UNDP-GEF Black Sea Ecosystem Recovery Project (PIMS 3065)

Cost Effective Measures to Minimise Nutrient Pollution

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Final Report on Tasks 4

Comparison of results- guidelines on how to select the most cost effective measures

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Table of contents

1 Introduction and objectives

The Black Sea covers 423,000 km2, at its deepest point is over 2 km deep and drains an area approaching 2 million km2 (about one-third of continental Europe); containing in excess of 160 million inhabitants. Every year, some 250-380 km3 of freshwater flows into the Black/Azov Sea system, approximately 55-60% of which is from the Danube. The Danube River is 2,870 km long and drains an area of just over 800,000 km2, including land in 19 countries with a combined population of about 82 million people. Further important rivers discharching into the western part of the Black Sea are the Dniester and Dnipro.

Beginning in the 1970s and continuing through to the early 1990s, nutrient-enrichment of the Black Sea resulted in oxygen depletion of being stripped out of the water column, causing mass mortalities of animal life within huge areas of the NW Shelf. The most significant process degrading the Black Sea has been massive nutrient enrichment largely from of agricultural, domestic and industrial sources. The loss of wetland habitat that once acted as a filter contributed to the problem. This reached a peak in 1990 when some 40,000 km2 of the NW Shelf bed was effectively considered to be dead (EEA, 2001). Nutrient-enrichment/eutrophication was identified as a major transboundary problem in both the first (1996) Black Sea Transboundary Diagnostic Analysis and the recent (2007) updated version BSERP et al (2007).

In the beginning-1990s, the economic collapse that signalled the end of the Soviet era had already occurred. As a result the nutrient load from agriculture decreased due to tremendous reduction in livestock density and fertiliser use.

So between 1988 and 1997 the amount of livestock numbers (excluding poultry) in coastal countries were reduced by about one third, and over the next 6 years by another third

Table 1: Dynamics of livestock numbers in the six Black Sea coastal country sub-basins [in millions] BSERP et al (2007):

	1960	**1970**	**1988**	**1997**	**2003**
Cattle	47.8	56.2	65.6	35.3	23.4
Pigs	27.0	31.4	40.3	20.6	15.2
Sheep & goats	46.7	46.2	47.1	22.3	15.4
Poultry	207.7	262.0	452.4	290.6	356.5

Similarly dramatic changes are also reported with regard to the use of inorganic fertilisers in arable farming (BSERP et al, 2007)

Further measurable improvements have been observed in the Danube and Black Sea ecosystems over the last decade due to several aid programs set up by the EU, GEF, World bank. However this decrease can not be expected to last any further as the countries discharging directly or indirectly are currently facing a period of economic improvement that might also bring new environmental pressures[1]. In recent years, economic development in the region has been relatively encouraging. The picture is especially positive with regard to Bulgaria, Romania, and Turkey. These three countries are not only economic leaders in the

[1] Interim Progress Report on the Danube – Black Sea Strategic Partnership

Black Sea region, but also among the fastest growing economies. Following severe economic crises in the late 1990s and early 2000s, each country has conducted intense structural reforms resulting in rapid economic development and political stability but also increasing the pressure on the environment (CSIS, n.y.).

The economic situation of the countries in transition is often used to excuse for not fully responding to the needs for environmental protection and to implement pollution control measures. So there is a large concern that nutrient pollution in the Black Sea is likely to increase.

In this context the main focus of future activities should not only be on the further reduction of nutrients. Policy action should also include measures that ensure that with the further economic growth environmental pressures are not increased and the overall situation is worsening; reaching pollution levels of the seventies or beyond.

1.1 Aim of this report

This third report has been prepared with the key objective to introduce national Black Sea policymakers to basic cost-effective approaches to nutrient pollution reduction. While the first report presents an “ideal” methodology for assessing cost effectiveness of various measures and the second report includes three case studies (agriculture, waste water and industry) this third part aims to summarize the findings of the pervious study parts (report on the methodology to calculate cost effectiveness in the agricultural, industry and waste water sector and report on case studies). It should be noted that the recommendations made in this report are related to large uncertainties concerned with costs and effectiveness of agricultural measures, and the fact that industry is only represented by a very specific sub-sector (fertiliser industry). However the recommendations made can be used on a strategic level. For the local and regional level it is strongly recommended to carry out a more detailed assessment in order to develop appropriate programs of measures.

Finally, this report should also guide readers to the types of information that are required at national level for policy development.

1.2 Limitations of the study

Ideally, when calculating cost-effectiveness of nutrient reductions measures information on the relation of nutrient loads and the ecological status of the receiving water exists. Unfortunately, this information could not be compiled within the given resources of this project. So no general recommendation in the “best set of measures” to tackle nutrient pollution in the Black Sea countries can be given. To do so improved modelling tacking account of the manifold processes of transformation, retention and loss [2]and a sound database would be necessary.

