Implementing the EU Water Framework Directive: A seminar series on water

Organised by WWF with the support of the European Commission and TAIEX

PROCEEDINGS

Seminar 1: Water and Agriculture

Brussels, 10 and 11 February 2000

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Foreword

The **Water and Agriculture** seminar organised by the World Wide Fund For Nature (WWF) with support from the European Commission was the first in a series designed to identify tools and approaches to promote the effective implementation of the forthcoming EU Water Framework Directive (WFD). The seminar took place in Brussels on 10-11 February 2000. Over 100 stakeholders from 23 European countries participated in the seminar and their experience and expertise provided a valuable input to the discussions. Participants were able to build on existing practices and knowledge of how to assess and reconcile the water and agriculture interests at the river basin level. Overall, the Water and Agriculture seminar fully achieved the main objectives of the seminar series:

- The seminar increased transparency and public awareness on certain measures of the WFD, and provided an opportunity for debate on the final stages of the adoption of the Directive;

- The seminar encouraged the sharing of knowledge, experiences and expertise regarding key elements of the WFD, and other policy and practical tools and approaches for integrating agriculture and sustainable water use, between the participants. A wide range of stakeholders involved in the management of water resources represented different economic sectors (NGOs, public bodies, researchers, private sector representatives) and regions of Europe (North and South EU plus EU Accession countries). Their input, plus the quality of speakers and the diversity of practical case studies (different sectors, countries and physical and socio-economic conditions), resulted in fruitful and stimulating discussions;

- A seminar synthesis note was drafted and “validated” during the last part of the seminar, based on the summary reports of each session.

These proceedings draw together the texts (in English) of the different presentations made during the Water and Agriculture seminar. They also include the seminar synthesis note that will soon be available in Spanish, French and German on the ‘Water Seminar Series’ web page (http://www.wwf.dk/freshwater/seminars.html). The content of these proceedings will contribute to the development of a guidance document[1] that will provide practical elements for the implementation process of the WFD.

We hope that the Water and Agriculture seminar proceedings, in particular the synthesis note, will already provide relevant information to many stakeholders and experts involved in the difficult task of reconciling the interests of water and agriculture. Furthermore, we hope they will contribute to the current debate on the search for new options that better integrate water and agriculture at the river basin level.

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[1] Your feedback (on the web page information, proceedings etc.) is welcome at any stage, as we are still gathering additional experiences and information for the development of the guidance document. Please e-mail your comments to Eva Royo Gelabert at ERoyogela@wwfnet.org

Acknowledgements

The seminar organisers are particularly grateful to the following:

- the European Commission’s Technical Assistance Information Exchange Office (TAIEX) which enabled the participation of stakeholders from EU Accession countries;
- cbe Europe for ensuring the smooth logistical running of the seminar;
- speakers: J.R. Aragón, G. Beaufoy, M. Confalonieri, A. Garrido, O. Jennersten, H. Kieft, K. Lanz, J. Madgwick, S. Nixon, A. Olmedo, A. Olsen, G. Peek, G. Phillips, E. Sequeira, H. Seul, G. Suette and J.M. Sumpsi;
- session chairpersons: G. Beltram, H. Blöch, T. Long, J. Maestu and H. von Munchausen;
- rapporteurs: A. Bamber Jones, G. Beaufoy, K. Lanz and P. Strosser;
- programme manager: J. Scola; and
- facilitator/proceedings editor: T. Jones.

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Acronyms and Abbreviations

Acronyms

CCD	Convention to Combat Desertification
CEE	Central and Eastern Europe
CEEC	Central and Eastern European Countries
COP	Cereals, oilseeds and pulses
EC	European Commission
ECw	Electrical Conductivity of irrigation water
ECe	Electrical Conductivity of soil saturation extract
EEA	European Environment Agency
ESP	Exchangeable Sodium Percentage (paper by E. Sequeira)
ESP	Spanish Pesetas (elsewhere)
EU	European Union
EUR	Euros ( )
EU15	15 Member States of the European Union
LF	Leaching Fraction
OECD	Organisation for Economic Cooperation and Development
SAC	Special Area of Conservation under the EU Habitats Directive
SAR	Sodium Adsorption Ratio
SEK	Swedish Crowns
TAIEX	Technical Assistance Information Exchange Office of the European Commission
UNESCO	United Nations Educational, Scientific and Cultural Organisation
WFD	Water Framework Directive
WWF	World Wide Fund For Nature

Chemical Symbols

Ca	calcium	Mg	magnesium
Cl	chloride	Na	sodium
CO_3	carbonate	N	nitrogen
Cu	copper	NO_3	nitrate
H	hydrogen	P	phosphorus
HCO_3	bicarbonate (hydrogen carbonate)	PO_4	phosphate
		SO_4	sulphate
K	potassium	Zn	zinc

Units of Measurement

cm	centimetre	mg	milligram (1/1000 of 1g)
dS	decisiemen	mg kg^{-1}	milligrams per kilogram
dS m^{-1}	decisiemens per metre	mg l^{-1}	milligrams per litre
g	gram	mm	millimetre
ha	hectare	µg	microgram (1/10,000 of 1g)
hm^3	cubic hectametre	<	less than
kg	kilogram		less than or equal to
l	litre	>	greater than
m	metre		greater than or equal to

Synthesis Note

1. Introduction

This meeting was the first in a series of three seminars organised by the World Wide Fund for Nature (WWF), with support from the European Commission, (EC) to promote implementation of the forthcoming EU Water Framework Directive (WFD), currently being discussed by the competent bodies of the EU and due for final adoption in 2000.

