Water Resources Management in Cooperation with Agriculture (WAgriCo)

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Procedures for cost predictions at the level of the individual farm, region, river basin area and Federal State

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1. Introduction

The Water Framework Directive stipulates that a good status must be attained in surface waters and in groundwater by the year 2015. Besides ecological aspects economic considerations must be taken into account in all steps of the decision-making process affecting water management. The economic analysis is a new element introduced to European water management through the WFD. By the end of 2009 programmes of measures for the individual river basins as part of the concrete management plans have to be prepared. A cost-estimation of selected measure combinations is part of the working package to develop appropriate programmes of measures.

The WAgriCo project concentrates on measures to reduce diffuse pollution due to agricultural activities. As the main problem regarding WFD objectives in Lower Saxony is high nitrogen discharge, the focus is on measures contributing to reduce nitrogen emissions into groundwater and surface waters. All following steps of measure planning are considered within the project, from the determination of targets, the selection of areas with necessity to act, the compilation of an overview of suitable measures, the screening of the measures including the definition of their potential ecologic efficiency (see D4.1), their farm economic cost per hectare as well as their cost-effectiveness in Euro per kg N-reduction (see D4.2) and the selection of appropriate combinations up to the optimisation to assess least-cost solutions. Finally, overall programme cost and if appropriate also macroeconomic costs have to be assessed as basis for future measure implementation.

According to the WAgriCo project proposal, this deliverable presents procedures for cost predictions at the level of the individual farm, region, river basin area and Federal State, in order to support an international discussion on the integration of water protective measures in agricultural promotion schemes. In the first step, an analysis provides insights into implications of the choice of policy measures and relevant parameters to be considered. In the next chapter, different cost concepts are explained, followed by a presentation of the cost concepts to be applied within the WAgriCo project.

2. The theoretical framework for cost predictions of measures to reduce negative environmental impacts on water

2.1 Cost components to be considered

In the WATECO guidance document on economics and the environment, there are several economic aspects included in WFD (WATECO, 2003):

– the estimation of the cost of each measure

– the estimation of the effectiveness (environmental impact) of each measure

– the ranking of cost-effective measures

– the assessment of the (expected) economic impact of a proposed programme of measures aimed at improving the water status.

The economic assessment of groundwater protection has to take into account site-specific characteristics. The costs and environmental impact of groundwater protection with adapted agricultural activities are largely determined by the farm management practice and hydro-geological characteristics of the catchments, and by the current and future uses of the groundwater.

One aspect that has to be considered is the relationship between physical effectiveness and economic efficiency. Main subject of this paper are economic aspects related to the selection of cost-efficient combinations of measures according to WFD article 11 and Annex III. Thus, aspects of water prices and cost recovery (article 9), and justifications of derogations from achievement of good status (article 4) are excluded from this analysis.

In the first step, technical or organisational measures have to be distinguished from policy instruments implemented in order to promote these technical or organisational measures. Including policy measures means a more realistic depiction of the implementation process including public cost components. Thus, for analysis in the WAgriCo project cost of the technical as well as the policy level will be considered.

2.1.1. Cost definitions

There are different theoretical approaches for assessing cost-effectiveness of WFD measures (see especially WATECO, 2003; also Borchardt et al., 2006; Interwies et al., 2004a; Interwies et al., 2004b; RPA Consortium, 2004) to be considered when reporting on cost of measures and programmes.

Financial versus economic cost:

- ***Financial costs*** (direct costs) constitute the private cost of production broken down in operating, maintenance and capital costs (principal and interest payment), and return on equity where appropriate. In relation to WFD measures this means the valuation of additional cost and revenues forgone at the enterprise level.

- ***Economic costs*** (indirect costs) are the opportunity cost, this is the value of the alternative foregone by choosing a particular activity. Here, the alternative use of limited factors such as capital, labour and soil is considered as reference.

Public versus private cost:

- ***Public costs*** comprise all fiscal or exchequer cost of implementing policy instruments, which have to be born by taxpayers. They include incentive payments and public investments on the one and administrative cost (‘transaction cost’) on the other hand, e. g. for negotiation and decision making, monitoring, control and enforcement of measures as well as reporting on the performance. Also technical advice and information forms often part of public cost, either born directly by public institutions or because such services are supported through public funding.

- ***Private cost*** are all (financial and/or economic) cost born by private enterprises and households.

Internal versus external cost:

- ***External cost*** exist when the following two conditions prevail: 1. an activity by one agent causes a loss of welfare to another agent; and 2. the loss of welfare is uncompensated. In the WFD, two kinds of external cost are distinguished:

- ***Environmental costs***: Represent the costs of damage that water uses impose on the environment and ecosystems and those who use the environment (e.g. a reduction in the ecological quality of aquatic ecosystems or the salinisation and degradation of productive soils).

- ***Resource costs***: Represents the costs of foregone opportunities which other uses suffer due to the depletion of the resource beyond its natural rate of recharge or recovery (e.g. linked to the over-abstraction of groundwater or scarcity of high-quality water).

The economic definitions of the WFD and the related documents for implementation do not explicitly distinguish between “microeconomic” and “macroeconomic”. Microeconomic costs are referred to the impact of measures at the level of single enterprises, e. g. the farm level, while the macroeconomic analysis refers to the "social cost" of policy measures. Social cost comprise in accordance to welfare economics both private and public cost, considering opportunity cost of reduced production, and public as well as private transaction cost for negotiation, decision-making, implementation, control and enforcement (Scheele et al., 1993), as well as cost of monitoring and evaluation of environmental effects. Implicitly, the economic analysis of cost-efficient combinations of measures according to WFD article 11 and annex III b represents the macroeconomic view on economic cost (and benefits) of the whole economy within the respective water catchment.

2.1.2 What are 'transaction cost' and how to determine them?

Negotiation cost, administrative cost of implementation, control and enforcement as well as additional documentation efforts can be added up to total '***transaction cost***' (TC), that can be understood as organisational cost of an economic system (Williamson, 1973 and 1985) Although these costs are difficult to quantify, they are crucial for the choice of abatement measures, and high transaction cost can even prevent the implementation of policy measures. Falconer and Whitby, 1999) denominate TC as the 'invisible' cost of implementation of agri-environmental policies, and Zeijts, 1999, p. 179) states that "studies on economic instruments for environmental policies tend to 'forget' administration and control costs" due to scarcity of quantitative data.

Negotiation costs depend on the procedures before the final decision on political measures is taken. Conflicts about effects on income and competition as well as rent-seeking behaviour of interest groups can raise these costs. Administrative cost of implementation, control and enforcement are mainly public cost, but can be partially transferred to the addressees through self-reporting and mandatory external auditing. An external audit of nutrient balances is an example, which could be further developed within the WAgriCo project. Also, cost of information acquirement, planning and filling of applications for voluntary measures can be accounted as private TC. Through technical advice provided by public bodies, information cost can be born partially also by the public.