A further limitation of the study is that we estimate only the costs which occur at the sectors

[2] The amount of nutrient transfer to water bodies is dependent upon the nutrient surplus of an area and a range of factors such as rainfall, soil type, topography and drainage density. For example in cases of high intensity rainfall, on poorly drained soils such as e.g. clays water is less able to infiltrate. This leads to high volumes of surface runoff that can readily wash soluble and particulate (that attached to soil) nutrients over the land surface to water bodies. In contrast, low intensity rainfall, falling on well drained soils such as e.g. sands promotes the infiltration of water and nutrients into the soil. Once in the soil horizons, a number of processes (asides from plant uptake) can act to attenuate further nutrient transport including adsorption to soil particles, denitrification and immobilisation. However, a substantial proportion of the surplus will continue to be leached, in soluble form, downwards either to groundwater or to surface water via subsurface flows.

directly involved in the nutrient-reduction programs, i.e. dispersion effects on other sectors of the economy and transaction costs associated with the implementation of cost-effective programs are excluded. Further environmental benefits, such as decreases in airborne nitrogen depositions are not included in this study.

Another important issue to be mentioned is that the study only covered the fertiliser industry which represents only a sub-sector (even if it is an important one) and not industry fully. In the urban waste water sector only “classical” approaches where assessed. More modern approaches such as constructed wetlands have not been considered. With regard to agriculture no detailed cost effectiveness ratios can be provided due to lack of data (see next section).

So this study shall therefore be regarded as a first step towards a more comprehensive analysis of cost-effective programs.

1.3 Existing data gaps

When compiling this study some data gaps where recognised which result in limitations of the outcomes. In order to close these gaps and to achieve better results in a potential follow up study these gaps are listed here:

- For the municipal waste water treatment the accessibility of data for the whole region is difficult. It recommended setting up a database for the Black Sea Region which collects standardised data in a systematic way. The data collected should include types of treatment but also costs.
- As industry in several Black Sea countries are not participating in the ICPDR or similar emission inventory it is difficult to estimate the total loads coming from this sector. In order to collect more reliable data the participation in such an inventory should become mandatory. Further, information on the application on BAT on the level of individual undertakings is mostly not public accessible. This hinders detailed calculations.
- For agriculture the data gaps can be found related to economic information including costs of labour, investment costs, existing subsidies but also to effectiveness of a measure (see also section 4).

However it should be noted, that these gaps have been identified when assessing information that was published in English. It might be the case that more detailed information is available in the national languages.

2 Main results from the case studies

In the following the main results from the sector case studies are summarised (see Report on Tasks 1b/2b/3b -Case study on calculating cost-effective measures to tackle nutrient pollution from the agricultural, municipal and industrial sectors in the Black Sea). Details on the overall methodology on calculating cost effectiveness of measures and the data needs to do so are outlined in the report Methodology for selecting cost-effective measures to tackle nutrient pollution from the agricultural, municipal and industrial sectors in the Black Sea (Tasks 1a/2a/3a).

Nutrient discharges from three sectors have been investigated to identify the relevance of nutrient discharges to the surface waters from each of the sectors and to evaluate potential measures, which are capable to reduce nutrient emissions either from diffuse (Agriculture) or point sources (Urban waste water treatment, industry, agriculture).

2.1 Municipal waste water treatment

Emissions from municipal waste water management significantly contribute to the total nutrient emissions in the Danube Basin. For phosphorus this sector is the one with the highest emissions, while in respect to nitrogen it is the second largest behind agriculture (Schreiber et al., 2003). It can be assumed that the situation is similar in the rest of the Black Sea catchment area. Thus, focusing on municipal waste water management is of high importance in regard to Black Sea nutrient pollution.

The requirements on municipal waste water management are manifold. Sewer systems are mainly built to increase life standards and hygienic safety in settlements by secure and continuous transport of waste water out of the settlements. In addition sewer development and maintenance contribute to the protection of local groundwater systems. In respect to nutrient discharges to river systems and the Black Sea sewer development leads to increased emissions, if the collected waster water is not treated properly including nitrogen and phosphorus removal (daNUbs, 2005). The main demand on municipal waste water treatment is the protection of local receiving waters by elimination of particulate matter and biodegradable organic compounds out of the waste water. An improved treatment by including nitrification into the treatment process as well is dedicated to improved ambient water quality protection. Nutrient removal in treatment plants designed for (organic) carbon removal with or without nitrification is a side effect of this treatment process and amounts to about 20 – 40 % of the influent loads to the treatment plant for nitrogen and about 40 % for phosphorus. If higher elimination rates are required specific upgrades for treatment have to be implemented (nitrificatation/denitrification and phosphorus precipitation or advanced biological phosphorus removal). Conventional municipal waste water treatment with nitrogen and phosphorus removal have elimination rates related to the inflow of 70 – 80 % for nitrogen and 80 – 90 % for phosphorus. Higher elimination rates may be achieved by advanced treatment steps (e.g. external carbon sources for denitrification, advanced flocculation-filtration for P-removal).

