# Selecting cost effective measures under the EU Water Framework Directive – The issue of scale

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## Abstract

The European Water Framework Directive (WFD) will prompt far-reaching changes and a fundamental reorientation of EU water management. This includes the attainment of specified environmental targets for all water bodies by 2015, whereby ecological aspects in particular, as well as economic considerations, must be taken into account in all decision-making processes affecting water management. One of the most demanding tasks is the selection of cost-effective measures to tackle various pressures on EU waters according to Article 11 of the Directive.

The first methodological ideas on how to proceed with the cost-effectiveness analysis have already been developed in a number of European Member States. Yet, important methodological challenges remain, in particular with regard to a scale adapted procedure. This paper takes up the current debate and develops ideas on how to address the problem of interlinking bottom-up and top-down approaches for the selection of cost-effective sets of measures under the WFD.

Keywords: Water Framework Directive, programmes of measures, cost-effectiveness analysis, bottom-up approach, top-down approach, scale of analysis, uncertainty.

## Introduction and Background

The EU Water Framework Directive (European Parliament and the Council, 2000) aims at achieving good ecological status of all Community water bodies by 2015. The Directive introduces a river basin management approach into European water policies, implying that water resources should be managed across national boundaries, choosing a co-ordinated and integrated approach within river catchment areas. Other aims of the Directive include promoting habitat protection, sustainable water use through incentive pricing and the implementation of the polluter-pays principle, public participation, a stepwise reduction of pollution caused by hazardous substances as well as the reduction of the effects of floods and droughts.

In order to reach the Water Framework Directive (WFD) environmental objectives, each Member State (MS) shall ensure the establishment for each river basin district (or for the part of an international river basin district within its territory) of a programme of measures by 2009. These programmes should help to bridge the current gaps in water status (i.e. bring all water bodies up to the level of "good status"). Article 11 of the Directive dictates that cost-effectiveness analyses (CEA) should be conducted to support the selection of measures in order to reach the Directive's objectives at minimum costs. Carrying out such CEA successfully calls for interdisciplinary work, an aspect inherent to the entire WFD implementation process. It requires close co-operation between economists conducting the

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CEA and technical experts who have to provide the relevant information about the effectiveness of measures to be tested and compared.

Due to the large variety of pressures and impacts on water bodies, a wide range of measures that must be applied at different levels (from local to river basin level) are under discussion within Member States. The types of measures that need to be considered within the CEA will include those that a community is able to implement on its own, that require changes in or new legislation, or that can only be implemented on a voluntary basis e.g. by farmers and industry (RBA, 2004). The currently ongoing discussion across the EU, as well as the WFD Article 5 reports submitted in March 2005 (Herbke et al., 2005), reveal that the knowledge on cost- effectiveness of measures and their combinations varies greatly.

Further, as the first methodological ideas on how to proceed with the CEA have been developed in a number of European Member States,[3] an important methodological challenge remains: The issue of scale. Indeed the existing variety of measures affects different levels of scale: a waste water treatment plan, for instance, acts on the local level, whereas taxes will have an impact on the river basin level. As a result, the development of a CEA will need to take this gap between local scale (bottom-up) and river basin level (top-down) approaches into account. This paper takes up the current debate and develops ideas on how to address the problem of interlinking bottom-up and top-down approaches for the selection of cost-effective sets of measures under the WFD.

## Cost-effective programmes of measures as the central planning tool

Programmes of measures, which must be applied at the river basin district level, constitute the central planning tool for reaching the aims of the WFD. Article 11 WFD distinguishes between basic measures (minimum requirements to be complied with), and supplementary measures. **Basic measures** consist *inter alia* of those measures required to establish discharge controls based on the so-called combined approach[4] (as set out in Article 10 WFD) and to implement Community legislation for the protection of water, including the list of environmental directives specified in part A of Annex VI (e.g. Nitrates Directive, Urban Wastewater Treatment Directive).

