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Introduction to AGWAPLAN

The aim of the EU-life project AGWAPLAN is to facilitate the practical implementation of the EU Water Framework Directive on farm level as well as on catchment level.



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A key issue for the project is “cooperation between the agricultural and the environmental sector” in order to get improved results for the environment as well as for the agricultural sector.

Three pilot areas participate in the project. They are all farmed intensively, and seen from an environmental point of view they have critical levels of N and P in either surface or groundwater.

By using the best available farm and environmental data in an Integrated Advisory System we have created plans for the farmer for how to optimize his production in a way that is consistent with his wishes for farming and consistent with the surrounding environment.

The conclusions

1. A common professional starting point – and a common understanding of the problems – is a key issue which takes a long time to gain.

2. Data must be precise, relevant and effective if they are to be acted on.
3. Structure for cooperation must be anchored in the different organisations.
4. Dialogue, cooperation, trust and insight are needed throughout the process.
5. Understanding and accepting the other side’s objectives provides a wider ability to act.
6. The easy measures are inexpensive to carry out for the farmers and for society. Which measures there are inexpensive vary according to specific conditions on the farms.

Challenges

1. Is the level of knowledge high enough around in the EU to be able to work with Integrated Advising at farm and catchment level?
2. Integrated Advising – the authorities and the farmers ready to invest in this method in order to find targeted

methods for the implementation of the WFD? ■

Establishing “good ecological status” by reducing nitrogen load of Norsminde Fjord



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Action plans for individual water bodies require a detailed specification of the sources of pollution and the options for taking action. The impact of N and P from point sources has been thoroughly described in Denmark, whereas specific information and requirements related to agricultural sources are inadequate. In the highly eutrophicated estuary Norsminde Fjord a draft tolerance limit of nitrogen load was established using monitoring data in hydrodynamic and biological models. A 50% reduction of the nitrogen load from agricultural areas in the catchment area was calculated to meet the requirements in the Water Frame Directive (WFD). Thorough investigations of soil characteristics were carried out and new methods of cultivation were introduced on farm level to minimize the loss of nitrogen.

Introduction

According to the WFD coastal waters in EU must achieve as a minimum a “good ecological

status” by the year 2015. Especially nitrogen but also phosphorus are the main environmental stressors in Danish coastal waters and the primary determining factor for numerous biological variables. In AGWAPLAN we have determined the critical load of nitrogen of Norsminde Fjord based on hydrodynamic models (Mike 21 and 3) and a bio-chemical module (Eco-Lab).

Study area

Norsminde Fjord is a small and shallow estuary situated in East Jutland, DK. It receives substantial amounts of fresh water and nutrients from the highly cultivated catchment area. Between 85 and 90% of the nutrient load is discharged through Rævs Å (main inlet) to the inner part of the fjord. The fresh water mixes with salt water from the southern part of the Bay of Århus entering through the gate, thereby creating a highly dynamical brackish and sometimes stratified environment. The vegetation is dominated by macroalgae

typical of highly eutrophicated estuaries such as *Ulva lactuca* repressing the natural population of seagrass (*Ruppia sp.*) and charophytes. Sometimes heavy blooms of toxic plankton algae occur.

Methods and results

Initially the factors and processes of importance for the ecosystem of Norsminde Fjord were analysed in order to choose a suitable model set up. The models are based on surveys of the bathymetry of the fjord and a large number of meteorological, physical, biological and chemical data recorded during an extensive 2 year field campaign from 2005 to 2006. The models show very good results on the reproduction of physical parameters, temperature, salinity and water level as well as bio-chemical parameters, nutrients, oxygen concentrations and phytoplankton. The description of macro algae and rooted vegetation (Eco-Lab model) is more complicated since the model do-

Table 1. Calculated nutrient levels (annual mean) in main inlet stream (Rævs Å) and in Norsminde Fjord.

Classification	Total-N, inlet µg N/l	Total-N, fjord µg N/l	Total-P, inlet µg P/l	Total-P, fjord µg P/l
Reference condition (1,09+/-0,46 mg N/l)	1090	480	50	26
Good ecological status scenario 1 (1,09 + 0,46 mg N/l) + 25%	1940	760	62,5	30
Good ecological status scenario 2 (50% reduction of annual N-load)	2600 (65 tons N/year)	850		

es not take into account grazing by swans or the wind induced transport of floating macro algae, making it difficult to reproduce the exact distribution of the vegetation. However the potential growth can be modelled and compared for various scenarios of nutrient loads from the catchment area.

Due to a delayed process in the EU-intercalibration network, classification of ecological status in surface waters has not been available in AGWAPLAN. A draft proposal in AGWAPLAN was based on data from reference rivers (representing nutrient levels with minor anthropogenic

impact), historical and sediment data from other fjords in Denmark. The nitrogen and phosphorus concentration in reference conditions is 0,400-0,750 mg N/l and 30-50 µg P/l respectively. Two scenarios indicating a good ecological status were proposed (Table 1).

The reduction target of inlet P-concentration in scenario 1 will be reached by 2012 due to improved waste water purification, although release of phosphorus from the sediment may still cause high concentrations in Norsminde Fjord during the summer. Scenario 2 was chosen for the project. We expect a lo-

wer production of macroalgae and phytoplankton, improved oxygen and light conditions thus improving conditions for rooted macrophytes, invertebrate fauna and waterfowls. This reduction target may be adjusted when the programmes of measures have been agreed on in the river basin management plans in order to meet the requirements of biological and physico-chemical indicators in the WFD.

Since 1980 there has been a 40% reduction of the main inlet concentration of both nitrogen (total-N) and phosphorus (total-P) due to improved waste water purification and reduced runoff from agricultural areas. However there is a substantial variation of annual nitrogen-load with high loads in years with a high precipitation like 1994 and low loads in the dry period 1996-1997 (Figure 1).

The present nitrogen load of Norsminde Fjord was calculated using the average discharge in Rævs Å in the period 1996-2005 (Figure 2). The main N-source is nitrate leaching from agricultural areas. According to scenario 2 the nitrogen load should be reduced from 129 tons N/year to 65 tons N/year (50% reduction).

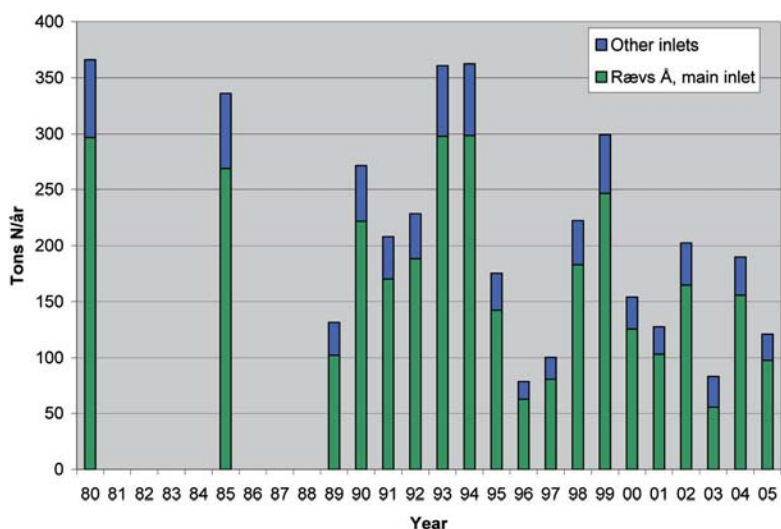


Figure 1. Annual nitrogen load of Norsminde Fjord.