The highest cost in respect to municipal waste water management is due to sewer construction. Sewer construction leads to increasing nutrient emissions to the surface water system. Thus, cost-effectiveness of sewer construction for nutrient emission reduction is negative. This is no wonder because nutrient emission reduction is not the focus of sewer development.

Strictly speaking cost-effectiveness for nutrient removal by municipal waste water treatment can only be calculated by assuming costs directly dedicated to measures for nutrient removal in relation to the improvement of nutrient removal by these measures (e.g. difference of costs between a plant including nitrification/denitrification and costs of a plant for carbon removal only in relation to the improvement of nitrogen removal). At Austrian cost levels the cost-effectivness for nitrogen removal with nitrification/denitrification instead of carbon removal only is 1,1 €/kg N and 1,9 €/kgN for treatment plants with > 100,000 pe design capacity and with < 50,000 pe design capacity, respectively. In the Ukraine the cost level for construction, operation and maintenance of treatment plants is about 25 – 30 % lower than in Austria. Thus, cost-effectiveness improves to 0,8 €/kgN and 1,4 €/kgN, respectively. Other considered countries (Bulgaria, Czech Republic, Hungary, Romania, Slovakia, Slovenia and Turkey) lie in between. The cost-effectiveness of nitrogen removal by nitrification/denitrification as compared to plants with nitrification (in cases where nitrification is required for ambient water quality protection) is about 0.35 €/kgN as an average value for all plant sizes at Austrian cost levels. For calculation of the cost-effectiveness of phosphorus removal costs and removal rates of plants with and without phosphorus precipitation are compared to each other. Cost for P-removal are about 4,3 €/kg P independently of the plant size at Austrian cost levels and about 3.7 €/kgP at Ukrainian cost levels. Results of other considered countries are close to values of Ukraine.

Altogether, for nitrogen there are higher differences in respect to cost-effectiveness with improving cost-effectiveness from smaller to bigger treatment plants and from countries with lower cost levels to countries with higher cost levels. For phosphorus differences in cost-effectiveness are small (< 15 %).

The best exploitation of expenditures in waste water treatment in respect to nutrient removal can be achieved if treatment plants are designed and operated for nutrient removal. The relation between total expenditures and removal rates is the best for treatment plants including nutrient removal up to 70 – 80 % for nitrogen and 80 – 90 % for phosphorus.

Advanced nitrogen removal up to 90% can be achieved at treatment plants without primary sedimentation tank simply by increasing the aeration tank volume. The cost-effectiveness is in the same order of magnitude as for removal rates up to 70 – 80 %. This treatment design usually is only used for plants < 50,000 pe. Bigger plants usually are operated with primary sedimentation tank and external anaerobic sludge stabilisation (usage of biogas). For these plants nitrogen elimination rates may by improved up to > 90 % by addition of external carbon sources. The cost-effectiveness for these additional measures is in the range of 5.2 – 12.9 €/kg N removed. If phosphorus removal shall be improved to 95 % and more (effluent concentrations of 0.1 to 0.2 mg TP/l) this may be achieved by post flocculation and filtration. Cost-effectiveness of these additional measures is rather poor. Cost are in the range of 65 – 167 €/kg P removed additionally.

2.2 Industry

Nutrient emissions from industrial sources in selected Danube countries (Austria, Hungary, Romania and Bulgaria) have been evaluated based on information from the ICPDR emission inventory 2002 (http://danubis.icpdr.org), which compiles emissions from major industrial facilities on the national level. For the respective countries the total nitrogen and phosphorus emissions from industrial facilities on national level ranged between 5-14% and 1-5%, respectively of the total point source emissions at the national level. In turn total point source emissions of TN and TP in turn cause between 19-35% and 28-43%, respectively of total TN and TP emissions to surface waters of the respective countries (Schreiber et al. 2003). In regard to total N and P emissions to surface waters on national scale point source contributions from industrial facilities are small at present (regarded time scale 2002-2003). In the end of the 1980's emissions from industrial facilities within these countries (and particularly within the new EU member countries) have been significantly higher contributing considerably to TN and TP loads of the surface waters (IWAG 1997). Due to the economic collapse in these countries after 1990 many large industrial facilities have been closed or had to be reconstructed to be able to compete on the new market with other international establishments. This resulted also in a considerable decrease in nitrogen and phosphorus emissions to surface waters from industrial facilities because of an improved environmental performance of the still existing, upgraded or newly constructed facilities.

However, one industrial sector was selected to evaluate potential measures to reduce nutrient emissions to surface waters - the fertiliser manufacturing industry. Depending on different types of fertiliser products (N-, P-, NP- or NPK-fertiliser) different production lines have been investigated in terms of liquid process waste waters containing nitrogen and/or phosphorus, which are discharged to surface waters after an adequate treatment. Emission levels have been defined which can be associated with the application of best available techniques for production and emission abatement to water and to air in accordance with EU IPPC directive 96/61/EC. The so called BAT emission levels have been compared for the different production lines to specific N and P emissions to surface waters of one case study plant. Information on investment costs and operating costs were collected for the implementation of BAT for emission abatement (to air and to surface water) for the respective fertiliser production lines. Calculated total annual costs (as sum of annual capital costs and annual operating costs) have been compared to specific BAT emissions and to specific fertiliser production.

