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Cost-effectiveness analysis in the implementation of the Water Framework Directive: A comparative analysis of the United Kingdom and Spain

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Abstract: One of the most innovative aspects of the European Water Framework Directive (WFD) is the incorporation of economic principles and tools into water management and water policy. Amongst the various economic analyses stated or implied in the WFD, the cost-effectiveness analysis (CEA) of mitigation measures needed to achieve the 'good ecological status' has been given a pivotal place. This is aimed at establishing the least costly combination of measures to be included in the so-called Programme of Measures (PoMs) of the river basin management plans. In this paper, first, we review and discuss the existing CEA methods related to WFD implementation. Second, we assess the progress made so far in the application of CEA and its limitations in two European countries: the United Kingdom and Spain. The overall aim is to assess the CEA approaches pursued, the achievements made, and the major challenges to-date in the design and implementation of WFD-related CEA studies to guiding water management and water-related policy decisions in these countries. Our results show that the two countries show different levels of experiences and progress in relation to undertaking WFD related-CEA. The key differences among the two countries relate not only to the nature of the main problems they face in their respective water environment, but also to the approaches in the estimation of costs and effectiveness and the up-to-date progresses in the implementation of the WFD. Major similarities among the two are: i) their primary focus on pressures (rather than on impact) when measuring effectiveness and ii) the importance of the agricultural sector in affecting and being affected by the WFD.

Keywords: cost-effectiveness analysis, Water Framework Directive, Spain, United Kingdom

1. INTRODUCTION

The European Union Water Framework Directive (WFD) outlines a general water-management strategy in Europe and establishes environmental objectives for water bodies (European Commission, 2000). The principle underlying the WFD is that water ecosystems constitute a collective heritage that must be preserved by ensuring water uses to be compatible with the preservation of these ecosystems.

The use of economic tools and principles for the achievement of the Directive's objectives is one of its most novel and interesting aspects. Amongst the various economic analyses stated or implied in the WFD, cost-effectiveness analysis (CEA) has been given a paramount focus. The Directive prescribes the Program of Measures (PoMs), which lists the measures to fulfil the environmental objectives, to be drawn up according to economic principles. Annex III (b) of the WFD stipulates that "judgements about the most cost-effective combination of measures in respect of water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures" need to be made as part of the River Basin Management Plans.

CEA is a decision-support tool that enables the assessment of the cost and the effectiveness of alternative policy options in realising a preset objective. In brief, it aims at identifying a combination of mitigation measures for achieving a given environmental goal at the least economic cost. CEA was adopted in most national guidelines for preparing PoMs, for instance, in Germany (Interwies et al., 2004), Spain (MARM, 2008), Denmark (Folketinget, 2003) and the United Kingdom (DEFRA, 2007). In the context of the WFD, CEA entails identification of environmental objectives for each water body, assessment of possible measures to meet the pre-specified water

management objectives set out in the Directive and estimation of their costs and of their impacts on the status of the water bodies (European Commission, 2003).

Drawing on the comparative analysis of the UK and Spanish cases, the aim of this paper is to examine the application of CEA in the implementation of WFD in two countries with different major water management problems. Specifically, we are interested in looking at the CEA approaches pursued, the achievements made so far, and the major challenges to-date in the two countries. These two countries face different water related problems which can be representative of two types of management needs: in the UK, as in a number of other northern and central European countries, there is a very strong focus on diffuse pollution abatement; whereas in Spain, as in other southern Mediterranean countries, the main problem relates to water scarcity and how to make compatible the achievement of the GES with growing pressure from competing users. We expect some of the challenges and implications of CEA to be similar across the two countries, but differences deriving from different management needs and practices are to be expected and to be of interest in the broader European level.

By focusing specifically on the experiences, challenges, and up-to-date progresses of in the two contrasting EU countries in relation to WFD-related CEA, this study adds to the literature on the context and country-specific applications of CEA in the implementation of the WFD. Balana et al. (2011) can be consulted for a review of water-related CEA studies in selected European countries. Berbel et al. (2011) present a specific case study in Spain and Van Engelen et al. (2008) discuss two cases in Denmark and The Netherlands. Kranz et al. (2004) discuss the German case. Except for Balana et al. (2011), these papers do not present a comparative analysis and evaluate the state of the situation in the various European countries.