TC are composed of fix cost of initial negotiation and programming, and of variable cost of yearly implementation and control. TC are often expressed as a percentage of overall public programme cost or of transfer payments for the respective measures. Although there is no harmonised method to measure TC, some general observations can be deducted from literature (Falconer and Whitby, 1999; Vatn, 2002):

- TC are more related to the number of transactions (e.g. number of farms addressed by specific measures) than related to the target area of measures.

- They are decreasing over time after implementation of new measures, as (the more or less fix) cost of programming are decreasing over time in relation to other expenditures (e.g. the yearly transfer payments).
- measures with small area and thus small budgets show a higher share of TC as a percentage of transfer payments dedicated to the respective measure.
- specific, more targeted and more ambitious restrictions increase transaction cost due to more complicated procedures to inform farmers, to adapt farm organisation, and to perform monitoring and control.

Costs of control are dependent on the definitions of technical control parameters and addressees (Scheele et al., 1993; van Zeijts, 1999; Bergschmidt et al., 2003; see also chapter 2.2):

- possibility of detection of the technological control parameter and complexity of the control parameter
- the scope for standardisation of procedures
- number of addressees to be controlled
- frequency and dates for on-the-spot controls (once in a the year and at any time, at specific times e. g. during ban of fertiliser application, or control of management measures performed continuously throughout the year implying a high control frequency)
- incentives for non-compliance (depending on sanction, risk of detection and cost of compliance with the respective requirements at farm level)

Hardly detectable technological control parameters as well as high numbers of addressees to be controlled can considerably raise control cost, and the complexity of control parameters might limit the scope for standardisation of monitoring procedures. Compared to the industrial and water purification sectors with emissions coming mainly from point sources, TC of policy measures aiming at the abatement of emissions from agricultural sources are likely to be relatively high (European Commission, 2000). This is due to the diffuse nature of emissions, depending on differing natural and management conditions, and the multitude of farm enterprises to be addressed.

There are only few published quantitative data on TC in agri-environmental policies, and methodologies for quantification are not yet standardised. Falconer and Whitby (1999) estimated TC of the public sector for area-based agri-environmental support schemes according to Reg. (EC) 2078/92 in UK, Sweden and Germany at 10 to 48 % of compensation payments, while TC for direct payments for arable crops support accounted only for 0.8 to 4 % of transfer payments to the farms. Vatn, 2002) quantified for Norway public TC of organic farming support at 18 % of support payments, and support for conversion to organic farming at 29 %. Taxes for fertilisers and pesticides caused additional TC of 0.09 and 1.1 % of the respective input tax revenues. These figures show that in addition to the 'visible' budget cost for transfer payments, TC can constitute a considerable component of total public cost especially in case of more targeted, voluntary support schemes and during introduction of new support. Also mandatory approaches targeted to the farm level cause high TC. Van Zeijts (1999) estimated total public and private TC of obligatory mineral book keeping in the Netherlands at 220 to 580 ECU (=Euro) per farm, with external checks by accountants as the major cost. Compared to this, TC of a levy system for fertiliser and feed would cost about 9 ECU per farm. However, improvements in bookkeeping and data processing could lead to lower cost, and additional benefits of improved nutrient management have to be considered.

For Lower Saxony, Meyer, 2004, found public TC for implementing both agri-environmental schemes and water protection measures of around 50 % of transfer payments. These figures are in contrast to estimates of Tiemann et al., 2005, for Baden-Württemberg and Thuringia, with public cost for administrative personnel for agri-environmental schemes (organic farming and other extensification schemes) of about 2.5 to 4.5 % of total transfer payments. These percentages are similar to the share of TC reported by Meyer, 2004, for direct payments. As in Baden-Württemberg and Thuringia the total budget for agri-environment schemes is much higher compared to Lower Saxony, and administration is concentrated in the hands of one or two institutions, it can be assumed that this difference in magnitude of TC is due to effects of scale (size of programmes with high number of addresses) and possibly also because of a higher level of standardisation (Osterburg and Stratmann, 2002).

In theory, there are two different methods to assess public TC, the one based on cost-centre accounting which is hardly applied at the level of differentiation needed for analysing single water protection measures, and the other based on estimates of hours of administrative personnel needed for specific steps of programme implementation. In the WAgriCo project, main sources of TC estimates will be based on Meyer (2004) as well as outcomes of evaluation studies on Lower Saxonies rural development programme NAU. Cost of technical advice can be derived from measures included in the new rural development programme PROFIL, and on current support of technical advice in designated areas for water protection.

2.1.3 Scope of the WAgriCo project regarding cost components

Compared to more general guidelines for implementing cost analysis for WFD adressing challenges of multiple objectives and multi-sectoral coverage (WATECO, 2003; Borchard et al., 2004; CEA Drafting Group, 2006; Görlach and Interwies, 2004; Ministerie van Verkeer en Waterstaat, 2005), the subject of the WAgriCo project in Lower Saxony is rather particular, but typical for many regions dominated by intensive agricultural land use: The focus is on target levels for nitrogen in groundwater bodies, and the main polluter is the agricultural sector. Thus, alternative improvements outside the farm sector are not an issue within the scope of the project, which will work on the question how to optimise activities targeted at nitrogen emissions of the agricultural sector. As the target level for groundwater is a precautionary value not directly linked to actual water use, there is no immediate need to cope with the validation of environmental and resource cost of the water quantity and quality. Contributions of WFD related measures to environmental and resource cost of water might arise in relation to drinking water when water quality is improved. However, this is not a focus of the analysis as WAgriCo will concentrate on implementation of water protection measures outside designated water protection areas.

From a purely economic point of view, political strategies for reaching WFD targets should focus on most cost efficient abatement measures (i. e. measures with most favourable cost-effectiveness). However, also social questions regarding income effects and equity are to be considered. Additional questions are therefore: 'Who is bearing the cost?' and 'Which is the best policy mix?' (e. g. mix of mandatory, voluntary and informational elements) considering impacts on the distribution of cost burden and distribution between cost components (such as production and opportunity cost, transaction cost).

2.2 Parameters of environmental policy measures

In order to 'mobilise' identified emission reduction potentials of technical measures, feasible political measures are needed. The cost of such "packages" of technical measures and policy intervention to promote those technical options has to be evaluated together with expected ecological impacts. Although the political instrument is frequently in the centre of discussion, political measures comprise more elements, leaving scope for optimisation. According to Scheele et al. (1993), four political parameters have to be defined:

– political instrument
– technological control parameter
– addressee
– regulation area

All these parameters have an influence on the feasibility, the effects and cost of policy measures. ***Instruments*** can be either mandatory standards, market oriented instruments, voluntary agreements or informational instruments like technical advice. In the WAgriCo project, the focus is on voluntary agreements and technical advice. Nevertheless, also mandatory 'basic measures', namely the German Fertilising Ordinance (Düngeverordnung, DüV), have to be considered, too, as the related requirements will get tightened within the period until the year 2015 (see D7.2). Instruments have impacts on the distribution of cost, arising due to environmental restrictions or actions required, which have to be born by private and/or public entities. While mandatory instruments put the burden on the affected enterprises (polluter pays principle – PPP), voluntary incentive schemes and agreements as well as technical advice offered free of charge put the burden on the public bodies and as a consequence on tax payers (public/taxpayer pays principle). In Lower Saxony, a ‘water cent’ is imposed as levy on water consumption, thus recollecting funds from consumers for water protection in designated priority areas for drinking water (beneficiary pays principle).