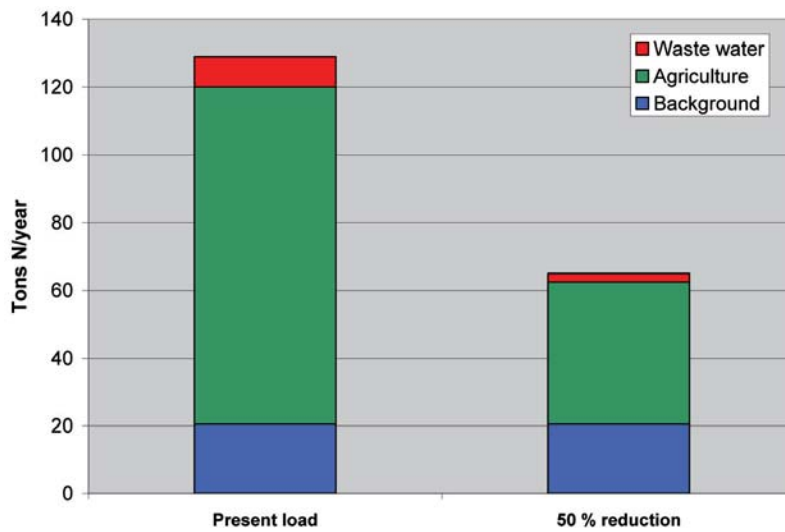


Figure 2. Present and scenario 2 load of nitrogen from the main inlet Rævs Å.

Fields in the pilot areas have been mapped and analyzed (texture, drainage conditions, slope etc.) and agreements were made with local farmers using a manual of good agricultural practice in order to minimize the future loss of nitrogen from vulnerable fields by introducing new methods of cultivation and wetlands. ■

Soil mapping at field scale using EM38

The newest techniques, supplemented with classical methods, were used to obtain detailed soil mapping of agricultural fields in the pilot areas of AGWAPLAN.



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It has been experienced from earlier soil classification studies that there is a significant variation in soil characteristics, even within smaller fields, which is not shown by downscaling the existing soil maps. Therefore, in order to obtain improved data for modelling the nitrogen leaching a detailed soil mapping of agricultural fields in the pilot areas of AGWAPLAN were carried out.

The soil mapping was performed by using an electromagnetic technique (EM38), where the apparent electrical conductivity of the soil is measured. This was supplemented with classical methods, where the soil profile to about 1 m was physically and visually characterized at strategic points in the fields.

The EM38 method

The principle of the EM38 method is based on induction and reflection of a magnetic field (Nehmdahl, 2000). Shortly, a magnetic field is broadcast from a transmitter coil, which crea-

tes an electrical current and a secondary magnetic field in the soil. A receiver measures the total magnetic field, and by comparing this with the known primary magnetic field, the relative electrical conductivity is determined. The conductivity, which is measured in milliSiemens per meter (mS/m), is well correlated with soil texture, and depending on the orientation of the instrument, the effective measuring depth will be 0.75 to 1.50 m. This means that the measurements give detailed information about the variability of soil texture across the entire root zone.

Table 1. Relationship between soil texture and electrical conductivity (Clay, 2000).

Texture class	Conductivity, mS/m
Sand	0.1 - 1
Loamy sand	1 - 5
Loam	5 - 12.5
Silt	12.5 - 25
Clay	25 - 100
Saline soil	100 - 200

The measurements were performed with the EM38 sensor mounted on a plastic-sledge, which was pulled over the field by a 4WD motorbike (Figure 1). The running speed was 15 -20 km/h, and one measurement was taken for each 10 to 15 m, which ensured a uniform and systematic measuring distance over the area. The position of the instrument was continuously registered and logged with a GPS system.

Several factors affect the measurements, of which the following can be mentioned: the content of clay, soil temperature, salts, metals, water and humus. However, in normal arable soil, clay content is the most important factor with highest conductivity, and sand has the lowest.

The technique has the advantage of being a non-destructive method, and allows measuring even with crops at a certain height on the field. A disadvantage of the method is that if a clay layer is overlying a sand layer, the clay will shadow for the un-



Figure 1. Apparent electric conductivity is measured using an EM38 sensor mounted on a sledge.



Figure 2. Soil samples are taken for physical and visual examination.



Figure 3. The map at left shows the results of measurements with the EM38 technique and classical methods, from which the final soil maps (right) are produced. Colours in the map to the right represent different clay contents, where white = 0-5%, grey = 5-10%, yellow = 10-15% and brown = >25%.

derlying sand, which is one of the reasons that the EM38 method needs to be supplemented with classical methods.

The classical method

As mentioned, the EM38 method needs to be supplemented with classical methods, which is based on physical analyses and visual examination of soil samples taken at strategic points in the field (Figure 2). The soils were characterized in three depths (0-30 cm, 30-70 cm and 70-120 cm) regarding geological origin and texture (clay, silt, sand and humus). Additionally in the AGWAPLAN project, larger 20 x 20 cm undisturbed soil cores were taken, on which hydraulic conductivity was measured.

The final soil mapping

Measurements with the EM38 method are combined with results of the physical characterization of soil samples and the final soil map can be produced (Figure 3).

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Calculating nitrate leaching at field scale using detailed soil data

The Daisy model has been used to calculate nitrate leaching on field scale. The results are used to determine the required improvements on farm scale.



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Introduction and methods

The nitrate leaching from arable land has been calculated with the Daisy model for 16 farms in the catchments of Norsminde Fjord and Lake Ravn (Ravnsø).

That means altogether 1.728 ha. The calculations are based on data collected from each farm concerning agricultural practice in 2005, i.e., crops, rotation, fertilizers, animal manure, straw

incorporation, irrigation, and crop yield. The use of detailed soil data collected with EM38 resulted in a detailed spatial calculation of the nitrate leaching.

Table 1. Nitrogen and water balance at 16 project farms in the Norsminde Fjord and Lake Ravn catchments.

	Norsminde Fjord	Lake Ravn
Area (ha)	1272	456
N-supply (kg N/ha/yr.):		
- fertilizer	158	187
- deposition	16	16
- atm. N-fixation	6	12
- seed	4	4
Total	184	219
N-removal (kg N/ha/yr.)		
- volatilization	4	6
- leaching	43	56
- denitrification	21	25
- harvest	120	138
Total removal	188	224
Change in soil-N (kg N/ha/yr.)	-4	-5
Water Balance (mm/yr.)		
- precipitation	853	830
- evaporation	530	520
- percolation (matrix)	201	232
- drainage	122	78
Nitrate concentration (mg NO ₃ /l)	58	80

Results

Table 1 shows an overview of the average nitrogen and water balance for the 16 project farms in the catchments of Norsminde Fjord and Lake Ravn. The average calculated nitrate leaching from arable land in the Norsminde catchment was 43 kg N/ha/yr. (58 mg nitrate/l). The average calculated nitrate leaching from arable land in the Lake Ravn catchment was 56 kg N/ha/yr. (80 mg nitrate/l). Figure 1 shows the spatial distribution of nitrate leaching in part of a catchment area.

