frame, instead of leading to higher prices that reduce demand and encourage greater efficiency in the multiple uses of water, the limited capacity to support water resource abstraction and discharge have led to a growing demand for major infrastructure and increased public support to put increasing amounts of water services available to users, worsening shortages and deepening the water crisis (Dinar and Subramanian, 1997; Dinar et al., 2005).

These systems for human water uses have additional impacts on the ecosystems that regulate the hydrological cycle (such as forests, water sources, riparian ecosystems, soils, floodplains, lagoons, deltas, etc.) and the natural flows that deliver water services to the economy (Young and Haveman, 1993; Winpenny, 1994). Most of the time, the impacts of unpriced (or unmanaged) water uses have negative impacts on ecosystems, environmental waters, and natural resource assets (from fisheries to forests) whose property rights are not always clear or allocated in markets (Brown, 2000).

PART I – The Assessment Framework

1. Structure of the framework

1.1 Introduction

The Assessment Framework (AF) consists of:

- A unified conceptual scheme of the ex-post and ex-ante assessments of Economic Policy Instruments (EPIs) described under WP3 and WP4 case studies (task 2.8);
- Indicators (organised in a database) appropriate to specific EPIs (tasks 2.1– 2.7);
- A toolbox of guidance documents and/or protocols that deliver uniform assessment of WP3/WP4 case studies (task 2.9).

The AF collects assessment criteria, assumptions and choices. Outcome-oriented criteria describe EPI performance, costs and induced effects. Contextual criteria describe conditions influencing EPI outcomes. Assumptions are necessary to connect policy outputs to outcomes; separate and quantify the impact of the EPI on empirical outputs/outcomes that are affected by other factors; forecast future outputs/outcomes; and estimate what baseline path would have occurred in a counterfactual scenario without the EPI (see Figure A-1). Choices include additional parameters applied during the assessment exercise such as the discount rate.

Indicators are qualitative or quantitative, direct or indirect (proxy) values of outcome-oriented and contextual criteria. Indicators can be specified as exact values, ranges (due to inexact measurement of impacts); or qualitative indicators. Indicators can also reflect temporal and spatial elements, to control for EPIs that have different effects over time or create spill over to adjacent communities. A groundwater extraction fee, for example, may reduce groundwater extraction during a wet period but be too low to matter in a dry period. In the same sense, the fee may affect an adjacent jurisdiction outside the fee's implementation area.

Policies target objectives with EPIs that will deliver outcomes. Outcomes that are difficult to measure are often approximated by intermediate proxy outputs (see Table A-1). An EPI that aims for an outcome of reduced residential water consumption (demand) may result in outputs such as higher sales of water-efficient appliances. Outputs are easier to trace, but they may be imperfect proxies for outcomes. A value of subsidies provided for water-efficient appliance, for example, does not provide a good estimate of total water savings if we are missing data on how households use those appliances.

The toolbox describes methods, models and other tools that can be used to evaluate criteria via indicators. A guidance document clarifies which tools are best for assessing an EPI, given information constraints and the expertise of the assessor.

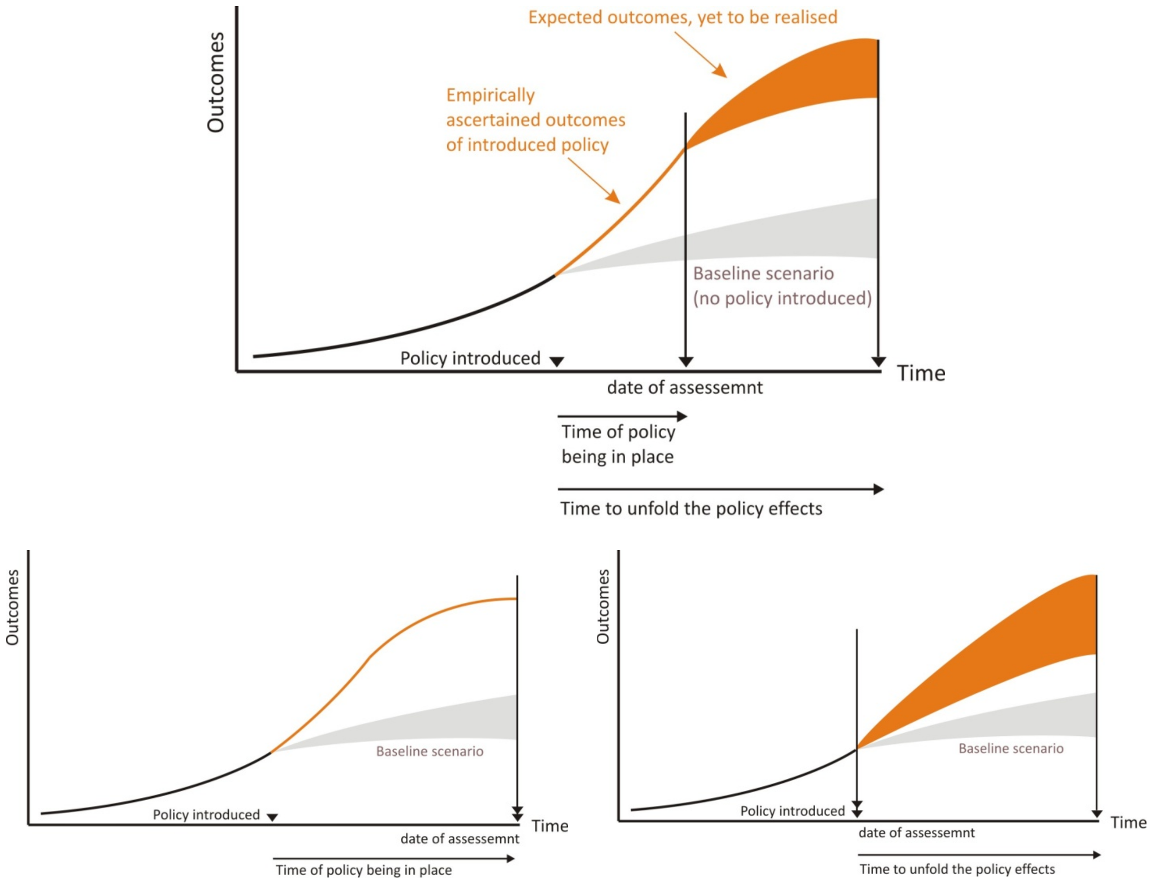

Figure A-1. Ex-post assessment compares outcomes after implementation of the EPI to a counterfactual baseline (bottom left). Ex-ante assessment compares the baseline future to the EPI-modified future (bottom right). Ex-post assessment may also compare future trajectories (top).

Table A-1. Examples of policy outputs and outcomes

Policy domain	Objectives	Outcomes	Outputs
Drought and water scarcity	Reduce disaster risk/Ensure water security/Improve preparedness/Increase community resilience	Population affected by mandatory water restriction/rationing	Per-capita water consumption/Count of water–saving appliances
Flood risk		Ratio of insured to uninsured flood losses	Insurance market penetration
Water quality	Achieve GES (Good Environmental Status)	Concentration of priority substances in water bodies	Population connected to tertiary sewage system

1.2 Economic policy instruments (EPIs)

The EPI-WATER project will analyse EPIs that use different means to reach objectives. EPIs can spur behavioural change through incentives or disincentives; change conditions to enable economic transactions, or reduce risk. The variety of EPIs means that the AF needs to be flexible enough to accommodate particular EPIs but specific enough to allow side-by-side comparisons of these EPIs.

Policies and objectives: A policy is assessed against the objectives for which it is designed. An insurance policy, for instance, targets resilience as an objective (hedging against low probability, high impact events such as floods, for example). This EPI would be assessed according to the extent to which it achieves the objective and its relative performance against other policies (e.g. state compensation/relief scheme) or measures (e.g. structural defence) targeting the same objective. Thus we can see that EPIs will be assessed against their objectives as well as compared to other policies. Assessments will go beyond direct effects, to include side effects (positive and negative) that were not considered when policies and objectives were designed or implemented.[1]

Objectives may be quantified (e.g. halve household water consumption) or generic (reduce water stress). They may be single or multiple, implicit or explicit. We assume that policy objectives for WP3 EPIs are either explicitly specified at the time of implementation or implicitly revealed by the choice of policy. We will compare EPIs with similar objectives and make adjustments for EPIs that target multiple objectives.

Clearly, EPIs have received widespread attention over the last three decades, and have increasingly been implemented to help achieve environmental policy objectives, often due to their (allegedly) superior efficiency compared to classical "command-and-control"-type regulation. (Grimble 1999; Pearce & Howarth 2000; REC 2001; Kraemer *et al.* 2003; Merrett 2004; Cantin *et al.* 2005; Da Motta *et al.* 2005; Sawyer *et al.* 2005; EC 2007; Pablo *et al.* 2007; Al-Marshudi 2008; Editorial 2008; Russell *et al.* 2009). Rather than specifying a particular type of behaviour that the regulatee has to comply with, economic instruments create the economic incentives (e.g. price signals) to encourage or discourage certain behaviour, but leave it to the regulatee to devise his / her own way of dealing with this incentive. Table 2-A describes the most common EPIs, their functions and purposes.

Notwithstanding well-established theoretical foundation, actual use of EPIs is relatively recent and implementation differs among countries and applications (groundwater quantity versus surface water quantity, for example) (PRI 2004; Cantin et al. 2005).

[1] Side effects are also called ancillary effects, externalities, or spill-overs.

Table A-2. Broad categories of economic instruments covered in the proposed case studies for WP3

Type of instrument		**Function/main purpose**
Taxes and charges	Water tariffs (pricing)	Collect financial resources for the functioning of a given water service and/or promote water efficiency. (includes full cost recovery pricing)
	Environmental tax	Internalise negative environmental impacts and/or collect financial resources for the central budget
	Environmental charge	Internalise negative environmental impacts and influence behaviour, to collect financial resources that are allocated to support environmental friendly practices and projects
Subsidies	Subsidies on Products	Increase the attractiveness of "green" products and production factors that have limited negative environmental impact/footprint
	Subsidies on Practices	Increase attractiveness of green products and production processes that limit negative impacts on water sources or producing positive environmental externalities
Markets for environmental goods	Tradable permit for pollution	Improve the allocation (increase the efficinecy) of pollution amongst sectors
	Tradable permit for abstraction	Improve allocation (increase efficiency) of water quantity among sectors (including the natural environment)
	Compensation mechanisms	Establish mechanisms where environmental degradation leads to financial payment that is allocated to alternative actions to compensate for the degradation; can also be provided via third parties (e.g., insurance)
Voluntary agreements*		Establish a contractual agreement between parties to promote good practices for the reduction of pressures on water resources (payment for ecosystem services) often linked to subsidies and compensation mechanisms

Note: * For the purposes of this project and because of its current relevance as an instrument for water policy in Europe, Voluntary Agreements (VA) have been included as a category in the broad categories of EPIs. But it is worth noting that there is an on-going debate in the literature about whether voluntary agreements (VA) can be regarded as a "pure" economic policy instrument or not. Environmental VAs are commonly defined "as an agreement between a government authority and one or more private parties with the aim of achieving environmental objectives or improving environmental performance beyond compliance to regulated obligations. Not all VAs are truly voluntary; some include rewards and/or penalties associated with participating in the agreement or achieving the commitments" (Gupta et al., 2007). Some economists interpret the "Voluntary" nature of the agreements as a version of regulation and therefore, argue that they do not belong to the economic policy instruments category.

1.3. Assessment criteria

The criteria for assessing EPIs describe outcomes and contexts. Outcome-oriented criteria describe how EPIs perform. They include intended and unintended outcomes; transaction costs from negotiating and enforcing policies; and the distribution of benefits and costs among the affected parties. Context criteria describe the institutional conditions (legislative, political, cultural, etc.) affecting the formation and operation of EPIs, the robustness of the EPI with respect to uncertain conditions, and process of implementing the EPI.

The EPI-WATER Description of Work lists criteria as Tasks 2.1 to 2.7 under Work Package 2. For the purposes of this document (and future discussions), we have reorganized these tasks to improve the evaluation flow and to emphasize links between the different criteria (see Figure A-2). Outcome-oriented criteria are divided into social (distributional effects), environmental and economic outcomes, including transaction costs. The context represented by coupled human and natural systems (aquatic ecosystems and water uses that are connected through man-made infrastructure positioned within the global institutions and economy) is integrated into the assessment through the analysis of the institutional and policy context. All these dimensions are further described below (with references to original task numbers). Detailed task descriptions in Part II are in their original order.

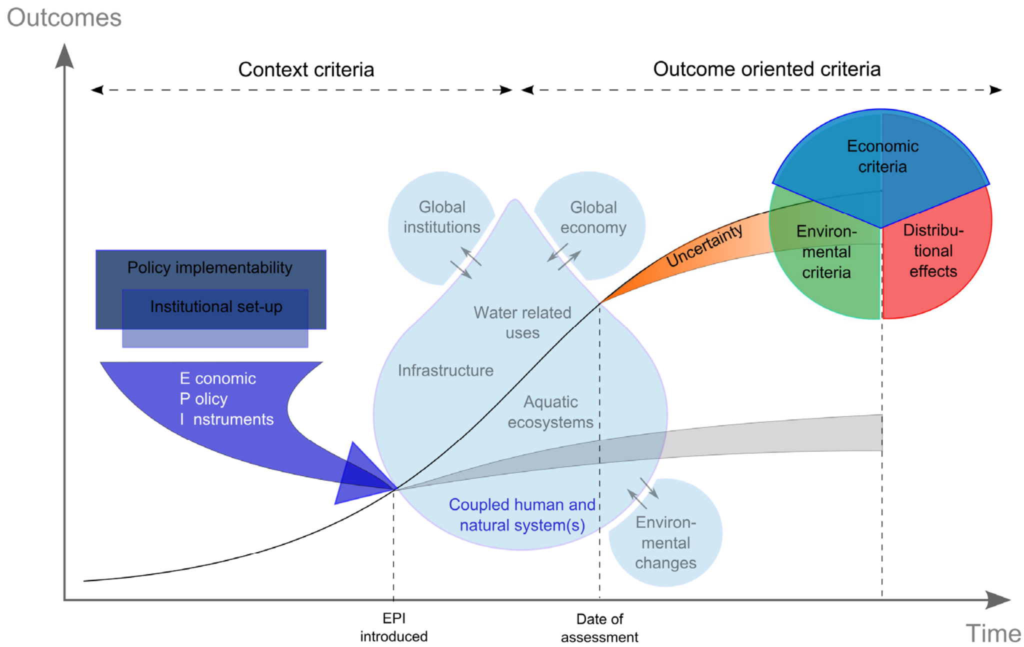

Figure A-2. Conceptual schematic diagram of the EPI assessment framework

Tasks and criteria relate in the following way: EPIs are devised and implemented within an institutional context (1.3.1). EPIs target objectives by producing outcomes on environmental (1.3.2) and economic (1.3.3) dimensions. These outcomes are associated with transaction costs (3.1.4) and distribution patterns (1.3.5) that affect the social impact of an EPI. Observed outcomes reflect one realized set of potential outcomes. Future circumstances may not produce the same outcomes (for good or ill), so it's necessary to understand how the range of outcomes may vary (1.3.6). All of these criteria (institutions, environmental outcomes, costs and benefits, equity and robustness) affect EPI implementation and the potential for implementing the same EPI elsewhere (1.3.7).

1.3.1 Institutional background

Institutions are the formal rules and informal norms that define choices by affecting the cost of exchange (transaction costs) and production (transformation costs) (North 1990). Most institutions are difficult to describe, highly adapted to local conditions, and effective in balancing many competing interests. Institutional constraints vary in strength, depending on their level; see Figure 4-A. We will separate institutions and transaction costs (TCs in 1.3.4) in our analysis by associating institutions with exogenous impacts on EPIs and TCs with the fixed costs of implementing an EPI and variable costs of using it. A water market, for example, is established with fixed TCs and operated with variable TCs, but both are affected (positively and negatively) by institutions. These effects should be kept distinct from the impacts of EPIs that create/modify institutions (e.g., new markets or tax adjustments, respectively) or influence the institutions of existing markets and bureaucracies, choices and behaviour (e.g., water law, policy or administration).

1.3.2 Environmental outcomes

EPIs target water policy objectives (e.g., reduce water demand or maintain WFD quality standards) or increase the social value of water by changing incentives to direct behavior towards collective goals. EPIs that target environmental outcomes will be assessed by comparing actual outcomes with alternatives (no action or regulation, for example) and evaluating positive and negative side effects. The economic valuation of environmental outcomes will be based on avoided costs that are translated into monetary values than can be used in a cost-benefit assessment (described in 1.3.3). This criterion will consider the response of economic agents to EPIs in terms of changes in demand for water services; the impact of these changes on the ecological status of water-related ecosystems, and the value of the environmental goods and services from these ecosystems to humans.

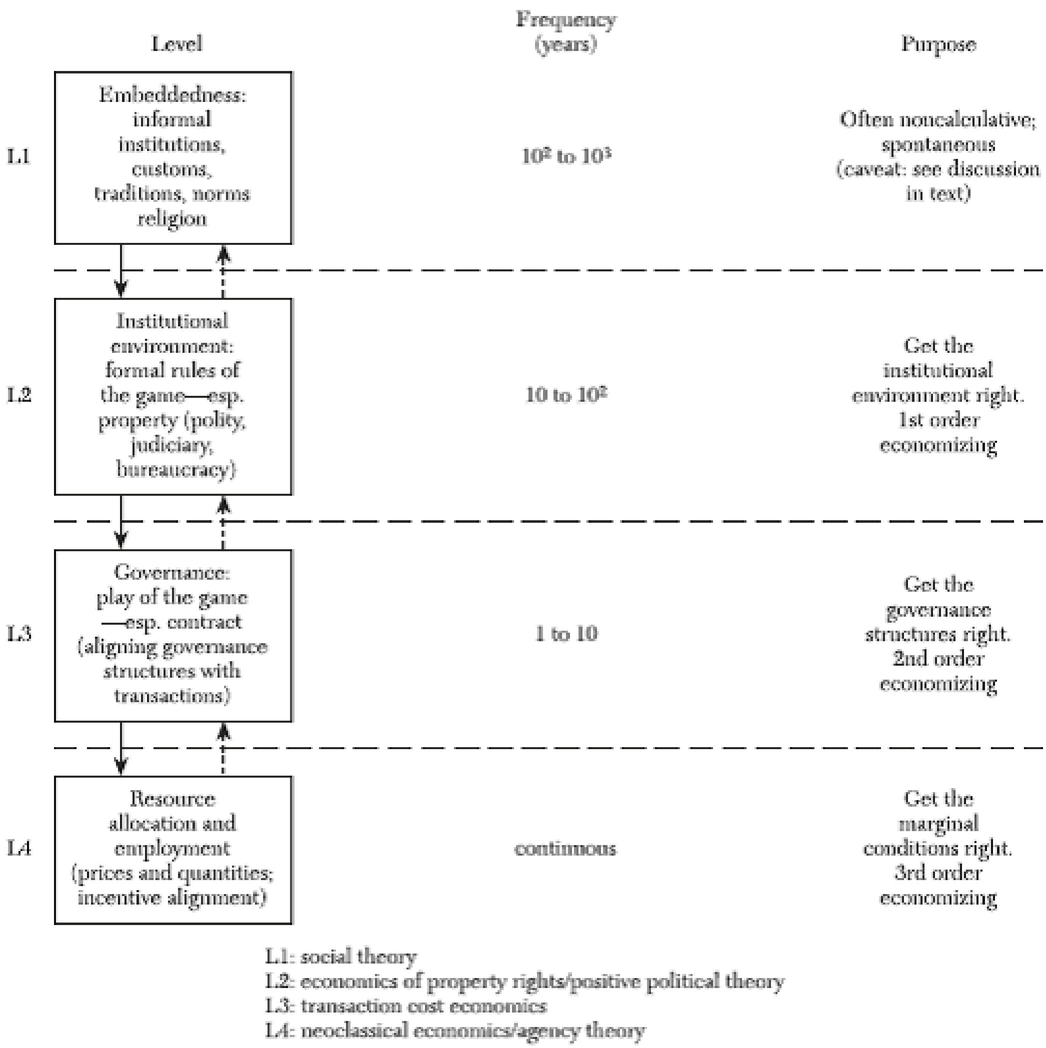

Figure A-4. Institutional levels from Williamson (2000)

1.3.3 Economic outcomes

This task provides an economic synthesis of the contents of criteria 1.3.1, 1.3.2 and 1.3.4 to facilitate evaluation of the outcomes. The economic assessment will evaluate the EPI based on efficiency using a cost-benefit analysis (CBA) that integrates incomplete and/or unreliable economic estimates. In addition, EPIs will be evaluated according to cost effectiveness, distributional effects (1.3.5 will examine the equity and ethical considerations from this distribution), risk reduction (with some evaluation deferred to 1.3.6), and promotion of innovation. Effects directly linked with environmental outcomes in 1.3.2 will be used as an input to the analysis here.

1.3.4 Transaction costs

Transaction costs (TCs) from implementing or using EPIs are different from typical direct costs. Krutilla and Krause (2010) examine "TCs related to the creation, implementation and operation of environmental policies." Their analysis refers to ex-ante TCs (e.g., negotiating new property rights) and ex-post TCs (e.g., monitoring costs). They also refer to "factors affecting the magnitude of TCs" such as cultural norms, the state of technology, etc. These exogenous factors affecting EPIs are examined under section 1.3.1. We use Krutilla and Krause's classification of TCs - noting that ex-ante TCs are equivalent to fixed costs and ex-post TCs are equivalent to variable costs associated with the EPI. We identify TCs by examining the flow from design and implementation (ex-ante) to monitoring and enforcement (ex-post). Asymmetric information falls under TCs in two ways. Ex-ante and ex-post TCs can change the information environment (e.g., establishing and running a monitoring program). Asymmetric information can impose visible and invisible TCs, e.g., the costly change in behaviour in response to incomplete information; see also section 1.3.6.

1.3.5 Distributional effects

The distribution of goods and burdens across different groups affects social equity and acceptability of EPIs. There are many arguments made in the social justice literature as to what constitutes a 'just' distribution. In EPI-WATER we focus on social equity and take it to mean reducing the inequalities between stakeholder groups. This criterion focuses primarily on assessing the nature of the distribution, highlighting inequalities in the allocation of goods and burdens as a result of the implementation of EPI. Assessment will consider both proxy indicators based on quantitative data and quantitative subjective measures of well-being (Stiglitz Commission 2009). These results will be assessed by comparing pre- and post-EPI implementation conditions. Results based on a simple +/=/- metric will highlight existing inequalities and changes due to the introduction of the EPI across various groups.

1.3.6 Uncertainty

An EPI's impact on any criterion is subject to uncertainty from imprecision (missing knowledge, estimation, inaccuracy or ambiguity), complicated interactions among policies, and/or future costs/benefits. For EPI-WATER, we propose to use the pedigree analysis inspired by van der Sluijs et al (2005). The pedigree represents an explicit account of the quality of information and the processes underlying the knowledge production process. The pedigree criteria are assessed through expert judgement, using qualitative statements.

1.3.7 Policy implementability

This criterion will examine the conditions under which an EPI is implemented or not. Failure may be traced to faults in design or implementation. Implementation is related to endogenous institutions (1.3.1) and exogenous transaction costs (1.3.4). The task will identify and define key factors that are important for implementation of

EPIs at the policy level and to make recommendations of methods for their measurement and elicitation for their evaluation. This criterion will consider the institutional setting, societal values, power relations, the impacts of other policies (e.g., CAP), and the EPI's flexibility with respect to local circumstances and changing situations (e.g. climate or socio-economic change).