The ‘***technical control parameter***’ is the starting point for the setting of incentives and disincentives, monitoring, control and enforcement of political measures. Detectability, data availability and cost of monitoring are decisive for the definition of appropriate verifiable indicators based on the technical control parameter, and thus for transaction cost of monitoring and enforcement. Pressure reductions are often used as approximated value for the impact on water quality. Indicators of pressures on the environment are defined as either direct (e.g. emission rates), or indirect (referring to the background factors that create pressures). In agri-environmental policies often simplified or indirect indicators for environmental performance of farms are used (Bergschmidt et al., 2003).

High cost of monitoring real environmental impacts on the ground as well as the time-lagged effects of measures are the reason why voluntary agri-environmental measures normally are based on prescriptions of specific actions to be performed, which are easily observable at farm or plot level. These prescriptions are considered to be environmentally beneficiary (‘action-oriented measures’, also called ‘input-oriented’) so that measuring real pressures (e. g. emissions of nitrogen) or impacts (e. g. immissions into groundwater) is considered to be unnecessary. However, the achievement of targets might be less certain when there is no automatism leading to improved environmental outcomes.

‘Result-oriented measures’ (or ‘output-oriented’) based on environmental impacts of farming measured at farm or plot level are rare in practice because of difficulties to detect the particular impact of the individual farm, limited influence of farm management on the indicator (e g. due to climate variation), and high monitoring cost. Thus, result-oriented measures have to concentrate on indicators which are as close as possible to the production and management activities at farm level. Immission values of groundwater can hardly be attributed to the activities of individual farms. As an example for WFD objectives, indicators for agricultural management are nitrogen surplus at farm and plot level or residual soil mineral nitrogen in autumn (‘Herbst-N_{min}’) at plot level. Both indicators are closely linked to the environmental situation, and potentially more significant compared to action-oriented technical measures with management prescriptions causing high variance of ecological impacts. A pilot scheme with nitrogen use efficiency as result-oriented indicator will be tested in the WAgriCo project in Lower Saxony. Applied to water protection objectives, result-oriented agri-environmental measures indicate directly the cost-effectiveness of a measure in Euro per environmental improvement (e. g. kg nitrogen avoided). In result-oriented measures the risk regarding the achievement of the environmental objective is born by the recipient of the support, in this case the farmer, and not – as in case of action-oriented measures – by the public (see figure 1).

Figure 1: Characteristics of action- versus result-oriented measures

	action-oriented	**result-oriented**
target definition:	administration	administration
choice of measures:	administration	farmer
realisation:	farmer	farmer
check of results:	administration	farmer
on-the-spot control:	administration	administration
farmer's behaviour	**executory**	**entrepreneurial**
measures are	clear-cut/ transparent	Flexible, risky
risk to miss target born by	administration	farmer
crucial	appropriate requirements	appropriate indicators

The ***addressees*** of political measures in the agricultural sector can be the farm enterprise, the supply side for agricultural inputs such as the mineral fertilizer industry or retailers, or the purchase side for agricultural outputs such as food industry or households. For example, measures to improve nitrogen use efficiency in agriculture can focus either on the farm level (e. g. when implementing a limit for nitrogen input per hectare) or on retailers of mineral fertiliser (e. g. when applying a levy on mineral nitrogen fertiliser). In the WAgriCo project the focus is on the farm level as the main addressee of WFD measures, and on groups of farmer organised in water protection co-operations. Special attention shall be paid to variations of cost-effectiveness and reduction potentials between farm types and the particular fertiliser management at farm level, which offer scope for optimising the selection of addressees.

The ***regulation area*** describes the spatial dimension of a measure and implicitly includes the question whether spatial allocation of environmentally relevant activities matters or not, and whether action at one or another location are substitutes regarding environmental objectives. For groundwater protection, spatially targeted or even site-specific activities focussed on particular addressees (farmers) may be necessary. In the WAgriCo-project, the regulation areas are water bodies with the need for additional action. Namely the water body under soils with a high groundwater recharge and a low denitrification potential are selected as target areas. However, within these regulation areas there is still considerable scope for optimising the selection of measures and locations. In contrast, regarding surface water there is potentially much higher flexibility for spatial allocation of measures, as downstream targets can also be achieved through measures implemented upstream if they are more cost-efficient.

2.3 Concepts for valuation of measures and policies

Wateco (2003) states that uncertainty about costs, effectiveness and time-lagged effects of measures need to be dealt with throughout the economic analysis process. The main economic methods for valuation are cost-effectiveness analysis (CEA), cost-benefit analysis (CBA) and multi-criteria analysis (MCA). Within the WagriCo project, analysis will rely mainly a CEA, considering side-effects and synergies like in MCA. CBA is mentioned in this theoretical part for the sake of completeness.

Apart from drinking water, other services and environmental benefits of clean water have no market price. Unfortunately, these non-use values of groundwater protection are even more difficult to quantify than the use values. This is because they are not linked to any tradable goods. If there is no market price for water, economic valuation methods like contingent valuation can be used to estimate costs. For this, either the willingness to pay (WTP) for environmental improvements or the willingness to accept compensations for suffering environmental damage (WTA) are suitable approaches. Because the results can be tedious, and because of doubts about the robustness of such estimates, non-use values are frequently excluded from the economic valuation of groundwater (Görlach and Interwies, 2003). As alternative approach, it is assumed that the value of clean (ground-) water is equal to the cost to avoid pollution (Interwies and Görlach, 2005). Although it is much easier to estimate the costs to reduce groundwater pollution, a large data set is necessary. One major problem is that the estimation of costs and benefits of groundwater protection is always site-specific and thus the results from one catchment can not be transferred one to one to another with different hydro-geological, biophysical and socio-economic conditions (Interwies and Görlach, 2005). It has to be considered that because of high variation of cost and effects, cost estimations and especially on a larger scale show a rather big uncertainty.

Many instruments of economic analysis are not easily applicable to groundwater protection. This is owed to the hydro-geological specifics of groundwater and groundwater pollution: the long and variable pollutant travel times and associated time lags between action and result, the dynamics of groundwater flows and the spread of contaminants, the potential irreversibility of pollution, the interrelation between qualitative and quantitative aspects as well as the invisibility of groundwater qualities for consumers are all factors that restrict the application of economic valuation instruments (Görlach and Interwies, 2003). Further, the effectiveness of measures can often be assessed quantitatively only for few environmental indicators, and not for the full range of environmental issues comprised in the definition of good water status (Brouwer et al., 2007).