The meeting addressed the relationships between agriculture and water use throughout Europe, covering both current EU Member States and the countries of Central and Eastern Europe. The other two seminars in the series, to be held in November 2000 and April 2001 respectively, will deal with 'The role of wetlands in river basin management' and 'Good practice in river basin planning'.

This first seminar was attended by 100 participants from 23 countries, with representatives of national and regional governmental bodies, farming associations, federations and unions, the water supply sector, water research institutes, water users' associations, environmental NGOs and EU institutions, including the European Commission and the Economic and Social Committee (see Annex I for complete list of names and contact details). Participation of EU Accession countries was sponsored by 'TAIEX', the European Commission's Technical Assistance Information Exchange office. The programme (see Annex II) consisted of a series of keynote presentations, case studies and interactive discussion sessions. The first day was devoted to identifying the key issues pertaining to the relationship between agriculture and water, whilst the second day focused on examples of efforts towards reconciling agriculture and sustainable water use in two very different contexts (i) over-abstraction from a major aquifer in central Spain, and (ii) nitrate pollution from intensive stock rearing in northern Germany. At the end of the second day, participants were invited to comment on conclusions drafted by the rapporteurs and to contribute additional information for possible inclusion in the meeting report.

The full texts of the 16 technical presentations form the greater part of these Proceedings. However, this Synthesis Note aims to complement the conclusions of the individual papers by summarising the key issues identified, together with the possible approaches and tools available for addressing these issues (with particular reference to the proposed Water Framework Directive). A similar approach will be taken to the Proceedings of the remaining two seminars, after which a non-statutory guidance document will be produced by WWF and the European Commission as a contribution to promoting sustainable water use in the framework of river basin management plans. A 'validation workshop', to finalise the contents of the guidance document, will be held in 2001.

2. The Water Framework Directive (WFD)

At the time of writing (April 2000), the WFD is still subject to discussion by the European Parliament and the Council of Ministers under the conciliation procedure and it is not possible to be certain of the final form of the Directive. However, the fundamental elements of this Directive, which are unlikely to change during the conciliation procedure, are summarised below, based on a presentation to the seminar on behalf of the Agriculture and Environment Directorates General of the European Commission.

- The WFD sets a clear environmental target of **'good water status'** for all ground and surface waters in the EU and provides a framework for the coordinated implementation of all existing water legislation.

- The WFD **maintains existing commitments** of Member States under the Nitrates Directive (91/676/EEC) and Urban Waste Water Treatment Directive (91/271/EEC).

- **Integrated river basin management** is the framework within which measures for achieving 'good status' are to be implemented. Member States must ensure that the necessary technical and institutional infrastructure is in place (including spatial definition of pressures and impacts).

- A **river basin management plan** must be developed, with transboundary basins requiring joint management between two or more Member States (and possibly with countries outside the Community). This provides for the spatial integration of measures in favour of sustainable water management.

- The precise measures to be taken within a given river basin will vary widely according to natural, socio-economic and cultural factors. The Directive foresees that **the choice of measures will be taken according to what is most appropriate at the basin level** (in turn reflecting what is appropriate for a given region or Member State).

- **Water pricing** is another central element of the Directive, acting as an incentive for the sustainable use of water resources and thereby contributing to achieving environmental objectives and helping to reduce unnecessary consumption.

- **Public participation** is a fundamental component of the WFD, with a recognition that solutions to current water problems need to be 'bottom-up' as well as 'top-down'.

3. The Links between Agriculture and Water Quality and Quantity

Agriculture is a major user of water in Europe, accounting on average for about 30% of total water abstraction in the 15 EU Member States. In countries with significant areas of irrigated agricultural land, notably southern Member States, this figure is much higher; up to 80% in the case of Greece and Spain. Agriculture may also have significant impacts on the quality of both ground and surface waters through the runoff of nutrients (from organic and inorganic fertilisers) and plant protection products (herbicides, pesticides and fungicides). Agricultural practices also have an important influence on soil erosion and consequently the silt loads reaching rivers and other water courses. Finally, the subsidy-driven push for increased production has also resulted in the drainage and conversion of large areas of European wetlands and water courses which used to act as natural regulators of water quality and quantity.