1.4. Terminology

Policy. A policy is a set of principles and terms guiding the governance of particular social, economic or environmental issues, implying the use of procedures or instruments for reaching some given objectives, goals or targets.

Policy goal. Objective to be achieved by implementing a policy and the respective instruments. Environmental policy objectives can be defined either in relation to the state of ("Good Environmental Status", GES), or the pressures on ecosystems (generally aiming at their reduction). Policy goals can be subject to discrepancies between stated and (frequently hidden) real policy goals.

Policy targets. Rather than generic objectives, policy targets are policy goals which have been defined in quantitative terms.

Policy Instruments. Mechanisms designed by policy makers to direct outcomes towards a targeted objective

Outcomes. The outcomes comprise all long-term consequences which can be attributed to the policy implementation, comprising both intended and unintended (targeted and not targeted) side effects or impacts, for instance in terms of pollution levels or international competitiveness of a domestic industry.

Output. Measurable direct effect of a policy, e.g. an amount of certain goods or services directly produced attributed to the implementation of a policy.

Side effect. Side effects are policy outcomes that are not explicitly connected with the policy goal, comprising (positive or negative) impacts on ecosystems, economic and social structures.

Impact. Impacts are the effects of a policy intervention on environment and society. Impacts can be either positive or negative, foreseen or unforeseen. Immediate impacts are called results, whilst longer-term impacts are called outcomes. Because of the more generic character of the term "impact", it is proposed to use the terms: outcome (long term impacts), side effect (unforeseen impacts) or output (amount of goods and services produced).

Cost. Costs usually comprise efforts, material, resources and time consumed, risks incurred, and opportunities forgone in order to reach a policy goal.

Effectiveness. Effectiveness is the degree to which policy goals are achieved by implementing the policy instrument considered. In contrast to efficiency, effectiveness is not determined with reference to costs and compares the outcome achieved by the use of a policy tool with the policy goal.

Cost-effectiveness. Cost-effectiveness has been labelled the "relaxed approach to the measurement of efficiency". It is the measure of the relationship between (money measured) inputs and the desired outcome, such as for example between the expenditure on the creation of water markets and the reduction of pressures on water-related ecosystems.

Efficiency. Efficiency relates to the achievement of maximum social welfare. More (or less) efficient policy instruments can be identified using a social welfare indicator for a comparison with a benchmark.

Risk. The combination of the probability of an event and its negative consequences (UNISDR 2009).

Uncertainty. Uncertainty exists when details of situations are ambiguous, complex, unpredictable or probabilistic; when information is unavailable or inconsistent; and when people feel insecure in their own state of knowledge or the state of knowledge in general (Brashers 2001).

Criteria. Criteria are rules used for judgement, in this case of policy instruments. The definition of criteria and of the respective indicators is part of the assessment design defined, in the case of the EPI-WATER project, in the overall assessment framework.

Assessment. The assessment is a systematic and methodological analysis of an intervention or situation, aiming at informing decision-making.

Indicators. Indicators are qualitative or quantitative parameters which represent the information needed for measuring change, in this case provoked by policy interventions (EPIs) on criteria. In order to be useful, indicators need to be able to represent trends which are significant for the policy or measure under exam. They measure key issues in relation to a criterion for decision making, often by representing larger realities in a single and comprehensive measure, as for instance CO_2 emissions are used as an indicator for the whole array of climate relevant emissions.

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PART II – Background Annex

2. Environmental Outcomes

Carlos M. Gómez Gómez, Gonzalo Delacámara and Miguel Solanes (IMDEA)*

2.1 Introduction

Water policy is about making economic development and social welfare enhancement compatible with the improvement and protection of water resources (see Figure B-1). Water and water-related ecosystems provide the economy with flows of water services or primary materials for the production of many valuable goods and services such as drinking water, food, electricity, manufactures, tourism services, etc. The quantity, the quality of all these water services as well as its stable provision depend on the state of conservation of all those ecosystems.

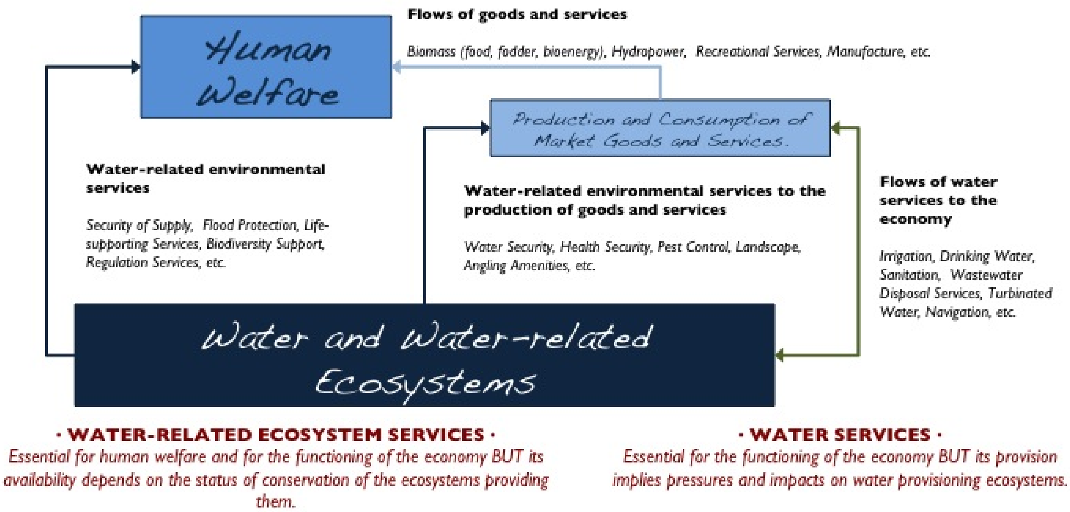

Figure B-1. Water Services, Ecosystem Services and Welfare (Source · Own elaboration)

None of these water services can actually be provided without a detrimental effect on these ecosystems (that is to say without water abstractions, impoundments, diversions, and so forth). Hence, assessing the environmental outcomes of water

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policy instruments requires a clear understanding of the supply and demand of these water services and, particularly, a notion on how these services are provided to the economy (with more or less impact on water ecosystems) and on how much welfare the economy is able to produce (by allocating and using them with more or less efficiency and fairness).

Besides providing water services to the current production of goods and services for the economy, water-related ecosystems provide a number of important environmental services, which are essential for human welfare and for the incessant functioning of the economy. These services include, for example, water and health security, flood control, biodiversity support and all the water regulation services, essential to preserve both water and ecosystem services.

The availability of all these environmental services depends on the status of conservation of the ecosystems that provide them. Modern water policy objectives are therefore defined in terms of a desired status of conservation of these water-related ecosystems. The choice of the appropriate policy instruments is thus based upon their ability to adapt the functioning of the economy to these goals.

Economic instruments are just but one kind of the different alternative means available to the ends of water policy. The essential characteristic of an EPI is that it is an incentive deliberately designed and implemented in order to make individual economic decisions compatible with some policy goal. Economic instruments for sustainable water management, as considered in EPI-WATER, are consequently designed and implemented both to induce some desired changes in the behaviour of all water users in the economy (individuals, firms or collective stakeholders) and to make a real contribution to collectively agreed water policy objectives (NCEE, 2001; Stavins, 2001; Kraemer et al., 2003; UNEP, 2004; PRI, 2005; ONEMA, 2009).[2]

Yet, behavioural changes, which are the direct purpose of EPIs, are indeed just transitional objectives to meet the true aims of water policy: the optimal use of water resources and water-related ecosystems. The latter generally consist of achieving,[3] maintaining and protecting a given ecological status of water bodies (Riegels et al., 2010).

Whatever assessment of the effectiveness of any policy instrument (in particular when they entail setting the incentives behind actual human behaviour), does not only require an analysis of the impact on the environment of intended changes in the economy, but also a consideration that "closes the circle," namely to show how

[2] Within the scope of EPI-Water and the assessment of environmental outcomes, the effects of water policy on other sectors will also be assessed (it is of paramount importance to do that as part of the assessment of instruments). On the contrary, the effects of other policies on water will not be analysed since this is part of the analysis of scenarios in which EPIs are to be assessed.

[3] The achievement of an ecological status, as in the WFD, means, by definition, an improvement.

environmental changes would in turn impact on the economy and social welfare (see Figure B-1).

Summing up, we can conclude that assessing the environmental outcomes of EPI implementation implies searching for an answer to the following relevant questions (see Figure B-2):

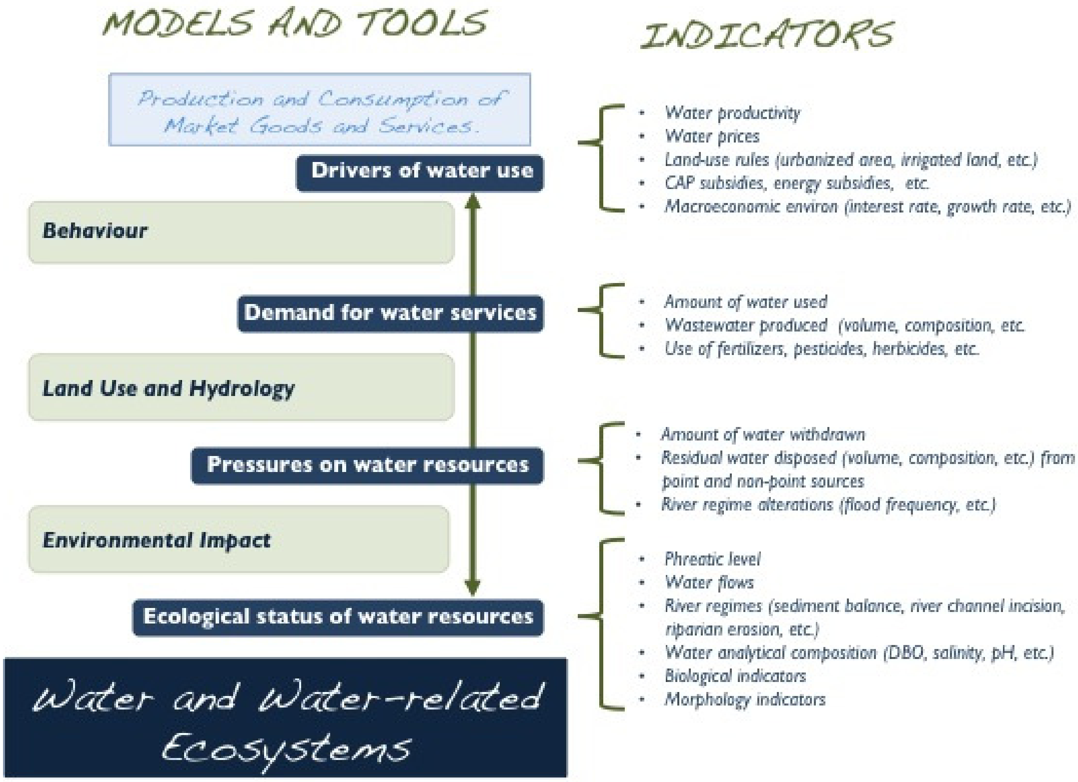

Figure B-2. Steps to Assess Environmental Outcomes Roadmap: Models, Tools and Indicators

What are the economic agents' effective responses to EPIs in terms of a reduction in the quantity and quality of those water services demanded or supplied?

- Answering this question requires an understanding on how decisions on water services use depend on the different economic, political, and institutional factors that explain how water is used in the economy (see section 0). All these drivers of water use as well as of the demand for water services in each relevant economic activity, can actually be described by a set of indicators (as shown in Figure B-2), and the connection between the drivers and the demand for water services is explained by behavioural models and analytical tools. Indicators are useful to describe the baseline and the intended and realized outcome of an EPI, in the same way that models and tools are essential to design and assess EPI effectiveness.

How these changes in individual behaviour translate into lower (or increased) pressures on water providing ecosystems? (See section 2.3.2)

- This question requires comprehension on how efficient the production of water services in the economy is, in the sense that satisfying a certain demand of water services (for example of water for irrigation) requires more or less pressures on the water environment (depending on the technical efficiency of abstraction devices, transport, delivery and application system in place). It also implies to understand how the concerned economic activities affect the water environment (for example by affecting runoff, erosion rates or by the diffuse disposal of pollution loads)

What are the likely or observed impacts of changes in pressures on the ecological status of concerned water-related ecosystems?[4] (See section 2.3.3)

- To answer this question it is critical to realize how pressures directly and indirectly affect water bodies. As in the previous question, some available indicators can describe pressures and the ecological status of water bodies but linking one to the other will require appropriate models and tools (Figure B-2).
- How changes in the status of water providing ecosystems would affect their potential to provide society with increased (or decreased) flows of environmental goods and services (or benefits)? (See section 2.3.4 and Figure B-2).

How valuable are these benefits? (See section 2.3.5)

All the discussion about the convenience of implementing innovative EPIs or about the failure or success of previous experiences is based upon the expected or actual answers to the above-mentioned questions. Moreover, an overall assessment of the effectiveness and the economic benefits of EPIs for water management is rarely found in the literature, maybe with the exception of models combining hydrological and economic analyses. Most of the available information on the effectiveness of EPIs does refer to *ex ante* evaluations, often based upon optimistic design (when not simplistic) assumptions, that is to say not necessarily confronted with realized outcomes. As shown below, in the different examples used to explain the steps of the assessment, rather than offering a comprehensive response, most relevant publications on the subject seem to have focused on solving one of the above-mentioned questions. This implicitly suggests the remaining answers will go in the same direction.

[4] One may argue that there are no water-related ecosystems as a separate class since all ecosystems have a water component. Yet, reconciling the use of terms such as water bodies, river basins, and ecosystems is not straightforward and is a non-solved problem in the literature (Kohli et al, 2010; Moller, 2009).

2.2 Typology of EPIs according to their intended primary environmental outcomes

According to the roadmap presented in the previous section it does make sense to use an extended classification of the many different water-related EPIs according to its expected primary outcome for sustainable water management as follows:

1. EPIs addressed to obtain quantifiable reductions of water services demanded by a defined set of users in some economic activities and at some given places. This is, for example, the case of incentives to reduce water demand for irrigation (Turner et al., 2004; Bartolini et al., 2007; Berbel et al., 2009; Rosegrant et al; 2009; Pinheiro and Saraiva, 2009; Olmstead, 2010), household consumption (Garcia and Reynaud, 2004; Nataraj and Hanemann, 2011; Millock and Nauges, 2010) or manufacturing (Worthington, 2010).

2. EPIs to increase the efficiency with which these water services are provided. This is the case of EPIs designed to abate pressures on water bodies stemmed from the need to satisfy a given demand of water service provision. These tend to include incentives to promote more effective irrigation systems (Perry et al., 2009), investment on improving water distribution networks or replacing assets (Tang et al., 2007), better water transport systems (Howitt et al., 2010), use of recycled water in manufacturing processes (Chen and Wang, 2009), etc. Within the same category some other EPIs can be found with the potential to reduce the negative impact of providing the economy with waste disposal and treatment services. They include, for example, incentives for investing in more efficient effluent treatment plants, reducing pollution loads, etc.

3. EPIs to promote the substitutions of water supply sources in order to reduce pressures on water bodies associated with the provision of a given set of water services, both for production and consumption activities. This is, for example, the case of incentives performed to promote the substitution of alternative resources (such as regenerated or desalinated water) for freshwater (Gleick, 2000; Zhou, 2005; Riegels et al., 2010) or to shift water supply from some traditional sources to others with lower negative impacts, etc. (Farreny et al., 2011; Mitchell et al., 2005).

4. EPIs to reduce impacts of specific economic activities on the structure and functional activity of water (providing) ecosystems. This may be the case of incentives to promote agricultural practices that increase soil conservation (Prager et al., 2011), reduce deforestation (Ring et al., 2010), minimize floodplain occupation (Mori, 2010), etc.

5. EPIs to reduce risk exposure to extreme events such as droughts and floods as in the case of incentives to deter land settlements in hazard zones or to promote water stress-resistant crops in drought-prone areas (Mendelsohn and Saher, 2011) or resilience and resistance measures for floods.

2.3 Assessment methods and techniques

This section presents the analytical methods available to answer for the assessment of the environmental outcomes according to the road map presented above.

2.3.1 Modelling behaviour[5]

The analysis of intended and observed changes in individual decisions and of the incentives required to attain a given outcome (such as a reduction in water demand), requires a proper understanding of the drivers of water use decisions. At an individual or activity scale this analysis can be based on existing or *ad hoc* water demand functions, able to inform on how water demand responds to, for example, changes in prices and income. It can be the case for instance of the dynamic modelling of water demand and adaptation strategies to climate change in power stations (Koch and Vögele, 2009), estimations of residential water demand (Schleich and Hillernbrand, 2009), etc.

Farmers' decisions, for instance, depend on a number of technical, economic, policy and environmental constraints. Additionally, in the case of water demand these constraints vary with space, according to land vocation, access to water use rights, water tariffs and availability of irrigation infrastructure, in such a way that a large scale or aggregated model might be vague about the driving forces behind water demand. Nevertheless local and low scale models require detailed information and their results might not be easy to generalize or aggregate.

So far, the construction of water demand simulation models is confronted with a trade-off between the model's capability to provide numerical results for policy evaluation and the coherence with basic economic principles. The need to represent complex decision problems with limited information has fostered the use of Positive Mathematical Programming (PMP) to simulate farmers' behaviour and to obtain water demands of which many are reported, for example, in Henry de Frahan et al. (2007), Berger et al. (2007) and Heckelei and Britz (2005). Apart from PMP, most of the existing simulation models that have been successfully used as tools for policy evaluation in many advanced countries are based on multi-criteria decision methods (MCDM) (Sumpsi et al., 1996; Bazzani, 2005; Bazzani et al., 2005; Feás and Rosato, 2006; Latinopoulos, 2009; Bartolini et al., 2010). Moreover, the assumption that farmers respond with linear preference orderings to changes in the policy, resource and economic environment and, similar to PMP, the use of a calibration mechanism effective but not rooted in explicit economic principles, are nevertheless issues prone to discussion. Models using a preference representation coherent with basic economic principles are for example found in Gutierrez and Gomez (2011). Moreover

[5] There are clear links between this issue and other WP2 tasks. After all, EPIs are incentives to induce behaviour changes and this links to labour demand (employment), income effects (distribution), bargaining (institutions, competition, market power), opportunity cost (cost-benefit analysis), etc.

the difficulties of running proper elicitation procedures with detailed data and the programming and optimization tools available at that time made these exercises difficult to apply because of the details needed to make them useful for policy assessment and project analysis.

A useful insight of these models is the extensive demonstration on how farmers do not simply act as profit-maximizing agents and on how taking other decision attributes, such as risk aversion and avoidance of management complexities into account, provides a better explanation of current decisions.

This is also the case of partial equilibrium models showing the residual benefit that farmers derive from having access to a reliable water source at the farm, the municipality or the irrigation district (Lavee, 2010). These models may provide the basic information about the surplus that may be derived through reallocating water, as well as information on the maximum willingness to pay for having access to more water (demand) and the minimum required compensation to voluntarily accept the transfer of prevailing water use rights (supply).

An important concern when determining the environmental outcome of EPIs refers to the scope of the analysis. Results can differ and be closer to the real outcome when moving from a project, static, partial equilibrium scale to a regional, dynamic, general equilibrium analysis. In the former, for example, it is assumed that nothing changes, apart from an increase in the efficiency of the irrigation system (farmers will need less water than they used to; a subsequently lower amount of water will need to be withdrawn, transported and delivered).

Rather, in a dynamic model, farmers are able to modify crop decisions (including the surface of cultivated land) in order to adapt to the new situation. Specifically, this will be done to take advantage of the increased per-drop yield and to use the water apparently "saved" thanks to a more effective irrigation device. Within a general equilibrium framework other economic sectors can use the water redundant and this water will be sold at a lower price by the firm, which in a new scenario (i.e. after some water has actually been saved), have an excess production capacity. This is why, through ignoring how individuals and markets adapt to any institutional change, partial analysis tends to overestimate the reductions in water use (Tirado et al., 2006; Palatnik and Roson, 2009; Calzadilla et al., 2010).[6]

For a number of reasons EPIs may fail to provide the positive effects expected when they were initially designed and implemented. In water scarce areas, subsidies to foster the adoption of more effective irrigation devices may lead to an increase in water consumption, as the per-drop productivity will be higher. In those areas, as

[6] Several authors (Ekasingh and Lechter, 2005) have argued for more use of agent-based models or multi-system modelling as innovative approaches. As a matter of fact, agent-based models are able to deal with social and political dimensions. Agent-based modelling may both help improve the representation of the dynamics of social processes in integrated models, and also the conceptual understanding of social learning processes (Pahl-Wostl, 2002).

above, water saved due to a specific efficiency measure can be used to cover the structural deficit between water demand and supply, and water consumption will in fact be higher than in the baseline scenario (that is, the situation previous to the technical improvement). Higher water prices will reduce water consumption but could also shift water use from legal and publicly controlled sources to uncontrolled water sources.

To assess the potential effect of an EPI on water use, the analyst must be able to isolate this effect from other alternative explanations. For example, an increase in water use, once water prices have risen, might be the result of an increase in household income, in the medium term, or rather of an exceptionally warm summer, in the shorter term. It may also be the case that the reduction in water demand in some farms after the installation of a more efficient irrigation device is the consequence of the decoupling of CAP subsidies, which made irrigated agriculture less attractive. For this reason, the best analysis tools (such as demand functions, economic and financial balances and simulation models of water users' behaviour) are those able to provide a comprehensive explanation of the various factors driving water use decisions.

2.3.2 From behaviour and water uses to environmental pressures

The connection between uses and pressures needs to be better understood in order to assess the potential of water-related EPIs not only to induce change of individual choices but, most importantly, to make a real contribution to the improvement in the ecological status of the water environment. Assessing environmental outcomes of water-related EPIs thus implies a clear understanding of the links between the economy and the environment, in particular to understand how the satisfaction of water demands is connected with different pressures over water ecosystems (see OECD, 1991, for a description of the PSR framework of environmental indicators; EEA, 1995). The expertise needed to do so is available in several comprehensive hydrological, spatial and agronomic physical models.

"Saving water" is not always equivalent to "using" less water, reducing risk exposure (in terms of erosion, for instance) or improving environmental quality (including instream ecological flow). Even if water abstraction is reduced, more efficient irrigation will mean lower physical returns and the water balance will become uncertain. When water supply is not enough to balance evapotranspiration, as it happens in water scarce areas, more efficient irrigation translates into higher yields, which are related, in turn, to higher amounts of used water. All this also explains why "losses" or "savings" at the scale of an individual farm or an irrigation project are not necessarily losses in a hydrological sense.

The assessment of these effects needs a minimum understanding of the rainfall and runoff pattern (hydrology) in the river basin (spatial analysis) and its use (behavioural analysis) to assess how a water policy in general and EPIs in particular would affect water pressures (abstractions and returns; pollution loads and natural assimilation capacities) not only in the project site but in the river basin as a whole. A widespread approach for measuring physical outcomes consists on using hydrological[7] characteristics as an input to holistic spatial assessment[8] through GIS software (Xu and Singh, 2004; McColl and Aggett, 2007; Saghafian et al., 2007). These models can be complemented with agronomic tools.[9]

In economic theory, one may also find an insightful hypothesis that explains that efficiency in water use may result in higher water productivity and, therefore, higher water demand. This is conceptualized under the proposition of the so-called Jevons' paradox or effect (Alcott, 2005; Polimeni et al, 2007; Madlener and Alcott, 2009). Contrary to common intuition, technological progress (introduction of low-pressure irrigation systems, for instance), that increases the efficiency with which water is used, tends to lead to the growth of the rate of consumption at a certain scale. Energy economists, studying consumption "rebound effects" from improved energy efficiency, have revisited this issue (Brookes, 1979; Khazzoom, 1980;Lovins. 1988; Saunders, 2000; Schipper and Meyers, 1992; Howarth, 1997; Wirl, 1997; Schipper and Grubb, 2000; Brookes, 2000; Binswanger, 2001; Sorrell et al., 2009).