2.3.1 Cost-effectiveness analysis (CEA)

The CEA compares the costs of different policy options which all lead to the same, given target. The target itself is thus not determined through the analysis: it has to be set ‘exogenously‘, i.e. through a political decision (Görlach and Interwies, 2003) and thus reflects implicitly the benefit of an improved environmental state. If the quality target is given beforehand, a CEA will usually be sufficient. The cost-effectiveness of a measure is calculated by dividing the cost by the environmental effect related to a given area and period of time. The measure with the lowest cost per unit of pressure (emission) reduction is the most cost-effective one. The approach can be applied to different scales and targets.

In standard CEA costs are summed that are necessary to achieve the given objective. The bundle of measures with minimum costs is preferred. A relevant question is therefore which costs (and benefits) are explicitly included in the CEA, e. g. regarding transaction cost, and flanking measures like technical advice. For agriculture it is important that positive side-effects of measures are included in the CEA (Reinhart, 2005). A cost-effective analysis based on fact sheets of measures bears the risk not to take into account all relevant information about costs and impacts of measures for abatement of diffuse agricultural emissions. For example, transaction cost are difficult to include, and effects on other natural resources are often not estimated.

2.3.2 Cost-benefit analysis (CBA)

Cost-benefit analysis is carried out to evaluate and compare the economic efficiency of alternative actions. Costs and benefits of different options for action are compared in monetary terms. Total benefits divided by total cost gives the B-C ratio. A measure is economically beneficial if the ratio is larger than one.

As already explained, it is difficult to provide reliable estimates for the benefits of groundwater protection policies - in opposition to the costs, for which there is usually sufficient evidence. If sufficient information is available for all possible alternatives, it is straightforward to choose the option that maximises net social benefits (benefits – costs) (Görlach and Interwies, 2003).

A distinction between a financial CBA and an economic CBA has to be made. In the financial CBA only expenditures and earnings directly associated with its implementation are considered. The economic CBA takes into account all positive and negative welfare effects, indirect effects and non-priced external effects on society and the environment are included. If such externalities are included in the analysis in monetary terms the economic CBA is also named extended CBA (Brouwer et al., 2007).

A full cost-benefit analysis is associated with a very extensive effort for collecting the required information, and consequently with very high costs. Due to extensive information requirements and the associated cost to conduct a CBA, a full CBA is only necessary in cases when there is a substantial doubt whether the costs of the measures are in line with the expected benefits (Interwies and Görlach, 2005). Therefore CBA are mainly used to underline the argumentation for exemptions. Görlach and Interwies (2003) stated that in the context of groundwater, it appears that a cost-benefit-analysis is an unsuitable instrument for assessing policy alternatives on a national scale.

2.3.3 Multi-criteria analysis (MCA)

MCA can be applied in cases where a single criterion approach like for CEA, which compares options based on cost-effectiveness regarding only one target, is insufficient. Multi-criteria analysis is a structured approach taking multiple objectives (environmental, economic and social objectives) into account, especially if those can not easily be measured in monetary terms. MCA does not need monetary valuation studies as non-monetary terms and qualitative information can be used. Also for a pre-screening of measures, this method can be helpful.

In the first step, a range of objectives in different dimensions are identified and the trade-offs between these objectives are specified for different policy alternatives. To the different objectives a score is given (e.g. 0 to 1). In a second stage, the different options are compared by attaching weights to the different objectives and finally the weighted scores are aggregated to calculate a global effect score. The aggregation could be done either by summation or by multiplication. The selection of the objectives, but especially the determination of the weights, introduces an element of subjectivity into the decision making process. A MCA can be used to identify a single most preferred option, to rank options, to make a short-list for subsequent detailed analysis or to eliminate unacceptable options (Brouwer et al., 2007).

2.4 The differentiation between basic measures and supplementary measures within the WFD

Basic and supplementary measures are two types of measures being part of the obligatory programmes of measures that have to be implemented to follow the objectives of the WFD.

2.4.1 Basic measures = mandatory requirements

Basic measures are the minimum requirements for programmes of measures and include measures to implement existing EU legislation for the protection of water such as the

Integrated Pollution Prevention and Control, Nitrates, Urban Waste Water Treatment and Habitats Directives. A full list of the EU legislation is given in Annex VI of the WFD. Even if not all objectives are met yet, they are assumed to be part of the present national policies. Thus the measures necessary to accomplish the EU legislation are a non-negotiable part of the programmes of measures. The costs on farm level resulting from their implementation have to be totally borne by the farmers themselves.

In Germany the main basic measure to reduce N losses to groundwater and surface waters is the fertilising ordinance (Düngeverordnung, DüV) that implements the EU Nitrates Directive into German national legislation. The fertiliser ordinance limits the N surpluses at farm level calculated with the help of an aggregated field-stable balance using fixed coefficients for organic fertilisers from animal excretion. The N surplus is calculated less unavoidable N losses occurring during storage and spreading of manure, based on a three years average. Starting with the year 2006, this net surplus has to fall below 90 kg/ha, and the average of the years 2009 to 2011 shall fall below a maximum of 60 kg N /ha.

The costs of basic measures are not considered within the cost-estimation as they are not costs of the WFD implementation. Therefore, they are also excluded as argument for exemptions from requirements to reach WFD targets. However, the way to implement and enforce the fertilising ordinance is crucial for both understanding the level of nitrogen emissions to be expected in future, and to assess the need for supplementary measures.

2.4.2 Supplementary measures = voluntary agreements plus technical advice

Programmes of measures may also need to include supplementary measures to provide further controls on pressures. The WFD provides in annex VI a non-exhaustive list of such measures including legislative and economic instruments, codes of practice, projects, promotion of water efficient technologies and education. In Germany the focus for supplementary measures in the agricultural sector is on voluntary measures with compensation payments, partly in combination with technical advice.

In voluntary schemes, compensation payments can be assumed to cover all private cost of participation, including additional cost and income foregone, private transaction cost and risk considerations. However, private TC and risk aspects are components often not explicitly calculated for when determining the payment levels. In WAgriCo as well as in other agri-environmental schemes in Lower Saxony, flat-rate payments for environmental measures prevail. As public costs are mainly determined by uniform payments, a major source of uncertainty with regards to cost-effectiveness is the difficulty to quantify and valuate environmental benefits. This applies especially for broad agri-environmental programmes covering a multitude of objectives like water and soil protection, landscape, biodiversity and habitat conservation. Thus, apart from transfer payments needed to reach a certain acceptance, transaction cost as well as environmental monitoring and valuation are crucial points when assessing cost-effectiveness.

Regarding income effects of public incentive measures (so-called windfall profits), the question has been discussed whether overcompensation due to incentive payments, going beyond the compensation of additional cost and income foregone, has to be considered as cost from an macroeconomic (social) cost point of view. It has been argued that the amount of transfer payments for incentives can remain unconsidered in the social cost concept (Isermeyer and Nieberg, 1996) as in accordance to welfare economics the monetary loss on the public side is an income gain for the programme participants.

However, this simple definition of windfall profits as a “zero-sum game” has been critically discussed. The negative allocation effects of taxing and redistributing public funds are to be considered (Alston and Hurd, 1990). As budgets dedicated to environmental objectives are limited, increasing the efficiency of public cost implies the maximisation of positive environmental effects at a given level of public funds. Minimising windfall profits can thus improve cost-efficiency as long as achieved savings are not outweighed by increasing transaction cost, or decreasing acceptance or environmental benefits (Osterburg and Runge, 2006). When including external effects of public interventions (e. g. increased value of environmental goods), this approach is compatible with the social cost concept. The public intervention is then defined as an investment and evaluated through cost-benefit-analysis.