For cost-effectiveness-considerations information on annual costs of measures and nutrient reduction of each measure is important. The latter information could be obtained for some of the production lines only. Thus, cost-effectiveness-calculations could not be performed since not all the different production lines were covered by the available information. In addition evaluated annual costs do reflect costs for implementation and maintenance of the emission abatement technology, which is assumed to be about 20% of total costs of fertiliser production (EFMA 2000). So a comparison to cost-effectiveness of measures undertaken in other sectors to reduce nutrient emissions to surface waters will not be trivial.

Nitrogen emissions from fertiliser production reduced by emission abatement technology ranged between 1.1-21 kg per ton of fertiliser produced. Specific costs per nitrogen emissions reduced ranged between 0.07-0.85 € per kg of reduced emissions. Specific annual costs per ton of product ranged between 0.7-11 € per ton of product for all the different production lines.

To apply measures for the reduction of nutrient emissions is not always easily possible. Applicability of measures for existing plants can be limited by old or obsolete production technology, which does not fit with present emission abatement technology. Application of emission abatement technology may imply the redesign of production processes as for the implementation of recycling processes. However the consideration of BAT for emission abatement for the reduction of nutrient emissions to surface waters is state of the art for the construction of new plants, for upgrading existing plants this is limited by the specific onsite production technology, which is reflected also in specific BAT emission levels which can be associated with the implementation of BAT. So, BAT emission levels are partly considerably lower for new plants than for upgraded existing plants. Another possibility to reduce nutrient emissions from fertiliser production is end-of-pipe treatment of liquid effluents. Cost-effectiveness of this measure should be comparable to those for the reduction of nutrient emissions for urban waste water treatment, although the treatment of liquid effluents together with domestic waste water or the addition of carbon sources can be necessary due to the excess of nutrients (N,P) in liquid effluents from fertiliser manufacture.

2.3 Agriculture

The largest source of nutrients to the Black Sea comes from agriculture and there is concern that economic improvements could lead to an increase. In response, Danube and Black Sea Governments should continue efforts to increase farmer awareness and the adoption/application of “good agricultural practice” (GAP). Under GAP several farm management measures to reduce nutrient can be taken, including the use of cover crops, optimal sowing times and tillage practices to prevent nutrient run-off; buffer strips, soil tests to measure nutrient levels in agricultural soils and plants to ensure fertiliser and manure inputs better address nutrient needs; improvement application of manure such as seasonal restrictions.

From a cost-effective point of view it is difficult to make clear recommendations as several uncertainties and data gaps exists and no common methodology has been developed so far. The effectiveness of the measures also varies widely depending on the local conditions and it is recommended to carry out some in-depth studies to reach a better understanding. However, knowledge and examples from EU are sufficient to start the work on developing and agreeing on a GAP.

3 Limitations when comparing different measures of

different sectors

Cost-effectiveness analysis (CEA) identifies the economically most efficient way to fulfil a pre-determined objective (e.g. reduction of nutrients). Usually the aim of a cost-effectiveness analysis is to develop a ratio that indicates the costs of achieving a per unit change in a specified physical outcome, with an alternative being to determine the minimum cost of meeting a specified physical outcome . In the case of nutrients reduction this outcome would be a certain amount of load reduction. CEA works mostly very well in respect to the comparison of different measures of one specific sector if a common methodical framework is available(e.g. municipal waste water treatment). However, in theory such a CEA might be possible for all different types of measures tackling all types of pressures, in practice there are several limitations. There is a need to understand these limitations in order to take appropriate decisions:

- Firstly the framework for the cost calculation varies among agriculture, industry and waste water treatment. So the costs considered in each sector are not fully the same. Further because of the different cost level in each Black Sea country the cost effectiveness varies to some extend. For example, Bulgaria and Romania as EU Member States are forced to pay compensation payment to farmers for environmental friendly production measures out of their Rural Development programs. Other Black Sea countries are not obliged to do so. In any case such payments increase the costs of a measure.
- Further, a comparison of cost effectiveness between different sectors has some limitations. The loads, pathways of pollution and impacts on the water body of each sector differ among the sub region of the Black Sea. In order to address these variations a balanced approach is needed and a "one measure fit all" approach does not exist. So ranking all measures tackling the different pressure among their cost-effectiveness not considering the pathways they address does not work. For example building a treatment plant might be most cost-effective, but it will help only there where urban pollution is an issue.
- Most important the framework for estimating effectiveness is different in the different sectors. In the case of point sources the effect of the measure directly influences surface water, as there is a direct link between surface water and the measure. In the case of measures in agriculture the effectiveness is related to several environmental compartments (groundwater, surface water, air and soil). In respect to surface waters more links are given indirectly via emissions into air and groundwater.
- The problem related to this is that if effects of a measure are only related to on specific goal (e.g. Black Sea protection from nutrient discharges) for calculation of cost-effectiveness, additional positive effects of a measure are not taken into account.
- Furthermore retention and losses of nutrients in the catchment and the river system highly influence the transport of nutrients to the Sea. Thus, the effect of measures on the loads transported to the Sea highly depends on the location in the catchment. The measure taken right before the mouth of a river will be much more effective for the loading of the Sea, than the same measure somewhere located at a small tributary. The measure located at the small tributary has his main effect in protecting the local water system.
- Time frame: It is difficult to compare some measure because of the different time frames until these measures become active. While measure addressing point sources show an immediate effect, other measures will only have an effect after a longer period of time due to time-lags (agricultural emissions from farm lands will not decrease immediately when emissions are reduced at farm level, but only after a certain period of time). Further it has to be considered that phasing-out does not

always mean that this substance will not be found in the environment anymore It might remain in the environment for a certain period of time. Therefore it is important to establish a relation between the effectiveness of a measure and the **attainment ratio** (see methodology report section 2.2.4). The attainment ratio is a function of the effectiveness ratio and defines the extent to which a measure contributes to reaching the environmental target.

- Appropriate model approaches exist and are in stage of improvement to calculate retention and losses in the catchment and related with this effects of measures taken in different sectors and regions on discharges to the Black Sea (daNUbs, 2005, MONERIS).However these models have to be modified and adopted to the situation in the Black Sea. If done so these instruments will allow calculating the effect of measure on discharges to the Black Sea and therefore cost-effectiveness in this respect (by the use of retention/loss factors). But it must not be forgotten, that by cost-effectiveness calculation based on such an approach important effects of a measure may be neglected. It has to be kept in mind, that the problem remains that measures that might be very cost-effective for protection of the local environment (surface waters, groundwater, air) might be not cost-effective in respect to Black Sea protection and vice versa.
- Measures to reduce environmental burdens often have an effect on several different problems. This was particularly marked in the field of urban wastewater. Here, one and the same measure had the effect of simultaneously reducing the emissions of several pollutants, however in different ratios. In order to make the cost-effectiveness of these measures comparable, an assessment of all these benefits is needed unless costs of a specific measure can be related to one specific effect (Costs for nitrification/denitrification can directly be related to nitrogen removal)

4 Selecting cost effective measures

Cost-effectiveness analysis (CEA) is a tool that can help to ensure efficient use of investment resources in sectors where benefits are difficult to value. It is a tool for the selection of alternative projects with the same objectives (quantified in physical terms). Cost effectiveness is defined as achieving one (environmental) target at minimum costs. In our case the environmental target is the reduction of the nutrient load to the Black Sea.

For the Black Sea countries where money for environmental protection is specifically limited a CEA should be seen as an important part of the new institutional framework to design and assess water policies. Further it also should be seen as a tool to help decision-making as well as an information system to improve transparency.

Integrating CEA and building a framework is therefore not a once for all task but an ongoing process to inform, assess and design the current water policy options and to monitor, audit and improve the quality of water policy decisions in future. In this sense, CEA information will need to be updated and cost and effectiveness estimations will also need to be changed with the new information available.

The following section outlines potential steps of how to make use out of the findings of this study and how to select cost effective measures in a practical way.

Step 1: Identify the objectives

In 2001 in the Memorandum of Understanding between the ICPBS and ICPDR the general objective for the Black Sea region was set. This target aims

- that in the long-term in the wider Black Sea Basin measures are taken to reduce the loads of nutrients and hazardous substances discharged to such levels necessary to permit Black Sea ecosystems to recover to conditions similar to those observed in the

1960s.

- Further as an intermediate goal, urgent measures should be taken in the wider Black Sea Basin in order to avoid that the loads of nutrients and hazardous substances discharged into the Seas exceed those that existed in the mid 1990s.

In addition more specific objectives for each water body have been set for the EU Member States in Black Sea region due to the implementation of the EU Water Framework Directive.

However when comparing the WFD and the BS objectives it comes clear that the objectives set under the WFD are more concrete as they require specific values for each water body with in a catchment. In order to select the appropriate measure at a later stage it would be beneficial to apply this approach to the overall Black Sea region. Local target not only allows to better monitor the impacts selected measures have, it also allows to better select the measures itself.