Conclusion

It is important to be able to identify areas that contribute most with nitrate to the sensitive recipients. Then it is possible to find a focused and economical optimal solution. This case

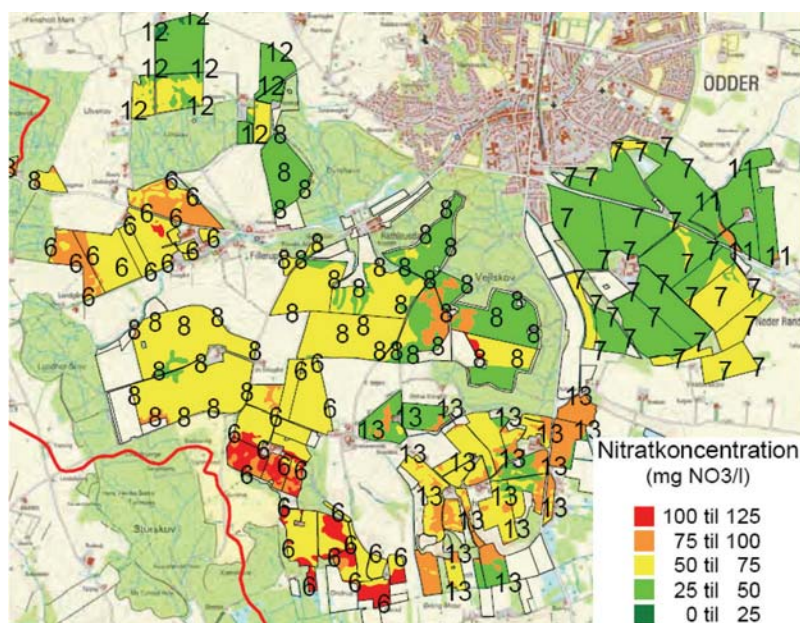


Figure 1. Example of calculated spatial distributed nitrate leaching in part of Norsminde Fjord catchment.

shows that it is possible to use detailed soil data (EM38) to model the spatial distribution of nitrate leaching. Thereby it is possible to focus the solutions to reduce nitrate leaching to a recipient.

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GAP manual - a tool for reduction of losses of nutrients from agriculture

The GAP manual contains a description of different methods to reduce the losses of N and P from agriculture at farm and at catchment level.



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The idea behind the GAP manual (Good Agricultural Practice) is a platform where descriptions of the different methods to reduce the loss of nitrogen and phosphorus from agriculture. The goal is to provide environmental authorities and farmers with a common tool when looking for the most cost-effective methods to reduce agriculture's impact on the water environment – i.e. groundwater, lakes, and the sea.

The GAP manual is elaborated as a tool which can be used when advising on methods for improved agricultural practice in catchments with sensitive water bodies. The manual contains a number of methods to reduce nitrate leaching and loss of phosphorus at farm and catchment level. It should be noted that the manual focuses on voluntary methods.

The GAP manual contains a short description of all the different methods:

- Where is the method relevant e. g. on clay or sandy soils, on cattle farms or in

plant production etc?

- The potential effect on the efficiency of nitrogen and phosphorus as plant nutrients in plant production.
- Nitrate and phosphorus leaching, volatilization of ammonia.
- Economy.
- How to implement the methods on the farms and in the catchments.

Besides the description of the different methods the GAP manual includes a spreadsheet where the effect of the different measures on nitrate leaching can be calculated on farm level. The spreadsheet further includes an evaluation of the different methods to reduce phosphorus loss. The calculations are based on existing and commonly accepted knowledge.

The calculations in the spreadsheet are table look-ups. It is important to notice that the table look-ups are mutually independent and to some extent independent of farm type and

soil type. The use of the spreadsheet therefore requires a skilled user.

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Using integrated advice in practice to reduce the nitrogen load of Norsminde Fjord at farm level

An Integrated Advice concept has been developed in order to find a way to implement the Water Frame Directive which takes into account both environmental goals and the farmers need for development and economic outcome. The concept builds on close dialogue between the farmer, the farm advisor and the environmental authority.



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A key issue for AGWAPLAN is cooperation between the agricultural sector and the environmental authorities in order to improve the water environment as well as economic conditions for the individual farmer. Three pilot areas participate in the project. They are all farmed intensively, and seen from an environmental point of view they have excessive loss of nitrogen (N) and phosphorus (P) causing eutrophication in surface waters or contamination of groundwater. By using the best availa-

ble data at both farm scale and catchment scale the intention has been to create action plans for the farmers describing how to optimize the agricultural production in a way consistent with both their wishes for farming and the objectives for water bodies in the WFD. An Integrated Advisory System has been tested and approved by 22 farmers in the pilot areas.

Study area

One of the pilot areas is Norsminde Fjord, a small and shal-

low estuary situated in East Jutland, Denmark. It receives substantial amounts of fresh water and nutrients from the highly cultivated catchment area.

The environmental status of Norsminde Fjord is poor because of high loads of both nitrogen and phosphorus. In order to meet the objective “good ecological status” a 50% reduction of the nitrogen load from agricultural areas in the catchment area has been calculated and used as a draft measure.

Methods

Initially, the farmers union was informed about the environmental status and reduction measure of Norsminde Fjord by the environmental authority. The overall objective and reduction measure at catchment scale was discussed, and a common strategy for management plans was agreed upon by farmers participating in AGWAPLAN. A major challenge for both farmers and environmental authorities was to overcome mutual distrust. One solution is to share knowledge on environmental protection and agricultural production at both catchment level and farm level with special attention to the individual farmer. Hereby a local commitment on both farm level and catchment level was created. The local agro-consultants played a significant role as mediators between the farmers and the environmental authorities.

During the project a number of very detailed maps of soil ty-

pes and calculated nitrate leaching were developed at sub-field level. Hereby the farmers recognize the variation of potential leaching making it easier to focus on vulnerable areas.

In addition, a user friendly manual of Good Agricultural Practices (GAP) based on scientific results from the University of Aarhus has been developed and used in the following integrated advice process, where the farmer, the local agro-consultant and environmental administrator meet “round the table” in order to reach a common platform of understanding as the offset to discuss and agree upon alleviation measures at farm level. A draft plan is written during the meeting, including examples of measures and consequences. The final plan is made by the agro-consultant commented by the farmer and environmental manager.

Conclusion

One of the key issues in AG-

WAPLAN has been to achieve a common understanding of environmental challenges developed through real dialogue between the partners. By understanding and accepting each others perspective common solutions are easier to find. The farmers change attitude to their farm management and the environmental authorities change attitude to the farmers and regard them as partners, which can help find solutions.