It has to be considered that for voluntary measures, incentive payments are an important driver of acceptance, so that acceptance will decrease when reducing the ‘overcompensation’. Even when optimising cost-effectiveness of budgetary cost, windfall profits might remain at a substantial level, mainly due to increasing transaction cost and decreasing acceptance when further reducing overcompensation.

The following graphs illustrate which factors influence the cost of voluntary agri-environmental measures and the resulting implications for cost-effective programming of measures. The assumption on marginal cost distribution and environmental benefits for each single measure is crucial for programming. In figure 2 three different situations are illustrated (a, b and c). Each of the three graphs consists of two parts, one illustrates the cost per hectare and the other the environmental benefit. In each of the graphs the course of the flat-rate payment (dashed line) as well a for the marginal cost of adaptation at farm level (red curve) are illustrated. As the measure implementation is voluntary, only farmers with adaptation costs less than the offered payment level will participate. The crossing of flat-rate payment line and the cost curve is the point where the payment is identical with the cost at the farm level.

In graph a) a situation is shown with a high variability of on-farm cost. (e. g. measures with a great influence on the yield). In this case farmers with low on-farm cost get a high information rent and thus windfall-profits are high. To limit these windfall-profits a graded payment could be offered instead of the today dominating flat-rate payment. The differentiated payment allows financing more farmers with the same budget and thus to reach farmers that have adaptation cost above the flat-rate payment. This is not without effect on the environmental benefit. Following the general assumption that high costs are combined with a high environmental effect it is possible to reach more farmers with graded payment where the participation results in a high environmental benefit.

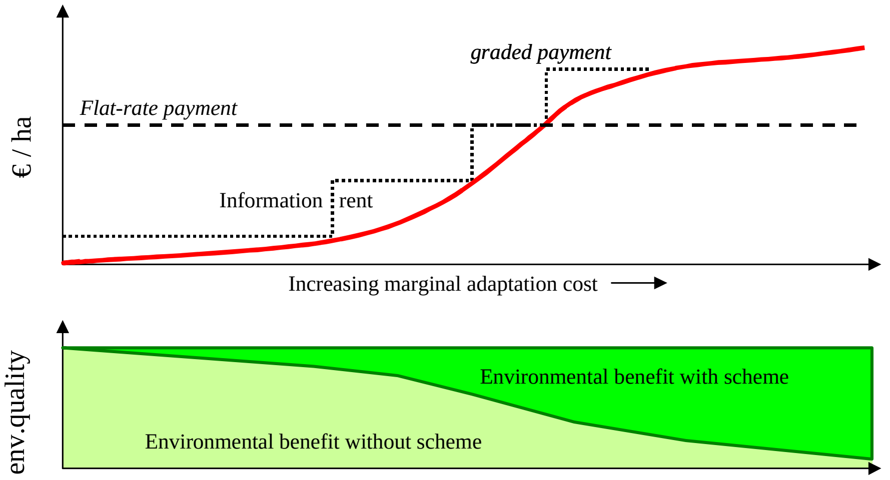
In graph b) a modest differentiation of marginal cost and a lower difference between the environmental benefit with scheme and without scheme is shown. This graph illustrates the situation for measures with a low variability of on-farm cost and little importance where the measure is implemented (e. g. catch crop growing). In this case the information rent for farmers with little cost is not much higher than for those with higher cost and thus a graded payment is less efficient. Taking into account the higher transaction cost for graded payments that are more difficult to administrate and the low effect that could be obtained it can be assumed that a flat-rate payment is the better solution in this case. It is very difficult to know the course of the cost curve *ex ante* as the cost are influenced by factors not known for all farms (problem of 'hidden information'). Neither the administration nor the farmers themselves can estimate the real costs exactly beforehand. However, both of them have to cope with that situation and while it is easier to find a more or less correct payment level for the case shown under b), it is much more difficult for situation a).

For cost-effective measure planning it is necessary not only to cope with 'hidden information' about the cost but also with the problem of 'hidden impacts' on the environment. In graph c), we assume a high variability of the environmental impacts of measure implementation. One example is the variation of environmental impacts of improved slurry application, which depends on crop rotation, fertiliser management, livestock density, etc. According to this graph, windfall profits might be less important for overall cost-effectiveness of public programmes, compared to an appropriate allocation of measures on farms with high improvement effects. For this, also the reference situation is important: Measures on farms that reach already a good environmental status without agri-environmental measures are less cost-effective compared to those starting in farms with bad environmental outcomes. Thus, selection of areas and farms matter when the aim is to increase cost-efficiency of supplementary measures.

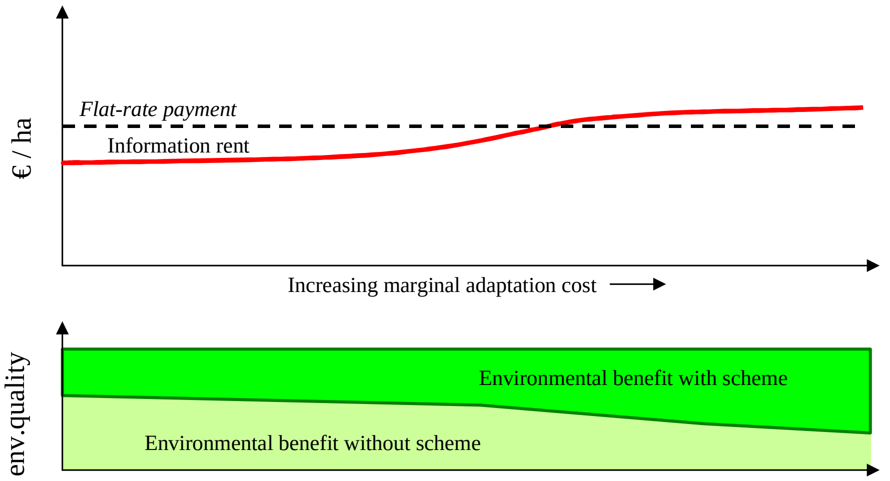
For the measures applied in the WAgriCo project, it can be assumed that most action-oriented measures aiming at reduced soil mineral N in autumn belong to the situation depicted in graph b) and thus a flat-rate payment is justified. In difference, cost of actions for reducing N surplus are less known and may vary within a wide range. Due to this, a result-oriented approach is justified, with remuneration of outcomes at a given cost-effectiveness.