It is important to recognise that not all agricultural activities are detrimental to water quantity and quality (see case study from northern Sweden presented by O. Jennersten (see page 75) which shows how low-intensity agricultural activities are essential for maintaining the biodiversity value of riparian wet meadows). In general, however, intensive, high input agriculture (including irrigated agriculture) is more likely to have adverse impacts than a low input regime. High input agriculture is the present 'standard' for western Europe, whilst most countries of Central and Eastern Europe have policies which foresee a move to intensive farming practices after the current low input phase imposed by recent economic crisis resulting from the opening of these countries to the global economy. Whilst in many cases it will be possible to identify measures to mitigate, or even avoid, impacts, it is first necessary to recognise the most important quantity and quality impacts within a given catchment.

3.1 Impacts of agriculture on water quantity

3.1.1 Irrigation

In recent decades there has been a general increase in the use of water for agriculture due to the expansion of irrigation (although there are signs that the rate of expansion of irrigated area is now slowing in most countries). The intensity of irrigation varies between countries, depending on the climate, the crops cultivated and the farming methods applied. The role of irrigation is completely different in southern Europe, where it is essential in order for providing competitive yields from certain crops (and therefore requiring a major overall increase in water consumption), compared to central and western Europe, where it is more frequently an 'insurance' option used for boosting production in dry summers.

The case study from the Autonomous Region of Castilla – La Mancha in central Spain (see page 95) demonstrates how over-abstraction for irrigated agriculture led to severe depletion of a major aquifer ('Aquifer 23'), with negative consequences for the conservation of wetland functions and values, as well as adverse impacts on agriculture itself. Over-abstraction may also lead to salinisation of groundwater (through intrusion of sea-water or saline groundwater), whilst in the dryland and semi-arid regions of southern Europe, irrigation is an important contributing factor to land degradation and desertification (see paper by E. Sequeira, page 31).

3.1.2 Drainage and water course regulation

Physical alteration of the landscape to increase the area and intensity of agriculture, especially through drainage of wetlands and regulation of water courses, has occurred in virtually all of Europe's major river basins. In some cases this has led to the almost complete disappearance of wetlands and unregulated streams and rivers, with consequently reduced water availability for other purposes such as local drinking water supply, recreation, fishing, and conservation of biodiversity. Land drainage and river regulation may also lead to reduced groundwater recharge, potentially accompanied by increased abstraction where semi-natural land cover is converted to intensive irrigated agriculture. These issues were touched upon by the seminar, but not covered in detail.

3.2 Impacts of agriculture on water quality

For further details on issues summarised in this section, see the papers presented by S. Nixon (page 17), G. Phillips (page 39) and E. Sequeira (page 31).

3.2.1 Eutrophication

Many of Europe's water courses and water bodies have been subjected to eutrophication – artificial enrichment due to human activities, with phosphorus (P) in the form of phosphate (PO_4) being the limiting factor. Eutrophication leads to increased algal growth, reduced oxygenation and lower water column transparency, with adverse ecological consequences. In certain cases, there may also be dangers to human health. Phosphate inputs to the aquatic environment as a result of human activity come partly from point sources (especially untreated or inadequately treated urban waste water) but also through diffuse runoff of nutrients from agricultural land.

In undisturbed rivers, total phosphorus concentrations are generally lower than 25 μg P/l. Natural minerals may in some cases contribute to higher levels. Concentrations higher than 50 μg P/l result from human activities and EEA data show that considerably more than half of all European river stations exceed that level. The highest levels are found in a band stretching from north-west Europe across the middle part of the continent, reflecting the intensity of agriculture and livestock production in these regions.

3.2.2 Nitrate pollution of surface and groundwater

Pollution by nitrates (NO_3) is considered to be a key reason why many ground and surface waters in Europe may fail to meet the WFD objective of 'good water quality'. Nitrate pollution is also a leading cause of eutrophication of European coastal waters. Nitrate is very mobile in soil, with important consequences for groundwater in areas where high levels of nitrogen fertilisers and manure are used. However, certain types of aquifer are more vulnerable to nitrate pollution than others because of differences in hydrogeology and land use. Alluvial and shallow aquifers are particularly vulnerable to nitrate pollution, whilst deep or confined aquifers are generally better protected.

The natural level of nitrate in groundwater is generally below 2 mg NO_3/l. Elevated nitrate levels are caused entirely by human activities, particularly agriculture, although local pollution from municipal or industrial sources can also be important. Concentrations from 2 to 10 mg NO_3/l are considered to 'approximate' natural concentrations. The Drinking Water Directive (80/778/EEC, revised as 98/83/EEC) sets a maximum permissible threshold of 50 mg NO_3/l. For eight of the 17 countries providing data to the EEA, about a quarter of all sites exceeded 25 mg NO_3/l . In one country (Romania), 35% of sites tested above 50 mg NO_3/l.