If the basic measures are not sufficient to achieve the environmental objectives, **supplementary measures** shall be implemented. The Directive provides a non-exclusive list of such measures in part B of Annex IV. However, MS are invited to adopt further supplementary measures with the aim of additionally protecting and improving the waters.

For the purpose of this paper, 'measures' within the meaning of Article 11 of the WFD are subdivided into technical measures and instruments: '*Technical Measures'* include concrete technical precautions with local effects (such as a wastewater treatment plant or a constructed wetland), while *'instruments'* are of an administrative, economic or informative nature and serve to support the implementation of measures by creating incentives for relevant actors to change their behaviour . Instruments tend to have a more long-term and

[3] See e.g. Methodological approach ('handbook') developed for the German context (Interwies et al., 2004), or for a scoping study developed for the UK context on behalf of the Department for Environment, Food and Rural Affairs (Defra), the Welsh Assembly Government (WAG), the Scottish Executive (SE), and the Department of the Environment in Northern Ireland (DOENI) (RPA, 2004).A methodological handbook was also developed in the Netherlands (MVW, 2005).

[4] This means that all discharges into surface waters are controlled through the setting of emissions controls based on Best Available Techniques or relevant emission limit values and of environmental quality objectives and standards.

widespread effect than measures, and necessitate co-ordination at a higher administrative level.

In the process of selecting programmes of measures, the cost-effectiveness of competing alternatives (technical measure X vs. technical measure Y, technical measure vs. instrument, instrument X vs. instrument Y ) should be considered. These considerations render a complex assessment of the different combinations of measures necessary, including both 'traditional' (constructing) as well as 'innovative' (e.g. renaturation of wetlands) measures.

Generally speaking, economic analyses are common practice in water management. However, the WFD introduces a new approach: rather than an assessment of single measures, the cost-effectiveness of their (potential) combinations should be tested. In addition, the effectiveness of different measures is no longer analysed for individual parameters (such as P or N), but instead for an entire set of parameters, which together constitute good ecological status. As a consequence, the development of appropriate programmes of measures becomes a highly complex issue that requires considering the various interactions between different factors influencing a water body.

## Cost-effectiveness analyses (CEA) and the appropriate scale of analysis

Cost-effectiveness analyses (CEA) are an economic tool to identify the option that reaches a certain pre-defined target (i.e. in this case the Directive's environmental objectives) at least in terms of cost. To this end, a ratio that indicates the costs of achieving a per unit change for a specified physical outcome is developed and compared with competing alternatives (RPA, 2004). It is not part of a CEA to investigate whether the pre-specified target that should be reached at minimum cost is justified in itself (i.e. the 'good status').[5]

The WFD demands that good ecological status be established within each water body as well as within the entire river basin. Accordingly, both levels – the level of a single water body and the level of the river basin – have to be considered when developing sets of measures. Due to several interlinkages and interdependencies it can not be assumed that if the first e.g. three water bodies are at good status, the fourth water body will reach the good status even if there are no additional pressures on it.[6] A more holistic approach is needed, which takes account of the various effects influencing water quality, in order to reach the goal of the WFD at river basin level.

Accordingly, CEA will have to be conducted for a broad range of measures ranging from single technical measures to instruments and their combinations. While the WFD does not clearly specify the scale (water body level or river basin level) at which such an exercise should be carried out, the WATECO Guidance Document[7] relates the CEA to the river basin level.

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[5] Such a justification test would entail a comparison of the social benefits derived from meeting the pre-specified target and the costs associated with doing so.

[6] For example: Due to the fact that along the pathway from a river source to within a larger water body, discarded substances are influenced by manifold processes of transformation, retention or loss, it is not sufficient to consider only a single water body and to extrapolate from it to the entire river basin.

[7] The task of the "WATer ECOnomics" working group was to clarify the understanding of the requirements for the WFD economic analysis due by the end 2004 (Article 5, Annex III). The group published a non-binding practical guidance document endorsed by the Water Directors in 2002.