Figure 2: Micro-economic cost of agri-environmental measures, payment levels and possible relation to environmental benefits

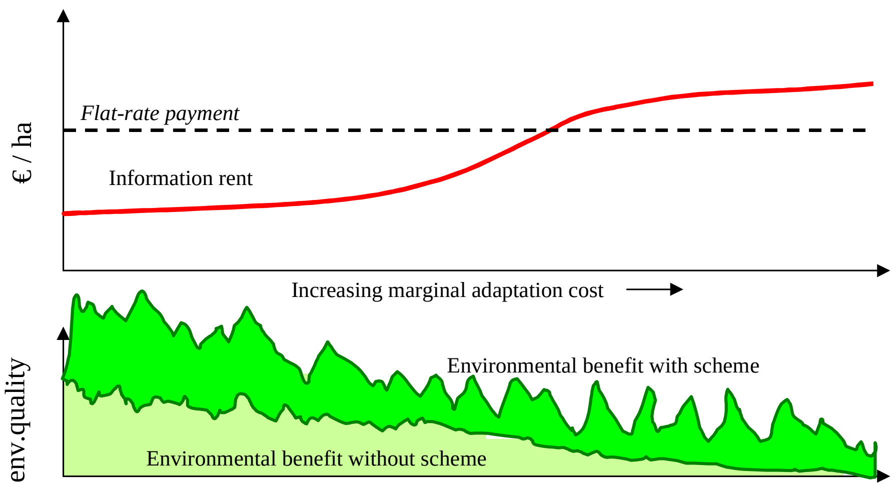
a)



b)



c)



3. Cost concept to be applied within the WAgriCo project in Lower Saxony

Within the project a bottom-up approach is applied. With a focus on technical and organisational measures and their impact on individual farms, thus the main objective is the micro level. Cost estimates will be based on calculated compensation payments for the respective measures. However, also public transaction cost and cost of technical advice offered free of charge to farmers, have to be considered for the macroeconomic analysis and for assessing overall programme cost. Compensation payments for voluntary measures are assumed to cover at least the private (microeconomic) cost, i. e. additional cost and revenue foregone due to measure implementation, and private transaction cost.

Other policy instruments like legal requirements are not part of the analysis. Therefore the cost predictions are limited to the implementation of action and result-oriented water protection measures and a set of selected combinations, plus complementary technical advice. The presented concept is used to select cost-effective combinations of measures necessary to reach a good status of groundwater.

As there is a considerable time lag between agricultural activities and measurable effects on water quality, especially for the groundwater, the effectiveness and costs of possible and appropriate measure combinations is expressed in terms of reduction of nitrogen emission. With the help of ecologic modelling as part of the project work it is possible to get rather detailed information about the whole nitrogen flow within groundwater catchments of the selected three pilot areas and for whole Lower Saxony. This allows estimations what improvements on farm land have to be achieved in order to attain a good status in the target year 2015. As the main problem is the high nitrate concentration of groundwater, the cost prediction concentrates on achieving a good groundwater status. No measures targeting surface water are considered, but the effect on surface water is modelled as the groundwater protection measures will also reduce the nitrate charge in surface water as a side effect.

The changing framework conditions, especially due to GAP and the implementation of the new fertilising ordinance has an important influence on farmers activities and thus simultaneously on the costs-effectiveness of voluntary measures to reduce N losses. Therefore, in addition to aa static analysis based on the average situation of the years 1999 and 2003, possible pathways of developments from the year 2003 to 2015 shall be considered (see D7.2).

3.1 Data sources used

In order to estimate the costs many different data sources are used. First of all the agrarian statistical data (1999 and 2003) at district level about land use, crop and livestock distribution has to be named. As these data give only a brief overview, but are not differentiated enough concerning different regional aspects and farm management systems, an inquiry on farm level is conducted: All farmers participating at the project provide information on their activities, the land surface of their farm and data on the nutrient input and outputs at least for the years 2003/2004 to 2006/2007. With the help of those data farm balances (farm-gate and field/stable) for each farm are calculated to get realistic figures for N surplus. By that way the project farms provide detailed information about the actual fertiliser/nutrient management and potentials for surplus reduction. Further, data on participation of the project farms in the 3 pilot areas in the measures offered are collected (the area of the eleven (2006/2007) or thirteen (2007/2008) action-oriented measures). Also, farms participating in the result-oriented measure will be interviewed regarding their estimates of reduction measures and potentials. This allows the identification of best-practice examples and real combinations of measures for the different farm types.

Because of the relatively small sample two additional data sources are analysed: the farm accountancy data (FADN) and monetary and physical accounting data from 7,000 farms in Lower Saxony (approx. 10 % of total farms), 1999/2000 and 2000/2001 (LandData). The data allow a classification into three groups of farm types (arable, dairy, pigs) and give information about land use and cropping patterns, yields, mineral N input and livestock numbers. From that data typical farms in Lower Saxony can be compiled.

Further, data from the Integrated Administration and Control System (IACS) for Lower Saxony shall be analysed. They allow an analysis of the land use and land use changes in the years 2000 to 2005 on the level of municipality or at least for the district level (nuts 1), especially the regional distribution of selected crops with potentially high soil mineral N in autumn (maize, rape, potatoes), typical crop rotations, the distribution of set-aside (obligatory and voluntary, with or without renewable energy plants), the shares of arable and grassland, and the regional distribution of already existing agri-environmental measures targeting water protection.

Soil mineral N samples from drinking water protection areas in Lower Saxony (1996-2006) and from the participating farms (year 2007) are used to determine the observable effectiveness of the water protection measures targeted at the reduction of soil mineral N in autumn. With the help of statistical with-without comparisons, the evaluation of these data shall help to verify the potential reduction of soil mineral N in autumn which is assumed to be subject to leaching.

To calculate the tolerable maximum N losses (N surplus) that allow reaching the environmental targets, different data sources are used. Data about natural characteristics allows a delineation of target areas for groundwater and surface water protection using an integrated hydrological/hydro-geological model (Tetzlaff et al., 2007). The modelling approach provides the actual status of nitrate concentrations in seepage water (leachate) for entire Lower Saxony on a 50 x 50 m resolution. In combination with information of N surplus on county level for the year 2003 the gap between the actual and the tolerable N losses and thus the necessary N surplus reduction can be defined. The methodology for the calculation of the N surplus on county level (local administrative units) is explained in Schmidt et al., 2007). Based on the definition of the environmental target (task 3.4) the tolerable input is defined as a certain value of the mean nitrate concentration in seepage water within a hydro-geological sub-unit (50 mg/l). From this value a maximum nitrogen load on arable land and grassland is produced by inverse calculation. The probability of achieving the targets is assessed by comparing this to the nitrogen concentration obtained with the selected basic and supplementary measures implemented.