Dissolved inorganic nitrogen, especially nitrate and ammonium, constitutes the bulk of the total nitrogen in river water. The EEA reports that nitrogen levels of relatively unpolluted European rivers range from 0.1-0.5 mg N/l. Apart from the Fenno-Scandian countries, which have extensive non-agricultural areas, 68% of the recording stations in all European rivers had annual average nitrate concentrations exceeding 1 mg N/l in the period 1992-1996. The highest concentrations are found in north-west and eastern Europe, reflecting the intensity of agriculture in these regions (mainly prior to 1990 in the case of eastern Europe).

3.2.3 Salinisation and sodisation due to irrigation

Irrigation can have severe deleterious consequences for both the quality of soils and of water resources, particularly where a 'cascade' system of irrigation reservoirs operates and salinisation and sodisation (see paper by E. Sequeira for definitions) increase with each dam in the system. It is important to recognise that the salt content of water used for irrigation will determine the quantity of water that must be used only for leaching purposes to avoid the build up of salts in the root zone. The higher the salinity, the higher the quantity of water which must be used. The WFD does not include any guidelines or thresholds relating to the quality of irrigation water, even though environmental problems may result from the use of water well within the quality limits for drinking water.

3.2.4 Pesticide pollution of surface and groundwater

Pesticides entering the aquatic environment may have serious impacts on flora and fauna and limit the use of water for drinking water abstraction. However, efficient monitoring of pesticide residues in the environment is complex and expensive. Whilst manufacturers supply details of analytical methods for their substances at product registration, financial and technical capacity limit the generation of detailed quantitative information in many countries. In other words, many pesticides are not found in groundwater simply because they have not been looked for. The minimum standard (i.e. maximum permissible concentration of pesticides) to be met by Member States is set by Directive 97/57/EEC, in line with the revised Drinking Water Directive (98/83/EEC), at 0.1 µg/l. The revised Directive also obliges Member States to ensure that monitoring of drinking water includes testing for pesticide residues. The EEA reports that atrazine, one of the two most commonly found pesticides in groundwater (the other being simazine), was found at levels exceeding 0.1 µg/l in more than 25% of sampled sites in Slovenia and at between 5% and 25% of sites in Austria.

3.2.5 Accidental spillages

The discussion above focuses on the long-term or ‘chronic’ impacts of normal agricultural activities on water quality and quantity. However, discussion during the seminar also highlighted the need to deal with accidental spillages of (e.g.) pesticides which may cause acute pollution impacts with serious effects on ecosystem and human health. A significant risk of acute pollution also derives from illegal dumping of agricultural chemicals and slurry.

3.2.6 Increased sediment loads

The loss of natural vegetation cover through clearance of land for agriculture, or development of tourism (especially in mountainous areas), together with the effects of cultivation practices such as ploughing, have contributed in many parts of Europe to significantly increased sediment loads entering water courses. This in turn may have negative impacts on freshwater ecosystems, reducing habitat availability for flora and fauna requiring low turbidity, and causing the accelerated infilling of wetlands. This may be a particular problem for smaller-scale wetland features such as ponds and small lakes in rural landscapes which are already under pressure from drainage activities.

3.3 Spatial and temporal variability

Sections 3.1 and 3.2 include many references to variations in space and time for the different impacts identified. Amongst the key variations which must be taken into account when implementing the WFD are:

- natural differences between regions of Europe (e.g. climatic differences between northern and southern countries, with typically irregular rainfall in southern Europe; the case study dealing with conservation of Aquifer 23 in Spain shows clearly the need for land and water use to be adapted for periods of drought).

- economic differences, including those between EU Member States (for example those differences addressed by the Cohesion Funds) as well as those between EU and non-EU Member States (see section 4.5).

- differences within a country or drainage basin owing to variability of land use, soil, bedrock – especially the differing responses and response times of different hydrogeological systems to changes in land use.

- climate change, which will have a major impact on both water and agriculture in Europe during the 21st century, requiring changes in current land and water use practices.

This high degree of variability means that it is not possible to find a universal ‘one size fits all’ approach to managing the interface between agriculture and water. Solutions must be appropriately adapted for each basin (and sub-basin), taking into account European-scale, national and regional/local factors and scales. Through advocating water management at the basin level, the WFD provides a suitably flexible framework for integrating these different factors and scales of intervention.

4. Approaches and Tools

4.1 The value of baseline data, target setting, models and monitoring

In order to develop an appropriate catchment strategy for removing or mitigating possible conflicts between agriculture and sustainable water use, it is essential to have sufficient baseline information. It is also important to set meaningful and realistic targets for water quality and quantity.

For example, in the case of England & Wales (see paper presented by G. Phillips, page 39) the Environment Agency is about to publish a eutrophication control strategy. This recognises that catchment control of nutrients depends crucially on having sufficient information about the sources of nutrient inputs for each catchment.