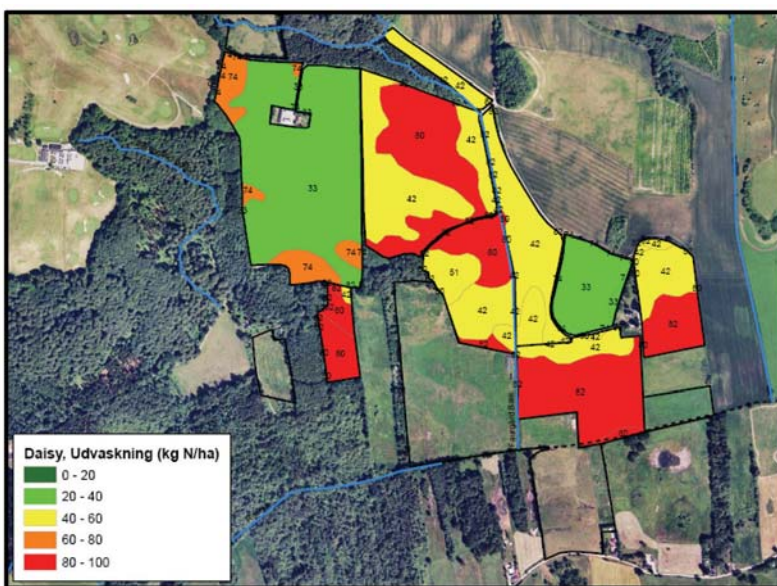
The project has shown, that the integrated advice process can identify the most easy and achievable solutions which are cost effective for the farmer and the society.

Discussion

There are some limitations to a full scale implementation of an Integrated Advisory System in other areas in Denmark or EU.

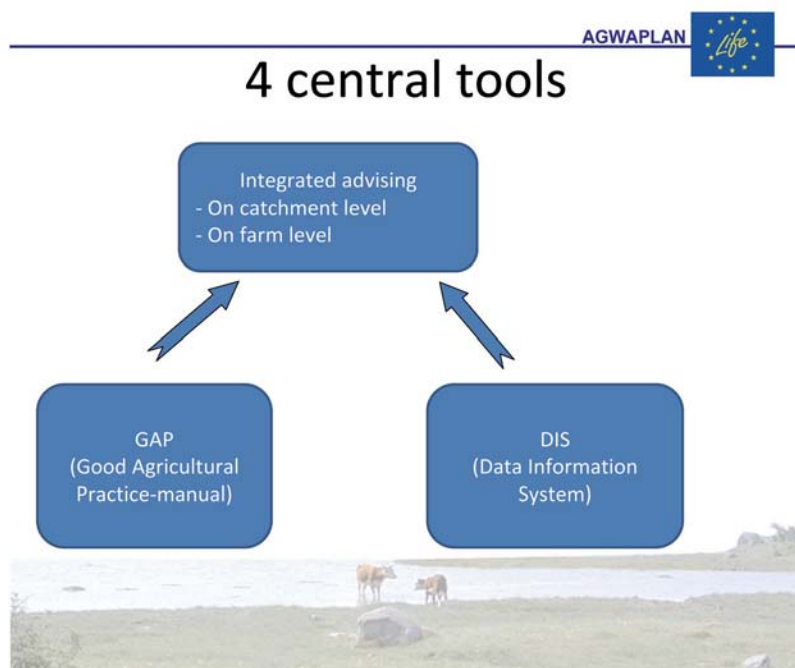
One limitation is that the amount of data available in this project is larger than in most other areas. This means that the uncertainty of estimated reduction measures at catchment level and on the calculated nitrate leaching at farm scale may be larger in other areas and therefore less reliable to use as background for voluntary actions. It is therefore essential that future monitoring programmes are designed in a way that can strengthen knowledge at local scale and show effects of management plans in the environment as stated in the WFD. In addition focus should be on establishing good basic data, i.e. soil data, at farm level for use in the integrated advice process.

Another limitation is that integrated advice on a national



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Figure 1. Modelled (Daisy, kg N/pr. ha) loss of nitrogen from the root zone at field level.



scale requires many human resources. But compared to the cost of for example waste water purification and the significance of the farmers' influence on the environment this may not be considered disproportional.

The environmental objectives in the WFD must be fulfilled by 2015. Management plans only based on voluntary agreements as in AGWAPLAN may therefore not be sufficient and the good results and dialogue between farmers and authorities may not always be the only outcome. We recommend that the national authorities pinpoint this integrated method as one of the key methods for the future implementation of the WFD. ■

Implementation of the Catchment Concept – exemplified with a lake catchment

How integrated advice meetings were used in the catchment concept and the difficulties that we met.



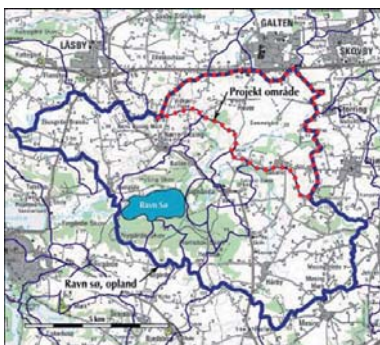
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The catchment to Lake Ravn

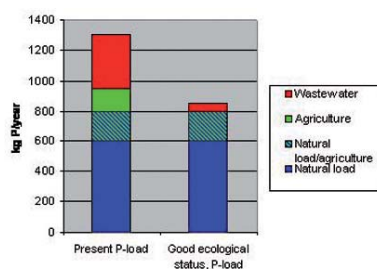
The catchment area to Lake Ravn has a total area of 5500 ha. Detailed monitoring of the streams in the catchment area as well as of the lake itself undertaken during the last 15 years proves that the lake is moderately polluted by nutrients and that there is a need to reduce the supply of particularly P to achieve good ecological status according to Aarhus Amt. The final indicator boundaries between good ecological status and moderate ecological status are not yet published.



Catchment to Lake Ravn and the project area.

The participating farmers farm 500 ha, which is equivalent to approximately 12% of the cultivated area in the entire catchment.

The target for the phosphorus load to Lake Ravn was calculated to 850 kg P/year using a hydrodynamic and ecological model. The total amount of P to the lake at present is 1300 kg/year with approximately 350 kg from wastewater, 150 – 350 kg from agriculture and 600 – 800 kg from natural loss. It is difficult to separate contributions from agriculture and natural loss. If the natural loss is 600 kg the contribution from agriculture is 350 kg and vice versa.



Total-P load lake Ravn

Integrated advising

In order to reduce the loss of P from cultivated fields, an integrated advisory meeting was offered to the farmers participating in the project.

Before the meeting, several documents and maps were prepared:

- Soil-mapping from EM38 and fieldwork
- P-index maps, showing which fields have the greatest risk of losing P
- Accounts for P use and harvest on the farm
- GAP – manual – with at list of methods to reduce loss of P
- And of course the farmers and our local knowledge

At the meeting

The P-index maps, together with knowledge of P-content in the soil water, the slope of the area and the present use of the area, were used to identify special areas with a high risk of losing P.

All the methods in the GAP-

manual were discussed at the meeting, and the farmer made an assessment of the possible use of the specific methods.

Afterwards the adviser calculated the total reduction of loss of P from each farm.

Results of integrated advising

After the integrated advisory meetings with all participating farmers, the total possible reduction of P was calculated. The result of these calculations was that the goal for Lake Ravn was not achieved.

Therefore a catchment solution was discussed.

The idea was that streams from the project-catchment area should run through a lake, where phosphorus could settle, before the water continued to Lake Ravn.

The project area contains a former lake (Gammelgård sø), which is pumped free from water from March to November. In the wintertime it is a lake. The water from this lake continues through a stream (Knud Å) to Lake Ravn.

Several problems appeared during this discussion. First about the present use of the land in the former lake. The land in question has several owners, who at present use the land in different ways. To re-establish the lake all owners must be willing to give up the land. For some owners their share of the land is of great value as part of their farm. Therefore these owners will expect some sort of compensation. Either from the public authorities or from other farmers in the area outside the former lake, who will gain from

the project.