2. APPROACHES TO COST-EFFECTIVENESS ANALYSIS

CEA is a form of economic analysis that compares the costs and outcomes (effects) of two or more courses of action. It is generally aimed at choosing the least costly option or combinations of options to achieve a given objective. As applied in environmental decisions, CEA is basically a multi-step procedure. Firstly, the environmental target to be met is exogenously determined. Secondly, alternative measures to achieve the stated objective are to be identified. Thirdly, the potential effectiveness of measures is assessed. Fourthly, the costs of implementing the measures are estimated. And finally, alternative options or combinations of options are assessed based on their costs per unit environmental outcome.

A range of conceptual approaches have been used to assess the cost-effectiveness of mitigation measures or policy instruments for meeting specific environmental objectives. Methods range from standard simple calculations, like the one proposed by Jacobsen (2007) and Van Engelen et al. (2007), and regression analysis (e.g., Fezzi et al., 2010); to complex mathematical programming models (e.g. Bartolini et al., 2007) and integrated bio-economic modelling (e.g. Semaan et al., 2007). Most CEA models, however, are based on variants of mathematical programming models, which may be either (i) cost minimization: achieving a predetermined environmental target at a least possible cost (Elofsson, 2003; Zylicz, 2003; Khanna et al., 2003; Yang and Weersink, 2004; Yang et al., 2005; Rashford and Adams, 2007; and Froschl et al., 2008) or (ii) benefit maximization: maximizing environmental benefits subject to budget constraint (Azzaino et al., 2002; Ancev et al., 2008).

A large number of applied CEA studies used linear programming models. For instance, Defra (2004) and Cuttle et al. (2007) to estimate the economic costs and effectiveness of range of agricultural diffuse pollution measures in UK; Froschl et al. (2008) to appraise the costs and effectiveness of four nitrogen load reduction measures to waters entering the Black Sea from Austria, Bulgaria, Hungary and Romania. The shortcoming of this approach is that linear optimization models use ‘average farm’ data and do not incorporate non-linear relationships and uncertainties. In response to this, a number of studies (e.g., Gren et al., 2002; Elofsson, 2003; Lacroix et al., 2005) have incorporated uncertainty and applied chance-constrained programming

modelling approaches in their cost-effectiveness studies. Similarly, the non-linear nature of effectiveness and costs of measures were recognized in a number of CEA studies (Semaan et al., 2007; Brady, 2003). Other methodological approaches in CEA include simulation and regression models (Paulsen and Wernstedt, 1995; Rashford and Adams, 2007) and Bayesian Belief Network (BBN) models (Bromley et al., 2005; Barton et al., 2006; Barton et al., 2008). BBN utilises probabilistic, rather than deterministic, expressions to describe relationships among variables. An extensive review of the alternative methodological approaches in CEA and their application in WFD-related CEA implementation are summarized in Balana et al. (2011).

From the above description, one can see that different methodological approaches can be used in CEA studies. The choice of a particular methodological approach or combination of techniques in cost calculations, effectiveness estimates i.e., emission reduction estimation, and combining costs and effectiveness in a given CEA study depends on the specific environmental problem at hand, the availability of data and the degree of uncertainty inherent in cost and effectiveness information. However, despite the specific approach chosen, two key issues that fundamentally condition its implementation are: (1) definition and measurement of costs; and (2) definition and measurement of effectiveness. The way how this has been undertaken in the context of the WFD in the UK and Spain and the implications for the CEA, among other challenges, is investigated in this paper.