A study in ‘The Broads’ region of eastern England has used an export coefficient model, in conjunction with historical information about landuse, to set a target for phosphorus levels in line with levels inferred (‘hindcast’) for a time just prior to general intensification of agriculture. Potential basin management measures will be assessed according to the contribution they are likely to make to reaching this target. The use of ‘hindcasting’ does not mean that a return to 1930s land use patterns or socio-economic conditions is advocated.

The export coefficient model was found to be particularly useful for assessing the relative contributions of different pollution sources (i.e. domestic, agricultural and industrial, as well as variations within these broad categories). The model showed that agriculture was an important source of phosphorous, so that costly installation of phosphorous stripping at sewage works would have only a limited impact on overall phosphorous inputs to freshwater systems.

In the Austrian province of Styria (Steiermark; see paper by G. Suette, page 61) an extensive phase of scientific information gathering preceded the development and implementation of land use regulations for water protection areas. These were modified in the light of data from ongoing monitoring, which showed initial results below expectations.

4.2 Sustainable rural development and the Common Agricultural Policy

One of the guiding principles for effective river basin management is that of sustainable rural development in which agriculture is just one component (albeit a key component) of multifunctional rural areas. This implies the need for setting socio-economic targets, in addition to environmental targets, when implementing the WFD. Reform of the Common Agricultural Policy (CAP) under Agenda 2000 has brought some progress towards more environmentally sustainable agriculture, but the CAP continues to favour maximisation of production over other possible scenarios. In particular, CAP subsidies for cereals, olives and tobacco continue to be paid in proportion to productivity per hectare (or specifically favour irrigated crops through higher payments) thus providing a strong incentive for continued use of irrigation over rainfed systems. Such an approach is liable to result in unbalanced and unsustainable rural development and continue to generate serious stress on water resources (both quantity and quality) in much of Europe. Further reform of the CAP is foreseen and will be closely linked to the EU enlargement process and World Trade Organisation negotiations, as well as to the future of Genetically Modified Organisms in farming. This further reform will bring important opportunities for helping to resolve some of the current conflicts between high-input agriculture and sustainable water management. The river basin management plans foreseen under the WFD will provide a sound basis for spatial planning, development and implementation of components of the CAP and Structural/Cohesion Funds.

There is considerable debate on the extent to which farmers should be compensated for avoiding practices likely to have adverse consequences on freshwater resources. Cross-compliance at national level offers one mechanism, whereby payment of agricultural subsidies could be conditional on farmers contributing to meeting the environmental objectives of the WFD. Many seminar participants stressed the need to move from subsidies that continue to reward high-input agriculture towards a system which rewards farmers financially for providing environmental services and benefits. While cross-compliance can provide an instrument to set a baseline, agri-environment payments may be necessary to target specific biodiversity objectives associated with rivers and wetlands.

The need for an integrated approach, involving participation of all stakeholders, was frequently stressed. For example, it was pointed out that supermarkets can play an extremely important role in determining agricultural practices for some agricultural products (e.g. vegetables, fruits) in western Europe. Supermarkets may demand that crops be irrigated with pristine water, even though this is liable to place pressure on water resources and not be justified in terms of consumer health protection. It was also emphasised that sustainable solutions require the support of water and land users if they are to be successful. In many cases the most effective solutions will be initiated at the local level. Constant consensus-building dialogue is required to maximise mutual understanding between different interest groups. For example, the case study dealing with Aquifer 23 in central Spain (see page 95) showed that the issue of illegal boreholes is a complex political and cultural issue, which cannot be easily solved by enforcement measures.

4.3 Tools for addressing the impacts of agriculture on water quality and quantity

4.3.1 Technical tools

A number of the case studies showed that significant improvements in water quality and/or quantity can be achieved by promoting technical solutions based on ‘best practice’ at the local (e.g. individual farm and field) level.

The case study from the Weser-Ems region of north-west Germany (see page 113) shows how one farmer was able to convert to more profitable organic production, with significant environmental benefits due to the corresponding reduction of inputs. This demonstrates how generating competence in production technology and marketing strategies led to significant improvements in groundwater quality. A total of 54 farms in 11 water conservation areas were provided with technical advice on how to make the transition from high-input conventional farming to organic production.

During discussion it was pointed out that experiments have shown how the nutrient content of animal feed (and hence level of potential risk to water quality from farm runoff) can be significantly reduced, without an adverse impact on farm productivity.

The case study dealing with over-exploitation of Aquifer 23 in the Guadiana basin of central Spain (see page 95) showed how technological changes, including the introduction of metering and a switch to drip irrigation can lead to a considerable drop in the volume abstracted from the aquifer. Metering, when combined with appropriate water charges, is widely recognised as an important technical monitoring tool for managing water supply and demand (when combined with an appropriate legislative/administrative framework and pricing system).

The same study in the Guadiana basin also referred to the use of another, large scale technical tool, namely the use of inter-basin water transfers. However, this approach, used to provide water ‘first aid’ to the desiccated ‘Tablas de Daimiel’ National Park, is unlikely to yield a sustainable solution, since it does not address the root causes of the problems and alters the hydrological functioning of an internationally important ecosystem.