Efficiency measures do actually reduce the amount of water demanded for a given use. But in addition, improved efficiency lowers the relative cost of using water, which in fact is an incentive to use more, potentially outweighing any savings from increased efficiency (Gómez, 2009; Olmstead, 2010).

Llop (2006) found out in her empirical research in Spain that, in line with this paradox, technical efficiency decreased water prices, and this raised industrial water consumption. On the other hand, the introduction of a tax on intermediate water uses led to an overall rise in prices and this significantly turned water uses down. Yet, most interestingly, the joint application of the two measures (technical efficiency, through heavily subsidized measures, plus tax on intermediate water uses), reduced water consumption, had no inflationary effects, and increased social welfare.

[7] Hydrological models can directly provide runoff and infiltration flows based exclusively on historical hydrological data (USACE, 2000a) or rather generate inputs to be used together with spatial data (Dalen et al., 2008, NRCS, 2004, USACE. 2000b). Among the latter group (known as Land Use and Land Use Change models, LULUC), widespread approach consists on providing curve number and minimum rainfall values as an input for further development of spatial models (NRCS, 2004).

[8] Spatial analysis models rely on hydrological and geographical data processing, mainly through Geographical Information Systems (GIS) (Pender and Faulkner, 2011). GIS models generate rainfall-runoff (and thus infiltration and erosion) data distributed along time and space. These models are mostly used for extreme events assessment, such as floods (Yusoff, 2011, Hoque, 2011).

[9] Agronomic models estimate physical crop production using as an input soil characteristics, meteorological variables (intensity and distribution), crop characteristics and management practices. These models are accurate but data intensive.

2.3.3 Impact assessment: from environmental pressures to the ecological status of water bodies

The likely impact of a change in water pressures on the status of affected water bodies and, in particular, on water quantity, quality, and the ecological structure and functions of the water system, also needs to be analysed. Some examples may show that the connection between pressures and the status of water bodies is not straightforward at all. For example, as water bodies are connected to each other, the water saved in a given place, for example a stream could be used to make up a deficit in other, for example the aquifer receiving the irrigation returns. To assess the effect on the different interconnected water bodies a hydrological model of the river basin is therefore required.

For example, the "non-consumed fraction" of the water used in an agricultural system inversely varies with irrigation efficiency. This irrigation returns may be partially or totally recoverable in the sense that it can be captured or re-used (through river flows, percolation to aquifers) or not at all (when water returns flow into the sea or deep non-financially feasible aquifers). The same effects can be considered when water is transferred from a water body as a result of marked transactions having negative impact in the giving basin.[10]

Furthermore, the positive effect of other interconnected water bodies will be higher should either water be saved or pollution loads controlled further upstream than, for example, near the shoreline where water savings have lower spillover effects and subsequent minor impacts.

Although the functioning of water ecosystems is still imperfectly known, assessing the potential effectiveness of water-related EPIs does require a due consideration of the potential effects of reducing water pressures both on affected and interconnected water bodies.

Since Bear and Levin (1970), Burt (1964), Booker and Young (1994), Gisser and Mercado (1972; 1973), Noel and Howitt (1982), Vaux and Howitt (1984), and Young and Bredehoeft (1972), there has been much progress in terms of hydro-economic models.

Most efforts, however, have been placed on holistic approaches, such as Cai et al. (2003), Díaz and Brown (1997), Fisher et al. (2005), or Pulido-Velázquez et al. (2006). There is some controversy in the literature, however, as to whether holistic or rather modular approaches (such as Draper et al., 2003) should be preferred. The discussion is explicit in Braat and Lierop (1987), Brouwer et al. (2007) – a holistic approach itself, and McKinney et al. (1999) – also a holistic approach. These integrated or holistic approaches are based upon the idea that an optimum can be reached both in hydrological and economic terms and, also, from an operational viewpoint, that this

[10] It must be stressed that since the emphasis, at this level, is to evaluate what the pressures are at the source, inputs from agronomic models, runoff models or pre-existing data on the efficiency of measures might also be relevant.

optimization can be performed just by introducing a parameter (shadow price, elasticity of demand, etc., provided by optimization algorithms) or, at best, a demand function (see MacKinney et al., 1999, for an insightful discussion on optimization versus simulation). Holistic models have clear advantages but, in order to solve simultaneous equations, components tend to be presented in a too simplistic way.

Although the assessment of physical impacts (either positive or negative), of EPI implementation is dealt with elsewhere in the document, it is important to emphasise on the fact that a number of initiatives has been developed regarding indicator systems. Some of them have been developed within the framework of environmental indicators (OECD, 1991; EEA, 1995); some others are more specific, such as the IMPRESS working group (WATECO, 2003b) or guidance documents produced by the governments of the UK (2004) or Ireland (2004). All these initiatives agree on the fact that data themselves might not be enough to assess impacts: a correct indicator of the expected impact must be constructed (WATECO, op. cit.).

Regarding hydro-economic models, the validity of some assumptions has been questioned in recent years and the scientific community is currently aware of a number of "paradoxical outcomes" that may occur. A clear example is the so-called "efficiency paradox" can be found when analysing water saving potentials (Dworak et al., 2007), which are based on the following argument: if one is able to improve the irrigation technique, less water will be required, thus diminishing water withdrawals and water bodies will thus be in a better. But there may be a fair way to go from water saving potentials to actual ones. Besides the fact that using less water per crop does not necessarily mean using less water overall (at a farm, irrigation district or basin level), (Ward and Pulido-Velazquez, 2008 and 2008.b), likewise water losses at a farm scale are not necessarily equivalent to water losses in a hydrological sense (Perry et. al. 2009). Environmental benefits could be said to be likely outcomes rather than proven facts.

2.3.4 The status of water bodies and biophysical flows of ecosystem services

Provided EPIs succeed in changing decisions on water resources and these changes are effective in reducing pressures (thereby leading to positive impacts on affected water bodies), improved water resources will then have a higher social value and a higher potential to provide society with stronger flows of a wider array of environmental services (or benefits).[11]

[11] Beyond the seminal paper by Costanza et al. (1997), and the monographic issue of Ecological Economics (vol. 25, no. 1, April 1998) around that paper, or even previous references, such as Pimentel et al. (1997), this line of research has lived halcyon days: Kreuter et al. (2001), Guo et al. (2001), Sutton and Costanza (2002), Zhao et al. (2004), Hein et al. (2005), Troy and Wilson (2006), Tong et al. (2007), Naidoo et al. (2008) or, more recently, Boyd (2010) – on ecosystem services and climate adaptation, Liu et al. (2010) or Norgaard (2010). In parallel, two initiatives led from international organizations, have contributed to gain momentum: the Millennium Ecosystem Assessment (MEA, 2003; 2005; widely discussed in

Ecosystem services clearly link ecological functions and the benefits (in terms of welfare) that people obtain from ecosystems. Following the MEA's typology (MEA, 2005),[12] these include provisioning, regulating and cultural services that directly affect people, and supporting services needed to maintain the biophysical flows of the other services. Freshwater supply is an example of linkages between categories (provisioning and regulating services) (see Table B-1 in section 6.7).

Permanent water bodies inland from the coastal zone, and areas whose ecology and use are dominated by the permanent, seasonal, or intermittent occurrence of flooded conditions, provide a wide spectrum of ecosystem services. The timing and intensity of runoff, flooding, and aquifer natural recharge are strongly influenced by changes in land cover, including alterations that alter the water storage potential of the system, such as the conversion of wetlands (Yang et al., 2008; Chen et al., 2009) or the replacement of forest areas with croplands and pastures or the urbanization of cultivated areas (Crossman et al., 2010).

The drivers of change in the provision of freshwater are mainly linked to population growth and development, water supply management patterns, land use and land cover change (Maes et al., 2009), climate change and variability, urbanization, and industrial development (MEA, 2005). These drivers, however, are linked to specific changes in water ecosystems, mainly physical changes (including drainage, clearing, and infilling), modification of water regimes, entry of invasive species, impacts from fisheries and other harvesting activities, water pollution and eutrophication, and shifts due to climate variability.

It is critical to point out that technology allows partial substitution of some water ecosystem services. For instance, water purification can be partially substituted through the construction of water treatment facilities. Yet, protecting watersheds to enable ecosystems to provide this service, creates the conditions for the conservation of other services such as the maintenance of fisheries, the reduction of flood risks or the protection of recreational and amenity values.

2.3.5 The economic value of environmental benefits from EPIs

One of the purposes of the assessment framework, based upon the state of the art and outcomes from WP3 ex post studies, does actually consist of determining the whole list of different potential benefits.

Amongst the many ways in which water policy can affect the environment, an important clarification concerns to, what the most relevant benefits for the purposes

Carpenter et al., 2009), called for by the United Nations Secretary-General in 2000, and the report on The Economics of Ecosystems and Biodiversity (TEEB, 2009), a programme hosted by the United Nations Environment Programme.

[12] It must be noted that Ficher et al. (2009) consider that the MEA classification is relevant to promote understanding and educate a larger public about ecosystem services, but not when the goal is economic valuation, due to aggregation and double counting.

of EPI-WATER are. The question arises because we are mostly interested in assessing instruments rather than water policy goals. In other words, EPIs are to be considered an option for water management provided they could make a better contribution to water policy when compared to other available alternative instruments. Many of the relevant arguments to test such hypothesis belong to the criteria analysed in other sections of this assessment framework (such as the analysis of transaction costs, cost effectiveness, social justice or political acceptability), and for which information on the environmental benefits and costs are clearly relevant.

In addition to that, for the sake of identifying benefits, our focus will not be on the value of the environmental services associated to a certain status of water-related ecosystems conservation (as this status is the concern of water policy objectives), but rather on the differential environmental benefits of using a particular EPI rather than its best available alternative. The most relevant question is then what difference in terms of environmental benefits will make using EPIs from the set of measures selected to obtain a particular water policy goal.

The list of potential benefits to be considered can be organized according to the following general categories:

1. Avoided opportunity costs of achieving a pre-determined environmental target. Being just one of the different measures with the potential to achieve a given environmental target, a potential benefit of EPIs is the avoided cost of the best feasible alternative (either another EPI or, for instance, command-and-control solutions). Within this analysis it is assumed that society is committed to a certain status of water bodies, such as in the European Union once the WFD came into force. The analysis of this kind of benefits will make it possible to draw a clear link to the economic assessment (see Task 2.4.), in order to compare the different instruments on cost-effectiveness grounds.

2. Avoided opportunity costs of reducing pressures over water resources. Natural capital can substitute human-made capital in providing some water services. This is why the improvement in the quality of water assets might lead to remarkable economic benefits. The increase in water flows might also soar the natural assimilation capacity of a water flow as well as coming out with a reduced cost of treating effluents in order to guarantee a pre-determined quality standard.

3. Avoided costs satisfying the demand of water services in the economy to obtain a given output. This is the case, for example, of pumping cost-savings resulting from higher phreatic strata, reduced pre-treatment costs for drinking water provision, or increased biological potential for fishing production. This is also the case of fertilizer cost savings due to the use of regenerated water for agriculture.

4. Benefits associated to the environmental services associated with a better conservation status of water resources. These services include:

a) Reduced drought risk, as the likelihood of a severe deficit in water availability over water demands is reduced, and higher drought resilience as buffer stocks are now improved and water allocation is contingent to water supply.

b) Improved flood protection, should floodplains be better protected, and disaster risk reduction as a result of lower vulnerability for people and real estate, and wise management of land and the environment.

c) Reduced health risk, as the likelihood of a decrease in morbidity or premature mortality rates, derived from exposure levels to water pollution.

d) Recreation and other amenities, as the consumptive (i.e., angling) or non-consumptive values (i.e., bird spotting) related to leisure opportunities linked to a good ecological status of water bodies and ecosystems.

2.4 Indicators

The work on indicators to assess the environmental outcomes of EPI implementation will build upon the roadmap presented in the introduction (see Figure A.2). Assessing the impacts on a water body requires some quantitative data to describe the drivers of the demand for water services, the uses of water services, the pressures on water ecosystems and the status of the different water bodies.

Regardless of the process to be adopted, the assessment may require a conceptual understanding of what actually drives impacts. At its simplest, this can be that if an effluent is discharged to a lake, for instance, there is likely to be at least a local impact in water quality parameters (an increase of pollutant concentration), which will need to be measured. The impact of an EPI implementation, if aimed at discouraging more discharges, would thus need to be measured against the business-as-usual scenario. Often, a simple approach would be suitable to assess the impact of a pressure and the EPI designed to weaken its negative influence. However, things might be more complex, given the range of catchment types, water bodies, interacting pressures, process conceptualization, data requirements, and scope of impacts,[13]

Thus, indicators for the assessment of environmental outcomes of EPIs will definitely need to be linked to drivers (an anthropogenic activity that may have an environmental effect, as previously described), pressures (the direct effect of the driver), the state of the water body (the condition resulting from natural and anthropogenic factors), impacts (the environmental effect of the pressure), and responses (the measures taken to improve the state of the water body). Sometimes the distinction is not necessarily clear. For instance, state and impact separates effects that are sometimes combined (or even confused); since many of the impacts are not easily measurable, state is often used as an indicator of, or surrogate for, impact.

Indicators to be used for the assessment of environmental outcomes will necessarily relate to:

[13] This is very relevant within the context of the River Basin Management Plans 2009-2015.

Drivers: diffuse sources, point sources, activities using specific substances, abstraction, artificial recharge, morphological, and other anthropogenic factors.

Pressures, which, in line with each driving force, should provide evidence on: point source discharges (i.e. rate of emission from wastewater, industry, mining, contaminated land, agriculture, waste management, aquaculture), diffuse source discharges (i.e. emission rates from urban drainage including runoff, agriculture, forestry), water abstractions (i.e. reduction in flow), water flow regulation (i.e. river management, transitional and coastal management, sediment flow), morphological alterations, and artificial recharge of groundwater resources (i.e. groundwater recharge rate).

State: biological elements (i.e. flora, benthic invertebrates and fish fauna); chemical and physic-chemical elements (i.e. general and specific pollutant concentration); hydromorphological elements (i.e. related to riparian forests).

On the basis of these three groups of indicators, *ad hoc* indicators for impacts and responses will also be developed for the assessment of environmental outcomes of EPIs.

IMPRESS (WATECO, 2003b)[14] stresses upon the idea that both the spatial and temporal scales for the identification of indicators are of paramount importance. The spatial scale is especially relevant for the correct identification of pressures, which requires a consistent identification of relevant targets, their size and their vulnerability to be impacted. Regarding the temporal dimension, it is important to recognize that some pressures may result in impacts many years in the future, as well as noting that some future impacts might relate to past pressures that no longer exist.

Closely linked to the efforts under IMPRESS, the UK technical advisory group on the implementation of the WFD (UKTAG), also developed the so-called "reference conditions" for each surface water body and collated and validated information for them. This is a quite in-detail characterization exercise, including both an outline of the approach to developing reference conditions and the type descriptions themselves, for lakes, rivers, and transitional and coastal waters.

Both IMPRESS and guidance documents on reference conditions developed by some EU member states, provide indicators for impact assessment for biological, hydro-morphological, and chemical and physic-chemical quality.

These more specific developments of indicators must be complemented with wider efforts, such as those of the OECD Environment Directorate or the European

[14]IMPRESS is a working group dedicated to the identification of pressures and assessment of impacts within the characterisation of water bodies according to Article 5 of the EU WFD (2000/60/EC). The guidance addresses the second requirement of Article 5, which refers to "a review of the impact of human activity on the status of surface waters and groundwater". For the purposes of EPI-Water, that this review has to be integrated with the economic analysis (WATECO, 2003a).

Environment Agency (EEA). EEA (2010), for example, includes the assessment of freshwater quality in the European Union. That report assesses various detrimental impacts of poor water quality on freshwater ecosystems.

Last but not least, it should be clear that indicators have not only been developed as isolated sets of data or *ad hoc* efforts to enrich information on driving forces, pressures, states, impacts and responses of water ecosystems. A more integrated approach has been followed with the amendment of conventional national (macroeconomic) accounting systems. The implementation of the WFD has led to an increase in the demand for water-related data, for further comparability across countries, and the availability of data, and a better integration of economic and eco-hydrological information.

In order to meet this growing demand, the possibilities of linking existing water information systems to the economic accounting system, previously investigated in the Netherlands (de Haan, 1997; van der Veeren et al., 2004), resulted in the creation of the National Accounting Matrix including Water Accounts (NAMWA), which is based on the system of integrated environmental and economic accounting (SEEA), and also of the SEEAW (UNSTATS, 2007), which is the object of Task 4.4. within EPI-WATER.

2.5 Demonstration example of the assessment of environmental outcomes: voluntary agreements and payments for environmental services in the river Ebro (NE Spain)

2.5.1 Brief description

The poor ecological status of heavily modified rivers can be explained by increasing pressures from water abstractions, gravel mining, canalization, and pollution discharges as well as by the successive modifications in the river morphology (Batalla et al., 2006; Zawiejska and Wyzga, 2009; Ollero, 2009). Restoring the ability of river ecosystems to provide basic environmental services can only be obtained at the cost of impairing the ability of water infrastructures to provide valuable socioeconomic goods and services, as hydropower, water supply, flood control and amenities (Bednarek and Hart, 2005; Robinson and Uehlinger, 2003). This explains the increasing interest in learning how to balance river rehabilitation benefits with the provision of goods and services by water infrastructures.

The large dams of Mequinenza and Ribarroja built back in the 1960s modify the hydrology of the lower Ebro River. Amongst other hydrological components, flood magnitude and frequency have been altered. Although the river still experiences natural floods and the impact of regulation is much smaller than that found in comparable large rivers such as the Sacramento and the San Joaquin in California (Kondolf and Batalla, 2005), and even in some of its main tributaries (Ollero, 2009), the river's physical and environmental conditions have remarkably changed in the last decades.

2.5.2 The economic policy instrument to be assessed

The particular EPI considered is the payment to the hydropower utility of compensation in exchange for water delivery according to a pre-determined time pattern producing two floods a year (one in autumn; the other in spring). Within this context, the analysis has been devoted to the design and implementation of flushing flows as a means to control and remove the excess of macrophytes[15] from the river channel.

These efforts started in 2002 when the above-mentioned problems were exacerbated after the succession of two extremely dry years. This context created the conditions for an effective cooperation between the hydropower company, water authorities and the scientific community. With the exception of dry years 2004 and 2005, flushing flows have been regularly performed twice a year providing a testing scenario for the increasing improvements in its design in order to enhance its effectiveness reaching macrophytes removal rates as high as 95% in areas close to the dam (Batalla and Vericat, 2009).

2.5.3 The assessment

a) Behavioural models

From the company's perspective, a mixture of natural and human-made capital assets composes the reservoir and its associated power generation facility. At any time, the operating company decides on the energy flow to be produced, taking account of the given technical specifications of the plant, current operating rules and the expected evolution of the amount of water stored in the reservoir and of energy price projections. From a private business perspective these decisions aim at maximizing the value of the expected flow of benefits along the entire life span of the reservoir (eventually over an infinite horizon). As the electricity produced cannot be stored for its future selling, the profit-maximizing company can be assumed to simultaneously make two kinds of decisions: choosing how much water to use every day, and choosing how to distribute the daily water used along the day.

Flushing floods are new constraints over the operating rules of the hydropower plant and are meant to reduce the value of the reservoir as a power-generating asset. When the utility is constrained to deliver water for a program of artificial floods, this would be the equivalent to introducing a new constraint in the second decision level on certain days and at certain times. Although the energy output and the revenue obtained by the company on flood days might be higher than in the baseline (given the increase in water delivery), in the following days, the quantity of water stored in the reservoir will be lower as it will also be the case for energy and revenue. Since the flushing flow implies a deviation from the optimal decision profile, the overall effect

[15] Aquatic plants growing in near water. They are beneficial to lakes where they are considered as eco-indicators, but growing on heavily modified rivers where its presence is an evidence of degradation, rather than good ecological status.

on expected financial profits and revenue might be negative and the opportunity cost might then be positive.

b) Effectiveness of the EPI

Despite the need to limit peak floods in order to avoid damages to riverside villages, flushing flows in the lower Ebro are currently a tested means to remove macrophytes, and then to enhance the biological productivity of the physical habitat, to entrain and transport sediments for the restoration of the river channel, to remove pollution loads and improve the water quality, to control salt intrusion and to supply sediments to the delta and the transition waters (ecotones).

The co-operation between power generation companies and water authorities is also a positive signal showing that flushing flows for river restoration purposes can be compatible with private corporate interests. These efforts are now considered as the innovative phase of a comprehensive restoration program of the river's ecosystem and a critical element of the River Basin Management Plan.

c) Pressures and impact assessment

The EU WFD (2000/60/EU) has contributed to this development both through the definition of the precise objectives for the correction of negative impacts of previous river management patterns and through clarifying methods and concepts for the assessment of river restoration measures and programs (Bratricht and Truffer, 2001; Ruef and Bratricht, 2007).

When dealing with the so-called Highly Modified Water Bodies, the objective of water policy is to recover the best feasible ecological status, and the measures that can potentially contribute to this target need to be assessed on the basis of both their own cost effectiveness and their potential benefits for the economy (WATECO, 2003a).

Likewise, research in biology and ecological engineering (Granata and Zika, 2007) shows that dams and other infrastructures, which alter river systems, can also be used as tools to artificially reproduce some of the functions performed in the past by the natural system. Channel maintenance flows together with sediment injections downstream can effectively restore the sediment balance altered by a reservoir (Buer, 1994; Kondolf, 1997). Similarly, modifying hydropower dams operation rules to guarantee the recurring release of properly designed flushing flows may effectively replace the role performed in the past by the natural floods distinctive of many Mediterranean rivers which served to maintain the structure and functions of the river ecosystem (Hueftle and Stevens, 2002; Vinson, 2001; Kondolf and Wilcock, 1996).

d) Economic valuation of environmental outcomes

Provided flushing flows are implemented by using sound economic criteria their opportunity cost is lower even in one or two orders of magnitude than people's willingness to pay to secure the benefits of river restoration programs. In spite of the variability in the flushing flood opportunity cost, due to the uncertain behaviour of water flows and stocks in Mediterranean rivers, this cost is lower than the benefits associated to the river restoration programs as measured by individual's willingness to pay. Depending on the size of the program beneficiaries, the opportunity cost can range from 10 cents or one euro *per capita per annum* (considering the million people living close to the river or the ten million people living in the entire river basin), whereas the willingness to secure the benefits of river restoration programs can be as high as 21 US$ per person-month as reported for example by Loomis et al. (2000) or Meyerhoff and Dehnhardt (2007). This information might be considered sufficient to judge that the agreement would be compatible with a cost benefit decision rule, and no specific valuation exercise is required.

The case studied shows that hydropower facilities in the lower Ebro can provide the artificial flows required for the restoration of the river channel at a cost that is equivalent to a small fraction of the overall revenue obtained during the year, just by accepting a marginal change in the energy output delivered to the market. The expected cost of two floods *per annum* (100,000 euros) is equivalent to only 0.16% of the average yearly revenue and is only a fraction of the average revenue obtained every day by the company (which amounts to *circa* 250,000 euros in the sample days).