3.2 Costs of the selected action-oriented measures and the result-oriented measure

Action-oriented measures

Within the project, a screening of existing measures to reduce N losses from agricultural activities was undertaken. 42 potentially suitable technical-organisational measures were identified, either being offered as agri-environmental measures through the schemes of the Rural Development Program 1999-2006 or as voluntary measures in the drinking water protection areas of Lower Saxony. These measures were assessed by experts from LWK, NLWKN, FAL and farmers collaborating in the working groups in the three pilot areas with regard to their ecological effectiveness, payment level, acceptance and controllability. This assessment was not conducted using a formal multi-criteria analysis, instead the selection was based on the exclusion of non suitable measures, for example measures that have to be implemented for more than the two years (project period) or those focussing exclusively on surface water. Furthermore, a priority was set on measures targeting arable land, because denitrification is far higher on grassland and thus the N losses to groundwater under arable land are more relevant. For 2006/2007 eleven measures appropriate for an action-oriented approach were selected. In a collaborative approach the concrete management conditions and the level of compensation payments were defined taking into account the site conditions and existing farm management systems in the 3 pilot areas. Cost-calculations were conducted within the project only for few selected measures, while most payments were based on previous calculations for voluntary measures in the drinking water protection areas of Lower Saxony. Also, a mutual consent exist that the payments per hectare shall be the same for all farmers participating in the WAgriCo project with the upper limit for the payments defined by already existing, similar measures. This approach was possible because for each measure co-financed by the EU a cost-calculation has to be conducted using a defined methodology (see also progress indicator 7.1). For 2007/2008 the measures were reviewed and two more measures were added. The costs of the measures are between 15€ and 125€ per hectare (see table 1).

For the thirteen measures the potential ecologic effect was estimated using the emission indicators N-surplus reduction and reduction of the soil mineral N in autumn. The N-reductions in kg N/ha are based on the assessment published in Osterburg et al., 2007, and adapted taking into account the management prescriptions of the selected measures and the site conditions in the pilot areas. For all measures the reduction rates (min, max, average) and the costs per hectare are documented (see table 1). For ten of the thirteen measures the minimum N-surplus reduction could be zero. This is due to the fact that the main objective of these action-oriented measures is a reduction of N losses during winter time and thus is focussed on soil mineral N in autumn. Only if the fertiliser management takes into account the remaining soil nitrogen and thus the fertiliser input is reduced for the following crop, a N-surplus reduction can be achieved. For more details about the ecological effectiveness see deliverable 4.2.

The input data for the hydro-geological model is the estimated N surplus when implementing the selected measures in accordance to potential area and farms and expected acceptance (uptake of measures by farmers). The statistic model approach is using annual values and can thus not cope with soil mineral N in autumn. Therefore the cost-predictions on catchments and Federal State level are based on calculations using exclusively figures of N-surplus reduction.

During the discussions within the modelling team of the WAgriCo project, it was agreed to include a reduction of N losses due to reduced soil mineral N in autumn, in addition to possible reductions of N surplus. This shall reflect the effect of increasing the N sink of the soil organic material e. g. through catch crops. However, in the longer run N surplus should be reduced as mineralization of N stored in the soil organic material will increase, and will allow for reduced fertilisation.

Table 1: The estimated cost-effectiveness for the N-surplus reduction for the WAgriCo action-oriented measures

Number and name of the measures		N-surplus reduction* [kg N/ha*a]			payment [€/ha*a]	cost-effectiveness [€/kg N]		
		Min	ave-rage	max		min	average	max
H1	Catch cropping after harvest (winter-hardy, late ploughing)	0	20	40	120 (in 2006: 100)	3	6	∞
H2	Catch cropping after harvest (standard)	0	20	40	80	2	4	∞
H3	Three-year fallow with active greening (only offered in 2006)	40	60	80	120	0.7	2	3
H4	Volunteer rye or triticale before summer crops (in 2006 also rape seedling)	0	10	30	30	1	1.5	∞
H5	No soil tillage/ploughing in autumn after maize/sugar-beet	0	5	10	25	2.5	5	∞
H6	Restrictions for farm manure application in autumn (application only to catch crop, rape, grassland with time restrictions)	10	20	30	15*	0.5	0.75	1.5
H7	Improved slurry application techniques (to winter cereals, winter rape, grassland)	10	15	40	25(35)**	0.6 (0.9)	1.7 (2.3)	2.5 (3.5)
H8	Reduced row spacing for maize	0	10	20	40	2	4	∞
H9	Use of ammonium based liquid fertilisers using injection technique in cereals	0	10	20	35 (in 2006: 25)	1.8	3.5	∞
H 10	Application of stabilised mineral fertilizer in spring on winter cereals and potatoes	0	10	20	25	1.2	2.5	∞
H11	Undersown catch crops in maize	0		20	125	6.25		∞
H12	Turnip (brassica rapa sylvestris) as catch crop before winter cereals (only offered in 2007)	0		20	60	3		∞
H13	Reduced tillage of volunteer rape seedlings before winter cereals respectively summer crops (only offered in 2007)	0	15 (20)	30 (40) ***	40	1.3 (1)	2.7 (2)	∞

* In 2006/2007 payment for arable land with cereal production: 30 €/ha; in 2007/2008 only fellow excluded from payment.
** 25 € / ha for drag hoses, 35 € / ha for trailing shoes or injection
*** 30 for winter crops and 40 for summer crops

<u>Result-oriented measure</u>

In addition to the action-oriented measures mainly focussing on the reduction of N losses during winter and following a single plot approach, a result-oriented measure was developed. The objective is an improvement of nutrient management at farm level. In the result-oriented approach the outcome indicator "N-efficiency improvement" is directly rewarded. Farmers who take part in the result-oriented reward scheme receive a fixed amount per kg nitrogen reduction (1.20 €/ kg N). They have free hand to decide how and to which amount they improve the input/output correlation for nitrogen and thus improve the N-efficiency compared to the average of three previous years.

The costs of adaptations at farm level are considerably influenced by production alignment, intensity and the extent of the adaptations and thus the costs for N-reduction may vary considerably between farms. The cost curves of nitrogen reduction are different for each farm and vary from year to year and crop to crop. The exact position of the cost curve can only be defined ex-post. Nevertheless, there is consensus that farmers could to a certain degree reduce their N-input at low cost, especially when starting from an relatively low N efficiency, and some farms could even benefit from N input reductions. When increasing the reduction of N surplus per hectare, the cost curve will presumably strongly increase (see figure 3). Especially farmers with high N-surpluses have in general a higher reduction potential and lower cost per kg N (see Osterburg, 2007).

Figure 3: Marginal cost of nitrogen surplus reduction

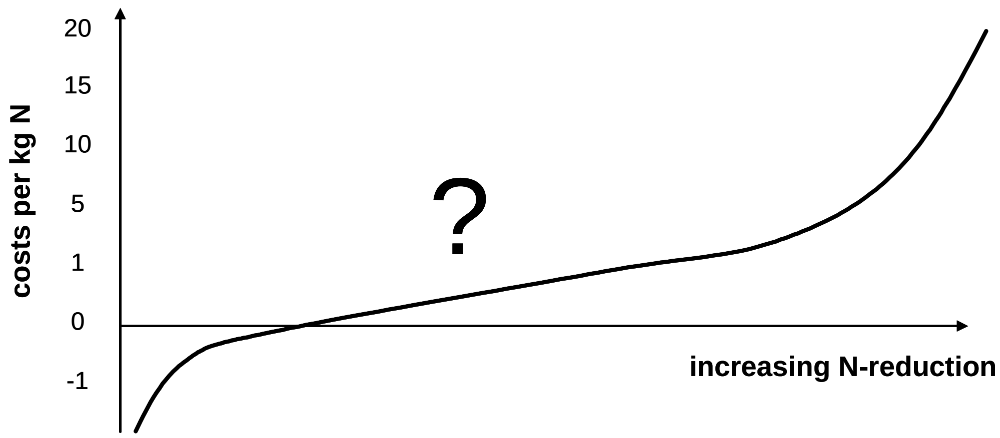


Figure 1: Little knowledge about costs for improved fertiliser management at farm level

The cost-effectiveness regarding the payment is the same for all participating farmers even if the individual cost at farm level varies considerably. Thus, the result-oriented approach is more risky for the farmers, but it is for sure that the reduction of 1 kg N will be at public cost of 1.20 €. The cost-effectiveness given through the remuneration level of the result-oriented measure steers the participation of farms and their selection of cost-effective measures. However, when supporting both action- and result-oriented measures in the same farm, double-support may occur especially if the action-oriented measures aim mainly at reducing the N surplus. Thus, for programmes of measures the compatibility of action- and result-oriented measures has to be addressed.