4.3.2 Economic instruments

Pricing or charging for water use and pollution is the first type of economic instrument to be considered. The original Commission text of the draft WFD gave weight to the concept of 'full cost recovery' as the basis for water charging. It remains to be seen the extent to which this guiding principle is included in the final text. Water charging that better accounts for sound economic and environmental principles is likely to reduce the pressure from agriculture on water resources. The paper by A. Garrido (see page 85) stressed the relatively rare use of water pricing as a demand management tool in the Mediterranean region, where the implementation of sound water pricing policies remains a key option for more sustainable management of a scarce resource.

To provision of financial incentives is a further economic instrument that can enhance the adoption of more-efficient, less-polluting practices and thus reduce pressure on water resources. The introduction of metering for Aquifer 23 was used in combination with agri-environmental payments (i.e. a financial incentive <u>not</u> to plant highly water-demanding crops such as maize and sugar beet), legal restrictions on water use, and a transition to drip irrigation to reduce water consumption. By 1995, 80% of the area was covered by agri-environment payments, and water abstraction had been reduced by 250 m^3/ha per year. Whilst many local stakeholders call for the maintenance of agri-environmental subsidies, critics argue that the high cost (100 million between 1993 and 1995) is not sustainable and that the aquifer is far from restored. It is also argued that the current agri-environmental payments conflict with the 'polluter pays' principle, since farmers are effectively being compensated for complying with water legislation. The results of modelling different policy scenarios for agricultural payments (see paper presented by M. Sumpsi, page 99) suggested that implementing 'ecoconditionality' (i.e. cross compliance) as introduced by the Agenda 2000 CAP reforms would be the most cost-effective solution for balancing water saving with the need to sustain farm incomes.

The case study from northern Sweden (see page 75) provides another example of financial incentives. It shows how Environmentally Sensitive Area payments have been used to enable farmers to convert to production of organic beef, for which there is an important market. The NGO sector has played an important role in facilitating pilot projects, contributing modest funding and providing technical and marketing information/advice.

However, financial incentives are not necessarily provided by the public sector (whether EU, national or regional).

The case study from Styria, Austria (see page 61) shows how new legislation led to technical measures for reducing nutrient inputs within water protection areas through changes to land use and rotation patterns and a decrease in the use of fertilisers. However, the cost of these measures, which are subject to agreements between the water company and the farmers concerned, is passed on to the consumer, so that the price of water has risen from ATS 9.50 per m^3 to ATS 12.50 per m^3.

The paper by A. Garrido (see page 85) reviewed the role played by another category of economic instruments, namely water trading and transfer of water rights/permits, in the Mediterranean region (and Spain in particular). A series of 'mini case studies' from different Autonomous Regions of Spain (Cataluña, Murcia and Andalcía) are used to illustrate a range of approaches: exchange of water rights for water infrastructure investment, water pricing with full cost recovery, and optioning of water rights. It is concluded that 'win-win' solutions are achievable, but that a balanced mix of instruments is both desirable and necessary to enable each individual instrument to deliver the benefits it is intended to provide. In the first case study, farmers agreed to transfer part of their water rights to a municipal water supplier in exchange for upgrading of the distribution system. The amount transferred was entirely offset by a more efficient supply network. The second case study showed how a sophisticated system of recording and charging for water (and fertiliser) use led to a 14% reduction in the overall volume of water used for irrigation. The third and final case study envisages an agreement between farmers and a municipal water company under which farmers would be obliged (in exchange for cash payments) to transfer part of their water rights to the city in times of drought. Further examples of water pricing as a demand management tool are given for Italy and Portugal.

Several participants highlighted the opportunities offered by the financial instrument known as LEADER (Liaisons Entre Action de Développement de l'Economie Rurale). This is an EC initiative (focal point DG Agriculture) to promote model rural development projects. Through the provision of grants, LEADER aims to stimulate innovative measures at local level within both private and public sectors and to assist with exchange of experience within and between Member States.

4.3.3 Legislative, institutional and administrative tools

Amongst the tools in this category are:

- EU Directives (e.g. Water Framework Directive);
- National, regional and local legislation;
- National regional and local policies;
- River basin management authorities and management plans;
- Consultative water user bodies;
- Inter-agency monitoring and data exchange programmes.

The forthcoming WFD provides an excellent example of a legislative instrument at EU level which must be transposed and implemented through national legal provisions. Several of the papers presented during the seminar showed how the targets set by other Directives (e.g. Drinking Water Directive) had been the trigger for implementation of measures to reduce adverse impacts of agriculture on water quantity and quality. Other contributions showed how the provisions of 'non-water' Directives, such as the Habitats Directive, could be applied in such a way as to provide important benefits for the healthy functioning and biological diversity of freshwater ecosystems.