These foregone benefits as a consequence of the flushing flow program result from the combination of two factors, the first one being the change in the electricity output during the flood and the absorption period, the second one is the lack of freedom to adjust the timing to produce energy during the flood to the moments of the day when energy prices are at their highest level. In the case of the Lower Ebro the expected reduction in the energy output is only the equivalent of 0.06% of the hydroelectricity produced by the system in an average year. In this case the implementation of the river restoration program does not seem to be in contradiction with the potential role of hydropower as a clean energy source and might not imply an increase in greenhouse gases emissions. Within this context the water conservation policy is not in contradiction with any global warming control objectives.

The foregone hydropower produced as a consequence of the flushing flood program represents an even smaller fraction of the overall production of the system. The cost of guaranteeing the periodical release of flushing floods by changing the operational rules of hydropower facilities also seems to be lower than any other alternative of obtaining water from other sources (such as saving water in agriculture and domestic consumption or from water recycling, desalination and so forth) in order to have the additional stock of water available for these purposes in the reservoirs.

Each artificial flood requires the delivery of 36 million cubic meters along 16 hours; considering the opportunity cost (as above, 76,000 and 33,000 euros for the autumn and spring floods), it can be shown that the cost per cubic meter delivered is around 0.2 eurocents euros for the autumn flood and half of that for the spring one.

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2.7 Additional material

Table B-1. Water ecosystem services[16]

Class	Ecosystem Service	Description
Provisioning	Food	Biomass production: fish, wild game, fruits, grains, etc.
	Freshwater	Storage and retention of water for domestic, industrial and agricultural uses
	Fibre and fuel	Production of logs, fuel wood, peat, fodder, etc.
	Biochemical (biological products)	Extraction of materials from biota
	Genetic material (biological products)	Medicine, genes for resistance to plants pathogens, ornamental species, etc.
	Biodiversity	Species and gene pool
	Abiotic products	Extractable and non-renewable raw materials such as metals, stones, gravel
Regulating	Climate regulation	Greenhouse gases (i.e. carbon fixation in histosoles), temperature, precipitation, etc.
	Hydrological flows (water regulation)	Groundwater recharge and discharge; storage of water for different uses (surface water runoff)
	Pollution control and detoxification (water purification)	Retention, recovery and removal of excess nutrients and pollutants
	Pest regulation	Invasive or pest species
	Erosion	Retention of soils
	Natural hazard	Flood control, storm protection, droughts
Cultural	Spiritual and inspirational	Personal feelings and well-being
	Recreational	Opportunities for recreational activities
	Aesthetic	Appreciation of natural features
	Educational	Opportunities for formal and informal education and training / and for non-commercial uses (i.e. archaeological values, knowledge systems)
	Conservation	Existence values for species and biodiversity.
Supporting	Soil formation	Sediment retention and accumulation of organic matter
	Nutrient cycling	Storage, recycling, processing and acquisition of nutrients
	Pollination	Support for pollinators
	Primary production	Aquatic vegetation for wildlife
	Habitat	Habitat for fishes, avifauna, mammals, etc.

Source: Own elaboration from MEA, 2005 and Hearnshaw, et al., 2010.

[16] An important question is whether these services are associated to water policy goals or they rather depend on the specific instrument to be used; if the former, this is not to be analysed in EPI-WATER, in the latter, it will.

3. Transaction Costs

David Zetland and Hans-Peter Weikard (WU)*

3.1 Introduction

Transaction costs (TCs) are often ignored in neoclassical economics; they represent market friction: the time and money cost of getting to the market, finding a buyer or seller, negotiating a purchase, consummating the trade, and returning from the market to consume the good. TCs deflect behavior from the perfect information scenario; they can explain the gap between predicted and observed outcomes. TCs affect direct costs and benefits, but participants in trades (or other activities) take them into consideration when taking actions to maximize the difference between total benefits and costs (direct and indirect, cash and non-cash).

This calculus means that some TCs are worth paying. The TC from monitoring groundwater may impede the adoption of such a tax, but it may also be worth paying to make sure the tax is effective. Likewise, a new water allocation mechanism may increase economic efficiency but impose high negotiation and enforcement costs, making simpler allocation mechanisms potentially preferable. The goal is to calculate and minimize TCs without negatively impacting the equity-efficiency tradeoff (Crals and Vereek, 2005).

Krutilla and Krause (2010) examine "TCs related to the creation, implementation and operation of environmental policies." Their analysis refers to ex-ante TCs (e.g., negotiating new property rights) and ex-post TCs (e.g., monitoring costs). They also refer to "factors affecting the magnitude of TCs" such as cultural norms, the state of technology, etc. We place these exogenous factors affecting EPIs under Task 2.5 (institutions).

We use Krutilla and Krause's classification of ex-ante and ex-post TCs. It's also convenient to see these as fixed and variable costs, respectively. With these differences in hand, we can look at the fixed ex-ante costs of establishing an EPI and the variable, ex-post costs of using it. As noted just above, other costs affecting EPIs that affect any and all methods of managing water (such as corruption) would be accounted for under institutions.

We identify TCs (using time or money indicators) by examining the "flow" of the EPI, from design and implementation (ex-ante) to monitoring and enforcement (ex-post). These costs can then be compared to environmental (Task 2.1) and economic (Task 2.4) benefits and costs, which can be directly attributed to the existence and operation of the EPI. A tax on groundwater extractions, for example, creates

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economic benefits from revenue and environmental benefits from improved groundwater levels; these benefits come with transaction costs for establishing a monitoring system, collecting taxes, and penalizing users for non-payment. The impact (incidence) of TCs will be covered under Task 2.3. Institutions (Task 2.5) affect the magnitude and form of TCs, which are identified according to their effects, burdens and political impacts under Task 2.6 (implementation).

TCs include the costs of reducing or ignoring asymmetric information: greater expenditure on monitoring can reduce asymmetric information, but asymmetric information can also increase the TCs from implementing or using the EPI. These TCs will be explicitly included under 2.2, but 2.7 (uncertainty) will explore how the range of TCs (and other criteria) may expands with unanticipated inputs, outputs or changes in ambient policy and environmental conditions.

3.1.1 Past treatments of TCs

Economists mostly ignored transaction costs until 1937, when Ronald Coase explained that transaction costs determined the boundary between a firm and the market, in the sense of determining which tasks were executed within the firm (using a non-market bureaucratic process) or outsourced to the market. Coase (1960) further developed this research when he considered the case of a missing markets for externalities (pollution) produced in the course of market or non-market actions (operating a car or mowing one's lawn, for example). He claimed it would be possible to achieve efficient outcomes (relative to regulation) through the use of property rights, i.e., when either the polluter or pollutee has the right to pollute (or not be polluted). This claim included the assumption of zero TCs, i.e., both sides can negotiate without worrying about the TCs of establishing harm and benefits and negotiating their division. As a corollary to this claim, Coase noted that non-trivial TCs could impede progress towards an efficient outcome. In such a circumstance, the continued absence of a market would recommend regulation of the polluting behaviour.

From this beginning came a vast research exploring different types of TCs, their incidence, application to different situations, and so on. Williamson (1975) put TCs into a larger context of institutions: TCs affect the implementation, enforcement and effectiveness of trades, with implementation as an ex-ante TC and effectiveness and enforcement as ex-post TCs. Note that a reduction in ex-post TCs for *other* actions following the introduction of an EPI, for example, would be considered an institutional benefit from that EPI, not a TC. Moreover, the evaluation of changes in transaction costs associated with an EPI that augments or replaces a previously existing instrument must consider all costs (Langlois, 2006). Higher TCs associated with a new instrument, for example, may be small relative to the benefits of that EPI in comparison to the counterfactual.

Saleth and Dinar (2004) put TCs into a water context. They discuss TCs as the time, effort and expense involved in obtaining the information required to negotiate, make and enforce an exchange. Saleth and Dinar note that TCs are sensitive to the cost of measuring valuable attributes under negotiation, market size, the need for monitoring and enforcement, and ideology. Ideology can be quite important, and it introduces political and social factors that may drive or dominate markets. As discussed under Task 2.5, ideology comes from deep institutional foundations that cannot easily be changed. Institutions that raise or lower transaction costs create a bias for or against certain actions. In similar work, McCann and Easter (2004) discuss the TCs of establishing a trading framework. These ex-ante fixed costs (which can include the costs of gathering information, ideology, negotiating with stake holders, etc.) can be large relative to the costs of trading once the framework is established. More important, they are often unique and thus difficult to predict or qualify in advance of taking the first step to establishing a market (or replacing any existing policy with an EPI subject to unknown unknowns). Risk-averse policymakers may prefer to avoid such uncertainty in favour of the "known evil" of an existing policy. Realistic and credible simulations that clarify the benefits of an EPI may persuade policy makers to work for reform. ACG (2006) divided TCs into *setup costs* (incurred by government and mostly fixed) such as the development of registers and water accounting frameworks; *ongoing costs* (incurred by trade participants) in effecting market transactions; and *cost of changing* the institutional environment and legal system (borne by government). According to Hardy and Koontz (2010) transaction costs include information costs (associated with the processes of gathering and organizing information necessary for group decision-making and actions), coordination costs (incurred to negotiate, monitor, and enforce agreements) and strategic costs (costs of interactions among actors, especially protecting one's interests from being dominated by others in the development of agreements or management plans).

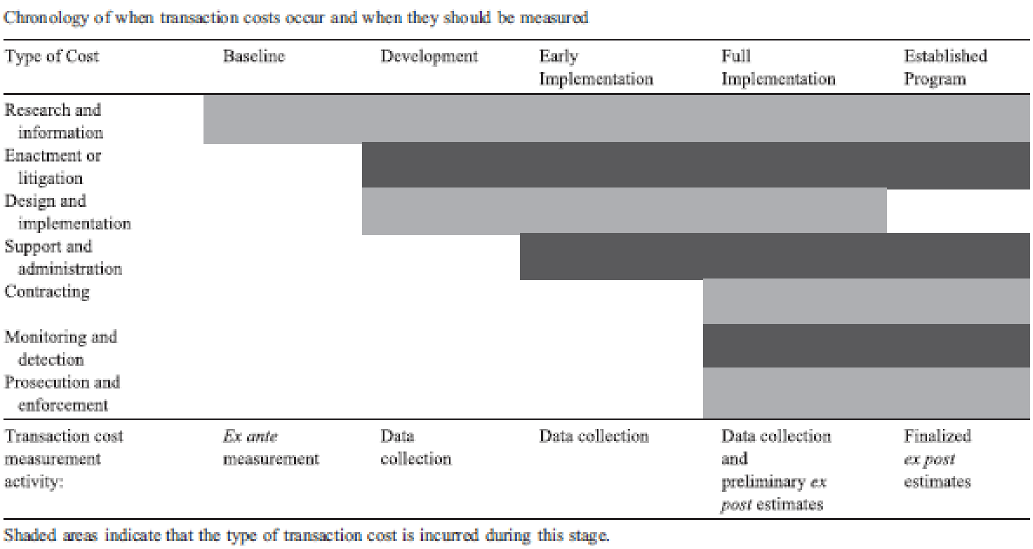
TCs also appear in literature examining water management, as an important, but peripheral factor affecting efficiency. Howe et al. (1990) investigated the impact of TCs on facilitating or blocking water transfers. Lund (1993) discusses the timing of TCs in decisions to pursue water transfers instead of traditional "solutions" to scarcity (tapping groundwater, recycling or desalinating water). He concludes [p. 3103] that "water transfers become more attractive to potential water purchasers if the probability of a successful transfer is increased, if more of the transaction costs for water transfers are incurred after a transfer has been approved, and if the costs of delaying implementation of alternative water supplies are small." Smith and Tomasi (1995) investigate the implications of Coase (1960) on nonpoint source pollution (NPSP) from agricultural tail water. After dismissing the unrealistic case of a zero TCs world where nonpoint polluters and pollutees reach an efficient equilibrium, they compare the efficiency of taxes and standards (regulations). The conclusion is that the most-efficient response to NPSP in a second best world of TCs can include taxes, standards or both. Thompson (1999) explores NPSP and trade-offs with an emphasis on resulting errors in cost-benefit calculations. Archibald and Renwick (1998) explore the TCs and institutional barriers to water trades in California, explaining why the rosy forecasts of Vaux and Howitt (1984) failed to materialize.

Both van Huylembroeck et al., (2005) and Mettepenningen et al. (2007) provide a useful description of the transaction costs farmers face in considering participation in and joining agro-environmental schemes (AES), a scenario that's directly applicable to the use of EPIs. Viaggi (2008) describes TCs related to information, monitoring and penalties in the design and implementation of contracts for agri-environmental schemes. Zhang et al. (2009) identify and analyze the transaction costs involved in the implementation of a water market in the Heihe River Basin in China. The aims of this project were to establish a new water use rights system with tradable water quotas and to reallocate and use water resources through market-based instruments. Their assessment showed that TCs blocked water trading in some areas but were low enough to allow trading in other areas. More recently, Ribaudo and Gottlieb (2011) discuss how water quality trading between point and nonpoint sources can be used for achieving water quality goals. They identify high TCs (finding trading partners) as one impediment to successful trading. They propose clearinghouses or third-party aggregators to reduce TCs.

There are thousands of scholarly article describing TCs, so we will stop here with the knowledge that it's important and useful to understand the presence and impact of TCs. Our objective is to identify TCs and quantify their impact on EPIs and alternative to EPIs. These costs are often relevant; sometimes their magnitude or incidence is enough to block the adoption or use of an EPI.

3.2 Typology

Transaction costs vary in their details. EPI-WATER case studies will list significant quantitative and qualitative TCs. An EPI will have many TCs. These will be identified and weighed according to their impact on the creation and implementation of the EPI. Figure B-3 illustrates the appearance and sequential interaction of TCs:



Source: McCann et al., 2005.

Figure B-3. Schematic example of when TCs affecting EPIs may occur

The existence of visible TCs sometimes leads to incorrect valuations of EPIs that create invisible environmental and/or economic benefits. Water trading, for example, has visible TCs, a socially-neutral exchange of cash, and invisible benefits from the net increase in surplus from the change of use. The allocation of transaction costs between different actors (e.g., public and private) is important, especially when costs go to one group and benefits to another (see also Task 2.3). These costs may also be hard to identify (invisible to individuals but substantial to society) if costs and/or benefits are spread across many or concentrated in a few. Uncertainties (and information asymmetries) can magnify the visible/invisible problem - also known as the problem of visible losers and invisible winners – to the extent that policy makers contemplating the adoption of EPIs mistakenly favour the status quo.

TCs can be quantified in cash (fees) or time (days) but these measures underestimate the cost to those paying time and money, i.e., opportunity costs of the TCs as well as lost surplus from transactions that do not occur.

Krutilla and Krause (2010) note that the level of TCs are influenced by information, technology, physical/environmental characteristics (asset specificity), economic and institutional context, cultural norms, and international environmental policy-making. Imperfect information raises TCs by necessitating assessment of policy consequences, and by creating the need for ex post monitoring of compliance. TCs vary over time due to the creation and evolution of relationships and learning through repetition.

Laurenceau, et al. (2009 p. 570) suggest investigating the following sources of TCs:

- the number and roles of actors involved;
- the time spent (on selecting measures);
- the existence of decision-support tools (i.e. models);
- the methods and methodology used;
- the distinction made between basic and supplementary measures;
- administrative procedures required to carry out the selection of measures;
- the documents/guidance provided;
- coordination that was required;
- number of studies undertaken/outsourced;
- potential staff hired; and
- number of meetings, discussions, negotiations.

3.3 Assessment methods and techniques

From the discussion above, it's clear that TCs can take many forms, affecting different parties at different times. Such variability can be confusing to someone seeking a comprehensive and balanced list and quantification of TCs.

This complication can be resolved by tracing the steps involved in implementing and using an EPI and looking for TCs at each of these steps. These calculations should be compared to a "friction free" counterfactual EPI to understand how a theoretically-optimal results may not materialize. They can also be compared to a counterfactual (but real) baseline regulatory regime to explore the costs and benefits of each alternative.

Once steps are laid out, it takes time to fill in the TCs. McCann et al. (2005) discuss the difficulties of measuring TCs that are diffuse/invisible in incidence or only qualitative. The distinction between private and public TCs is important (Libecap 2008). Public TCs require documentation about personnel assigned to specific tasks, internal budget, etc., but these costs need to be "marginalized," i.e., what are the additional TCs from an EPI on a public bureaucracy that already has full time employees who may not be completely active? Private TCs are harder to identify, since they are more diffused.

Stakeholders are obvious authorities on the types and magnitude of TCs. Interviews of participants can be useful but they take effort: TCs are difficult to explain; small compared to other costs, and mixed in with other costs (and TCs from other policies; Mettepenningen et al. (2007), had to collect information about full compliance costs to agri-environmental schemes to properly identify TCs). It's easy to make large mistakes in assessing their value.

3.4 Possible or suggested indicators

Appropriate indicators will be identified for each case study using the McCann et al. (2005) chronology and Krutilla and Krause (2010) typology.

For EPIs addressing water quality, possible indicators include the cost of installing measurement instruments (or taking a mobile measurement), the time it takes to make a measurement and report its results, the number of authorities involved in collecting and disseminating data, the time it takes to compare measurements against local or regional benchmarks, the process of enforcing penalties against violations, the cost of penalties to participants and process of clearing a penalty, and so on.

It's clear from this example that TCs will depend on the EPI, local conditions, institutions, and other factors. Case study authors will identify appropriate TCs using their judgement, the literature cited in Section 2.2 and indicators described in 2.3. Some indicators will be proxies for TCs (e.g., cost of a full time employee instead of actual hours spent on a case). In most cases, it will be difficult to exactly identify or quantify TCs, but it's more important to use the same (imperfect) process to compare

TCs from an EPI to TCs for the status quo counterfactual (regulation, another EPI or lack of any constraint on use of the water).

3.5 Demonstration Example

The TCs for groundwater taxes and fees in the Netherlands fall into ex-ante cost of negotiating the 1994 national groundwater tax and the ex-post monitoring and collection of taxes. Given the lawful nature of Dutch people (an institutional characteristic), these costs are quite low – perhaps negligible. More interesting is the absence of TCs from measuring groundwater levels. Since the tax is aimed at fiscal revenues (not behavioral change), there is no monitoring of irrigation activities, flood prevention, etc. The resulting absence of TCs (good) is paired with an absence of measured benefits, if any (bad). These relatively small TCs are probably proportionate to relatively small benefits. This EPI is not aimed at changing behavior but "greening" the tax profile of the Netherlands. Its benefits are supposed to come from improved incentives to work based on lower income tax rates – not improved groundwater management or environmental health (there may be accidental benefits since industrial and drinking water extractions are taxed, but most farmers are exempt from the tax).

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4. Social Equity and Acceptability

Colin Green, Joanna Pardoe and Christophe Viavattene (MU-FHRC)

4.1 Introduction

At its most basic, social equity concerns questions over 'fairness' in the allocation of goods and services across different members of society. There are many different models of social equity which dictate different interpretations of fair resource allocation and just distributions of wealth and capital (Elster, 1992; Sagoff, 1988). For example some models advocate that a fair distribution of resources is one in which everyone results in an equal quantity of resource (Equality). However, others argue that it is more socially just for resources to be prioritised towards those that will make the best use of them so as to enhance the utility of resources for society as a whole (Utilitarian) (Mill, 1863). Another different stance views social justice as resource allocation that compensates those least well-off to bring them to the same standard as better-off members of society (Rawls, 1971).

The above concepts of social equity describe social equity in terms of the resulting distribution of goods and services. However, social equity does not simply concern the *distribution* of resources, it also considers the process(es) by which the distribution is arrived at. Social equity can therefore be viewed from the perspective of distributional justice (the outcome of resource allocation) and it may also be viewed from the perspective of procedural justice (which is the process by which the allocation is arrived at). For example, one definition of procedural justice sees the allocation of resources based on equality which states that all groups must be allocated the same resources, despite their initial resource collection i.e. at a party every guest is given an equal slice of the birthday cake, however, some guests have already been given a slice of chocolate cake so some guests have one slice of cake whilst others have two. The process by which the cake was distributed is considered fair because it was equal, but the final distribution is not equal because some began with an extra slice of cake and ended up with two slices (Sandel, 2010).

Assessing social equity from a procedural perspective in EPI-WATER would enable the assessment of the factors that influence the final distribution in addition to highlighting where tradeoffs might be made and an understanding of social acceptability. However, as social acceptability varies considerably between actors and individuals, there are limits as to how universally applicable the lessons may be. Furthermore, considering the procedural only does not enable an understanding and accounting of the externalities inherent in EPI application in practice. Indeed, stakeholders may make choices based on anticipated outcomes that may not be achieved in practice once externalities come into force. As such it is vital that the distributional consequences are assessed to understand the social justice implication of an EPI.

Task 2.3 is primarily detailed to consider the distributional consequences of EPIs from the perspective of the social justice. In this respect it is possible to assess the social equity implications of applying an EPI in practice, accounting for the inherent externalities and subjective choice mechanisms central to stakeholder engagement. Task 2.3 will therefore focus on assessing the *distributional* consequences of EPI. In this task 2.3 social equity focuses on the achievement of a distribution of goods (and conversely also burdens) in a manner that reduces inequality between stakeholder groups and shares benefits equally.

4.2 Typology

Social justice is a complex subject in itself, the consideration of which clearly requires an assessment of a broader range of factors than the traditional neo-classical approaches. Traditional approaches typically view impacts merely in terms of wealth (costs and benefits, monetary values). However, this approach has long been recognised as inadequate. As such and to enable consideration of a broader range of social factors, well-being will be measured as a set of eight components outlined by the Stiglitz Commissions.

In order to assess a full range of social justice implications of EPI, the typology will be drawn from the Stilitz report (2009) on the "Measurement of Economic Performance and Social progress". The Stiglitz Commission has gone beyond simply measuring economic performance and social progress based on standard indicators such as GDP. Instead, the commission advocates measuring performance and progress in terms of wider goals of 'wellbeing'.

The Stiglitz Commission (2009) defined the independent components of 'well-being' as consisting of:

- "Material living standards (income, consumption and wealth);
- Health;
- Education;
- Personal activities including work
- Political voice and governance;
- Social connections and relationships;
- Environment (present and future conditions);
- Insecurity, of an economic as well as a physical nature."

Thus, it is logical to examine the distributional consequences of any possible intervention strategy in terms of each of these components. The conventional practice of simply identifying the distributional impacts of some action in terms of the single component of 'material living standards' is obviously only appropriate if this is the dominant determinant of well-being in a particular instance.

The Stiglitz Commission was explicit in arguing that these are independent components of well-being and so there is no single, simple function by which they can be ordered to form a single measure of 'well-being'. Furthermore, they argue that both objective and subjective indicators should be included, allowing for emphasis to be placed on aspects of well-being that citizens particularly value.

Before considering the components of well-being in greater detail, it is important to highlight that these components do not exist and influence well-being in isolation or as individual components. In effect, these components feedback and interlink with each other to contribute to overall well-being. As such there is a danger that double counting may occur. The following descriptions (see Table B-2) of the components has attempted to reduce the potential for double counting by focussing on particular interpretations of the components, however it is important to be aware of the potential for double counting and that in assessments the feedback and inter-linkages between components may be too complex to report in such a discrete analysis.