From the current methodological debate on the selection of the most cost-effective combinations of measures, two broad categories of approaches seem to be developing in response to the above mentioned challenges (Pielen, et al., 2005):

- **Bottom-up approaches** focus on the technical specifications of measures at a very local scale (e.g. water body) and contain detailed information on the exact techniques applied, but mostly neglect the wider economic costs associated with these techniques.
- **Top-down approaches** concentrate instead on the wider impact of instruments (e.g. taxes) on areas larger than the individual water bodies or group of water bodies (e.g. basin / sub-basin), often without investigating their exact technical specifications.

Both approaches need to be interlinked and both, when applied, have their individual shortcomings. By using the bottom-up approach, the effects of instruments selected cannot be calculated precisely because of their river basin district wide effects. Furthermore, when extrapolating the data from a single water body to the river basin district level, interactions between measures selected for different single water bodies cannot always be taken into account adequately.[8] When using a top-down approach, the area covered includes a large number of water bodies, making it nearly impossible to estimate precisely the effects of a selected instrument on a specific water body. While the basis for decision-making may in many cases nevertheless be sufficient, this lack of precision may result in the need for additional (technical) measures in each single water body in order to reach 'good status'. However, this might potentially lead to higher overall costs within the entire river basin.

Due to these shortcomings and the variety of existing pressures and impacts, it can be expected that Member States will have to apply both approaches at the same time in order to fulfill WFD objectives (Pielen, et al., 2005). Even though some Member States are currently working on the combination of both approaches there is so far no practically applicable methodology known to the authors. Additional work has to be conducted to link these approaches and to develop an appropriate combination of approaches especially under the requirement of achieving cost-effective solutions (Dworak, under preparation).

## Selecting cost effective measures: Linking bottom-up and top-down approaches

In order to overcome the above mentioned shortcomings, a connecting element linking both approaches has to be developed, which aids the decision-making process for the CEA on the appropriate scale. The following proposed methodology is a first attempt to develop such a linking element considering the interactions between technical measures and instruments. Although this is a rather theoretical approach, still leaving several questions open (e.g. detailed rules for calculating costs of measures),it provides a first idea of how bottom-up and top-down approaches might be linked. Figure 1 provides a graphical presentation of the methodology, consisting of three main steps. The individual steps will be described in more detail in the following sections.

[8] The positive or negative effects of a measure which are external to the water body under investigation but internal to the entire river basin may not be considered adequately. For their measurement, the concept of avoided costs may be applied.