There are several examples of the important role of national/federal legislation. In Austria, the Federal Water Act led to the establishment of groundwater protection areas with restrictions on land use. In Spain, the 1986 entry into force of the Water Act provided the impetus for efforts to tackle over-abstraction.

One of the central tenets of the proposed Water Framework Directive is the management of fresh water on a river basin level, and the requirement to establish river basin management plans. The river basin (or 'catchment') approach is well-demonstrated by several of the seminar papers, notably the case study dealing with 'Aquifer 23' in Castilla-La Mancha. This example demonstrated the need for, and respective contributions of, a basin management authority, user groups and multi-disciplinary research teams.

In some cases it will be necessary to establish mechanisms for consultation and action between basins and/or between countries affected by a common problem. Formal, permanent structures exist for several larger basins, including the well-known Rhine and Danube Commissions. However, it is stressed that less formal consultations can also be of great value. One example of such a mechanism was the international workshop on 'Development of a Groundwater Protection Policy for Agricultural Regions in the Drava River Basin' held in Slovenia at the end of March 2000, with support from the EU's Phare programme.

However, some of the papers also draw attention to the gulf which sometimes exists between legislation and implementation. For example, returning to the case of Aquifer 23, there are a large number of illegal boreholes on the aquifer, but owing to the limited resources of the river basin authority and the potential for serious civil unrest, the legislation is not enforced effectively. This clearly demonstrates the need to address technical, legislative and socio-economic issues in an integrated way.

4.4 Selecting the tools to use

The seminar demonstrated that there is a wide choice of tools available for helping to remove or minimise the adverse impacts of agriculture on water quantity and quality (see Summary Table below).

Summary Table of range of tools examined by the seminar

Tool/Instrument	Reference in Proceedings
1. TECHNICAL	
Improved agricultural and irrigation practices	Kieft & Znaor, p. 47; Confalonieri, p. 67, Sequeira, p. 31.
Conversion to sustainable low-input farming (e.g. organic)	Kieft & Znaor, p. 47; Lanz, p.113, Seul, p.117, Peek, p. 123
Land withdrawal	Suette, p. 61
Water metering	Beaufoy, p. 95
Large scale basin transfers	Beaufoy, p. 95
2. ECONOMIC	
Water pricing	Garrido, p. 85
Trading of water rights/quotas	Garrido, p. 85
Financial incentives to adopt better technologies/practices • agri-environment payments	Garrido, p. 85 Jennersten, p. 75; Beaufoy, p. 95
3. LEGISLATIVE, INSTITUTIONAL, POLICY	
Water Framework Directive	Finalisation and adoption anticipated for the second half of 2000; Olsen *et al*., p. 59.
CAP reform	Beaufoy p. 95; Sumpsi, p. 99.
Cross-compliance	potential in framework of Agenda 2000.
National and regional water laws local abstraction regimes	Suette, p. 61; Beaufoy, p. 95; Aragón, p. 103; Lanz, p. 113.
River basin organisations	Beaufoy, p. 95; Aragón, p. 103.
Economic diversification (i.e. development of new economic activities) in rural areas	Jennersten, p. 75; Beaufoy p. 95; Olmedo, p. 109.
National/regional legislation	Suette, p. 61; Lanz, p. 113; Seul p. 117.
Participatory approach, consensus building	Suette, p. 61; Olsen et al., 59; Jennersten, p. 75; Aragón, p. 103; Olmedo, p. 109.
4. ANALYTICAL (CROSS-CUTTING TOOLS FOR USE WITH OTHER CATEGORIES)	
Research and monitoring	Sequeira, p. 31; Phillips & Johnes, p. 39; Olmedo, p. 109.
Predictive modelling	Sequeira, p. 31; Phillips & Johnes, p. 39; Sumpsi, p. 99.

It is important that the available opportunities are seized, but the range of options is sometimes bewildering. The following ‘guiding principles’, arising from the presentations and discussion, may assist the decision-making process:

- It is essential to set clear objectives from the perspectives of both water use and agriculture;
- It is usually necessary to choose a mix of instruments (there is unlikely to be a single answer to a given problem);
- The instruments chosen must be adapted to the appropriate spatial scale (i.e. from the broad policy framework at EU level, through river basin management plans, to specific measures on individual farms);
- All tools used should have a sound legal basis;
- All tools should be supported by adequate data gathering prior to implementation to assess the likely impact of various options on environmental, social and economic indicators;
- Monitoring is essential for assessing the impact and effectiveness of the tool(s) selected;
- A participatory approach should be developed so that all stakeholders at the appropriate scale are fully informed and involved in the choice, development and application of instruments. This in turn requires trust and cooperation. External moderation may be helpful.

4.5 Agriculture and water in Central and Eastern Europe

The seminar drew particular attention to the significant differences between the current 15 EU Member States and Central and Eastern European Countries (CEECs), many of which are actively engaged in accession negotiations (Bulgaria, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovak Republic and Slovenia). These differences must be taken into account when assessing approaches and tools for reconciling water and agriculture in this region of Europe.