Table B-2. Welfare components derived from the Stiglitz Report (2009)

Component	Description
Material living standards	Assessment of material living standards incorporates the traditional measures and indicators of welfare. These include considering income, consumption and wealth. Material living standards can change as a result of EPIs based on whether citizens will be required to contribute more or less of their income and wealth towards water resource management and access.
Health	Water is an essential component for human life. Access to a sufficient quantity and quality of water are key basic determinants of health. In addition, some groups require additional water resources to maintain their basic health- for example kidney patients require considerably more water for dialysis.
Education/Information	In order to enhance support for and improve effectiveness of EPIs, education about EPIs and the roles of individuals in promoting efficient water use can be valuable in ensuring successful implementation
Personal activities including work	Changes in time and effort, and the allocation of both between activities e.g. time budgets may be affected. In terms of water, this may relate to changes in time budgets for access to water of sufficient quality and quantity as a result of the introduction of an EPI.
Employment	EPIs may provide opportunities for increased or decreased employment. In addition the type of occupations affected and the skill level associated have implications for different groups in society.

Component	Description
Environment	Environment will be considered in detail under Task 2.1 (Environmental Outcomes). To avoid double counting, this section focuses on individual attitudes towards the local living environment and whether these promote or reduce a sense of well-being.
Insecurity	Fears and anxieties play a role in reducing welfare. There are different sources of insecurity, i.e. personal insecurity due to crime and accidents and economic insecurity due to illness or old age. As economic insecurity is considered under employment and health, personal insecurity is more relevant here to avoid double counting. Personal insecurity in terms of water resources and EPI may constitute insecurity over certainty of water supply.
Political voice and governance	Political voice is essential in welfare as enabling citizens to be involved in framing policy and holding institutions to account. EPIs inherently involve a shift of power to money at the risk of a loss of power in the vote.
Social connections and relationships	Social capital. Concerns in agricultural communities that water sales will reduce viability of the community; effects of community relocation temporally or permanently; feminisation of agriculture

4.3 Assessment methods and technique

In order to assess social equity, it is important to understand that different groups will be affected to varying degrees and in different ways to the impact of an EPI. As such, the consideration of welfare components will be tailored to the following key impact groups (see Table B-3 below).

Table B-3 Descriptions of Impact Groups

Impact Group	Description
Farmers	Those whose employment primarily involves the farming of crops and/or livestock located within the area directly affected by the EPI
Local community/ residents	Those living in the area directly affected by the EPI.
Wider community	Those living outside of the area directly affected by the EPI but who may experience indirect effects of the EPI.

Impact Group	Description
Businesses	May be subdivided into categories of large, medium and small businesses. These are any business directly affected by the EPI.
Water companies/ organisations	Businesses, organisations and services involved in the provision of water and sanitation services, in the area affected by the EPI.
Future generations	Viewed as local community/residents of the future.

The assessment will consider the impact on each of impact groups described above in addition to considering the impact overall. This assessment will be conducted as described below.

In order to assess the social justice implications of EPIs based on the welfare typology described above, there will be several stages to assessment.

First, for each aspect of welfare described in the typology, the base scenario will need to be determined by assessing/ measuring the situation prior to the introduction of an EPI to develop a 'base' scenario. This assessment may be conducted ex-post by accessing existing data collected prior to the EPI's introduction or by consulting with stakeholders who experienced the pre-EPI situation using the qualitative methods described in the 'key question' tables.

Once a base scenario has been established, the post EPI situation will also need to be assessed using the same methods and collecting the same types of data and information. From this point it will then be possible to assess the change that has occurred from the base scenario to the post application situation. This process is outlined in Figure B-4.

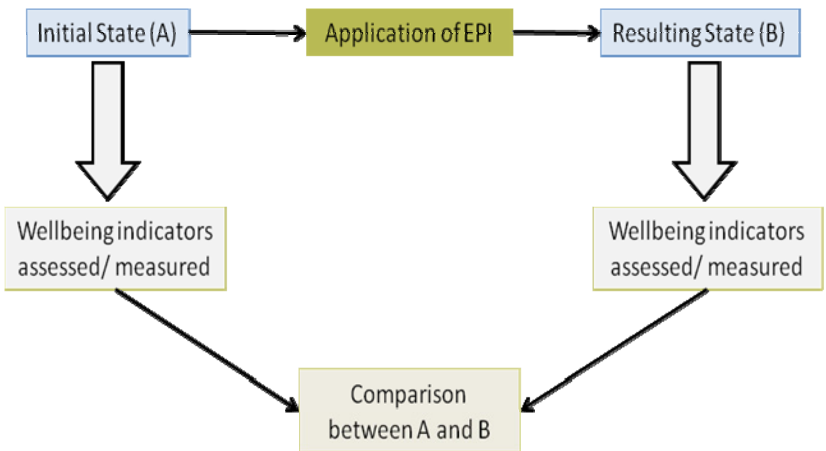

Figure B-4. Assessment Framework for Task 2.3

4.4 Indicators

As the Stiglitz report emphasises, the welfare components should not be assessed merely in terms of money or quantitative measures. Instead, qualitative methods should be employed to capture features that are important to society but not necessarily effectively quantifiable. The methodology for this task takes this into account and has thus developed an assessment framework and techniques to enable both quantitative and qualitative data to be considered.

Each case study will have access to a different range of data and measures. As such, it is not possible to provide a comprehensive set of indicators that will be useful for the case studies. Instead, case studies will work on supplying information to answer 'key questions'. For each impact group a set of key questions has been developed tailored to the relevant stakeholders. These are provided in section 4.8, but an example for the 'farmers' impact group has been provided below (Table B-4). These key questions are provided with suggestions on the tools and methods that may be used to acquire the necessary information and data.

Table B-4 Example of key questions for 'Farmers' impact group

Welbeing component	Key question	Type of method	Tool	Comments
Material Living Standards	Has income from produce changed? Have costs of production changed?	Quantitative	Income data- national, regional or local statistics. Possibly even individual farm accounts?	e.g. are farmers receiving a higher income for better quality crops? e.g. Are farmers having to spend more money on production methods?
		Qualitative	Surveys or interviews with a sample of farmers	To supplement the quantitative data where necessary
Health	Has the physical strain of work changed? Have stress levels altered? Is work safer?	Qualitative	Surveys or interviews with a sample of farmers	Qualitative surveys may be based on national health surveys.
Education	Is a level of education required for effective implementation? Is a level of experience required for effective implementation? Does the EPI process provide education in itself?	Qualitative	Surveys or interviews with a sample of farmers Observation	

Welbeing component	Key question	Type of method	Tool	Comments
Personal Activities	Have time budgets changed- has the amount of leisure time increased or decreased? Have leisure activities themselves been (indirectly) affected?	Qualitative	Surveys or interviews with a sample of farmers	Specifically assessing perceived changes in the time budget- i.e. do they have more or less leisure time as a result of the EPI?
Employment	Have staff reductions or increases been made? How has employment altered in the sector as a whole Have staff wages been affected? Have staff bonuses or benefits been affected such as holiday allowance or overtime pay? Have employment opportunities been affected? i.e. apprenticeships, new posts, career progression?	Qualitative Quantitative	Data on employment figures form national, regional or local statistics Surveys or interviews with a sample of farmers	What proportion of these changes can be attributed to the EPI?- qualitative can answer this question.
Environment	Have farmers noticed a change in the appearance and quality of their environment?	Qualitative	Surveys or interviews with a sample of farmers	Measurement of superficial aspects
Insecurity	Do farmers feel more or less secure in their practice as a result of the EPI? How do they feel about the future e.g. in terms of income, sales, staff etc.?	Qualitative	Surveys or interviews with a sample of farmers	
Political Voice	Do farmers feel they have a greater or weaker say?	Qualitative	Surveys or interviews with a sample of farmers	
Social connections and relationships	How have social connections and relationships changed	Qualitative	Surveys or interviews with a sample of farmers	Are some groups interacting more or less with each other?

By collecting data and information such as set out in Table B-5, the assessment will need to consider both quantitative and qualitative data. In order to assess this data so that it may be combined to give an overall result, the data will need to be converted into a standard format. Schiellerup and Chiavari (2009) have used a simple method on a similar project to enable the analysis of such mixed data. Their approach was simply to consider the change from the initial state or base scenario to post implementation as either a positive, negative or neutral change. Thus, for each impact group and within those, each of the welfare components it will be possible to complete a table such as the example below. This will demonstrate the nature of a change and to emphasise the degree of change, two pluses or two minuses may be used if there is a large, notable change.

Table B-5. Example of results table

FARMERS	Type of measure	Direction of Change
Material living standards	Quantitative	+
Health	Qualitative	0
Education	Qualitative	-
Personal Activities	Qualitative	++
Employment	Quantitative	+
Environment	Qualitative	--

Notes: + represents a positive change from base scenario to implementation of EPI;
0 represents no discernible change from base scenario to implementation of EPI
- represents a negative change from base scenario to implementation of EPI

4.5 Social Equity Assessment

Following the generation of results on the impact of the EPI for each of the welfare components, it is then possible to analyse the results to conclude on the social equity impact of the EPI. The objective of the EPI from a social equity perspective should be to reduce inequalities and result in an overall improvement in welfare for the stakeholders. By assessing the status of wellbeing prior to EPI implementation and again post implementation it will be possible to consider how the distribution of goods and burdens changes following the introduction of an EPI. By comparing the data and results between impact groups it will also be possible to identify where inequalities may have been reduced or increased as a result of EPI.

Any clear differences between the impact groups that benefit most and least may also lead to questions over social acceptability. For example, if farmers are found to have reduced welfare as a result of the EPI but local residents see improved welfare then this may pose a problem in terms of acceptability if farmers have a strong political voice where residents don't. In this respect, this assessment may highlight potential problems for social acceptability.

4.6 References

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4.7 Additional material

Small/independent businesses, large businesses and water companies

Welbeing component	Key question	Type of method	Tool	Comments
Material Living Standards	Have profits changes? Has income and expenditure changed?	Quantitative	Income data- national, regional or local statistics. Possibly even individual farm accounts?	
Health	Have workers' stress levels altered?	Qualitative	Surveys or interviews with a sample of employers and/or employees	Qualitative surveys, may be based on national health surveys.
Education	Is a level of education required for effective implementation?			
Does the EPI process provide education in itself?	Qualitative	Surveys or interviews with a sample of employers and/or employees		
Observation				
Personal Activities	Have time budgets changed- has the amount of leisure time increased or decreased?	Qualitative	Surveys or interviews with a sample of employees and/or employers	Specifically assessing perceived changes in the time budget- i.e. do they have more or less leisure time as a result of the EPI?

Employment	Has employment in the sector increased, decreased or stayed the same? Has employment within the business increased, decreased or stayed the same? Have employment opportunities within the sector changed	Quantitative - Qualitative		Qualitative for employment opportunities question

Welbeing component	Key question	Type of method	Tool	Comments
Environment	Have employees and businesses noticed a change in the appearance and quality of their environment?	Qualitative	Surveys or interviews with a sample of employers and/or employees	
Insecurity	Do business managers feel their business is more or less secure as a result of the EPI?	Qualitative	Surveys or interviews with a sample of employers and/or employees	
Political Voice	Do business managers feel they have a greater or weaker say?	Qualitative	Surveys or interviews with a sample of employers and/or employees	
Social connections and relationships	How have social connections and relationships changed	Qualitative	Surveys or interviews with a sample of employers and/or employees	

Local community/residents and Wider Consumers

Welbeing component	Key question	Type of method	Tool	Comments

Welbeing component	Key question	Type of method	Tool	Comments
Material Living Standards	Has household expenditure and income increased or decrease?	Quantitative	National, regional, local statistics	Data may be routinely collected at the national and/or local level that could be of use here.
		Qualitative	Surveys or interviews with a sample of local residents	To supplement the quantitative data where necessary
Health	Has the EPI resulted in an improvement or decline in drinking water quality?	Quantitative	Water quality tests	This may be conducted as part of another task, in which case beware of double counting. Possibly ask about colour and odour changes instead.
Education	Does the EPI involve a process of education or does it require a degree of education to be effective?	Qualitative	Observation	Identification as part of the implementation process. Project leaders can assess this.
Personal Activities	Does the EPI result in an increase or reduction of time for leisure purposes?	Qualitative	Surveys or interviews with a sample of local residents	Specifically assessing perceived changes in the time budget- i.e. do they have more or less leisure time as a result of the EPI?
Employment	Does the EPI provide employment prospects or losses of employment?	Quantitative	National, regional, local statistics	Data may be routinely collected at the national and/or local level that could be of use here.
		Qualitative	Surveys or interviews with a sample of local residents	Specifically assessing perceived changes in employment- i.e. do they think employment as increased or decreased?
Environment	Has the appearance of the local environment improved or declined?	Qualitative	Surveys or interviews with a sample of local residents	Specifically assessing perceived changes in the environment- i.e. do they think the environment is better or worse off than before?

Welbeing component	Key question	Type of method	Tool	Comments
Insecurity	Has the EPI increased or decreased faith in local water quality?	Qualitative	Surveys or interviews with a sample of local residents	Assessing how people feel towards water quality as a result of the EPI.
Political Voice	Has the EPI given a stronger or weaker political voice to any particular groups?	Qualitative	Surveys or interviews with a large sample of local residents	Cover a range of local groups to assess where power may have shifted and where gains and losses have accumulated
Social connections and relationships	Have social connections altered following the introduction of the EPI?	Qualitative	Surveys or interviews with a sample of local residents	Cover a range of local groups to assess where social connections and relationships may have shifted

Future Generations

Welbeing component	Key question	Type of method	Tool	Comments
Material Living Standards	Will income and expenditure increase or decrease?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	
Health	Will drinking water quality be improved?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	
Education	Will there be a requirement for an ongoing process of education?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	
Personal Activities	Will time budgets and leisure	Qualitative	An assessment of the trend following	

Welbeing component	Key question	Type of method	Tool	Comments
	time be affected?		the introduction of the EPI and indications from surveys and interviews with local community.	
Employment	Are employment opportunities likely to be affected? Will they be greater or worse as a result?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	
Environment	Is the appearance of the environment likely to be improved or worsened?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	
Insecurity	Can any insecurity issues be foreseen?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	This feature will be particularly challenging to assess and full assessment may be unrealistic
Political Voice	Can any impact on political voice be foreseen?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	This feature will be particularly challenging to assess and full assessment may be unrealistic
Social connections and relationships	Can any social connection changes be foreseen?	Qualitative	An assessment of the trend following the introduction of the EPI and indications from surveys and interviews with local community.	This feature will be particularly challenging to assess and full assessment may be unrealistic

5. Economic Assessment Criteria

Davide Viaggi, Laura Sardonini and Meri Raggi (UNIBO)

5.1 Introduction

The main objective of this section is to develop the content of Task 2.4 in the context of WP2. The content of task 2.4 is preliminarily defined in the DoW: "The guiding principles and criteria of the economic assessment will depend on the scope of the analysis and the ultimate goal for policy identified in previous tasks. The assessment may rest on:

- economic efficiency principle, based on a cost-benefit rationale (both costs and benefits are estimated in a total economic value perspective, hence including both use and non use values, and, from a different perspective, both private costs/benefits and externalities);
- cost/effectiveness principle under which the benefits need not to be monetized;
- criteria related to distributional and equity effects of proposed policies (that is who benefits from and who bears the burden imposed by the policy instruments);
- cost recovery, revenue generation and promotion of innovation; risk reduction / avoided damage" (EPI-WATER DoW, 2010).

The different economic criteria can be used to quantify different (and complementary) economic aspects in the performance of EPIs, e.g. they are delivering different information and are not substitute of each other. As a consequence, there is no priority among economic criteria. The preferred combination of economic criteria to be used in each case will depend on the specific policy issues related to the decision making process, but, generally speaking, they are suitable to look at the economic side of policy implementation from different perspectives. Besides definitional issues, we also try to discuss the different information content of each criteria, its advantages, disadvantages and limitations. Finally information needs in relation to data availability are considered, as they are relevant determinants of the ability to qualify each criterion and hence the practicability of its use in the policy assessment process.

It is well recognized in the literature that the implementation of water policy and the incorporation of economic criteria in policy design and implementation is a quite difficult task; as Rogers et al. (2002) states: "… the promotion of equity, efficiency and sustainability in the water sector and water pricing is probably the simplest conceptually, but maybe the most difficult to implement politically". A sound use of economic criteria needs to take into account of such difficulties and limitations.

These economic criteria are seen as a partial component of information needs to assess a policy making process and, for the aim of the project, as a component of policy relevant information necessary to study the performance of EPIs either ex-ante and ex-post (WP3, WP4). The assessment process, as it is well known from the literature, can include a large set of considerations about the consequences of the alternative courses of action, including effects upon the environment, the economy and people (Stiglitz 2009).

We are aware that economic criteria will not be the only or the final criteria for EPIs' performance. The final users of policy information are the stakeholders, the general public and the relevant administrative bodies. Public consultation and social agreement on water resources management are relevant requisites for an EPI's implementability and sustainability. Decision makers will mediate economic criteria with other criteria, particularly when EPIs raise issues such as social/equity concerns, public goods etc. This also means that project/policies with a negative net economic benefit could be actually implemented nonetheless. However, we do not address these issues here (task 2.6 will address this), except when we comment about the information content and usability of specific economic evaluation parameters.

Instead, we focus on economic criteria used to assess different courses of action. Such criteria derive mainly form the literature concerning project evaluation and economic policy evaluation.

Economic criteria for the evaluation of EPIs can be better understood/used against the main water policy objectives. Some broad policy objectives are available at the EU level. For example in the context of the policy objectives about the environment and natural resources, at the beginning of 2011, the EU Commission published a document about the resource-efficiency in Europe (EU, 2011) which gives some background about efficiency in the use of water as a general policy objective. The WFD itself identifies general policy objectives and instruments to achieve them. More commonly, and in accordance with the WFD itself, policy measures' objectives are defined locally and contingent to specific interventions. Nevertheless, some general principles (such as general economic efficiency, costs recovery, full costs consideration, etc.) can be regarded as economic criteria of relevance, in principle, for all instruments and areas in the context of the WFD.

For the purposes of this task we consider three main approaches to (components of) the use of economic criteria:

1. Efficiency estimate as an overall aggregation criterion;
2. Economic information as one or more partial criteria in the evaluation framework;
3. Economics of policy mechanism.

Each of these three approaches will be treated as a sub-section of section 9.3.

In particular, the overall aggregation criteria section will consider the more general and global economic assessment based on the efficiency criterion which generally speaking compares the value of resource used with the value of resources produced in a process. This general principle can take the form of the net benefits maximization if considered in a static context, or be based on the net present value (NPV) in an intertemporal framework. It aims to strike a balance between costs and benefits and to evaluate if a project (measure or policy) provides a net social benefit. In this part, the cost-benefit analysis (CBA) will be explored as a method to assess in a more complete vision costs and benefits; different levels of completeness of the components will be described in order to examine how to deal with incomplete and/or unreliable economic estimates.

Subsequently, in the section about economic information as a subset of criteria, all those criteria that are partially able to asses only some defined and precise components (in particular costs of a measure) will be considered. In this part the following will be included: a) cost/effectiveness criterion which uses the criterion of cost minimization against an equal outcome; b) criteria related to distributional effects e.g. how policies affect the economic situation of different individuals or groups; c) risk reduction/avoided damage through the economic value of potential (negative) uncertain events; d) promotion of innovation (as a major issue connected to the dynamics of policy effects).

The last direction is about policy mechanisms among which we consider the cost recovery/revenue generation i.e. the ability of the instrument to cover the costs incurred for the provision of a given service or policy costs, and incentive compatibility.

5.2 Typology

Different typologies of costs and benefits are relevant of economic analysis, at different levels of detail. Some major distinctions can be recognized in the following distinctions:

1. Financial, opportunity and environmental costs;
2. Internal and external costs (either environmental or not);
3. Emerging cost vs. foregone economic benefits (opportunity costs in a wider sense?);
4. Use values vs. non-use values;
5. Intended effects vs. side-effects

A component to have in mind regards the relevance of opportunity costs in policy evaluation. In the identification of opportunity costs, the requirement of some direct capital and O&M costs have to be considered. Sometimes they may be substantial, for example when allocating water requires building new water transport facilities;

sometimes they will be negligible, as for example letting water flow through a turbine in a hydropower plant. In any case, though, direct costs are relatively uninformative of the actual opportunity cost of EPIs and this is one of the real problems we will need to face in making the case in favor of EPIs. In addition there are some important opportunity costs (as those associated to produce a constant flow of electricity along the day, to maintain minimum flows in the river, instead of producing all the energy at noon when the price and the demand are at its peak). When bargaining over water is allowed between different regions, sectors or water jurisdictions, the opportunity cost for those who sell water are covered by the compensation received; the indirect cost, however, of the reduction in the economic activity is not necessarily eligible for compensation. This is of particular concerns for no mobile production inputs, such as land (abandoning land in dry areas may increase erosion, soil loss and desertification risk, depopulation might threat heritage and increase the cost of providing basic services such as water and education to the few who will remain in rural areas) and is a matter of discussion for mobile factors.

Taking a more detailed perspective, economic analysis can be supported by a classification of costs and benefits, which, in turn, can be related to specific EPIs. Table B-6 reports examples of costs and benefits associated to specific measures.

Table B-6. Typologies of policy measures, benefits and costs

Measures	Benefit	Cost
Better water resource allocation (voluntary transfer of water rights)	Output increasing without increasing the overall use of water	Transaction costs, Management costs
Multipart tariffs for water	Decreasing of the overall environmental cost and releasing additional resources for more valuable water uses in the economy overall.	
Buying the land of people living in flood-prone areas	Higher economic benefit out of reducing risk exposure and improving flood control services provided by ecosystems	Transaction costs
Farmers with the right to sell water	Increasing the technical efficiency of irrigation systems at the same time that more water is available for other uses increasing the output without further deterioration of freshwater sources	Transaction costs

Compensating firms	Environmental services to restore river flows.	
Water markets in drought-prone areas: conversion of irrigated agriculture into a water buffer	Avoided costs of the best available alternative.	Transaction costs
Water market in irrigation district	Increasing the overall output compensating losers and avoid the monitoring and enforcement cost of the command-and-control alternative	Transaction costs, costs of means
Multipart tariffs for drinking water	Reduce lower-value water demands and, compared to its best available alternative for the same target, it reduces the cost of providing the water service as lower-size water works and lower operational expenditures would be required.	
Buy land in flood-prone areas	Increase the security	Avoid costs of providing security
Restoring the minimum flows		Compensating hydropower companies

5.3 Assessment methods and techniques

In this section, different methods and techniques responding to the economic principles will be illustrated under the three main directions defined above.

5.3.1 Overall aggregation criteria

The more general and global economic assessment is based on the efficiency criterion which can be addressed using different approaches (and indicators) depending on:

1. The object of analysis: policy or project;
2. The components of cost and benefit;
3. The suitable optimization principles, that are also usable as proxies of the actual economic efficiency if an indicator of overall efficiency is not readily available or measurable.

The most popular methodology implementing the economic efficiency principle is cost-benefit analysis (CBA) based on the comparison of the costs and benefits of a project (INEA, 2009). The CBA is an ex-ante evaluation method used to investigate if a project meets the criterion of acceptability (feasibility) based on its profitability. Initially developed mainly for projects, CBA methods have been used also for policy evaluation, including rather wide issues (e.g. policies related to global change). The CBA can be done considering three points of view:

1. financial analysis based on the private (project proposer) point of view;
2. economic analysis based on the point of view the community/society as a whole;
3. social analysis based on the point of view individual stakeholders and stakeholders' groups.

The main difference between financial and economic analysis regards the attribution of the net benefits of the project. The financial analysis only takes into account the monetary income earned by the investor, while, the economic analysis takes into account all the benefits that the whole society obtains, both the investor and individuals in general which, in a direct or an indirect way, are affected by the project (Nuñez-Sánchez, 2005). The social analysis somehow connects the CBA with social and equity concerns, hence with Tasks 2.3.