3. IMPLEMENTATION OF WFD-RELATED CEA IN THE UK AND SPAIN

3.1 The United Kingdom

The United Kingdom has been one of the forerunners in the implementation of the WFD in terms of transposing the WFD requirements into the national Law in 2003; undertaking River Basin District characterization, review of pressures and impacts of human activities on water environment, and economic analysis of water use (Article 5); and River basin management plan (Article 13); Programme of measures including CEA (Article 11); and public information and consultation (Article 14). All these activities were accomplished according to the timetable set out for the implementation of WFD in UK. The river basin management plans (RBMP) each of the 15 RBD in UK have been published. The responsibilities to the implementation of WFD in the UK are devolved to its four constituent countries (England, Northern Ireland, Scotland and Wales). Much of the work to implement the WFD in the UK is being undertaken by what the Directive refers to as the 'Competent Authorities'. These are the UK environment agencies i.e., the Environment Agency (EA) in England and Wales, the Scottish Environment Protection Agency (SEPA) in Scotland and the Northern Ireland Environment Agency (NIEA) in Northern Ireland. Guidance for the WFD implementation at the UK level is provided by the UK Technical Advisory Group (UKTAG), a partnership of the UK environment and conservation agencies established in 2001. Among other things, the two key tasks of UKTAG are: (i) to provide technical advice to the UK Administrations, and (ii) to develop guidance and methods to support the consistent implementation of the Directive by the UK Agencies (see http://www.wfduk.org).

The key water environment problem in the majority of the river basin districts (RBD) in the UK is water quality issues. Specifically, sediments and pollutants (chemical compounds, pesticides, herbicides and nutrients)) from diffuse sources (mainly from land-based activities) pose significant challenges to the water environment in the UK. As agricultural activities are considered to the major contributor of diffuse pollution, significant improvements are needed to farm practices to protect water quality and allow wildlife to thrive, discharges from sewage works impact on the quality of water. Rivers and estuaries have been highly modified physically, to facilitate development, flood and coastal risk management or navigation. Physical modification needs to be addressed in order to achieve more natural functioning of wetland ecosystems, and protect fish and their habitats into the future. Water environment in some RBD (e.g., Thames) is under threat from invasive non-native species, such as the signal crayfish. These invasive species have an adverse affect on the natural

fauna and flora. In general, diffuse pollution, physical modifications, abstractions and other flow regulations create range of pressures in different RBD in the UK. The RBMP documents published in 2009 contain the main issues for the water environment in each RBD and the actions i.e., the PoMs needed to deal with them. The choice of these actions was based of economic analysis of water (including the CEA) at each RBD level.

One of the most comprehensive and earliest scoping studies on outlining alternative methodologies for conducting WFD-related CEA in the UK has been provided by Postle et al. (2004). This study suggested that the CEA methodology to be applied in the UK should adopt full economic costs (as opposed to financial costs) as a basis for measuring costs to appraise potential measures. Within the context of delivering good environmental status, a range of economic costs to be considered in CEA were identified including: direct costs of complying with the requirements, any welfare losses to consumers, any non-water environmental costs, induced effects to the wider economy, and transaction costs. The study also proposed a generic framework for estimating and aggregating costs at different scales (local, basin, and national levels). Formal optimization methods were suggested for combining the estimates of costs and effectiveness in order to develop the most cost-effective combination of measures. Building on Postle et al. (2004), the UK Collaborative Research Programme (CRP) on River Basin Management Planning Economics has developed six sequential projects. The focus was on the progressive development of the approaches and data required to assess the costs and benefits of Programmes of Measures (PoMs) proposed under WFD. One of the core projects of CRP (project 2) was on "developing a methodology and guidance to assess the cost-effectiveness of measures and combination of measures for the WFD" (Risk and Policy Analysis (RPA), 2005). This project provides an overarching framework for undertaking CEA under WFD in the UK. A series of studies commissioned by the Department for Environment, Food and Rural Affairs (Defra, 2004 and 2005), assessed the cost-effectiveness of a large number of mitigation options for different pollutants such as phosphorous, nitrates ammonium, pathogens and biological oxygen demand. A study by Cuttle et al. (2007) on "An inventory of methods to control diffuse water pollution from agriculture (DWPA)", was more informative and detailed than the three earlier Defra commissioned CEA studies, and developed a 'User Manual' for DWPA which provides a platform for model framework development and succinct information on individual mitigation methods to assist the user in developing policies to control diffuse water pollution.

Anthony (2006) developed a new methodology for calculating combined effectiveness of multiple mitigation methods and the cost of implementing them. By allowing integrated assessment of the effect of combinations of methods, the new approach has brought about novel ideas compared to the previous approaches.

Agricultural sector is the key target. But most CEA studies were based on 'representative' farms instead of actual farm accounts (see Fezzi et al, 2008; Bateman et al., 2008). Also, CEA has been conducted at different spatial scales (field level, farm, catchments, and multiple catchments).