3.3 Approach for cost prediction at the level of the individual farm

To get some additional information about ecological and economic effects of the water protection activities at individual farm level, analysis will be conducted using data from the participating farms of the three pilot areas. In 2006 49 farmers signed water protection agreements and implemented at least one of the offered eleven action-oriented measures and all farmers agreed to participate in the result-oriented measure. Thus for those farms, farm-gate as well as aggregated field-stable balances will be provided for the years 2003 to 2007.

On the basis of the detailed inquiry of participating farms, case studies on possible effects of the measures can be elaborated. The detailed analysis of the participating farms provides information on the selected set of measures and their areas. In addition, acceptance of typical types of water protection measures within designated areas will be analysed in order to derive estimates of acceptance of measures. On that basis it is possible to develop suitable combinations of measures dependent on farm type / farm condition and natural conditions, and to derive estimations of the acceptance for the selected voluntary measures. Finally, information on participating farms complemented by statistical data, the N-reduction potentials for typical farms and the cost-effectiveness of measure-combinations will be estimated. These figures are elementary input values to conduct the cost prediction for the three pilot areas.

3.4 Approach for cost prediction at the regional level for the pilot areas

Hydro-geological modelling (see task 3) provides information about the priority areas, defined as groundwater catchments where the target value is expected not to be reached without additional activities. Implementation of the action-oriented measures will be limited to the target areas for groundwater conservation. These target areas are clearly delimited within the pilot areas. The model results provide the information how much N surplus has to be reduced to reach a nitrate concentration of the leachate below the amount of 50 mg/l in 2015. The average of the years 1999 and 2003 is defined as reference. There is no static situation between 2003 and 2015, therefore it has to be defined which situation could be reached in 2015 due to the general framework set by the GAP without further water protection activities besides the implementation of existing legal instruments (basic measures), especially the fertilising ordinance (baseline scenario). For more details see deliverable 7.2. The set of technical-organisational measures and the farm surface involved will differ considerably depending on the actual situation of the individual farms, assumed developments until 2015, and the levels of expected acceptance of measures. As it is not possible to derive estimations neither for all individual farms nor for all local conditions the proposed approach will deliver only a rough estimation of expected costs.

The scope of the WFD is the river basin area and the sub-catchments therein. Theoretically it is possible that some farms produce high N surpluses while others have very low N surpluses if together they allow reaching the target value of 50 mg/l. As it is very difficult, perhaps even impossible, to define which farm type has to reduce to which degree the N surpluses, the following approach is implemented. For the selected farm types in combination with 5 defined natural site conditions (different soils and rainfall levels) the applicable measures will be selected and possible combinations of measures at the farm level will be defined. In a second step the impacts of measure uptake in the different farm types within target areas on N surplus reduction will be assessed. For this, the potential to implement measures within the farm types, the expected acceptance and estimated impacts of the single measures and their combinations are calculated (for more detail see deliverable 4.2). These data are the input data for the calculation of the reduction potential of the different catchments taking into account the proportions of the different farm types.

Once the necessary N reduction to meet the 2015 target is known, the cost for N surplus reduction can be calculated. To make cost prediction at regional level it is necessary to know the regional distribution of the different farm types and their production activities regarding land use and livestock. Statistic data are used to define the portion of different farm types in the sensitive areas. Therefore it is assumed that the farm types have the same portions in the sensitive areas as in the districts the target areas belong to. The agricultural statistic at the level of municipality (nuts4-level) is used. Besides the official statistics, IACS will be an important data base, allowing for a spatial join of detailed land use information and target areas. Also, more detailed data are available for the participating farms within the pilot areas in a 'case study' style.

Different scenarios will be calculated: Starting from a baseline scenario without additional supplementary measures, it will be estimated whether with the help of the selected measures the good groundwater status could be reached. A problem will be to distinguish between the impact of basic measures, obligatory to fulfil legal obligations, and supplementary measures. In Lower Saxony many farmers, especially in the regions with intensive livestock production, have to make an effort for adapt their fertiliser management until 2011 in order to meet the legal requirements of the fertilising ordinance (see Osterburg, 2007). While no compensation is paid for adaptations at farm level necessary to reduce N-surplus, the supplementary measures are voluntary and remunerated. However, if farmers improve their fertiliser management to comply with the legal rules, further measures to reduce N-losses will be more costly, as additional impacts on N surplus reduction will diminish. For more detail about scenarios see deliverable 7.2.

Another problem is the addressee: While the fertilising ordinance targets the individual farmer, the WFD defines targets for the different water catchments. If a reduction of the N load beyond the legal level is necessary, not all farmers need to reach further improvements. The reduction of the N losses should be concentrated on those farms with the best cost-effectiveness. An important step that has to be further discussed during the project is the process of selecting appropriate farms as 'addressees'.

3.5 Approach for cost prediction at the level of river basins and Federal State

At Federal State level, the aim is to provide overall programme cost, including an estimate for public transaction cost for measure implementation, monitoring and control, and for technical advice offered free of charge to the farmers as a flanking measures. While catch crop growing needs only little advice, more complex measures like improvement of fertiliser management as an element of the result-oriented measure requires more technical assistance, at least when starting the measure. A challenge for the estimation of overall programme cost will be therefore the assessment of cost for technical advice needed for a cost-effective programme performance.

The main river basins in Lower Saxony are Weser, Ems and Elbe. In each of them one of the pilot-areas is located. Within the WAgriCo-project no detailed cost-calculation for the single river basins is planned[1]. The cost-prediction for Lower Saxony will be conducted using data at municipality level (nuts 4) and the hydro-geological model results about the necessary reductions of N losses for all groundwater catchments in Lower Saxony. In this way it is possible to allocate the site specific information to the different river basins. In a first step the portion of sensible areas within the different districts and the average N reduction will be assessed. In a second step natural site conditions and the portion of the farm types for each district will be defined. Afterwards, the cost-calculation will be conducted in analogy to the cost-prediction for the pilot areas.

[1] In the project AGRUM the whole river basin of the Weser is considered, FAL is partner in this project.

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