The catchment concept brought about questions about compensation in general; how are the farmers who own the land that solves a problem compensated by those who benefit from the project.

Another issue in re-establishing for example a lake is evaluation of the land that will be covered by water. This could be valuable nature with rare species of flowers, insects etc. The environmental authorities have to make an evaluation before the re-establishment can be made and perhaps grant an exemption from laws protecting valuable nature. Likewise the changing of the way of a stream would require approval from the environmental authority.

Due to these difficulties we are now trying to establish a small sedimentation basin/pool at the end of artificial drains from the field with the highest P-index – before the final outlet to the stream. If this solution proves possible, we will need a lot of basins/pools in the future which is why it is essential that they are cheap and easy to construct. The advantage of these small distributed basins/pools is the localisations near the source of phosphorus and of course their small size. The disadvantage is that it is not possible to catch any loss of soil from the banks of the stream and difficulties as to where they are placed optimally. ■

Implementation of the Catchment Concept – exemplified with a groundwater catchment

Statements from the work in the groundwater catchment Hinnerup. A prerequisite for achieving the necessary solutions for groundwater protection is a high degree of knowledge about the catchment and the farms within it combined with a high degree of involvement from the farmers.



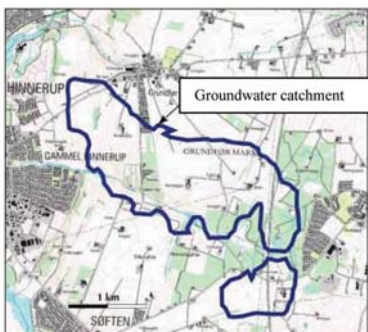
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During the last three years we have worked in AGWAPLAN to find solutions for the groundwater catchment Hinnerup. The environmental authority, local agricultural advisers and five project farmers have participated in the project. In the project we have tested a new method of integrated advising. Simultaneously we have worked to find common solutions on catchment level. The results of our work are presented below in 3 statements.

Catchments are dissimilar – and demand different solutions



The Hinnerup Waterworks

catchment area consists of 340 ha arable land. Waterworks and wells are placed furthest to the west in the catchment. The main part of the area (90%) is nitrogen sensitive. In order to reach the environmental objectives in the area the present leaching from farmed areas must be cut by 46%. The catchment of the Hinnerup Waterworks is close to urban areas and within half an hour's drive from Aarhus (Denmark's 2. biggest city). To the east the catchment borders on forest area and there are possibilities for achieving subsidies for afforestation.

The Hinnerup groundwater catchment area is a good example of a catchment where it is necessary to work at both farm level and catchment level in order to reach the environmental objectives. It is our belief that this area will be unsuitable for intensive livestock production in the future due to the catchments' proximity to urban areas. Solutions point to less intensive land use or recreational use

of the most urban areas. Those areas are vital to the groundwater protection as the most water is pumped from here. In the eastern part of the catchment a possible solution may be afforestation.

The fact that farms and farmers are different is mirrored in the possibility to create solutions



A meeting at the home of a farmer.

The 5 farmers who participate in AGWAPLAN farm around 55%

of the land in the catchment. Most of them are older farmers on their way to winding up their farms. None of them have children who want to take over and two farmers plan to sell within a few years. Today the catchment is farmed intensively.

Since the farmers in the Hinnerup area are older they do not wish to invest in new technology that might help to reduce nitrate leaching. Instead we have concentrated on more traditional means - especially on catch crops. The fact that some of the farmers expect to sell their farms creates other possibilities. It makes it possible for the Waterworks to buy the land and permanently change the land use to for instance grassland or forest. In order to position the extensive use where it will have the greatest biggest effect it might entail that land must be redistributed among the farmers within the catchment.

Since the area is situated close to the motorway and Aarhus we find that the area could be attractive to part time farmers who often use their land less intensively. Part time farmers often demand amenity value such as nature, well kept buildings, and a view from the farmhouse, which is why we have worked with plans for making the properties and their surroundings more attractive.

Knowledge is essential as well as involvement

In order to obtain a constructive dialogue it is important that all partners have access to the same knowledge, acceptance of it, and have a knowledge and understanding of each other's real-

ity.

There has to be at high degree of knowledge about the environmental objectives, the border of the catchment area e.g. as well as about the connection between exposure and loss of nitrogen to the surrounding environment. In AGWAPLAN we have successfully given the farmer knowledge about the means to reduce nitrate leaching. We obtained this through integrated advising as well as at catchment area-meetings between all 5 farmer families with the catchment area as subject. In this way we have taken several steps towards obtaining the environmental objectives through voluntary changes in the farming praxis on each farm.

The project has also shown that lack of knowledge can stop the processes. This is exemplified by the fact that Hinnerup Waterworks are planning on finding a new location for a supplementary well. A supplementary well will change the border of the catchment area. This creates an uncertainty about on which fields a requirement for reduction of nitrate leaching will be placed. From this follows a certain restraint among all partners when it comes to solving the environmental problems and it illustrates, why environmental objectives must be settled before the farmers are contacted.

Overall conclusion

- Results can be achieved through efforts on farm level as well as on catchment level. Farm level solutions are the easiest and the cheapest, but catchment level solutions may be neces-

sary in order to achieve the required reduction and still keep agriculture in development, especially when the requirements are far from the present level.

- Involvement from all partners is essential if an environmental objective is to be fulfilled in practice and the presumed effects are to be reached. Often the farmer has local knowledge which can contribute to the solutions, and often the farmer's motivation for finding solutions grows after taking ownership of the environmental objectives.
- Basically respect for each other and each other's objectives is essential in a constructive dialogue. By looking at environment and production as a whole you find new ways of solving problems. ■

Mapping the risk of P loss

Risk areas for P losses on agricultural land were mapped with the Danish P Index.



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Authorities and advisers require tools for identifying critical source areas of phosphorus (P) loss to aid mitigation planning. The P Index is a practical tool well suited for screening large areas since it has comparatively low requirements regarding data input and is integrated with GIS. The P Index can rank fields according to their relative risk for P loss and is not a quantitative loss predictor. In Denmark a national, web-based P Index is

presently being implemented, and the following is a brief summary of the principles with examples from the Ravn Lake catchment.

Method

Risk areas for P losses on agricultural land were mapped with the Danish P Index, which is a modification of P indices developed in the U.S.A. during the last 15 years (Sharpley et al., 2003). The Danish P Index maps each of the P loss proc-

esses individually: erosion, surface runoff, leaching via the soil matrix and leaching via macro pores. Each P loss pathway is characterized by three factors: the P source, the risk of P mobilization from the source, and the risk of transport of mobilized P to surface waters. Each of these factors is based on relatively easily available parameters (Table 1). Erosion and surface runoff were mapped with simple topographic models using a 10-

Table 1. The Danish P Index (prototype and thus not yet fully documented in a scientific publication). E: erosion; SR: surface runoff; MA: leaching via the soil matrix; MP: leaching via macro pores.

P loss pathway	Source	Mobilization	Transport
E	Soil test P. Fertilizer and manure taking into account amounts, timing and method of application	Modelled soil erosion	Distance along flow path from eroded area to nearest surface waters
SR		GIS-derived upstream discharge area to DEM-cells at the edge of field. Accumulated winter precipitation.	Distance along flow path from edge of field to nearest surface waters
MA		Sub-surface P sorption capacity	Annual net-precipitation. Presence of tile drains
MP			Presence of macro pores. Likelihood for macro pores to be active. Presence of tile drains.