An alternative way to present the three points of view of the CBA can be made considering the historical evolution of the CBA in the evaluation of projects. This evolution had to consider the changing in function of the objectives of the development policies. There are three stages:

1. Traditional approach: a clear economic approach that aims to increase the level of welfare in monetary terms. This approach was applied until the late 1960s.
2. Socio-economic approach: arises when the concept of social equity is incorporated. The aim is to achieve equitable income distribution.
3. CBA with environmental externalities valuation is the third approach and results from the incorporation of environmental criteria are included in the decision-making process.

In its widest application as a unique comprehensive synthesising criterion the CBA can put together any effect that can be translated into monetary values, including environmental (see Task 2.1) and equity (e.g. through weights for different social groups) concerns.

In the following, the reference point of view will be the economic analysis, as the most direct perspective concerning policy, which can be identified as a collective decision and action.

The CBA of a project can be developed in several steps (modified from Hanley and Spash, 1993):

1. Analysis of project objectives'/Identification of alternatives (including a baseline)/identification of time horizon;

2. Identification of project's effects;
3. Monetary evaluation of project effects;
4. Comparison between costs and benefits;
5. Judgment on economic feasibility.

It is well recognized in the literature that the steps can be formulated in several alternative ways. Also, while the stages listed above trace an ideal path for project evaluation, the decision making process is generally not linear and may be considering at the same time the objectives and the means to achieve them.

At first, the CBA has to consider the setting of the decision problem, including the objectives of the project, the identification of alternatives and the time horizon of the project (step 1). The identification of effects (step 2) throughout the time horizon of the project. The effects of the project are expressed in terms of benefits and costs. The net benefits are the difference between benefits and costs, which represent the contribution of the project to social welfare. After the identification of effects, their evaluation can be made (step 3) and it is important that the prices system reflects the values assigned by society. The comparison (step 4) and the opinion on economic feasibility (step 5) are linked and depend on some indicators (NPV – Net Present Value, IRR – Internal Rate of Return, B/C ratio – Benefit-Cost ratio) which can be considered in the comparison process.

The NPV is the difference between discounting benefits and costs. If we let t be the indicator of time horizon from 1 (first year of the project) to T (last year of the project) and given a series of benefits B_t and costs C_t, then the NPV is defined as:

$$NPV = \sum_{t=1}^{T} \frac{B_t}{(1+q)^t} - \sum_{t=1}^{T} \frac{C_t}{(1+q)^t}$$

where $1/(1+q)^t$ represents the discount factor.[17] The criterion for project acceptance is to accept only if NPV>0. If the choice is between two projects, the project with the higher NPV has to be chosen. The NPV indicator has some limitations: a) it supports larger projects because they give a higher NPV and b) it depends on the discount factor used. This second point is quite important; in fact, when the discount factor is equal to zero then NPV is the simple difference between benefits and costs, but when the discount factor increases then the NPV decreases. In spite of these limitations, the NPV remains the reference parameter in CBA.

[17] There are several problem in the discount rate identification even if its selection is important. Economic theory has actually struggled to identify a single and theoretically correct value, or to go from theoretically valuable principle to numerical values. Typically, governments set national discount rates for use in public policy appraisal.

The IRR is the discount factor yielding NPV = 0. In Figure B-5, the IRR for the project A is s_A and for the project b is s_B. The criterion for project acceptance is to accept if the IRR is higher than a fixed discount factor.

The B/C ratio represents the unit net benefit: B/C > 1 means than the discounted benefits are higher than the discounted costs. Some limitations of B/C ratio consists in a) its identification depends on the classification into costs and benefits (sometimes it is not so easy to distinguish) and b) it is not possible to use it in direct projects comparisons (except for ordering of several project potentially implementable) because the B/C ratio does not maximize the total social welfare.

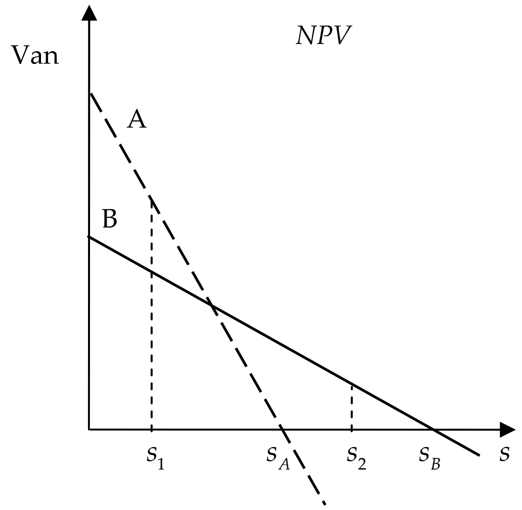

Figure B-5. Relation between Net Present Value (NPV) and different discount rates

The single consideration of each evaluation parameter is not able to make a right opinion about the project feasibility. Also, as known in literature, the CBA analysis has a large number of disadvantages and problems linked to the reliability of indicators, the need to provide a monetary evaluation of each benefit/cost item and the discount rate definition. However, it still remains a reference method for evaluating projects or policies.

5.3.2 Economic information as a set of partial criteria

In this section, selected economic information that can be used as a form of partial criteria will be discussed, in particular with reference to components of the costs of a policy measure.

Cost/effectiveness principle

The cost effectiveness principle is considered as one of the partial criteria because it is based only on the evaluation of the costs. In fact, it can be considered as a relaxed CBA, which benefits are not measured, leading to the concept of cost effectiveness analysis (CEA). Using the CEA, the evaluation of the benefits can be avoided, skipping some of the difficulties in the economic estimation of benefits related to water resources.

The criterion is based on the costs minimization principle on equal conditions, such that between two or more alternative actions that produce (at least) the same benefit or result, the action chosen will be the one that has a lower cost.

Under the conditions of budget and time limitations, the CEA is more feasible than CBA; the two main indicators of the CEA, which are based on a mix of economic and physical characteristics, are:

- The cost per each unit of result: the ratio between costs and effects of action.
- The result per each unit of cost: the ratio between effects and cost of action.

Cost-Effectiveness Analysis, together with Cost-Benefit Analysis is the main method for the economic evaluation of water programmes. Within the context of the WFD, the most widely accepted method is CEA, because it allows the outcomes of a programme to be measured in terms of physical units. From a practical perspective, CEA should be used to select combinations of measures that allow the desirable ecological objectives to be attained at the lowest costs.

In addition to the common indicators, regarding the evaluation of actions about water, there are several indicators which are a modification of the previous ones. In the context of the measures for a water use reduction, the general net present cost is modified introducing the levelled cost (White e Howe, 1998; Fane e White, 2003; Fane et al., 2003). In particular this approach is used in the project evaluation regarding production/saving of resource such as energy and water. The method returns a unit cost of produced or saved resource. For this reason, this indicator is quite useful in the comparison of projects aimed at resource conservation.

Within the framework of the cost-effectiveness principle, several other indicators can be included, that have in common the fact of relating some economic performance with a physical unit of resource use. Some examples are performance indicators related to irrigation systems. As can be seen in Garcìa-Vila (2008):

- Water Productivity (WP) in €/m3 represents the value of agricultural production per unit water used;
- Irrigation Water Productivity (IWP) derived by (Malano e Burton, 2001) represents the added value of irrigation about the increasing of agricultural production per unit water used;
- EvapoTranspiration Water Productivity (ETWP) represents the agricultural production value for each evapotranspiration water unit.

The reasoning of the cost/effectiveness principle has to consider two aspects: i) the actual objectives of water policy to which the implementation of EPIs contribute and

ii) the alternative instruments to reach that objective. This depends on information about costs and benefits; then it is possible to assess if the proposed incentives will bring to reduce the opportunity cost of water policy. This is so for two important reasons: the first is an obvious one; what we will be assessing are the instruments and not the goals of water policy. On this basis, EPIs are to be preferred should they allow reaching the prescribed social goals at a lower opportunity cost. The second is that in fact, one of the main claims in favor of EPIs is that increasing the efficiency with which water services are allocated over the entire economy is a powerful way to make the preservation of the water environment compatible with maintaining and increasing economic welfare.

An important caveat to bear in mind is that, different from command-and-control options, that are more intensive in known direct and administrative costs, incentive-based options rely more on transaction, indirect, and institutional costs (fines are less costly than deterring and continuous monitoring to prevent bad behaviour, provided moral hazard and enforcement costs are ignored. Thus, a proper assessment cannot be performed, from our viewpoint, if relying only on direct costs; information requirements to put incentives and prescriptions in the balance are more stringent than simple cost-benefit analysis at a project level.

Distributional effects

In literature, the concept of distributional effects is linked to equity. However, because of the different nature of the two concepts, the equity issue will be illustrated in task 2.3. In this part only aspects concerning the economic distribution effects will be considered. In line with the examples, the studies on distributional effects of EPIs are usually motivated by one of two different reasons: i) to better understand the impacts on particular stakeholder groups in order to assess their responses or ii) equity concerns which of course requires a definition of an equity concept.

In the perspective of distributional issues two approaches will be presented: the one focuses on the estimate of a measure about the inequality of distribution and the other focuses on the inequality accounts in the water tariffs.

The first strategy is based on the Gini's indicator that is the most popular approach in the evaluation of inequality of a distribution. The realms of application concern the evaluation of the income and wealth distribution. In the context of water policy evaluation, there are some examples of the use of the Gini's indicator for the comparison of several price systems. Under the hypothesis of introduction of different rate structures on consumer (Rawls et al. 2010). In addition to the Gini's indicator, a graph (Lorenz curve) can be designed to represent the degree of inequality. In the paper, the authors plot the relative Lorenz curves for a specific water rate structure, mapping for example the proportion of water use by different customer income groups against the proportion of utility revenue collected from these income groups. Each Lorenz curve is compared with the perfect equity distribution line, where each customer income group contributes equal shares to the total utility water supply and the total utility revenue. In turn, all Gini coefficient values are numbers between zero and one, and the lower the coefficient, the more equitable a rate structure is. A Gini coefficient of zero represents a perfectly equitable distribution.

The second approach used to evaluate the distribution and welfare effects of changes in block price systems related to household uses is to estimate the equivalent variation (EV) based on Marshallian demand function (Ruijn 2009). The EV measures the "amount that a consumer would be indifferent about accepting in lieu of the price change" and it is a proxy of an ex-post utility. The object of the policy is to evaluate the impact of alternative pricing policies on the basis of households demand, welfare and distribution effects of changing water prices. This policy comes from the evidence that poor households use a large part of their income in the water bill even if the richer households have an higher water bill.

Comparison between flat system and a progressive block price shows an expected result; for the richer the better solution should be the adoption of a flat pricing system while for poorer the block price systems is preferred. Consequently, if there is no accounting for the inequality aspect, the social welfare is highest in a flat price system but when inequality is accounted then the block progressive price system shows effects on poverty and welfare.

Risk reduction and avoided damage

Risk reduction and avoided damage can be considered as other partial criteria for economic evaluation of EPIs.

The risk issue recalls uncertainty and in the environmental economics literature it is connected to the option value, which is considered as the insurance premium that a risk-averse individual is willing to pay to maintain resource for future use. Because of the nature of the water resource, the uncertainty about its use is an intrinsic characteristic.

In the context of environmental economics the risk evaluation is not well defined; in fact, only the approaches relying on the simplification of the problem based on the use of probability distributions are well defined and widely used (Costanza and Cornwell 1992, Crowards 1996).

The evaluation of uncertainty in supporting decision-making for environmental policy can follow several steps introduced by the US Environmental Protection Agency (EPA). In this case the main question is not about avoiding the uncertainty but it is about its accounting. Furthermore, the uncertainty is one of the aspect to consider in the communication process between evaluator and policy makers.

The analysis starts with the preliminary description of the future action in terms of present outcomes or conclusion based on expected or most plausible values, then a description of all known key assumption, biases and omissions, perform the sensitivity analysis on key assumptions, and justify the assumptions used in the sensitivity analysis.

In several cases, the outcome of the initial assessment of uncertainty may be sufficient to support the policy decision process. If the preliminary description is not enough detailed and sufficient, then more complex analyses (decision tree, Delphi-type method, meta-analysis and probabilistic methods) have to be used (Brouwer, 2005).

The risk and uncertainty are sometimes related to the cost-effectiveness of programs of measures to improve the surface water quality (Brouwer and De Blois 2008). The estimation of uncertainties is based on a combination of statistical assessment and expert judgement using different assumptions about the statistical distribution of these uncertainties.

Another way to consider risk is through the assignment of economic value to uncertain negative events. In this case, risk is commonly defined in economic evaluation as the product of the damage brought by a negative uncertain event times the probability of its occurrence. In this case, one approach is to treat the possibility to reduce the risk or to avoid damages as an estimate of the benefits generated by a project or policy. In line with this, the Global Facility for Disaster Reduction and Recovery (GFDRR)/World Bank and the United Nations International Strategy for Disaster Reduction (UNISDR) have jointly commissioned an Assessment of the Economics of Disaster Risk Reduction (EDRR) to evaluate economic arguments related to disaster risk reduction through an analytical, conceptual and empirical examination of the themes. Findings of the Assessment are intended to influence broader thinking related to disaster risk and disaster occurrence, awareness of the potential to reduce costs of disasters, and guidance on the implementation of disaster risk-reducing interventions (Subbiah et al. 2008).

One possible approach to this principle is based on the idea to adopt early warning systems (EWS) especially for flood damage reduction. The EWS adoption produces benefits (reduction of damage or loss) which are evaluated using the cost-benefit analysis.

Aspects related to the EWS adoption are mainly linked to Lower and Middle Income Countries. In particular the risk of disaster arises when hazard interacts with vulnerability and low resilience.[18]

As an example, let A be the loss due to a disaster without early warning as A and B the decreased loss that may be incurred after appropriate measures following early warning, then the potential reduction in damages (or the actual benefit) due to EWS is A minus B. However, let C be the cost or investment required for providing the EWS, then the actual benefit is A-B-C. The benefits due to adoption of the early warning may be estimated by summing the monetary benefits obtained: direct and

[18] Hazard is a natural event that causes loss of life, injury or other adverse impacts; vulnerability refers to physical, social, economic, environmental and individual factors (poverty, disability, disease, etc.) that increase the likelihood of loss from hazard; resilience is the ability to resist, absorb, accommodate from the effects of a hazard

indirect tangible benefits. The cost of EWS is calculated under three broad components: scientific, institutional and community. In the adoption of the EWS there are several constraints' levels: policy, political, technical institutions, community.

Promotion of innovation

Technological change is a relevant issue in changing the production function of water and hence affecting economic performance of water using sector.

The performance of different policy instruments in affecting technology through long term changes is discussed in the environmental literature (Requate, 2005), leading to the general conclusion that economic instruments are more effective than regulatory instruments in inducing both adoption and development of advanced abatement technology.

The number of contributions on this issue in the water policy literature is rather poor, particularly concerning economic instruments.

Adoption and development of innovative water saving or efficiency improvement technologies can be seen as an effect, i.e. a component of the evaluation of policy outcomes.

However, with regard to this issue, we should first introduce a distinction between different policy instruments: a) those instruments directly aimed at providing incentives for technology changes (e.g. subsidy supporting substitution of irrigation machinery), for which innovation is also a policy objective; b) those instruments that are not directly aimed at technology changes, but can have effects in this direction (e.g. volumetric pricing), for which innovation is not necessarily a policy objective.

Technology change occurs over time. The effects of a policy can be seen as: a) an acceleration of the process of technology change (e.g. more efficient irrigation techniques spread more quickly); b) an incentive to move technology change in a specific direction (e.g. water saving).

Water policy can affect changes in technology different from water use technology, hence contributing to determine long term performance (as opposed to short term economic performance) of water using sectors; such effects can be classified as side effects to some extent.

A typical area of research concerns the study of adopting agents in terms of attitudes to technology adoption and speed of adoption. Structural changes is an area in which the understanding of non-economic factors in decision making is stronger than short term decisions. For example tacit knowledge and organization's attitudes show to have a role in infrastructure developments (Wolfe and Hendriks, 2011).

A different perspective is given by pointing to technology change in water management as the main target. Studies advocate the use of economic instruments (e.g. pricing) as a way to increase technology change (Krozer et al., 2010). A range of policy instruments to promote cleaner decentralized water technologies is discussed in Partzsch (2009), concluding that each as strengths and weaknesses compared to the others, and leading to the idea that a combination of instruments could be the best option.

5.3.3 Policy mechanism

Economic analysis can also be used to describe and to assess policy mechanisms. Policy mechanisms can be studied from different perspectives. The relevant concept here is the ability of different policy mechanisms to provide the "right" incentives. This can also be seen as a way to judge to what extent actual mechanisms are able to bring the kind of behavioural change that is expected from an optimal pricing mechanism. This kind of concerns provide a bridge between theoretical policy design and policy implementation.

Prices have three functions:

1. to provide a secure revenue stream sufficient to recover all the money costs of the service provided;
2. to allocate scarce resources between competing uses; and
3. provide a signal and incentive to both producers and consumers as to what behaviours to adopt. In this last role, an increasingly important role is to promote invention and innovation.

In a perfectly competitive market, not only do prices just fall out of the market but they simultaneously satisfy all three functions. But in the real world, prices not only have to be set but the three functions may be more at less at variance with each other. Thus, a number of writers have proposed that it can be desirable to approach the three questions separately rather than to seek a single approach to dealing with all three functions. This leads to the use of partial parameters such as cost recovery to assess the suitability of actual policy mechanisms.

Cost recovery and revenue generation

Cost recovery can be associated to three main functions informative, incentive and financing (Unnerstall e Messner 2007). The informative function uses the tariff to inform consumers about all costs which depend on their uses. In this way the consumers are motivated to value the resource and to be careful in its use. The incentive function regards more in detail aspects related to economy. In fact, all consumers have to support direct and indirect costs (extraction, distribution, environmental and resource) about used water. This function then will be based on a payment and this function replies to the efficiency principle. At the end, the financing function is based on the idea that consumers payment serve to financially support the costs of services (future investments, environmental protection).

These three main functions work in the ideal world, while when we work in the real world difficulties arise. In the context of water, the cost recovery was introduced by the WFD 60/2000 in a somehow wider perspective: "member states shall take account of the principle of recovery of the costs of water services, including environmental and resource costs, having regard to the economic analysis conducted according to Annex III, and in accordance in particular with the polluter pays principle" (Article 9).

The theory about the cost recovery is quite intuitive, but difficulties arise in the applications because the cost definition depends on the context, and several typologies have to be considered (financial, economic, social, environmental, opportunity, direct, indirect).

In the WFD vision, the full cost components are: financial, resource and environmental. If the financial costs are easily calculated from classical economic accountancy, for the other two it is not so simple.

In the Easter and Liu (2005), irrigation cost recovery is divided in three parts: direct project costs, environmental costs, and marginal user costs. "Direct project costs are the easiest of the three to measure, and most projects take only direct costs into account in determining cost recovery. Environmental costs include soil erosion and damage to the surrounding ecosystem during and after the construction of an irrigation project as well as water logging and salinity problems caused by the irrigation. However, few irrigation projects in practice include environmental costs as part of their full cost to be recovered. Environmental costs could substantially raise the total costs of many irrigation projects. Marginal user cost is defined as the present value of future sacrifices implied by current resource use (Howe 1979). It involves the higher costs of obtaining future water supplies because more accessible and less expensive water resources are used up first. In an extreme case, a water resource is completely used up in the current period. This cost is especially relevant for groundwater resources with little or no recharge. Excluding marginal user costs in the price of groundwater often results in overuse of the resource." (Easter and Liu 2005).

When in a project there is a large indirect benefits, some of the costs may be allocated to the beneficiaries. For example, in countries where the government pursues a low food price policy, food processors and consumers both may benefit more from irrigation improvement projects than farmers. In such cases, subsidizing the project through tax revenue from the benefiting consumers and processors might be an alternative to help fund the project (Easter and Liu 2005).

There are two key steps in cost recovery: the first is to design a pricing mechanism that covers the appropriate costs; the second is to achieve high collection rates through effective water management

Another aspect to consider when cost recovery is examined is the assessment of the payment ability by the users, i.e. the affordability. This issue has become important since the European countries are facing important investment which, according to cost recovery principle, must be paid by the user. Therefore, many authors have assessed this issue in different countries and conditions (Danesi et al., 2007; Fankhauser and Tepic, 2007; Carvalho et al., 2010).

Incentive compatibility

Incentive compatibility criteria may relate with the ability of EPIs to provide the “right” economic incentives to agents. This is partly detectable through policy design and economic expectations related to them, e.g. as it occurs for marginal pricing. “Efficient water use policies are about bringing water's opportunity costs in line with its correct marginal value. In principle, if water's price includes all real marginal costs, an efficient resource allocation can be reached: marginal net economic benefits of water are equal across different uses, and society's water-related welfare is maximized. In the absence of well-functioning water markets, opportunity cost assessment requires a systems approach combined with a number of assumptions about impacts and responses to them (Ward and Pulido-Velazquez, 2008)” In Ward and Pulido-Velazquez (2009) a brief review of policy efficiency principles is given: for Lund and Israel (1995), the efficient water pricing is normally equivalent to pricing at marginal social cost; for Rogers et al. (2002), when the price of water reflects its marginal cost, including environmental externalities and other opportunity costs, the resource will be put to its highest-valued uses; for Briscoe (1996), despite the concept’s apparent simplicity, measuring the opportunity cost of water is difficult and in the absence of well-functioning water markets, opportunity cost assessment requires a systems approach and a number of assumptions about real impacts and responses to these impacts.

One possible example of EPIs for efficiency is the use of a two-part tariff structure. In some OECD countries (Australia, Austria, Denmark, Finland and the United Kingdom) the two part-tariff is used considering fixed and variable parts. The fixed element protects the supplier from demand fluctuations and reduces financial risks. The variable element charges the consumer according to his consumption level and therefore encourages conservation. One the advantage is the possibility to stabilize the revenue. (Roger et al. 2002, OECD 2010).

Incentive compatibility is a particularly relevant issue when water is not metered and straight mechanisms to guarantee incentives to optimal water use cannot be applied (Viaggi et al., 2010).

5.4 Possible or suggested indicators

Considering the three main directions of the economic criteria, we can illustrate some questions related to each criterion.

The main objective of the overall aggregation criteria based on the economic efficiency may consider these questions:

- Do EPIs, when compared to the best command-and-control alternative, make a clear contribution to increase the efficiency to which water resources are used by the economy?
- Do EPIs, when compared to their best alternative, allow increasing welfare by reaching at the same time the actual goals of water policy?

The main objective of the economic information as a set of partial criteria may consider these questions (divided by criteria):

Cost effectiveness:

- Should EPIs be included in the set of the available measures to reach a given water policy target, would they be part of the least-cost set to reach this policy target?
- Do EPIs represent a real option to reduce the opportunity cost of achieving the actual goals of water policy?
- When comparing a particular EPI to the policy instruments in place, does this EPI implementation leads to specific cost savings for water users and for the economy as a whole?
- Which kind of EPIs has the higher potential to reduce the overall opportunity cost of meeting a given target set by a water policy?

Distributional effects:

- Does the implementation of EPIs, instead of complementing the policy instruments already in place, improve the personal situation of someone without worsening that of others?
- Do EPIs provide a different distribution of income/costs/benefits compared to alternative instruments?

Risk reduction / Avoided damage:

- What actual contribution can EPIs make toward reducing risk when compared with the best command-and-control alternative?
- Does the EPI offer a better option to reduce risk and exposure compared to the existing command-and-control option which the EPI is supposed to substitute?

Promotion of innovation

- How the introduction of an innovation can help in the water policy development in the long period?