Besides the identification and measurement of costs, another key issue in the overall assessment of cost-effectiveness is the question of how effectiveness is to be measured. This question is central to determining whether the CEA methodology will provide a robust ranking of measures, as different indicators may lead to different rankings. Postle et al. (2004) proposed a staged approach for assessing the effectiveness that moves from the screening of measures to a generic and higher scale (national/regional) to a more detailed assessment carried out at a lower scale (river basin/water body). They suggested that, the national level assessments have to be re-assessed when the analysis moves to the more detailed water body level. The proposed effectiveness assessment is based on expert judgements and modelling techniques such as simulation models. The assessment incorporates uncertainty (using ranges of values instead of point estimates) and allows examination of effectiveness at different scales. CPR in one of its projects (project 2B (see: http://www.wfdcrp.co.uk) provided a detailed description of the methodology of measuring effectiveness of measures. The five steps suggested in this description were: problem definition, identifying measures, predicting effectiveness, developing combinations, and comparison of combinations. Step 3 (predicting effectiveness) is the core of the methodology which includes the

assessment of the magnitude, certainty, and characteristics effects. The methodology also includes assessment practicability and potential side effects. The effectiveness of measures included in the diffuse water pollution from agriculture (Cuttle et al., 2007) was based expert judgements and environmental models.

3.2 Spain

In the northern and central European countries, the implementation of the WFD has been dominated by the water quality related aspects of the ecological status (Martin-Ortega et al. 2011). However, water quantity aspects related to the various uses of water are of particular importance in southern Europe and the Mediterranean regions, where all indicators point to an increase in water scarcity problems with negative implications towards current and future sustainability (Iglesias et al. 2007). In those contexts, the allocation of water for the environment to achieve a GES has to compete with various water users (mainly irrigation, but also growing urban and industrial water uses) (see for example, Martinez-Paz and Perni (2011) and Mesa-Jurado et al. (2012). The pressure on the resource is expected to increase due to predicted impacts of climate change that suggest a dryer and warmer Mediterranean region (e.g. Huntingford et al. 2003; IPCC 2007). In those regions, the PoM needs to address mainly water supply and demand issues. This is the case in Spain, where a key feature of river basins management plans relate to the need of matching supply and demand and making that compatible with the achievement of the GES (i.e. maintaining a certain level of water flow to ensure the provisioning of ecosystem services). This does not imply that other type of water problems is not relevant or dealt with. For example, the literature on the valuation of environmental benefits of the WFD has also looked at water quality improvements (e.g. Perni et al. 2012; Del Saz-Salazar et al. 2010; Martin-Ortega et al. 2009; Martin-Ortega and Berbel 2010).

The WFD was transposed into national legislation through Article 129 of Law 62/2003 on fiscal, administrative and social measures. This transposition was somewhat precipitated due to the tight European timetable and a lack of foresight on the side of the Spanish legislator. It was further developed in the Reglamento de la Planificación Hidrológica (RPH), approved in 2007 and further more in the Instrucción de Planificación Hidrológica (IPH), which provides extra guidance by setting specific technical criteria, with the aim to homogenise the management plans across river basins (MARM, 2008). The IPH mandates the use of cost-effectiveness analysis for the PoM and prescribes that for each measure a cost-effectiveness index has to be calculated. The competent authorities for the implementation of the WFD are the so-called Confederaciones Hidrograficas, which in Spain hold the responsibility for water planning and river basin management.

In Spain, a great deal of effort and resources have been invested in the first phase of the implementation of the Directive, and it is fair to say that Spain is mid-ranked against other countries, between the forerunners (e.g. UK and Norway) and the less advanced (e.g. Italy and Greece; Balana et al., 2011).Water bodies have been mapped in geographical, social and economic terms, and the gaps between the actual and desired state of the water bodies have been identified. An enormous amount of information has been gathered in the process, providing a good overview of the river basins' conditions. However, there has been a significant delay on the preparation of the river basin management plans, failing to meet the 31 December 2009 deadline fixed in the WFD. The main reason for this, as stated by Gomez-Limon and Martin-Ortega (2011) is that water policy makers and water managers were unprepared for, and inexperienced with economic analysis, leading to difficulties and delays.