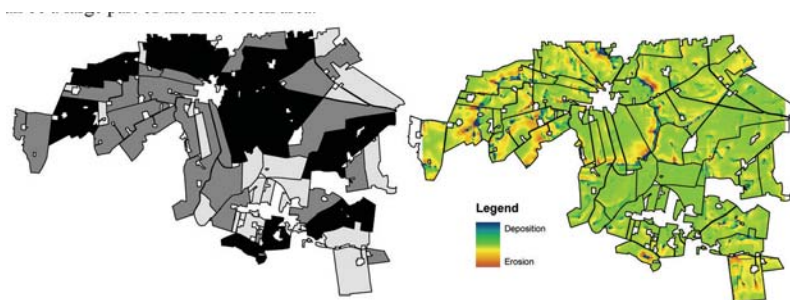


Figure 1. P Index classes for the transport process erosion in the Ravn Lake catchment (a). For presentational reasons the whole field block is assigned a risk class in (a), although the eroding area may only comprise a minor part of the field block (b). Legend (a): light grey: low risk; dark grey: medium risk; black: high risk.

m resolution DEM. Information on crops, fertilizer and manure applications were taken from national agricultural databases. Cropping and fertilization were in accordance with typical agricultural practice in Denmark. Since data on soil P are not commonly available, a default value of 50 mg Olsen P kg⁻¹ was used initially.

P Indices for the Ravnsø catchment

Risk classes for P Indices of individual transport processes were delineated by choosing as class limits the median and the 90th percentile from the corresponding distributions of P Index values established for all agricultural land in Denmark. For mapping P Indices nationally representative regional distributions of soil P values were used

instead of a default value, as done here. We chose percentiles as class limits because the scientific basis for defining absolute class limits is lacking. Figure 1 shows the P Index classes for the transport process erosion as an example for the Ravnsø catchment. Table 3 shows the total area of high risk areas for P loss processes. Most likely, the calculated risk area is over-estimated since a relatively high soil test P value of 50 mg Olsen P kg⁻¹ soil was used for all field blocks. Additionally, a riparian buffer zone width of 0 m was used for all streams and lakes, since actual riparian buffers do not appear on the maps used for calculating the P Index, and since no buffers are demanded along e.g. open ditches in and between fields. However 2-m buffer zones are mandatory along most streams.

Table 2. Size of high risk areas of P losses to surface waters for different P loss processes in the Ravnsø catchment as estimated by the Danish P Index. Numbers in parenthesis state the high risk area as a percentage of the total agricultural area.

P loss process	Area classified as high risk
Erosion	82 ha (8%)
Surface runoff	97 ha (9%)
Matrix leaching	601 ha (55%)
Macropore leaching	481 ha (44%)

In the approach presented here, the area at risk of losing P was considered in the calculation of the P Indices, which in the case of P leaching processes (matrix and macropore transport) can be a large part of the field block area.

Mitigation measures

After having identified high risk areas various mitigation measures can be planned for fields prone to erosion, such as for example establishing permanent grass or fallow on sloping fields or introduce buffer zones along also small ditches and creeks. In practice, before measures are being implemented local environmental authorities have to evaluate the risk mapping by field visits and farmer interviews.

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Barriers to the implementation of the Water Frame Directive (WFD)



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The AGWAPLAN project builds on the basic assumption that cooperation between farmers and the environmental authorities in specific catchments is the most optimal solution for implementing the WFD for the involved parties, both in economic, environmental and human terms. Integrated advising and good agricultural practice (GAP) have been chosen as the central themes for testing the framework for cooperation in the present project.

On the assumption that technical, agronomic and economic barriers can be managed, we have been focusing on social and institutional conditions in the sociological research in order to get the cooperation to work in practice, and not least, what is the framework required for the cooperation, and how should this framework be established in practice. As an introduction to the AGWAPLAN project a sociological barrier report was made, where the different stakeholders were interviewed about

both their understanding of the agronomic, technical and environmental barriers to reaching the goals through integrated advising and what barriers were seen as worth considering in order to make integrated advising work in practice. Main conclusions from the research were:

- Initially not all farmers share the idea about cooperation and good agricultural practice as a means of implementing the WFD. Some farmers already felt that they practised GAP within the economic limits.
- The farming enterprises are very different in their organisation and management and there is a need to meet them with different approaches and solutions to achieve cooperation.
- It's a challenge to convert WFD targets at catchment level to operational and fair targets at farm level.
- In many cases an optimal solution is expected to require cooperation at catch-

ment level.

- It is a challenge to establish a reliable organisation for cooperation between farmers and environmental authorities and for integrated advising in the catchment.
- It is a challenge for the parties to agree on how to establish the actual basis of calculation for environmental decisions.
- Many participants expressed concern that they did not have institutional and organisational support.

These results we have sought to integrate in the development of integrated advising in the project. The present session will focus on the results from a sociological point of view, partly via the reflections by Eike F. Stubsgaard as a project participant, initially representing the county council and later the municipality.

Mads Lægdsgaard Madsen will subsequently present the results from the sociological eva-

luation and the experiences that have been made in the project. Here focus will primarily be on the challenge of integrating and relating to the institutional base. Finally, we will discuss the future challenges and perspectives. ■

Cooperative approach - structure and time schedule

In catchment areas, where reduction measures are very high, a reference-group-structure should be established for dialogue on means of achieving the objectives.



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The Water Frame Directive (WFD) represents a new way of governing. Guidelines for reduction have until now been mainly general national guidelines, but with the WFD the targets and methods of achieving the targets will be determined by local conditions.

Why cooperate?

Preliminary calculations show that in some places it will be necessary to make considerable changes in land use in order to reach the environmental objectives. One example is Norsminde Fjord, where preliminary model calculations show that a 50% reduction in nitrate leaching will be necessary in order to achieve a “good ecological status”. At present the final environmental objectives that will be necessary in order to fulfil the WFD have not been communicated from the EU Commission. Thus the necessary efforts in order to reduce leaching might vary, but a reduction of up to 50% is a challenge to agricul-

ture’s survival, and agriculture has good reasons to enter into a dialogue and find the solutions that are most suitable for their production.

The environmental authorities purpose with cooperating is to utilize the possibilities for a total plan for the catchment, including further environmental, nature related and recreational perspectives.

Cooperation – how?

AGWAPLAN has shown that there is a limited tradition for cooperation between environmental authorities and agriculture. There is no existing structure for cooperative approach and there is a lack of knowledge transfer. A “process at catchment level” must solve these challenges. During the process there are two levels:

- A catchment level where the national Environment Centres take the initiative
- A sub-catchment level where the municipalities take the initiative.

We suggest that the Environment Centres establish a forum for municipalities and representatives of the stakeholders thereby creating a platform for dialogue and exchange of knowledge in each catchment area i.e. the Gudenaa catchment. Each Environment Center must ensure that knowledge is transferred to the municipalities and to the representatives of the stakeholders. Thus the forum must consist of technical representatives/ preferably not politicians.

The municipalities and the agricultural advisers must ensure:

1. that the farmers have the necessary knowledge to assess the effect of different kinds of agricultural praxis and
2. that the farmers have the necessary qualifications to understand scenarios and to unassisted suggest solutions on catchment level / across boundaries of the individual farm.