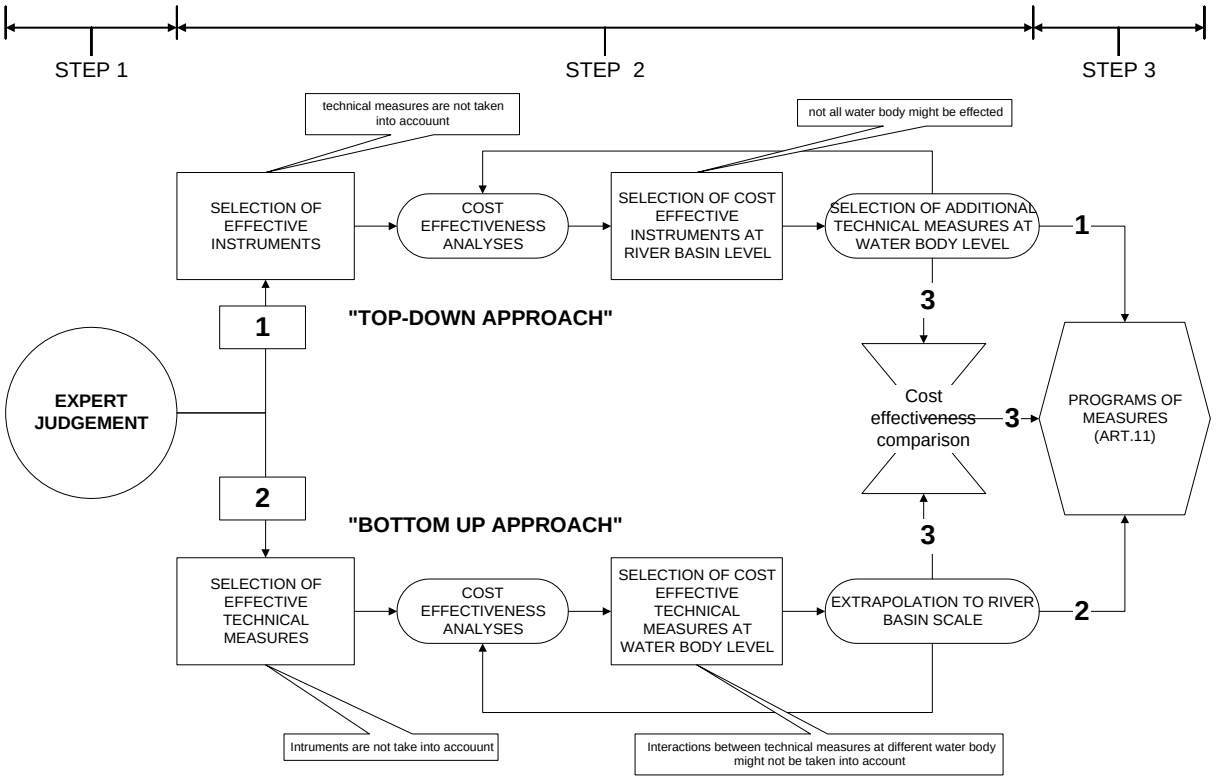


**Figure 1: Methodology for a CEA linking bottom-up and top-down approaches**

### Step I: Selection of the appropriate approach for the CEA,

Bearing in mind the results of the impacts and pressures assessment under Article 5 WFD as well as the goal to achieve a cost-effective solution on a river basin level, expert judgement should serve as a first classification tool for the appropriateness of either a top-down approach (path 1), a bottom-up approach (path 2) or a combination of both approaches (see Figure 1). It can be expected that only in a few cases across the EU, the application of either the top-down or the bottom-up approach will lead to a cost-effective solution (Pielen, et al., 2005). In most cases, a combination of both approaches will be appropriate. In such cases, both paths should be followed.

### Step II: Calculation of the most cost effective technical combination of measures/instruments

Based on step I, a CEA for the combination of pre-selected technical measures (path 2) and instruments (path 1) has to be carried out.[9] As there is a wide variety of measures and instruments, expert judgement in combination with "catalogues of measures/instruments"[10] can be used as a starting point for pre-selecting measures/instruments. Such a pre-selection of theoretically relevant individual measures may be derived from the list of possibly

[9] A more detailed description of step II can be found in Dworak, under preparation.

[10] Such "catalogues of measures/instruments" could provide a list of possible measures/instruments and their related key data on e.g. costs, effectiveness, expectance. Depending on the local conditions a first pre-selection can be made limiting the number of measures/instruments to be considered in a CEA. If such catalogues of measures are not available a CEA has to be calculated for each individual measure.

interesting types of measures. Non-effective or too costly measures could be sorted out from the beginning in order to reduce the possible options for carrying out a CEA.

As a next sub-step the remaining technical measures/instruments have now to be combined with the results of the impacts and pressures analyse[11]. Depending on the path chosen this might require:

- for the top-down approach: the selected instrument might have to be complemented by water body specific technical measures where appropriate.[12]
- for the bottom-up approach: the effects of the selected measures have to be extrapolated to the river basin level, taking into account effects of interaction.[13] Furthermore, the administrative costs of instruments used for putting technical measures into place have to be considered.

Independently of the approach chosen, the complementation or extrapolation process might lead to changes in the ranking of the cost-effectiveness of possible combinations of measures and instruments respectively might result due to. For example, an instrument that seemed to be most cost-effective at first might become more costly through the need for a large number of additional cost intensive measures at the water body level. On the other hand, several single technical measures that seem to be cost efficient for a certain pollutant might be less appropriate due to the interrelations with other measures tackling mainly other pressures.[14] Such risks can be minimised by establishing feedback loops. In both cases, extensive modelling and/or expert judgement at the water body level as well as on the river basin scale may be necessary.