Cost-effectiveness analysis of water management practice and policy was not present in Spain previously to the WFD. Some preparatory work on CEA was made for the Cidacos River Basin for a series of irrigation measures, such as counselling and the implementation of good practices (Government of Navarra-MIMAN, 2002), as part of the WATECO (European Commission, 2003) guiding work at the European level. A CEA study also exists for the Jalón sub basin (Confederación Hidrográfica del Ebro-MARM, 2008). Some cost-effectiveness information has been put together by the Ministry of Environment in the form of Technical Guidelines for the Evaluation of Measures

(MARM, 2009a) and an Information System for Characterization of Measures for the CEA, SICMACE database (MARM, 2009b). But both sources of information are still rather incomplete and at early stages. Among the academic literature, we only find the study by Berbel et al. (2011) which examines the cost-effectiveness of the measures of the Draft Management Plan of the Guadalquivir river basin. This study investigates details of the different steps and challenges regarding CEA for water saving measures.

There is, therefore, very little information about how actually the cost-effectiveness analysis has been or is being incorporated in the Program of Measures, but we expect that significant methodological and practical implementation gaps are going to remain unresolved and this is what we discussed next on the basis of what is prescribed by the IPH. With regard to the definition of costs, the IPH prescribes the inclusion of investment and maintenance and operational costs of measures, but it says "economic, social and environmental costs, and indirect costs, may also be included when it is possible to monetize them". However, due to the lack of a more clear definition and the difficulty associated with the measurement of these other costs (particularly environmental costs), it is expectable that the Program of Measures will only include the direct financial costs. It has been argued (Jacobsen, 2007) that in the implementation of the WFD, the social costs are related to the cost recovery of water services and are not to be included in the CEA for the PoM. However, the way that cost-recovery is implemented, at least in Spain, does not include environmental and resource costs either (Gomez-Limon and Martin-Ortega, 2011). The consequence is that CEA in Spain is expected to be exclusively a financial (budgetary) type of CEA. This is for example the case in the Guadalquivir river basin, as studied by Berbel et al. (2011).

According to the IPH, the cost of the measure should be expressed as the equivalent annual cost, i.e. the annualised investment, plus maintenance and operational costs. It has been argued (Aulong et al., 2009), that using annualised unit costs favours large scale, high cost water measures, while using average incremental unit cost makes smaller and cheaper measures seem more attractive. A possible consequence of this approach is that, when tackling water scarcity, water demand saving measures could eventually be disfavoured to some extent face to infrastructure works.

Regarding effectiveness of measures, the IPH establishes that it has to be quantified through its impact on water bodies. In the event that no information is available about the impacts, the IPH also allows the change in pressure to be used. For example, with regard to water-saving measures to ensure an ecological flow, the preferred ratio would be "annual cost/change in flow" (e.g. euros/litres per second). If there is no information about the change in flow, the indicator "annual cost/m^3 of water consumption saved" may be used, as there is a functional relationship between pressure (water extracted) and impact (water flow in the river). Effectiveness of measures could be seen either from 'pressures' or 'impacts' point of view. This has important implications for the CEA because it can lead to different rankings of measures. The bias will be stronger for large interconnected river basins where return flows are very important, as is the case for the Guadalquivir explored in Berbel et al. (2011).

Another important related aspect in Southern European countries is the eventual impossibility of achieving the water saving reduction target by only using measures validated through the public participation process. For example, in the case of the Guadalquivir, Berbel et al. (2011) highlight that effect of the combined measures included in the draft River Basin Plan is not sufficient to achieve the GES. Authors suggest that to overcome the remaining gap 'drastic' measures, such as a reduction in the irrigated area of the region and the partial withdrawal of water rights over groundwater extraction would be needed. Nevertheless, these are highly costly measures both in economic and social terms that are unlikely to happen, leading to a delay or lowering of the environmental target (the Draft Guadalquivir Plan does prohibits the introduction of any new entrants to the river basin but no the withdrawal of existing rights, see Berbel et al. 2012). These measures would have an important social impact in the region.

Regarding the treatment of uncertainty in the estimation of both the costs and effectiveness, the IHP only makes reference to uncertainty as regards effectiveness and it prescribes, as a way of

addressing it, to include effectiveness "as a range of values". The Ministry for the Environment has addressed the issue by applying "optimistic", "realistic", and "pessimistic" scenarios to the cost and effectiveness calculations in its database of measures (MARM, 2009), but this information system is only in its early stages and still rather preliminary. Additionally, climate change is not expected to be taken into the uncertainty analysis in a significant way.