The main objective of the policy mechanism may consider these questions (divided by criteria):

Cost recovery, revenue generation:

- Do EPIs make it easier (or more difficult) to meet the overall objective of advancing towards the full recovery of the opportunity cost of water services provided to the economy?
- What particular advantages to recovering water services provisioning cost can be derived from implementing a given EPI in a particular water policy context?
- What differences with respect to cost recovery may arise from implementing a particular EPI instead of another one?

Incentive compatibility

- To what extent is water policy providing the right incentives (compared to ideally optimal pricing or "true" values of resources)?
- To what extent proper incentives actually apply to agents in cases of asymmetric information (moral hazards, adverse selection)?

The following list of indicators will serve to address questions related to the economic principles discussed above.

Indicator: NPV (net present value)

- Do EPIs, when compared to the best command-and-control alternative, make a clear contribution to increase the efficiency with which water resources are used by the economy? Proxy: Differences between the marginal values of different uses
- Do EPIs, when compared to their best alternative, allow increasing welfare by reaching at the same time the actual goals of water policy? Proxy: Differences of marginal net economic benefits of water across different uses

Indicator: NPC (net present cost), Performance Indicators

- Should EPIs be included in the set of the available measures to reach a given water policy target, would they be part of the least-cost set to reach this policy target? Proxy: Cost per each unit of good used or saved
- Do EPIs represent a real option to reduce the opportunity cost of achieving the actual goals of water policy? Proxy: Water Productivity (WP)
- When comparing a particular EPI to the policy instruments in place, does this EPI implementation lead to specific cost savings for water users and for the economy as a whole? Proxy: Irrigation water productivity (IWP)
- Which kind of EPIs has the higher potential to reduce the overall opportunity cost of meeting a given target of water policy? Proxy: Evapotranspiration water productivity (ETWP)

Indicator: Partial (stakeholder oriented) CBA

- Does the implementation of EPIs improve the personal situation of someone without worsening that of others?

Indicator: Gini indicator

- Do EPIs provide a different distribution of income/costs/benefits compared to alternative instruments?

Indicator: Percentage of recovered costs

- Do EPIs make it easier (or more difficult) to meet the overall objective of advancing towards the full recovery of the opportunity cost of water services provided to the economy?
- What particular advantages to recovering water services provisioning cost can be derived from implementing a given EPI in a particular water policy context?
- What differences with respect to cost recovery may arise from implementing a particular EPI instead of another one?

Indicator: Risk

- What actual contribution can EPIs make to reduce risk when compared with the best command-and-control alternative?
- Does EPI offer a better option to reduce risk and exposure rather than using the existing command-and-control option in its stead?

5.5 Demonstration Example

Irrigation schemes in Italy (Emilia Romagna) are good examples of the articulation and complementarity of these criteria. Project decisions are mainly based using CBA technique (if any formal technique is used). Cost-effectiveness methods are being proposed for complementary infrastructure or water saving components of irrigation infrastructures. In the allocation of water use opportunities, a mix of equity (same water availability to all farmers, or per hectare) and incentive mechanisms are used (e.g. some fixed payment to gain the right to access water pipes). Water pricing is mainly set in order to achieve costs (O&M) recovery, so often not compatible with marginal pricing or other incentive mechanisms. However a debate is open about shifting to volumetric pricing, with related infrastructural and metering costs. The possibility to shift to some form of water market is precluded by the lack of any legal basis at the moment in Italy. In addition, the idea of rights transfer among farmers seems often to conflict with the pricing strategies by the irrigation boards (e.g. block tariffs if available).

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6. Institutions

David Zetland and Hans-Peter Weikard (WU)*

6.1 Introduction

Institutions are the formal rules and informal norms that define and modify the choice sets of individuals and their interactions by affecting the cost of exchange (transaction costs) and production (transformation costs) (Saleth and Dinar 2004, p. 25; North 1990, pp. 5-6). Usually, the level of an institution or its depth and persistency (see further below) determines whether it imposes a hard or a soft constraint on decision makers' choices. Most institutions are difficult to describe, highly adapted to local conditions, and effective in balancing many competing interests. Robust institutions have a greater impact (limiting or directing action); fair institutions apply limits to everyone; efficient institutions increase social welfare. Weak institutions allow elites to exploit the majority, wasting resources to extract benefits for themselves.

Neo-classical models of interaction tend to ignore institutions, which means that deviations from predicted outcomes can perhaps be partly attributed to missing or misspecified institutions (Hodgson 1998, 2006 and Williamson 2000). Production decisions, for example, may consider opportunity costs that are visible to producers but not analysts. Institutional constraints derived from "culture," work methods or other rules can keep production inside the efficiency frontier that omits institutional effects.

Institutions can form an insurmountable barrier to the importation of foreign ideas, such as EPIs, but the uncritical imposition of institutional modes in differing contexts may be "dysfunctional and even counter-productive" (Shah et al 2005, p. 46), as the development of water management institutions is highly contextual, path-dependent and incremental (North, 1990; Bandaragoda, 2006). Outdated institutions cause trouble. Saleth and Dinar (2004) explain how the combination of outdated institutions and water scarcity can lead to more scarcity, because policies meant to alleviate the problem instead worsen it [pp. 8–13]. The implementation of a water market in an area without restrictions on groundwater use, for example, may lead to increased groundwater pumping to replace surface waters that are sold to out-of-area buyers.

Institutions and transaction costs (TCs, see Task 2.2) both affect "frictionless trade." They can be related and separated by visualizing a continuous line that extends from one extreme (action is prohibited by an institutional barrier) through a

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middle (institutions have impacts and transaction costs have strong effects) to the opposite extreme of zero TCs (pre-Coasian neoclassical markets). We will separate them in our analysis by associating institutions with exogenous impacts on EPIs and TCs with the fixed costs of implementing an EPI and variable costs of operating it. A water market, for example, is established with fixed TCs and operated with variable TCs, but both are affected (positively and negatively) by institutions.

EPIs create/modify institutions (e.g., new markets or tax adjustments, respectively) or influence institutions (water law, policy or administration) that affect existing markets and bureaucracies, choices and behavior. The case for adopting EPIs grows stronger with water scarcity (Saleth and Dinar 2004).

Institutions can be viewed as a constellation of hierarchically nested rules which Williamson (2000) analyses on four interconnected levels (see Figure 4 in Part I). The top level (L1) refers to "culture" and other informal norms that evolve over centuries. L2 refers to basic rules (such as constitutions) that rest for decades or centuries. These rules change very slowly. L3 is most relevant to EPI because it refers to the institutions that guide interactions in L4. EPIs are implemented at this level, but they must consider - and will be affected by – L1 and L2 institutions. L1 institutions often create path dependency; L2 and L3 institutions can be designed; emergent behaviour is seen in L4 institutions (transactions). These behaviours can lead to changes in L2/3 institutions or be integrated into L1 institutions.

Williamson describes how institutional characteristics create constraints that limit feasible options to a "2nd best" action, for example. Application of such institutional analysis when comparing an existing (or proposed) EPI to a counterfactual (or existing) situation is necessary for objectivity and relevance.

Institutional analysis often focuses on the unique factors or interactions that affect outcomes. Such lack of generality means that most mathematical and numeric models of institutions are useless in the same way that a 1:1 scale map is useless. The tacit nature of institutional details makes them hard for outsiders to see, understand or weigh, even as insiders have a "feel" for how institutions affect the process that turns inputs into outputs.

Pommerehne and Feld (1994), for example, explore how a German community was able to overcome free-rider problems to build an incinerator in France. Under traditional economic theory, local citizens would have been unable to find a voluntary method to coordinate their actions, and they had no legal framework for force cooperation. Local norms made it possible for them to cooperate to contribute to the public good.

Our objective in EPI-WATER is to identify and describe institutions that affect the design, implementation and operation of EPIs. Our descriptions are unlikely to be quantitative in the same way that it's difficult to quantify "cooperation" or "market-friendliness" in a community. It may be possible to import national indicators (e.g., Transparency International's Corruption Perceptions Index), but these large-scale indicators do not often describe local conditions or individuals working with EPIs.

We will merely identify relevant institutions and how they support or undermine EPIs.

6.2 Typology

Institutions are relevant for all case studies in EPI-WATER. They influence the ex-ante status quo; options for action and implementation of EPIs; TCs (information, negotiation, implementation and enforcement); and the probability of success. Institutional characteristics include culture, path-dependency, tacit knowledge, multi-dimensional objective functions, aggregated objective functions, and so on. Some institutions need to be created anew in each location (e.g., via social learning), others are persistent (e.g., path-dependency) or recurring (the EU regulations affecting interactions with non-EU members). Institutions may conflict (e.g., formal rules of the WFD that conflict with informal norms), but they rarely change as fast as expected. Institutions evolve in response to physical and human forces, recent developments, and future expectations of changes in costs and benefits.

Institutions can intentionally or unintentionally improve productivity: The European norm of dense housing that originated in a past of scarce building materials, slow transportation and defence against attackers, for example, facilitates modern public transportation, wireless infrastructure and cooperative tendencies. They can also raise costs and lower productivity: monopolistic water utilities established long ago may not have the scale to treating water to current standards, but they cannot be forced to merge.

Look for a mismatch between institutions and conditions (costly institutions) or flexibility in dealing with outside shocks (beneficial institutions). Institutions for managing water (in any sector) are usually better at dealing with risk if they are designed for specific tasks and scales (e.g., flood control within a watershed), mainly because such specialization makes it easier to match costs and benefits.

Those general statements are vague, so it may help to use a more concrete definition from Saleth and Dinar (2004), who characterize [p. 97] water institutions in a way that's very similar to Williamson (2000), i.e., as a combination of water law (L2), water policy (L3) and water administration (L4).[19] They go on (chapters 6–10) to try to identify significant variables associated with each of these broad categories, but their technique makes it hard to draw strong conclusions:[20] They find that overall performance of the water sector depends on four legal indicators (effective conflict resolution provisions, legal integration, centralization within law, water-rights format), two policy indicators (cost-recovery status and effectiveness of user

[19] They divide institutions into formal "arrangements" (organizations or governance structures) and informal "environments" (institutions), but these categories often overlap.

[20] They combine survey answers from over 100 water policy professionals into two- or three-stage sets of structural equations meant to reproduce dependent/independent relationships connected to water sector performance. The system is too complicated for ceteris paribus analogy, analysis and conclusion.

participation policy), and five administrative indicators (seriousness of the budget constraint, technology application, balanced functional specification, information adequacy, existence of an independent water-pricing body); the weights attributed to each of these indicators by respondents varies with their discipline (e.g., social scientist vs. engineer) and their local water conditions [p. 311].

6.3 Assessment methods and technique

EPI assessment should consider benefits that are direct (e.g., improvements in water quality) and indirect (e.g., changes in health conditions) as well as costs (e.g., subsidies for environmentally friendly behaviour) must also be counted. Institutions affect these costs and benefits by changing incentives that change behavior that lead to direct and indirect outcomes.

Institutions are difficult to test in simulated or toolbox conditions. In some ways, they are totally inappropriate for dissection and analysis via any sort of "tool" that pretends to simplify and normalize. Coase (1998), for example, says:

> *Mainstream economics...is in fact little concerned with what happens in the real world... economists think of themselves as having a box of tools but no subject matter... I have expressed the same thought by saying that we study the circulation of the blood without a body... I think we should use these analytical tools to study the economic system... That such work is needed is made clear by another feature of economics. Apart from the formalization of the theory, the way we look at the working of the economic system has been extraordinarily static over the years... The costs of coordination within a firm and the level of transaction costs that it faces are affected by its ability to purchase inputs from other firms, and their ability to supply these inputs depends in part on their costs of coordination and the level of transaction costs that they face which are similarly affected by what these are in still other firms. What we are dealing with is a complex interrelated structure. Add to this the influence of the laws, of the social system, and of the culture, as well as the effects of technological changes... and you have a complicated set of interrelationships the nature of which will take much dedicated work over a long period to discover.*

Coase's warning implies that our best shot at assessment lies with a simulated comparison of a past real shock, response and impact to a future or proposed shock. It may be impossible to benchmark or assess unique institutions in different places. An institution for managing water that produces a 10 percent increase in yield in one irrigation district may reduce yield by 5 percent in another location, probably because it's not so easy to "copy and paste" an institution. On the other hand, this result may make it easier to compare and identify the factors that differ from one place to the next and perhaps highlight institutional elements contributing to efficiency, portability, and/or failures of EPIs.

It's possible to compare the outcome under an existing set of institutions against a "friction-free, perfect efficiency" benchmark derived from a mathematical or simulated model, but this technique can be wrong in two ways. First, because it may be impossible to actually implement the framework in the model (i.e., the institutional status quo is already second-best). Second, the replacement of an institution that serves multiple functions may result in perfect efficiency in the target area but total disaster in the ignored area. A storm water system may be very good at draining water from streets, but the resulting concentration in flows may reduce groundwater recharge and overwhelm the wastewater treatment plant.

6.4 Possible or suggested indicators

Based on Williams (2000), one could identify for each case study whether the links between levels (L1-L4) in each institutional setting facilitated or impeded the EPI. For example, Chile's adaptation strategies to the prevailing L1 geography and climate shaped its L2 water markets (Iseman, 2010). The Arkansas Water Bank Pilot Program was established by a change in legislation (L2 influences L3) but L3 legislative allowing out of the basin transfers has not resulted in trade, because L4 (or L1) people are not interested (Clifford et al, 2004).

In theory, we need to identify all related impacts from an EPI, the changes it imposes on "unrelated" status quo institutions, and the administrative parties that may have nothing to do with costs and benefits from the EPI but who are necessary to implement the EPI. It also makes sense to survey local familiarity with the EPI; ideas that are too strange cannot fit within local culture. Note that "strange" is quite subjective. Farmers who pay for fuel, seed and rented land may not understand that they should pay for water extraction. Is that because they don't want to pay for anything (L4) or because the whole idea is just too foreign (L1)?

A sequential description of institutional effects can fit into the 2.2/2.6 narrative framework, i.e.,

1. Describe institutions affecting the creation of the EPI
2. Tell how EPI operations were affected by institutions.
3. Tell how EPI changed existing institutions or established new institutions
4. If the EPI fails, then what was the cause? Blocking majority? Failure to consider institutional details?

6.5 Demonstration example

WUR is examining groundwater taxes (national) and fees (provincial) in the Netherlands. Both are based on certain types of groundwater extraction (e.g., drinking water, livestock, tulips and pasture are treated differently). They are affected/complemented by regulations on water use and how taxes are levied (small pumps are exempt, for example). The institutional dimensions of the taxes and fees vary at the provincial level in a way that can be compared (water use for pasture is allowed in some provinces but not others) and cannot be compared (the fees cover the cost of staff and equipment devoted to "sustainable" groundwater use). National taxes are not meant to affect behavior at all; they are green taxes meant to reduce other taxes (e.g., income tax), not to change behavior.

So we may say that the national tax is mostly ineffective in changing groundwater consumption, except that was the goal. The institutional indicator may be "what's the targeted goal/weakness?" (fiscal vs. behavioral instead of both, which is often the promise of win-win EPIs). The provincial user fees are targeted at the indicator of "user pays," i.e., what's the distribution of costs and benefits from the EPI? Contrast this to the *within* user distribution of costs and benefits from the fee (of the tax) that takes place in the agricultural community. Some farmers, lands and activities are exempt – either because of historic favouritism, lobbying, strategic interest, political favouritism, hydrological facts, or monitoring costs.

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7. Policy Implementability

Manuel Lago, Jennifer Möller-Gulland, Benjamin Görlach and Thomas Dworak (Ecologic Institute)

7.1 Introduction

This section explores what aspects ought to be taken into account when addressing policy implementability, that is legitimacy, political viability, social acceptance and flexibility/adaptability of EPIs. Policy implementability is closely related to other assessment criteria, notably transaction costs, institutional background, distributional effects and uncertainty. We pay attention to both, design of policy instruments – its flexibility and perceived potential to deliver, and process of putting the policy instrument in practice, thus obtaining and retaining acceptance by those who are affected. In more narrow sense and in order to avoid overlapping with other AF criteria, we focus on 1) implementation process, 2) ability to adapt to local and changing conditions; and 3) policy interplay or synergies with other existing policy objectives and instruments.

The policy analysis described in this section will be different for the ex-post and ex-ante assessments that are undertaken within the EPI-WATER project in WP3 and WP4 respectively. The ex-post assessment exercises will collect experiences and lessons learned from earlier attempts to put EPIs in place in different, favourable or not, contexts. The ex-ante exercises on the other hand will include the lessons learned into the design of the proposed policy instruments in order to increase the prospect of their successful implementation. In both cases, the efforts to understand the drivers behind the implementability of water policy instruments are still in an exploratory stage.

We look into drivers of policy success and failure, more explicitly in the policy design (wrong assumptions made in the design process) and/ or in the policy implementation process (too many exemptions granted, insufficient administrative capacities to actively enforce the instrument, conflict with existing regulation etc). The choice of policy instruments to achieve a pre-defined policy goal is fundamental.

7.3 Typology

7.3.1 Implementation process

For the purpose of this document, a *policy* is defined as a principle or rule to guide decisions and achieve rational outcome(s). The *policy cycle* is a simplified, perhaps oversimplified, view on how a policy is developed and implemented (see Figure B-7).

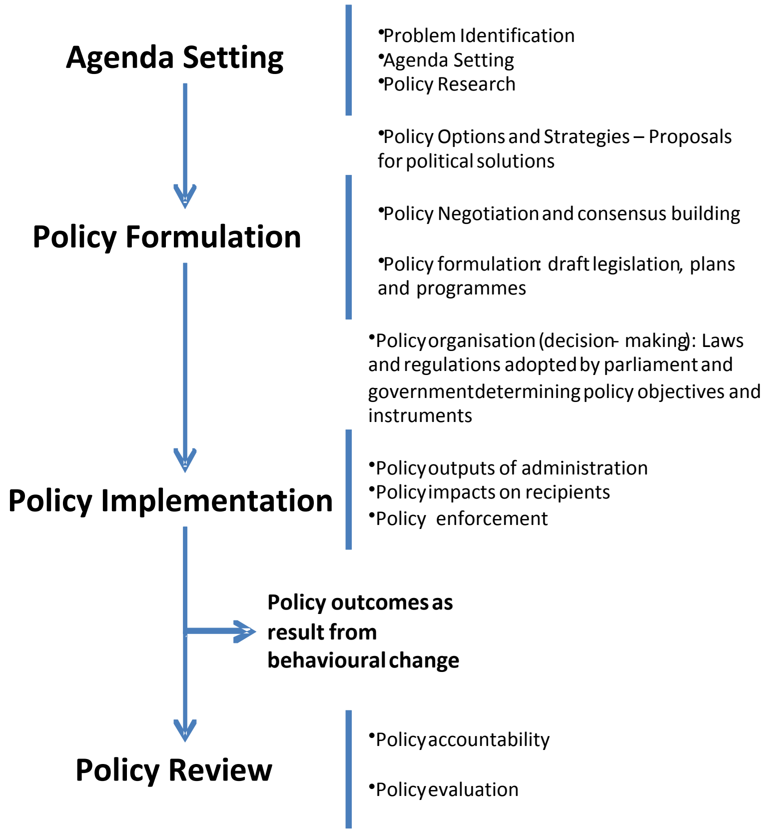

Figure B-7. The policy cycle

Policies and policy goals are put in practice via *policy instruments* that may be regulatory (e.g. legislations and regulations), economic (e.g. taxes, subsidies), or others.

Policy design and implementation are iterative processes. Ideally they start with recognising an issue as the precursor to setting the objective(s) of the policy. The policy instrument(s) are designed to solve or contribute to solving the issue.

[25] Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters, signed on June 25, 1998 and entered into force on 30 October 2001.

The introduction of an EPI (or more generally new policy instruments) may necessitate organizational reform, "as new tasks are developed, new procedures will be created, responsibilities will shift, some divisions and departments will gain importance, while others may be abolished and new patterns of internal resource allocation will emerge in accordance with the demands of new policies" (Crosby, 1996 in Sutton, 1999). Fitting new policy goals into the old public sector organizations can be promoted by establishing cross-cutting task force promoting the reform agenda (Crosby, 1996).

The policy change comes along with new monitoring, enforcement and evaluation tasks (UK Cabinet Office, 2003). The introduction of credible financial penalties and sanctions, combined with an easy to understand technical basis and adequate capabilities of the oversight agencies to monitor and evaluate tasks for which it is responsible, can enhance the acceptability of the EPI (UNEP, 2004).

A high degree of public participation in policy formation and implementation is essential nowadays, also for the formulation and design of policy instruments. Gregor and Winstanly (2006) find great value in involving communities which are expected to implement the formulated and designed policies or plans, as it will reduce the possible scenario in which these policies or plans cannot or will not be implemented or will result in unintentional and undesirable side effects.

Regulated firms might oppose EPI regulations as they fear higher costs. For example, the opposition of the business community to effluent fees during the 1970s in the US (Buchanan and Tullock, 1975; Sutton, 1999) highlights that communication is an essential requirement in policy reform. Companies compliant with existing regulation bear the sunk cost for meeting the policy requirements and although the additional cost may be small, the initial cost burden can acts as a market barrier for new entrants, thus limiting competition.

Whilst dialogue regarding participation is widely viewed as originating from the UN Conference on Environment and Development in 1992 and the global action plan Agenda 21, it is the publication of the 1998 Aarhus Convention which is often attributed to the shift in consideration of who should be involved in decision making. The Convention gives direction that European Member States should include participation early on in the decision-making process. Inclusion in traditional decision making processes was often viewed as a means of gaining compliance to the views or agenda of a restricted number of decision makers or a single organisation and a single solution. The Convention emphasises that participation should take place "when all options are open". This implies that participation should play a role in actually informing the outcome and so participation is deemed to occur when there is increased access to decision-making. The Water Framework Directive (WFD) (2000) placed further emphasis on the need for member states to implement participatory processes. The WFD widened the call for participation to include not simply the public but "all interested parties". Interested parties are often referred to as stakeholders and a working definition of a stakeholder can be taken as follows:

Stakeholder includes all persons, groups and organisations with an interest or "stake" in an issue, either because they will be affected or because they may have some influence on its outcome. This includes individual citizens and companies, economic and public interest groups, government bodies and experts (HarmoniCOP "Learning Together to Manage Together")

At best participation generates a process of social learning where a two way exchange of knowledge and understanding of decisions can take place between stakeholders. This can result in a degree of ownership by the stakeholders which might be expected to lead to a more effective implementation of the outcomes (Stirling 2004). Such a process of social learning can foster greater understanding and therefore trust between the stakeholders involved (Burningham et al 2008, Bayley and French 2008 and Cronin et al 2004). For those instigating or coordinating participatory processes they usually have their own stake and agenda in the issues.

Assessment questions:

- Is the EPI in line with broadly held societal values (equity, fairness)?
- To what extent do stakeholders have to be included in the policy cycle and what were the most successful strategies for this EPI?
- Acceptability
    - (as perceived by relevant sectors/stakeholders) – not only related to acceptance of EPI itself, but also in comparison to alternative regulation: is an EPI accepted as the "lesser evil", as the existence of an EPI avoids stricter regulation of another type of intervention. Can EPIs reduce the (perceived) regulative burden (red tape, bureaucracy) imposed to a sector/firm?
    - important to distinguish between "higher costs compared to no regulation" (business always oppose new regulation, irrespective of the type of regulation) and "higher cost compared to alternative instruments")

A recent review report commissioned by the EU Economic policy committee on the evaluation of economic instruments to reach energy and climate targets indicates that there are substantial direct economic and fiscal implications to understand prior to the implementation of policy instruments to tackle and adapt to climate change (EPC, 2007). The report mentions as an example the auctioning of allowances in the third phase of the EU Emissions Trading Scheme (EU-ETS). This instrument is expected to generate significant new revenues while also introducing greater volatility in levels of revenue and displacing existing revenue streams. The report recommends that the need to understand the wider macroeconomic implications and managing distributional impacts as an essential requisite in achieving overall energy and climate policy goals; and it concludes that any policies that have a potential impact on fiscal revenues or have significant budgetary implications should be considered by Finance Ministers.