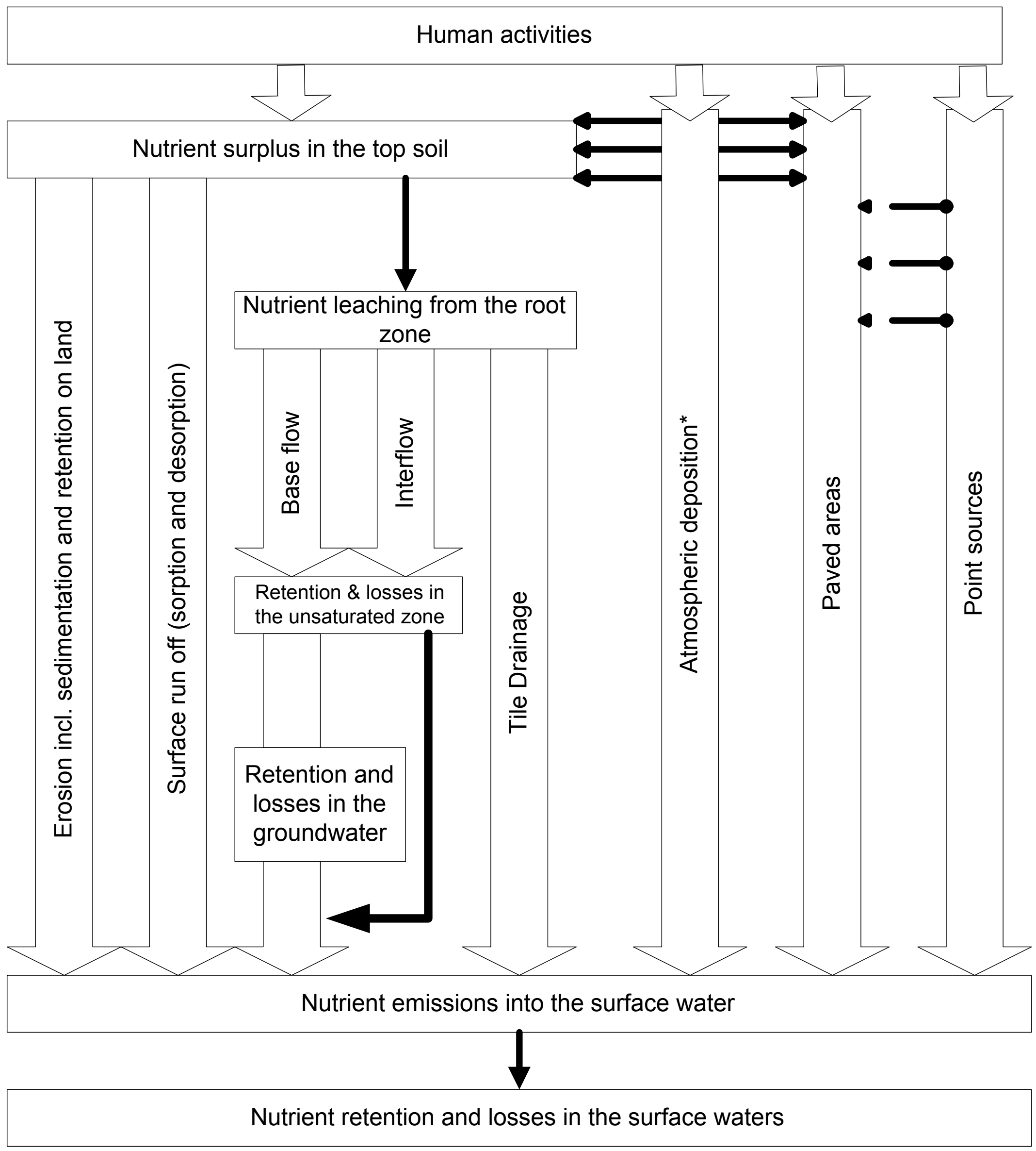
Step 2: Identify existing problems and the distance to the target

Before evaluating cost-effectiveness it is necessary to know the current status and the future objective for each water body. Defining the status of a water body should include also an assessment of the link between significant pressures[3] and impacts. While it is quite easy to establish a relation between a significant pressure and an impact in the water in the case of point sources, such a link is much more difficult for diffuse sources.

Once a pressure is classified as significant it is important to assess its effects on the water body. Assessing such impacts requires some quantitative information to describe the state of the water body itself, and/or the pressures acting on it. The type of analysis will hinge on the available data. Regardless of the particular process to be adopted, and as with the identification of significant pressures described above, the assessment requires a conceptual understanding of what causes impacts.

It is indispensable to be familiar with the different pathways pollutants (see Figure 1) can take into groundwater and surface water in order to select appropriate measures for tackling these pollutants. While point emissions from waste water treatment plants and industrial sources are directly discharged into the rivers, diffuse emissions into surface waters are caused by the sum of different pathways, which consist of separate flow components.

[3] All human activities related to water have an impact on water but might not always be significant. Significance is given in cases where the human activity impacts the status of water negatively. E.g. the discharge of untreated waster water from one household in the Black Sea does not have a negative impact on the status of water, but the discharge of untreated waster water from several thousand households will have.