A final element regards the measures to be included as part of the CEA. The Spanish legislation states that CEA should not be applied to those measures that have to be introduced in any case to comply with other European legislation (a collection of 17 Directives). These measures will have to be included in the PoM, without being tested via CEA or public consultation[*]. This precludes a scrutiny of these measures with regard to both their costs and their effectiveness

4. DISCUSSION

In this section we discuss the comparison of the key features of the implementation of WFD and the related CEA in the two countries. As summarized in table 1 the major difference between the two countries emanates mainly from differences in the nature and type of water related problems they face. In the UK the main worry concerns water quality issues such as mitigation of diffuse water pollution, while in Spain the main focus of concern is on quantity issue i.e., on ways of matching the needs for environmental flow to achieve the GES with meeting great demands for water, and therefore, water saving measures are at top of the agenda (water quality is also present but it is dominated by water quantity issues). However, this is not the only factor. There exists significant difference in the level of experience that the two countries had prior to the WFD. Also, since the WFD entered into force in 2000, the UK has exerted significant efforts and preparatory works both at the policy level and the academic scientific level. Among the key progresses made in the UK in the implementation of WFD are: (1) the establishment of UKTAG in 2001, (2) WFD transposed into national laws 2003, (2) Collaborative Research Programme (CRP) on River Basin Management Planning Economics (water economics and CEA) 2004-2008, (3) huge number of WFD-related researches, including the CEA, were commissioned by Defra and the UK environment agencies (EA, SEPA, and NIEA), (4) Publication RBMP for all the 15 RBD in 2009. In this respect, the UK seems to appear at the forefront in the implementation of the WFD and its economic analyses, including the CEA, whereas Spain had, prior to the implementation of the WFD, limited experience in applying economic analysis in general and CEA in particular as a tool in water management planning. Despite very significant efforts and the mobilization of significant amount of resources for the implementation of the WFD, Spain exhibited a significant delay on the preparation of the River Basin Management Plans.

In the UK, the CEA approaches pursued are mainly of optimization modelling type, i.e. using variants of optimization techniques to combine model based effectiveness estimates of measures with estimates of the costs of measures. In Spain, there is still not clear evidence on how the methodological approach is being undertaken, since the large majority of the River Basin Plans have not yet been published. There is however room to believe that significant practical and methodological gaps are going to remain unresolved.

Regarding the definition and estimation of costs, the CEA that is expected to emerge in Spain is of financial (budgetary) nature, and environmental and resource costs, as well as other social and indirect costs are not expected to be included. In the UK full economic cost approach was proposed, but depending on the availability of data and the context of the proposed measures, cost estimates could be based on costs to the directly affected sector.

[*] In this line, Alcon et al. (2011) proposed that measures proven to be proportionate on themselves (i.e. benefits higher than costs) should be considered for inclusion in the PoM (for example, the use of reclaimed water in agriculture in the Segura river basin in south-eastern Spain).

Table 1. Comparative summary

Attributes	UK	Spain
Main management problem	Quality (diffuse pollution) is the key concern	Quantity (water scarcity) i.e., balancing demand and supply with the GES
Level of preparedness	High	Low
Type of costs	Full economic costs (direct costs, welfare losses to consumers, non-water environmental costs, induced effects to the wider economy, and transaction costs)	Financial aspect (annualised investment, plus maintenance and operational costs). Other costs considered in the legislation, but expected not to be accounted for
Costs units		Equivalent annual costs
Effectiveness estimates	Mainly focus on pressures reduced (e.g., Kg of P reduced to the water body); less emphasis on impacts	Both pressures (e.g. water saved in m^3) and impacts (e.g. change in flow in Euros/litres per second) contemplated in the legislation. Pressures expected to be more frequently addressed
Treatment of uncertainty	Range of values	Restricted to sensitivity analysis
Main type of measures included in CEA	Diffuse pollution measures (e.g. buffer strips) and point source measures	Water saving measures, including technical (e.g. modernization of irrigation systems) and economic measures (e.g. cost recovery)
Up to date level of progress	Major WFD milestones are all accomplished: WFD River Basins approved on time	Deadline for RBMP not met
Place at the European Context	Frontrunner	Mid-rank