Cooperative approach, when and how to do it?
Figure 1

Water- and Action Plans	Environment Center and Municipality	Agricultural Advisor	Farmer
Idea phase	<ul style="list-style-type: none"> Establish structure for cooperation on catchment and sub-catchment level 	<ul style="list-style-type: none"> Understand and communicate environmental objectives and processes 	<ul style="list-style-type: none"> Understand environmental objectives and their own influence on achieving the objectives
Suggestion for Water Plans	<ul style="list-style-type: none"> Find optimal solutions for environmental interests early in the planning process 	<ul style="list-style-type: none"> Integrated advising 	<ul style="list-style-type: none"> Strategic planning
Final Water Plans and action programmes	<ul style="list-style-type: none"> Understand and communicate environmental objectives and processes 	<ul style="list-style-type: none"> Participate in cooperative structure on catchment level 	<ul style="list-style-type: none"> Participate in the farmers' own reference groups in the sub-catchment
Suggestions for municipal Action Plans	<ul style="list-style-type: none"> Determine demands for reduction on farm level Integrated advising on farm and catchment level 	<ul style="list-style-type: none"> Establish reference groups for farmers in the sub-catchment Find optimal solution for production interest early in the planning process 	<ul style="list-style-type: none"> Find solutions on farm level and sub-catchment level possibly in cooperation with other sectors
Final Action Plans 2010	Integrated advising	Integrated advising	Carry out their own strategy as well as that of the sub-catchment



Figure 1. The cooperative approach is to build a structure of reference-groups with representatives from the stakeholders on catchment level, on sub-catchment level and maybe even minor local levels. In the reference groups there is dialogue, knowledge transfer and estimation of solutions in an iterative process.

AGWAPLAN has shown that the agricultural advisers play a very central role in the implementation of the WFD. Those agricultural advisers who have specialised in environmental work are strong professional sparring partners for the Environment Centres, as well as for the municipalities and the farmers.

The agricultural advisers have, or have the possibility of acquiring, the competencies that are necessary in order to operate on catchment level and on the individual farm. The agricultural advisers are able to understand and juggle the various

scenarios and to communicate with environmental authorities as well as farmers about advantages and disadvantages of the scenarios.

Simultaneously the agricultural advisers have the farmers' trust. Thus the advisers can mediate the wishes of both parties and facilitate the implementation of the environmental objectives.

The success criteria for the structure of cooperation are that the farmers:

- are involved and obtain a knowledge level that makes them able to participate actively and competently in

local reference-groups.

- achieve insight and trust in the professionalism behind the environmental objectives.
- examine the possibilities of achieving the environmental objectives on their own farm or in the catchment/sub-catchment.
- implement the environmental objectives.

All stakeholders are responsible for ensuring that a structure is built and knowledge transferred to an extent that will make this possible. ■

Results from the evaluation of integrated advising in the AGWAPLAN project



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The AGWAPLAN project is of current interest because as it has run as a pilot project in advance of the implementation of the WFD. All participants in the project have been interested in making a solid contribution to the project to test if there is a general advantage to be gained from providing an integrated advisory service.

This presentation summarizes results from the final evaluation of integrated advising in the AGWAPLAN project. The evaluation is based on a sociological interview survey involving representatives from all groups of participants. Based on the activities and experiences in the project, the evaluation draws conclusions about how to use the integrated advising concept in the future implementation of the WFD and about which conditions and demands should be made from the participants to ensure the best result from integrated advising.

Integrated advising in catchment areas

From the analysis of the interviews you will find that the farmers involved in integrated advising in the AGWAPLAN project to a large extent changed their understanding of the problems and their agricultural practice commensurate with the reduction targets. The farmers' contribution is very dependent on the catchment having a common objective that cannot be solved by one farm alone, and a well-defined target that can be pursued by the farmer. In other words, to ensure that farmers take an active part, there has to be a very precise formulation of the problem to make the farmer understand the causal relations between his fields and the environmental problem in question. The results from AGWAPLAN show that it is important that the Environment Agency and local authority cooperate to provide such an operational frame for the integrated advisory approach.

Organisational challenges

The involved parties in the planning and execution of the integrated advisory service have expressed their satisfaction with the dialogue produced by the integrated approach. But at the same time it is characteristic for this dialogue that it mainly exists between individuals and not on an organisational level. The cooperative approach in the shape of integrated advising is as such not just a challenge to cooperation and dialogue between involved organisations, but maybe to an even greater extent a challenge to the internal integration in the organisations. If integrated advising should combine environmental and production considerations, there are three challenges to be taken into account:

Internal integration in the organizations

Agricultural advisory service

It is important that the farmer does not rely solely on his crop production adviser. It is impor-

tant that the environmental advisers' knowledge becomes part of the daily advising. The consultants in the agricultural advisory service are becoming increasingly specialized, which results in an increasing demand for change in the organisation that must be able to integrate knowledge from both production and environment in one complete advisory service for the farmer.

Local authorities

The local authorities are also faced with challenges if integrated advising is to become an option outside AGWAPLAN. For the provision of integrated advising the local authority has been represented by employees who normally work in the area of environmental approvals and regulation of farms. The planning of catchment solutions implies that the planner has appropriate knowledge about the local agricultural conditions. Therefore it is an organisational challenge for the authority to integrate local agricultural knowledge in the planning of future reduction targets. The specialisation means that the employees working on planning the action are not in dialogue with the other participants and so the cooperative approach to reduction targets gets very difficult.

Integration across organisations

Environment agencies and local authorities

On 1 January 2007 the environmental agencies and local authorities took over the responsibility for the implementation of the WFD from the erstwhile

county councils. The influence of the new environmental agencies in AGWAPLAN was considerably reduced because the environmental authority was transferred to the local authorities. At the same time much of the biological and geological expert knowledge was transferred to the environmental agencies. The necessary exchange of knowledge between these organisations is a challenge if future implementation of legislation is to find a reasonable level between production and environmental considerations. ■

WAgriCo – An EU project pursues a new approach - Water management and agriculture join forces for clean water

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The aim of the European Water Framework Directive is good water quality. In many places, however, present knowledge indicates that the situation does not conform to the requirements of the Water Framework Directive. One reason for this is diffuse pollution from the agricultural sector (e.g. nitrate, pesticides) which has a serious impact on the quality of groundwater and surface waters. In line with the Water Framework Directive there is therefore a need to develop suitable strategies and programmes of measures that can help to reduce harmful inputs into bodies of water. This is precisely the central point of attack of the three-year Life project WAgriCo that is being run jointly with German and English partners in representative pilot areas of Lower Saxony and the United Kingdom. The project is designed to make an active contribution to sustainable use of water as a resource.

Together with farms and in close cooperation with research establishments, the project is identifying and testing ways of achieving good groundwater and surface water status and reconciling the interests of water resource management, agriculture and nature conservation.

The WAgriCo project is based on more than 10 years experience of the cooperation model in the Lower Saxony drinking water abstraction areas, and on the work of the Voluntary Initiative on Pesticides (programme for reducing pesticide inputs) in the United Kingdom. The focus in this project is on large-scale implementation of improved water conservation measures and the development of innovative cooperative approaches (multilateral cooperation).