* Portion of deposition that is related to human activities

Figure 1: Pathways of nutrients resulting from human activities into water (based on the MONERIS Model)

Step 3: Select your measures

The choice of measures and instruments to be included in the cost-effectiveness analysis may vary from one country to the next depending on the methodological, economic, social and political issues that countries are confronted with. Detailed guidance on how to select measure on the local level can be found in several publications related to the Common Implementation Strategy of the WFD. Most recent examples are:

- German Handbook (in English) "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", (Interwies, et al, 2004)
- Dutch Handbook (in English): "In pursuit of optimal measure packages", (Ministere van Verkeer en Waterstaat, 2005)
- UK Handbook: "Development of a Methodology to Determine the Cost-Effectiveness

of Measures and Combination of Measures for the Water Framework Directive, (RPA, 2005)

In the context of the Black Sea and remembering the target group of this paper it seems to be more appropriate to outline some general principles:

- The selection of measure should always consider the different nutrient loads coming from each pressure. For example if the total loads of a region are shared 10% Industry, 30% agriculture 55% urban waste water and 5% others, the selection of measures should consider such a share. For the same region the overall most cost effective measure in terms of Euro/kg Nutrient removed is considered to a mandatory winter cover on all arable land. However applying this measure would only solve a maximum of 30% of the total problem. In other words applying the most cost effective measure does not automatically solve the problem. This approach indirectly suggests also that the greatest environmental benefits are to be gained by an abatement policy that is targeted on areas/pressures which lack any measures, rather than on making further improvements to areas/in pressures that have already some measure in place.

- There is a need to account for future development. As already stated before it is likely that due to future economic developments environmental pressures will increase. This can also imply a change of the significance of a pressure (e.g. decrease of nutrient loads from industry because of applying BAT, increase of agriculture due to intensification). Accounting for these changes in the selection process is a must in order to avoid further damage.

- The impact of a certain measure for the reduction of nutrient load on the Black Sea is determined by the location where the measure is taken. This can be taken into account by the application of appropriate nutrient emission and transport models. For the Danube catchment the application of the MONERIS-model is in the stage of development and improvement. If the source of nutrient emissions is located some distance away from the coastal waters of the Black Sea, (if any) only a fraction of any reduction is finally felt in the marine waters. The same applies to any inbound water body and a measure taken in its catchment. The share of reduction that reaches the coast/water body depends on the retention or losses of the nutrient that may occur at various points between the source and the coast. This fact also has an impact on the cost effectiveness of a measure with the objective of reducing the nutrient level in Black Sea waters. Nevertheless the measure might be cost effective in reducing nutrients in general terms and it is worth to be applied in order to improve the local situation. Further for many types of measures, it is not possible to use generic cost data, because they are highly site specific. Expert opinion could provide a suitable solution in such cases.

  Nevertheless even if there are some uncertainties exist, there are several measures such as applying Best Available Technique in municipal waste water management and industry or best available practice in agriculture that can be certainly applied, if these sectors are identified as relevant for the targeted problem. For these measures there is enough knowledge on effectiveness and cost in order to take appropriate decision and to action.

- Consider the issue of scale. The scale on which the combinations will be designed, and then evaluated, can normally not be defined a priori (it would raise infinite methodological issues): Beside the technical measures discussed in this study, there are also some instruments that should be considered (e.g. taxes). If such instruments are discussed it should be evaluated very local measures interfere with such instruments from a cost and effectiveness point of view.

- Wider economic effects, should be included at full CEA, but they are often difficult to grasp and therefore not part of cost effectiveness calculations. Early warning signs should therefore be developed to ensure that those costs are not ignored so as to avoid selecting inappropriate or costly measures (e.g. effective public participation processes would usually provide such “early warning signs”).

- Some wider economic costs may only become apparent or relevant when aggregating the programmes of measures for an entire river basin, even if such costs were minimal for programmes of measures prioritised at the level of a single water body. This issue might need to be specifically considered when examining the cumulative impacts of decisions at a regional or national level.

Appropriate feedback loops in the selection process allow to consider the above mentioned issues and should therefore be actively considered.

Step 4: Dealing with uncertainty

Uncertainty exists where there is more than one possible outcome to a course of action. The form of each possible outcome is known, but the probability of reaching any one outcome is not known. Uncertainty may affect several aspects of the cost-effectiveness analysis and reduce the reliability of results. Areas of uncertainty when carrying out the cost-effectiveness analysis may include:

- **Uncertainly about the pressures.** For example, uncertainty exists about the extent to which point and diffuse sources contribute to (impact on) the water quality problem through the often-complex environmental source-effect chain in time and space. If it is impossible to identify the main sources of pollution, it will be impossible to determine which measures are most effective.
- **Uncertainty around future trends**. When predicting changes/trends of pressures on water bodies and hence effectiveness of measures, between now and the future, decision makers are faced with the fact that there is uncertainty surrounding the baseline scenario, i.e. future economic development on the local level and the related negative environmental effects.
- **Uncertainty around effectiveness estimates.** There may be uncertainty with regard to the effectiveness of the measure itself, either because of geographical, political or behavioural (e.g. response to economic instruments) circumstances or because of imperfect knowledge about the technical performance of a physical measure (mainly an issue in the agricultural sector).
- **Uncertainty around cost estimates.** There may be considerable uncertainty as to the actual likely costs that would arise from the introduction of a measure. There is uncertainty about direct financial costs of the measure and also about the wider economic costs. Moreover, environmental costs are typically transferred from other sources and their application to specific areas will therefore be subject to uncertainty.