Despite the differences discussed so far, the two countries share some common issues with regard to the implementation of WFD:

- The agricultural sector plays a key role in both countries: in the UK in emitting diffuse agricultural pollution (compromise quality), while in Spain as the major water consuming sector (compromise water availability and good ecological status).
- In both countries, it is expected that effectiveness would be measured mostly in terms of the reduction of pressures (e.g. phosphorous load in the case of diffuse pollution, and the reduction of abstraction), and not the reduction of the ecological impacts. These can be problematic since depending on the hydrology at the catchment level, there might not be a straightforward relationship between the reduction of the pressure and the related impact. In this sense, pressure driven CEA could lead to a significant different ranking and prioritization.
- Measurement challenges: Inaccuracy in the measurements of both the costs and effects is another important problem that both countries share, and we expect the same across Europe. This can be manifested by either under or over estimations that may arise due to, for instance, externalities, co-benefits, private vs. social considerations, and double counting problems.
- Some similarities can be found in the way of dealing with uncertainty. In the case of Spain, uncertainty is barely conceived as a sensitivity analysis, and there is still very little information on different cost and effectiveness estimates under different scenarios regarding uncertainty. In the UK, uncertainty in the estimates of costs and effectiveness is also incorporated with the help using range of value estimates (as opposed to single estimate).
- Human resources and organizational capacities are another key area of concern. As CEA involves measurements and estimations of both the biophysical and economic aspects of measures and also integrated modelling, it requires skilled manpower in the various related subjects. Significant progress in this respect still needs to be made in both countries.

5. CONCLUSIONS

In the UK a very significant amount of preparatory work for the implementation of CEA has taken place, which is reflected by a quite abundant literature. Spain was much less ready for undertaking the economic analysis required by the WFD, and this, together with other factors has lead to a significant delay in the preparation of river basin management plans and a very scarce literature on the implementation of CEA. This has lead to different levels of progress, with the UK as a front runner and Spain in a mid-rank position in the context of the other European countries.

Differences in the application regard the estimation of costs, the pre-WFD level of preparedness and the up-to-date progress. Similarities regard the focus on pressures for effectiveness estimation and the importance of the agricultural sector.

Key challenges remain ahead for the continuation of the implementation process of the WFD. Climate change is particularly relevant in this respect. Change on climatic conditions will impact greater uncertainties on the estimates of costs of measures and ecological responses of water bodies. Besides the economic-environmental trade-offs (particularly in agriculture) that the full implementation WFD is expected to impose, climate change entails a major challenge in the realization of the WFD objectives. Thus, it is essential that in addition to mitigation, appropriate and adequate adaptation measures to climate change should be an integral part of water management planning. In the spirit of the Common Implementation Strategy for the WFD guidance document (European Commission, 2003), future trends referring to climate change impacts should be assessed and incorporated in baseline scenarios. Utilizing a climate change scenario in conducting the CEA could reduce the uncertainty in cost and effectiveness estimates that stems from climate change. Incorporating climate change effects in cost-effectiveness studies implies a number of issues to be properly addressed. Scale is considered to be one of them. Climate change constitutes a global problem, but the kind and the intensity of the effects tend to vary at the regional, national or even local level. Hence, the scale at which climate change impacts are assessed is a significant issue to address in CEA studies. The "climate-proofing" character of the proposed water management measures should be investigated to ensure that the related measures support adaptation to climate change or at least do not run counter to it. Excluding climate change impacts in CEA may result in selecting packages of measures that are not viable or cost-effective over time. Also, the cost-effectiveness of options may vary according to the discount rate used, and this may be important particularly for longer-term options. The implication is that there are several issues to consider when climate change impacts are taken into account in the long-term water management planning in order for the most cost effective and viable package of measures to be selected and successfully implemented.

These and other challenges (e.g. improvement the incorporation of uncertainty in CEA modelling) can only be effectively addressed with inter-disciplinary and consultative science. Natural scientists and economists need work together for the development and implementation of operational frameworks in which hydrological responses and economic implications are solidly linked. At the same time, CEA and other economic analysis within the WFD need to be co-constructed with stakeholders to ensure that the research progress not only seats on policy-making needs but also is effectively incorporated in new planning phases.

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