Project results: Modules for sustainable water resource management

Practical solutions through participation by farmers and other stakeholders

- Development of innovative water conservation measures, e.g. rewards for improving utilisation of nitrogen at farm level
- Suggestions for ecologically and economically efficient water conservation measures that can be integrated in agro-environmental programmes to support sustainable water resource management in the EU
- Transfer of WAgriCo project results to other EU member states
- Support for the planning and implementation of water conservation measures for various interest groups from local to national level

The project receives assistance under the European Union's LIFE Environment programme.

For further information: www.wagrigo.de and www.wagrigo.org

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Perspectives for implementation of the WFD in Germany

Supplementary agricultural measures. Process of selection and types of measures.

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The experiences with the selection of supplementary agricultural measures in the Lower Saxony region of Germany indicate that supplementary measures in Lower Saxony are necessary because the Nitrates Directive is not sufficient for dealing with sensitive areas in all cases unless the strictest level is applied to the entire state area. The latter would restrict agriculture in general disproportionately.

The tandem of basic and supplementary measures allows for designing tailored programmes to comply with the timeframe introduced by the WFD. To have the cooperation of farmers, it has been necessary to communicate issues and discuss measures – in Lower Saxony this stakeholder participation process was helped by a LIFE project, WAgriCo.

It is essential to know how to derive reduction aims, and how to approach to assess the gap between WFD targets and the baseline. As an example nutrient levels between coastal wa-

ters and rivers and matching surface water quality targets based on modelling techniques can be compared.

An interesting point raised concerning communication with farmers was that it was helpful to discuss issues and measures in terms of load reductions rather than concentration levels.

In terms of selecting types of measures, voluntary measures were given highest priority (catch crops, manure management, reduced tillage etc.). Additional regulatory measures will only be introduced if voluntary measures prove insufficient. Financial instruments (e.g. introducing a N-tax) would distort the market if it was not applied at EU level. Incentives to encourage N-efficiency improvements are under consideration.

In Lower Saxony the approach to determine the target areas for reducing nitrogen has been based on a range of cost-efficiency estimates for different measures based on detailed research.

Cost-effectiveness of measures and their acceptance by farmers was subject to intensive discussions. Measures to reduce fertiliser use seem to be cost effective but of little acceptable to farmers. Promoting catch crops, improved manure management and low-tillage cropping are viewed as being cost-effective measures as well as being of appropriate acceptance.

A flexible approach is considered a prerequisite for a successful programme implementation. In most of the cases it has been reported that acceptance levels improve through advisory services. Furthermore, advisory is required to utilise synergy effects. ■

The UK model



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On February 2008 Defra Minister Hilary Benn launched the government's water strategy for England. The water strategy sets out the government's plans for water in the future and the practical steps that will be taken to ensure that good clean water is available for people, businesses and nature.

The success of the voluntary approach taken up by farmers to tackle diffuse agricultural sources of pollution has been recognized by the government, and the water strategy states that Defra will continue to support farmers on Catchment Sensitive Farming, through the provision of advice, guidance and funding of good agricultural practices. Defra has provided a national budget for advising.

Farming

The single largest threat of diffuse water pollution is from agriculture. This is unsurprising, as agriculture covers 70% of the land area of England and sources of diffuse pollution, in-

cluding nutrients from fertilisers and manure, are essential parts of farming. Increases in nutrient levels can result in toxic algal blooms, resulting in adverse impacts on the food chain which supports fish, animals and birds.

Catchment Sensitive Farming Programme

Catchment Sensitive Farming is land management that keeps diffuse emissions of pollutants to levels consistent with the ecological sensitivity and uses of rivers, groundwater and other aquatic habitats, both in the immediate catchment and further downstream. It includes managing appropriately the use of fertilisers, manures and pesticides; promoting good soil structure and rain infiltration to avoid run-off and erosion; protecting watercourses from faecal contamination, sedimentation and pesticides; reducing stocking density; managing stock on farms to avoid compaction and poaching of land; and separating clean and dirty water on farms.

There are a number of approaches to ensuring that these practices are adopted: advice, scheme and regulation, and these are all managed through the Catchment Sensitive Farming Programme.

Why should agricultural diffuse pollution be reduced?

Raised concentrations of pollutants, such as nitrate and phosphorus, can have serious effects on the health and diversity of our fresh and marine waters including the plants and animals that live in those environments. Diffuse pollution can also prevent the use of water for drinking and recreation, for example, from the presence of pesticides and faecal indicator organisms. Additional pollutants such as sediments can affect the health of aquatic organisms, adding to the loss of species diversity. Farming is not the sole cause of these problems, but it does contribute approximately 60% of nitrates, 25% of phosphorus and 70% of sediments entering our waters,

amongst other pollutants

How will reductions be managed?

There will be taking forward three specific strands in the programme as outlined in the Government response to the 2007 consultation: advice, scheme and regulation to tackle diffuse water pollution from agriculture.

- [Government response to consultation on diffuse water pollution from agriculture.](#)

Advice elements of the programme are delivered through the England Catchment Sensitive Farming Delivery Initiative (ECSFDI). This is delivered across 40 Priority Catchments in England, rising to 50 from October 2008. In addition, some limited capital grants are offered in these catchments. The **regulation** is intended to be implemented through an amendment to existing legislation for Water Protection Zones, under Section 93 of the Water Resources Act 1991.

CSF quick links

- [Catchment Sensitive Farming \(CSF\) Programme](#) - What is CSF? How does CSF link with the Water Framework Directive (WFD)?
- [The England CSF Delivery Initiative \(ECSFDI\)](#) - What is the ECSFDI?
- Who is my [CSF Officer](#)?
- Who apply for a [capital grant](#)?
- Protection against water pollution from agriculture, [diffuse sources. Summary of responses received](#)

References

www.defra.gov.uk/farm/environment/water/csf

Environmental Stewardship

A key focus is the targeting of Higher Level Stewardship (HLS). The aim is that these tailored agreements secure maximum gain for the environment by channelling money efficiently to farmers and land managers who can create environmental and public benefits.

21 years of achievement

Since 1987, agri-environment (AE) schemes have:

- restored more than 17,000 km of hedgerow
- created over 4,800 km of footpaths, and 2,400 km of cycle paths and bridleways
- assisted recovery of a range of species including the stone curlew, bittern, twite and curlew bunting,
- helped toward the target of bringing 95% of Sites of Special Scientific Interest into favourable condition by 2010.

Uptake of schemes

Environmental Stewardship (ES) was introduced in 2005 as the successor scheme to ESA and CSS. It is already clear that the Entry Level Scheme (ELS) is a major success, accounting for over half the area of Utilisable Agricultural Area (UAA) in England. Altogether 63% of the UAA is currently in an agri-environment scheme. This is the baseline against which we must measure future progress.

Where to next with ES?

Our target is to get 70% of eligible farmland into an agri-environment scheme by the end of March 2011. We have the funding to do this from the UK and the EU. It means we need to increase the overall uptake of land by 7%. We would expect most of the new land to come into Entry Level Stewardship, with some moving into Organic Entry Level Stewardship and Higher Level Stewardship.

However, around 33% of the land in schemes is in agreements that are due to expire before the target date of 2011. Most of these are in ELS and to meet our 70% target we must renew these agreements. This will be a major undertaking, particularly the large numbers of agreements that come to renewal in summer 2010. We need your continued support and advice if we are to succeed! ■