In the case where the expert judgement under step I clearly decided in favour of either the top-down (path 1) or bottom-up approach (path 2), the results gained can directly feed into step III,. As stated before, the need to use a combination of both approaches is expected in most river basin districts. Indeed, cost-effectiveness comparisons (path 3) between the results obtained through the top-down and the bottom-up approach are needed.

When making such comparisons, not only the costs but also the effects should be measured against each other, and this may necessitate a Cost Benefit Analyses (CBA)[15]. The following points have to be considered:

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[11] If the pre-selection of measures/instruments was based on expert judgement, for the remaining individual technical measures/ instruments a CEA has to be calculated now.

[12] The selection of the cost-effective combination of instruments and additional technical measures under the top-down approach is a difficult task as different combinations of measures and instruments have to be considered. For example: as a result of the top-down approach, the most cost-effective measure (resulting in e.g. 20 Euro per kg nitrogen reduced) is the introduction of a nitrogen tax with a threshold value of 120 kg/ha. The bottom-up approach, however, suggests a combination of specific farming techniques (i.e. changes in fertilisation and crop rotation) that might be the most cost-effective combination (e.g. 25 Euro/kg N reduced). By simply comparing the results from the bottom-up and top-down approaches, the top-down approach would be favoured. As a result of mixing both approaches, a third solution (e.g. N-tax with a threshold of 140 kg/ha plus changes in crop rotation) might be the most cost-effective one (resulting in e.g. 12 Euro/kg N reduced). Modelling might support this exercise.

[13] A more detailed description of this problem within the “bottom-up approach” can be found in the Dutch handbook for selecting cost effective measures (Ministerie van Verkeer en Waterstaat, 2005).

[14] Measures aiming at hydro-morphological pressures might also reduce nutrient pollution.

[15] While the CEA is used to select the most cost-effective combination of measures, a CBA may help subsequently assess its broader social consequences (i.e. the monetary and non-monetary effects).

- A common cost framework (i.e. which cost will be considered) including a clear definition of the direct and indirect costs of a technical measure or instrument should be defined. The same applies to the associated benefits.
- Subsidies should not be taken into account.
- The area of investigation covered should be the same.
- Annual base rates should be calculated in order to make the different depreciation rates of measures comparable.

**Step III: Development of Programmes of measures**

The results of step II provide the input for the **Programmes of measures**. To achieve a successful implementation of these programmes, co-ordination at two levels is needed within international river basin districts (Startenwerth, 2002):

1 At **sub-basin level**:

   a) Co-ordination within a sub-basin: This is especially necessary when developing solutions for "hot spots" (e.g. local pollution through industry) which cannot be appropriately regulated by instruments applied for the entire river basin district (e.g. emission regulation).

   b) Co-ordination between sub-basins: In the case of larger sub-basins, a co-ordinated approach between the different responsible authorities is needed to decide jointly on the measures to be taken. This might be especially relevant in the case of diffuse pollution, where the pollution is discharged from a wider area (e.g. agricultural land) and instruments at the river basin level might not be appropriate (e.g. N-taxes).

2 At **river basin district level**: the environmental objectives and the way of implementing the WFD has to be co-ordinated and agreed upon among the stakeholders involved. This process might be very difficult because of the different political interests and priorities set by the individual Member States (such as different water uses, different pricing policies) as well as possible different interpretations of the WFD. Standards and general rules should therefore be set at this level to establish a harmonised approach along the different sub-basins within a river basin district.

Even if this co-ordination (as well as co-operation) will help solve several practical implementation problems, some issues still have to be faced:

- If different (national) approaches are used for selecting cost-effective combinations of measures, they may not be compatible with one another and will thus increase the difficulty in extrapolating the related effects to the river basin level.
- It will be politically difficult to establish the same instrument in the same way within an entire international river basin district, even if the chosen instrument offers the most cost-effective solution. Instead, technical measures at water body level seem to be more feasible to implement and therefore preferred despite the better knowledge available on the CEA.