Finance Ministers, with their expertise in the design of market-based policy instruments and understanding of the wider budgetary, fiscal and economic implications, therefore have a central role to play in the setting and design of environmental EPIs. In the case of climate policy the above mentioned report states that for reasons of subsidiary and sustainable public finances, revenues from auctioning should be used in line with sound budgetary principles and, specifically, not be subject to mandatory earmarking or hypothecation at EU level (EPC, 2007). The report ends up reminding that the use of such revenues by Member States should not be inconsistent with EU efforts to tackle climate change and should avoid perverse environmental incentives.

Additionally, traditional evaluation of EPIs has neglected important distinctions and interactions between the geographic scope of different pollutants, the enforcement authority of various levels of government, and the fiscal responsibilities of the various levels of government (Alm and Banzhaf, 2011). EPIs are likely to have their strongest advantage in the context of national policies. The reason for this is that much of their efficiency arises from the fact that they allow more abatement to be borne by polluters who have lower marginal abatement costs, and heterogeneity in these costs is likely to be greater the wider the geographic scope. However, the ability of an EPI to generate revenue and its geographical scope is inevitably linked with the revenue-raising role and experience of the institutions/government in charge of its implementation. For example, very often environmental protection is a devolved matter to regional government whilst fiscal policy remains (for the most) a national matter (e.g. Spain, UK).

Assessment questions:

- Revenue generated by the EPI (tax revenue, auctioning proceeds from tradable allowances)
- Total Costs of EPI implementation (administrative burden for the regulator, administrative burden for the regulated, impact on economic activity / competitive distortion and associated impact on revenue from other taxes)
- Involvement of financial and tax industries (are revenues earmarked, are EPIs set to maximize revenue, or to internalize externalities?) (Andersen, 1995) - Government support for EPIs versus other instruments due to their capacity as financing mechanisms
- Credible commitment that revenues generated by the EPI will be recycled to assist the affected parties
- How does one design EPIs in a decentralized fiscal system in which externalities exist at the local level and in which sub-national governments have the power both to provide local public goods and services and to choose tax instruments that can finance these expenditures and also correct the market failures of externalities?

- Which level of government (local, regional, state, EU) should implement environmental instruments when the choice is open/ which instrument might be most fitting at different levels of government?

To assess the situation described above (policy implementation process) in a homogeneous way across case studies under WP3, the Table B-7 provides an overview on questions which could be asked and indicators which could be used to assess the policy implementation process of an EPI. As this section interrelates with other sections of this assessment framework (e.g. transaction costs, institutions and public acceptability, etc.), these indicators are not duplicated here. Nevertheless, while the assessment of these indicators will take place in their respective tasks, some findings would be relevant also for the assessment of the policy implementability criteria of EPIs.

7.3.2 Flexibility and Adaptability

The flexibility to adapt to the local circumstances and adjustments to changing situations (e.g. climate or socioeconomic change) is of key importance for the success of EPIs (Harrington, Morgenstern and Sterner 2004). Mandated flexibility: Environmental legislation allows for some flexibility to tighten or relax the policy provisions to fit local circumstances and to take uncertainty into account. In the Water Framework Directive (WFD), this flexibility is provided by various exemptions such as extensions of deadlines, less stringent objectives and the deterioration of the quality status as a result of natural or human causes. However, the exemptions allow water authorities to weigh in uncertainty, technical feasibility, costs and benefits, i.e. policy factors beyond scientific rationalization. Their application, however, needs to be justified. The EU Commission and the Water Directors of the EU Member States have detailed which qualifying conditions need to be met (CIS 2007; WD 2008).

The involvement of public interest groups helps to retain public oversight of policy implementation and to ensure that flexibility does not taint the lack of response, or that uncertainty is not used as an excuse to deter action where this is not warranted. The provisions of the UNECE Aarhus convention[25] provide a much broader base for this right. The convention consists of three basic environmental rights (pillars): access to information, public participation in decision-making, and access to justice on environmental matters. The European Union aligned EU legislation with the requirements of the Convention before ratifying it in 2005. The third right – access to justice – has so far only been fully transposed into Community law with an effect on Community institutions.

Table B-7: Guiding questions and indicators for the assessment of the instrument implementation process

Link with other tasks	Questions to be asked	Proposed specific Indicators?

	What are the main elements and mechanisms of the policy, the measures to control and enforce the achievement of the policy goals and safeguarding mechanisms to avoid negative side effects? To what degree has the EPI been designed collectively and recognise the values and interests of the affected parties (public participation/ role of stakeholders) Has an impact assessment been performed?	Qualitative comparative assessment
Transaction costs	Can the transaction costs prevent the effective implementation of the EPI? Are there viable trade-offs between transaction costs and the policy performance of this EPI which can increase its effective implementation and be adjusted from case to case?	See indicators proposed under the task on transaction costs
Public Acceptability	Are there national/cultural differences in the acceptability of the EPI? Acceptability - Current level of sectoral regulation	In addition see indicators proposed under the task on distributional effects Analysis of responses to public consultation documents. Identification of who favoured/opposed the instrument.
Institutional background	How transferable/ specific are the main institutional prerequisites for the effective EPI implementation? How can the EPI be monitored and enforced for effective compliance?	See indicators proposed under the tasks on institutional background and transaction costs

To assess the flexibility and adaptability of EPIs in a homogeneous way across case studies, the following table shall provide an overview of questions which could be asked and indicators which could be used for the assessment.

Table B-8: Guiding questions and indicators for the assessment of the flexibility and adaptability of EPIs

Policy Implementability

Indicator	Questions to be asked	Proposed specific Indicators?
Front-end	Can adjustments to the EPI be made before its implementation to take the local particularities into account? What are the costs and the timeliness of these adjustments?	Qualitative comparative assessment Costs of and time needed for adjustments
Back-end	Can the EPI be adjusted following a post-implementation review (i.e. annual mandated review; review of the EPI implementation after predefined time period) Can adjustments be made later if conditions change again or if changes are different from those expected today? What are the costs and the timeliness of these adjustments?	Qualitative comparative assessment Costs of and time needed for adjustments
Urgency/ Timeliness	How long is the time-lag between implementation of the EPIs and the effect of the measures?	Indication of estimated time-lag

7.3.3 Policy Interplay

Policy interplay is the degree to which a policy or policy instrument contributes to solving issues for which these were not initially adopted. For example to what extent the reform of Common Agricultural Policy (CAP) contributes to solving water stress induced by even increasing demand for irrigation?

Water, energy, food and climate change are closely linked. Every step in the integrated water cycle – drinking water treatment and supply, wastewater collection, and purification – requires energy, and water is used in the generation of hydroelectric energy and in the operation of most thermal power plants (GWRC, 2010). Agriculture water requirements can stand in competition with water requirements for energy generation – biofuels are seen as a green option to generate energy, but can also compete for water needed for agricultural produce. The most widely recognized aspect of the water-energy-food relationship is power production in large scale hydroelectric dams. However, water and wastewater utilities have other opportunities to develop energy supplies. These include biogas cogeneration at wastewater treatment plants and development of local renewable resources on water and wastewater utilities' extensive watersheds and rights-of-way (EPA, 2006).

The relationship between energy, food and water resources and climate change needs to be kept in mind as e.g. the application of measures required by the WFD to improve water quality or measures to increase water supply may lead to noteworthy increases in energy use. Moreover, energy policies may have effects on water quantity and quality and on the effectiveness of the economic instruments applied for water management. For example the subsidies to bio-fuels may have an effect on the demand of water. Also it would be appropriate calculate the carbon footprint and/or the emission of GHG of each measure proposed to improve the management of water resources. Further, measures related to climate change policies, such as an increase in renewable energy, can lead to, as mentioned above, increased competing water uses due to e.g. biofuel crop production. These interrelations raise the need to consider joint and coordinated policies for all resources In this sense, in the U.S.A. and Australia there are some experiences in relation to the search for synergies and coordination of the water and energy policies (Wang, 2009; Retamal, 2009) while in Europe the development of these strategies is much more limited.

The goal in this task is to identify what is relevant to know about other policies, in terms, of incentive to use more or less water, or to pollute the water more or less, or to provide cross-compliance incentives. As a first step, relevant policies need to be identified and the interaction between their main objectives assessed. Policies to review will include among others the: Water Framework Directive (WFD), EU Flood Risk Management Directive (FRMD), EC Communication on Water Scarcity and Droughts, Common Agricultural Policy CAP, EU Energy policy, Climate change adaptation and mitigation policies. Examples from the ex-post case studies need to be identified and reviewed for the development of this task. Reviews should include a section on the interplay with existing regulatory instruments and EPIs under different policy contexts. For the assessment of the impact policy interplay on the implementation of the EPI, a matrix will be used which allows a strategic comparison between the policy objectives of the EU policies mentioned above and the objectives of the EPI. By asking the strategic questions illustrated in the table below, potential synergies and/or barriers will be identified in a comparable way between the case studies.

Table B-9. Guiding questions and indicators for the assessment of the policy interplay

Indicator	Questions to be asked	Proposed specific Indicators?
Policy Interplay	Can synergies between the EPI and other sectoral policies be identified and taken advantage of? Does any policy create barriers to the successful implementation of the EPI? Examples of environmental policies to take into account: Water Framework Directive (WFD), EU Flood Risk Management Directive (FRMD), Common Agricultural Policy (CAP), EU Energy Policy, EU Climate Change, Adaptation and Mitigation Policies, EU Nature Conservation Policies (e.g. Natura 2000)	Qualitative assessment supported by an impact interaction matrix.

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8. Uncertainty

Jaroslav Mysiak (FEEM)

8.1 Introduction

"Uncertainty" has a wide variety of interpretations and usage, overlapping to some extent: lack of knowledge, knowingly incurred imprecision, measurement inaccuracy, limited faculty to know, lack of confidence, inconsistency and arbitrariness of action, ambiguity and vagueness. Some of them reflect practical limitations to gathering, collating or using knowledge, others make it difficult to communicate information, and all potentially hinder the public acceptance of claims to knowledge.

Recent emphasis on uncertainty in environmental policy making reflects numerous changes in environmental science and policy making over the past few decades. First, environmental policy problems increasingly involve large, interconnected and complex social choices. For example, climate change, ozone depletion, biodiversity loss, genetically engineered crops, environment-related diseases and health risks involve large scale, long-term impacts, whose precise causes and consequences are often poorly understood. Given these uncertainties and the risk of irreversible environmental changes, different perspectives about the nature, policy implications, or even the existence of a problem are inevitable (Rittel & Webber 1973; Ackoff 1979; Rosness 1998; Sarewitz 2004).

Secondly, as a consequence, environmental policies[26] have shifted to more precautionary (Dorman 2005; Dupuy & Grinbaum 2005; Tallacchini 2005; van Asselt & Vos 2005; Vineis 2005), non-structural (Hooper & Duggin 1996; Faisal *et al.* 1999; Sabino *et al.* 1999; de Loe & Wojtanowski 2001; Lu *et al.* 2001) and demand-led approaches (de Santa Olalla Manas *et al.* 1999; Mohamed & Savenije 2000; Froukh 2001; Gumbo *et al.* 2004).

Thirdly, and also as a consequence of these new environmental problems, the process of policy making has increasingly favoured interdisciplinary, pluralistic, and inclusive methodologies (Tacconi 1998; Meppem 2000; van den Bergh et al. 2000; Shi 2004), with scientists participating alongside other stakeholders in deliberative decision making (Baber 2004; Davies & Burgess 2004; Renn 2006), participatory assessment (Kouplevatskaya-Yunusova & Buttoud; Argent & Grayson 2003; Cramb *et al.* 2004) or group model building (Vennix 1999; Sterman 2002; Stirling 2006).

[26] Relevant examples in the EU include the Sixth Environment Action Programme (EAP); Pollutant Emission Register; Regulatory framework for the Registration, Evaluation and Authorisation of Chemicals (REACH); Council Directive 96/82/EC on the control of major-accident hazards involving dangerous substances called also Seveso II Directive; proposal of EU Framework for Community Action in the field of Marine Environmental Policy (Marine Strategy Directive); Strategy for Sustainable Development; Water Framework Directive.

Environmental policy-making has to proceed in spite of uncertainties. Scientific uncertainties may be underplayed or overplayed for political advantage; used as an argument to compel or postpone policy action. For example, the perceived partiality of the Bush administration and the U.S. government in handling uncertainty of climate change prompted allegations of politicization of science. It is wrong however to dismiss all environmental policy disputes in which uncertainty is a major concern as attempts to politicize science. Uncertainty in policy making arises because of choice and subjectivity in problem formulation; discussion, contention and consensus building among interest groups; multiple and conflicting criteria; and political and social influences on priorities and policy. "In contested domains, scientists will be attacked both for not acknowledging the full range of uncertainties and for cautiously overstating uncertainties" (Shackley & Wynne 1996).

In 2007, the U.S. Supreme Court ruled out that the U.S. Environmental Protection Agency (EPA) erred to decline requests to regulate greenhouse emissions from motor vehicles under the mandate given by the Clean Air Act (Nash 2008). The EPA justified its reluctance to regulate emissions by pointing to "substantial scientific uncertainty" about the effects of climate change on human health and the environment, and about the best means to address the issue. The 1970 Clean Air Act authorizes EPA to set vehicular emission standards for substances that could reasonably be anticipated to endanger public health or welfare. The EPA released standards for smog and other pollutants, but not emissions of greenhouse gases including carbon dioxide. Relying on the report of the National Research Council (NRC 2001), the agency acknowledged scientific consensus on climate change but pointed to poor understanding of its health consequences.

8.2 Typology

Different definitions and classifications have been proposed to convey the diversity of meanings of uncertainty and to provide guidance in assessing and communicating it. The definitions proposed are vague, and arguably a satisfactorily broad and unambiguous definition of uncertainty is precluded by this diversity. Some authors approach a definition through the context requiring it. According to Pielke and Rayner (2004), uncertainty means in general that a problem has multiple possible interpretations, multiple possible outcomes or that one outcome can be reached through multiple alternative pathways (equifinality). Zimmermann (2000) is more specific about products afflicted with uncertainty, attributing to uncertainty a "situation (in which) a person does not dispose about information which quantitatively or qualitatively is appropriate to describe, prescribe or predict deterministically and numerically a system, its behaviour or other characteristics". This merely shifts the problem to defining "appropriate" and seems to suppose, wrongly, that one cannot usefully describe or predict with uncertainty. Brashers (2001) on the other hand presents a definition with respect to the reasons for which we are uncertain: "Uncertainty exists when details of situations are ambiguous, complex, unpredictable or probabilistic; when information is unavailable or inconsistent; and when people feel insecure in their own state of knowledge or the state of knowledge in general". In our view this focus on the frame of mind of the person confronted with uncertainty is helpful, as it permits application of a notion of uncertainty to the perceptual and judgemental aspects of the information-gathering and information-using process leading to policy.

Numerous typologies and techniques have been developed to conceptualise, classify, assess (qualitatively and quantitatively), propagate, control, reduce and communicate uncertainty. Various classification schemes for uncertainty have been developed that extend explicit definitions while maintaining a degree of generality. The existing typologies differ in scope (for example uncertainty in modelling versus uncertainty in decision making) and purpose. It has been proposed (Walker *et al.* 2003) that one should categorise the nature or roots of uncertainty (reducible vs irreducible, epistemic vs ontological), location (context, model, inputs, parameters, outputs), and level (statistical uncertainty, scenario uncertainty, recognised ignorance, unrecognised ignorance). The problem with this and other typologies is that their authors are primarily concerned with resolving apparent inconsistencies and lack of detail in terms and meanings ascribed to different concepts of uncertainty. In other words, a "top down" view is taken. A consequence is that it is easy to overlook very specific aspects, sources or types of uncertainty that are particular to their context yet demand effective handling. As for models, typologies of uncertainty are abstractions that are useful only as far as they are responsive to specific situations and helpful as tools to address them (Norton *et al.* 2006).

Kandlikar *et al.* (2005) proposed an useful way how to characterise the magnitude of uncertainty. Ideally, a full probability distribution can be determined either numerically or through a formal quantitative survey of expert views. In other situations, a likelihood or probability of occurrence can be determined for an event or for representative outcomes, e.g. based on multiple observations, model ensemble runs, or expert judgment. Is this information not available, it may at least be possible to determine a range (e.g. upper and lower bounds or as 5th and 95th percentiles) of a variable. Finally, the least accurate information can be expressed through the order of magnitude or the direction of change (increase, decrease, no significant change).

Uncertainty is pervasive to **all dimensions of assessment framework** but in many different ways. *Environmental benefits* of EPIs, their *costs* and *distributional effects* (at least to some extent) can be characterised quantitatively and are usually combined in an aggregate measure of cost-benefit, cost-effectiveness or there like. Uncertainty arises because of the effects and costs of the economic policy instruments cannot be determined precisely and because the observed attainments cannot be uniquely attributed to a single policy or a portfolio of policies.

To make it clear, it is practical to distinguish between policy outputs and outcomes. Outcomes are short or long term achievements brought about by the introduced policy. Outputs on the other hand are activities or their straight achievements or milestones that anticipate or approximate the outcomes. For example, the reduced residential water consumption (demand) is an outcome of a policy such as water efficiency standards or financial incentives to increase the use of water-conserving appliances. The outputs of these policies are a number of modern water appliances sold or a number of households/dwelling units that have been built in compliance with the water-sensitive building standards. Although better traceable, the outputs are imperfect proxies of the ultimate policy outcomes. The number of water saving appliances does not give immediate information about the total volume of water saved since that depends on the dwelling or household specific use of those appliances. The imperfect knowledge about the underlying relationship between the policy outputs and the outcomes is a source of uncertainty. Furthermore, the observed attainments, in terms of outputs and even more so in terms of outcomes, may not be easily attributable to a single policy or a policy mix.

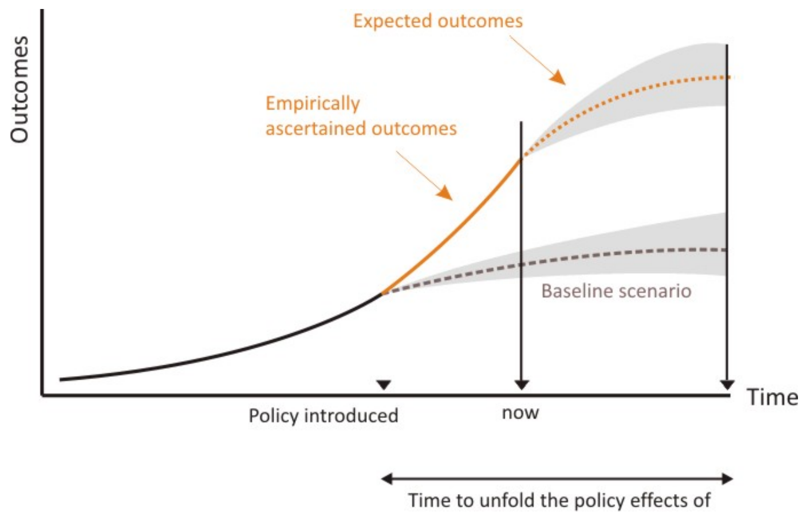

Figure B-9 Primary sources of uncertainty in the assessment of the policy attainments

Because the attained benefits and a part of the implementation and compliance costs lay in the future, at the moment of the assessment exercise these can only be approximated. Uncertainty is comprised in 1) the specification of the 'everything being equal' baseline describing the degree to which the objectives were fulfilled had no policy been introduced; 2) the empirically ascertained policy outputs/outputs realised up to the assessment date (measurement or observation imprecision or biases); and 3) projection of the policy outputs/outputs up to the date the policy effects are fully unfold (Figure B.9).

Institutional set up and other factors governing *policy implementability* and *success* are variables which shape the level of the fulfilment of the policy objectives and the costs. For the most part these criteria are qualitative and thus difficult to combine with the likelihood of the costs/benefits.

The overarching goal of sound natural resource management is an equitable, efficient and sustainable use of managed resources (e.g. water, forests, and species stocks). The governance systems put in place in democratic societies to reach this goal must respect the principles of good governance, as laid down in the EC White Paper on Governance (EC, 2001): to be transparent and accessible, inclusive, effective, coherent and accountable. Good environmental governance is both an end in itself and a mean to reach higher level environmental goals. This suggests that the ultimate policy outcomes may be measured by how closely these goals both can be, or have been achieved.

8.3 Assessment methods and technique

There is a large number of techniques for expressing, manipulating and using uncertain quantities. Such expressions range in detail from bounds, to the fuzzy-set approach, and probability distribution functions derived from observed frequencies, expert judgements or both.

For the scope of the EPI-WATER project we propose to use the pedigree analysis drawing on, or inspired by, the assessment techniques developed by van der Sluijs *et al* (2005). The pedigree represents an explicit account of the quality of information and the processes underlying the knowledge production process. In the basic form (van der Sluijs 2007), the pedigree criteria is a set of variables named *proxy* (functional relationship between the outcomes and outputs), *empirical basis*, *methodological rigor*, and *validation*. The pedigree criteria are assessed through expert judgement, using qualitative statements as in the Table B-10.

Table B-10. Pedigree criteria (van der Sluijs 2007)

Code	*Proxy*	*Empirical*	*Method*	*Validation*
4	Exact measure	Large sample direct measurements	Best available practice	Compared with indep. mmts of same variable
3	Good fit or measure	Small sample direct measurements	Reliable method commonly accepted	Compared with indep. mmts of closely related variable
2	Well correlated	Modeled/ derived data	Acceptable method limited consensus on reliability	Compared with mmts not independent
1	Weak correlation	Educated guesses / rule of thumb estimate	Preliminary methods unknown reliability	Weak / indirect validation
0	Not clearly related	Crude speculation	No discernible rigor	No validation

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8.4 Demonstration example

Aiming to achieve better management of energy, the large-scale roll-out of smart meters is a recent major energy efficiency policy initiative in the UK (DoECC 2011). The project will involve a visit to every home and many businesses in Great Britain, and the replacement of around 53 million gas and electricity meters. The benefits of installing smart meters are that they provide consumers with near real-time information about energy use, and more accurate bills. Smart meters, together with real time in-home displays, can provide consumers with detailed information on their energy use and access to a wide range of off-peak electricity tariffs. Smart meters also allow suppliers to collect meter readings electronically, leading to more accurate energy bills and cutting costs.

Costs of delivering the smart metering system in every home and the associated communications technology is expected to reach GBP 11.3 billion. The costs will be borne by energy suppliers. The Department of Energy and Climate Change expects costs and cost savings to be passed down to costumers. Public expenditure on smart meters will be limited to the cost of programme management and consumer engagement work.

The Department expects economic benefits of the program to reach GBP 18.6 billion between 2011 and 2030, achieving a discounted net present benefit of GBP 7.3 billion.

Several uncertainties and risks of the programme have been identified by the UK National Audit Office (NAO 2011). On the one hand these concern consumer benefits, as international experiences and domestic trials together provided only limited evidence to support particular assumptions about how much and how long consumer behaviour will change. Costs may also increase more than expected, and major technical and logistical challenges may also arise. Furthermore, there is also a risk that suppliers do not pass on the net savings to their costumers.

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