To deal with these uncertainties it is recommended to use ranges, with a lower and upper estimate. Such ranges may be wider for more experimental measures, for which the effects are more uncertain. Using this information in a sensitivity tests, using lower and higher values for all parameters allows identifying if this has an impact on the ranking of measures. It is recommended that such uncertainty be noted explicitly with an assessment of possible implications. This could also lead to the gathering of additional information in order to improve knowledge and reduce uncertainty.

Step 5: Develop appropriate implementation structures

Central and eastern European countries in particular, during the period of centralized planning system, failed to develop adequate environmental protection policies and subsequent measures to fully respond to water pollution and degradation of river ecosystems.

Appropriate water management concerns must be better integrated into municipal, industrial and agricultural policies and legislation to assure sustainable human development and promotion of economic activities. The Danube/Black Sea Basin Programmatic Approach shall assist countries in transition to respond to the regional and global environmental concerns with particular attention to nutrient reduction and the elimination of toxic substances in the water bodies.

5 Main recommendations

Cost-effectiveness calculations are an important basis for developing strategies of environmental protection. As shown above they have to be handled with care due to different restrictions and uncertainties if different sectors and questions of big spatial scale - as the Black Sea catchment is - are considered. Even if this report is related to large uncertainties concerned with costs and effectiveness of agricultural measures, and the fact that industry is only represented by a very specific sub-sector (fertiliser industry) some clear recommendations can be made to limit nutrient losses from agriculture, industry and households:

- Due to the expected increase of economic activities and the risk of growing environmental pollution coming from these increased activities the most important action to be taken is the development of a precautionary approach involving tackling nutrient emissions from all sectors. Such a precautionary sectoral action plan for water resources management should indicate priority actions in each sector, but also should coordinate the individual measures between the sectors.
- For **agriculture** it is recommended to carry out regional assessment, analysing roughly the nutrients load coming from the different agricultural sub-sectors (e.g. different animal production, different crop cultivation) and to develop standards of “good agricultural practice” (GAP). The definition and application of GAP has to be seen as a minimum baseline (a “red line”) for environmental protection. The main focus when developing such GAP has to be on closed nutrient cycles and environmental friendly application of fertilizer and manure as well as limitations of the intensity of agricultural production. This is in particular important to ensure that an increase in agricultural activities does not lead to severely increased environmental problems. In order to reduce point pollution from agriculture large animal farms are point sources which should be subject to legislation for industry (e.g. IPPC-Directive).
- **Industrial** discharges of nutrients from individual point sources have to be controlled based on a strong precautionary principle (IPPC-directive) at least based on BAT.
- Under financially restrictions in respect to municipal **waste water** management the main question is, if the development of a public sewer system is necessary due to local aspects of life standard, hygiene and groundwater protection. This mainly will be the case in densely populated areas. In other cases alternatives with appropriate onsite disposal should be considered. Where sewer systems already exist, appropriate treatment has to be built. New sewer systems must not be built without including appropriate waste water treatment. Due to the sensitivity of the Black Sea waste water treatment in the catchment must include nutrient removal up to a level of 70 – 80 % for nitrogen and 80 – 90 % for phosphorus. These treatment performance guarantees the most efficient use of municipal waste water infrastructure in respect to the reduction of nutrient emissions.
- The definition of quality targets (as required under the WFD) for each water body should become mandatory for all Black Sea countries. This would allow monitoring

the effectiveness of measures taken and the overall improvement s (if any).

- Tools for assessment of nutrient fluxes on catchment scale (e.g. MONERIS) should be further developed and applied for the whole Black Sea catchment. These tools will become decisive in the future if specific water quality targets are not met based on measures defined before and questions of advanced measures arise.

6 Further work to be done

- At present, it is obvious that data on the environment are still missing/incomplete and of highly variable quality. This was a fundamental problem with information on nutrient and other chemical loads presented in the original 1996 Black Sea TDA, and while the situation has improved, there is still a great deal of progress to be made.
- More info the effectiveness of certain measures: Develop greater understanding at a national/regional level of the relationship between agricultural practice (fertiliser, manure and land management) and the risk of diffuse nutrient
- The work on the cost should include two aspects. Firstly a common cost framework to be applied at al measures should be developed and agreed. Secondly a cost data base should be developed, that allows tracking the area specific costs. This would allow to better compare different measures from a cost perspective.
- Define best practice for agriculture with a strong focus on the limitation of nutrient losses.

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