## Uncertainties related to the CEA

When discussing potential approaches towards measure selection, the uncertainty inherent in the CEA methodology should not be ignored. For example, with respect to the expected effectiveness of measures, uncertainties can be related to the length of time measures will require before their desired effects take place, and the precision with which the costs of measures can be estimated.

### Uncertainties related to the effectiveness of WFD measures

In order to choose between different measures, their effectiveness needs to be assessed. In some cases, straightforward and easily measurable indicators will be available (e.g. the reduction rate of a wastewater treatment plant). In other cases, however, the effectiveness of measures will be more difficult to assess (e.g. changes in fertilisation procedures). This is particularly true for “soft” measures such as advisory systems and training activities. Uncertainty in terms of effectiveness adds further complexity to the process of selecting cost-effective sets of measures. Nevertheless, regarding measures’ effectiveness, the considerable knowledge of technical experts can be drawn on in most Member States.

### Uncertainties related to costs

Particular uncertainties may also relate to the costs involved in the implementation of measures, or even more importantly, for the implementation and administration of instruments. In the absence of exact criteria for the environmental objectives, “distance to target” and thereby the required investments cannot be assessed with certainty. Further difficulties relate to the differentiation between WFD-related costs and other water management expenses. The costs for the application and enforcement of other Community legislation for the protection of water (e.g. Nitrates Directive) cannot be simply added to the costs of implementing the WFD. In the end, it is not always possible to distinguish between the water management costs incurred by the implementation of the WFD, and the costs which would have been incurred in the absence of the WFD.

### Uncertainties related to the overall methodology

The WFD consists of several cycles and there is no doubt that many of the uncertainties related to the implementation of the first cycle (2009 –2015) will become less important in the future. The cyclic approach of the Directive opens up opportunity to clarify gaps and develop methodologies for closing these gaps further.

Even if all uncertainties and shortcoming related to the CEA are minimised in the future, the uncertainty of the acceptability of measures for the stakeholders and the general public will remain. The bottom-up and the top-down approach affect people in a river basin in different ways. When carrying out cost-effectiveness estimates, it should be noted that significant difficulties can be related to the quantification process, e.g. regarding the assessment of the cost-effectiveness of information / education programmes for farmers etc. The reason for this is that the form of those measures and thus the related costs are, to a large extent, specific to the target group involved, i.e. to their decision behaviour (e.g. the extent to which the information offered is taken in and actually changes behaviour). When estimating these parameters, there is the fundamental problem that forecasts of human behaviour are by definition uncertain. In addition, the effectiveness depends to a large extent on a careful optimisation of the measures, so that reliable estimations of the cost-effectiveness of measures can only be derived after the measure has actually been implemented and initial results are available. Indications for the concrete assessment of these parameters can only

be reasonably obtained on the basis of extensive pilot projects and their systematic evaluation (Böhm, et al., 2002).

The legislative framework established by the WFD provides several approaches for implementing the Directive's requirements. An important element is the public participation approach under Article 14 WFD. The underlying assumption of all these approaches is that river basin management planning is too complex to be managed without the involvement of all those holding a stake in the matter. At the same time, collaborative management of natural resources will facilitate a common learning process through a better understanding of the issues at stake and the pool of possible solutions, which can eventually also lead to enhanced management capacities for decision-makers and stakeholders alike. A careful and transparent selection of stakeholders is necessary at the beginning of the process in order to overcome several possible uncertainties mentioned above.

## Summary and conclusion

The WFD will prompt far-reaching changes and a fundamental reorientation of EU water management. This includes the attainment of specified environmental targets for all water bodies by 2015, whereby economic considerations must also be taken into account in all decision-making processes affecting water management. One of the most demanding tasks is the selection of the most cost-effective combination of measures to tackle various pressures on EU waters.

While economic analyses for some of the single measures are common practice in water management, the required cost-effective analysis of (potential) combinations of measures is rather new. In addition, the effectiveness of different measures is no longer analysed for individual parameters only (such as P or N), but instead for an entire set of parameters, which together constitute good ecological status. As a consequence, the development of appropriate programmes of measures becomes a highly complex issue that requires taking into account various interactions between different factors influencing a water body. Finally, efficiency of measures is not only required at the local level, but rather on the scale of the river sub-basin or river basin district.

This has lead to new methodological questions such as the interlinkage of bottom-up and top-down approaches. Both approaches have their individual shortcomings. In the case of the top-down approach, not all water bodies might be sufficiently affected by the instrument(s), or undesirable side-effects may result. In case of a bottom-up approach, where the appropriate measures, or combination thereof, are selected for the different water bodies and extrapolated to the river basin scale, it should be noted that complex interactions between different water bodies might not be adequately taken into account.

In order to overcome these shortcomings and to bridge the gaps between both approaches, this paper presented first ideas for the further selection of cost-effective measures. The three-step approach that is suggested tries to use the benefits of both approaches to establish a bridge between cost-effective (technical) measures at the local scale (water body) and cost-effective instruments at the river basin scale. The proposed three-step approach can only be regarded as a small advancement on present practice as it is still on a very general level and includes various uncertainties and shortcomings.

Further effort must also be spent on the development of a methodology on cost-effectiveness comparison, which is needed to compare results obtained through bottom-up and top-down approaches. In addition to the development of a common framework, more effort has to be

expended on the interactions between technical measures/instruments, but also between the single measures under the bottom-up approach. In this regard, modelling will play a central role.

Finally, with regard to the above mentioned uncertainties, the establishment of case studies for testing the proposed methodology on a small scale will be needed.

## Bibliography


Böhm, E.; Hillenbrand, T.; Liebert, J.; Schleich, J.; Walz, R. (2002): Kosten-Wirksamkeitsanalyse von nachhaltigen Maßnahmen im Gewässerschutz – Kurzfassung, UBA Texte 12/02, Forschungsbericht 299 21 289, UBA-FB 000221, Fraunhofer-Institut für Systemtechnik und Innovationsforschung, Karlsruhe

Dworak, T. (under preparation): Assessment of measures to reduce water pollution under the terms of the Water Framework Directive with respect to nutrients. PhD Study, Institute of Sanitary Engineering and Water Pollution Control, University of Natural Resources and Applied Life Sciences, Vienna.

European Parliament and of the Council (2000): Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22/12/2000, p. 1.

Herbke, N., Dworak, T.; Karaczun, Z. (2005): WFD and Agriculture – Linkages at the EU Level, Pressures and Impacts, Broaden the Problem's Scope. Background Paper, Version 3, 12 Oct. 2005.

Interwies, E., Borchardt, D., Kraemer, R.A., Kranz, N., Görlach, B., Richter, S., Willecke, J., Dworak, T. (2004): Basic principles for selecting the most cost-effective combinations of measures for inclusion in the programme of measures as described in Article 11 of the Water Framework Directive. Berlin: Ecologic, Institute of Water Resources Research and Management at the University of Kassel.

Ministerie van Verkeer en Waterstaat (2005): In pursuit of optimal measure packages – Dutch Handbook on cost-effectiveness analyses for the EU Water Framework Directive.

Pielen, B.; Görlach, B.; Holländer, R. (2005): Results of the Workshop on the implementation of economic aspects of the Water Framework Directive - Future challenges in the Elbe river basin, July 7-8, 2005.

RPA, Risk & Policy Analysts Limited (2004): CEA and Developing a Methodology for Assessing Disproportionate Costs, Final Report for Department for Environment, Food and Rural Affairs (Defra), the Welsh Assembly Government (WAG), the Scottish Executive (SE), and the Department of the Environment in Northern Ireland (DOENI).

Stratenwerth, T. (2002): "Die Bewirtschaftung nationaler und internationale Flussgebiete", in Keitz, S. von; M. Schmalholz (eds.): Handbuch der EU-Wasserrahmenrichtlinie - Inhalte, Neuerungen und Anregungen für die nationale Umsetzung. Berlin: Erich Schmidt Verlag. p. 323-342.