H. Kieft and D. Znaor presented a paper based on a four-year EC Phare project which aimed to provide agricultural policy advice to the governments of Bulgaria, Hungary and Romania (see page 47). This involved setting up cooperative teams of farmers, government officials, NGOs, researchers and western European consultants in each country. The study confirmed the significance of agricultural non-point sources on levels of nitrogen and phosphorus, whilst recognising that inputs of agricultural chemicals have fallen dramatically since 1989. However, whilst yields have also dropped considerably, the reduction in yields has not been as great as the reduction in chemical use. This implies that the current situation of economically dictated low-input agriculture may offer a ‘window of opportunity’; i.e. a time period during which yield improvements may be stimulated through introduction of better agricultural practices, rather than through a return to the environmentally damaging input levels of pre-1989. Seizing this opportunity would help to ensure sustainable, long-term improvements to water quality in particular.

In the case of the Danube basin, it has been found that fertiliser inputs need to be fixed at approximately 40-50% of their 1991 levels to avoid further eutrophication of the Black Sea. These levels approximate to the current situation, inferring that no increase of inputs should take place. This is at odds with present government policy in most of the region. More attention should be given to the development of sustainable agriculture, with a focus on the environmental and socio-economic benefits that can be derived. This should incorporate aspects of conventional (high input), integrated and ecological agricultural practices and requires a different way of thinking at macroeconomic level (rather than at the farm level) to ensure that water pollution costs are internalised.

For example, in the case of Hungary, when the external environmental costs of nitrate leaching were internalised in modelled produce prices by charging 1 per kg of leached nitrogen, sustainable (i.e. low input) agriculture was shown to generate net production values 40% higher than conventional (high input) agriculture.

During discussion the importance of mobilising CEEC expertise and marrying it with experience gained in the EU and US was highlighted. There is a particular need for joint action to increase availability of information on marketing techniques in the context of privatisation of land and businesses and the overall shift towards a market economy. However, it is important that capacity building responds to needs identified from within the CEE region if inappropriate 'solutions' are to be avoided. This requires constant communication and dialogue at all levels, so that training courses and other capacity building measures can be designed to meet specific requirements (e.g. to ensure access to information on 'best practice' cultivation and land management techniques for maximising environmental benefits and minimising input costs whilst maintaining profitable production levels).

Further discussion of the experience of one country in the CEE region is provided in Annex III, a paper developed during the seminar and contributed to the Proceedings by three Polish participants representing the Lower-Silesian Foundation for Sustainable Development (NGO), the Institute for Land Reclamation and Grassland Farming, and the Regional Environmental Center for Central and Eastern Europe - REC.

5. Conclusions

- ✓ The seminar confirmed that agricultural impacts on water status are a major concern across Europe - both in terms of water quantity and quality. There are obvious regional differences, for example between north-west Europe, the Mediterranean and CEECs. Apart from the impacts on the biodiversity and landscape of Europe, this 'water stress' threatens human health and the long-term sustainability of food production. Direct impacts include over-abstraction of groundwater and pollution of ground and surface waters due to excessive fertiliser application. But there are also ecosystem shifts that have resulted from intensification of agricultural practice during the last 50 years or so. For example, eutrophication has become widespread across the continent, causing significant damage to rivers, lakes and wetlands and resulting in economic losses, such as declining fishery production. As a result of drastic physical alteration, such as loss of natural vegetation cover and regulation of river systems, the landscape now has a reduced capacity to store and eliminate nutrients and pesticides. In southern countries, salinisation and sodisation triggered by inappropriate irrigation systems and practices (though practice is often restricted by the system in place) now limits the area of land available for agriculture. All of the current impacts are likely to be accentuated by climate change.

- ✓ Some of the existing legislation, such as the EU Nitrates Directive, has had little effect in combating these problems, due to inadequate implementation by many Member States. Subsidies derived from the Structural/Cohesion Funds and the CAP support intensive farming practices which add to the pollution burden and enable the further extension of irrigated agriculture, for example through the development of dams, water transfer schemes and higher subsidies for crops requiring irrigation, regardless of environmental, social or economic sustainability. Some agri-environment schemes have been targeted at reducing or reversing water pollution or abstraction problems but the scale of their impact is very limited due to the very small share of the CAP allocated to these measures (around 4% in 1998).

- ✓ The new opportunity for attaching environmental conditions to CAP payments at the national level ('cross-compliance' or 'eco-conditionality') introduced in the Agenda 2000 CAP reforms offers a means to encourage farmers to adopt improved practices to reduce the negative impact of agriculture on water resources. However, the extent of its influence on the ground will depend on Member States' commitment and eagerness to implement this new policy instrument.

- ✓ Some examples focused on using public funds to help reduce the damage of existing agricultural impacts – for example nitrate pollution controls to improve drinking water quality and reduced abstraction from over-exploited aquifers. Whilst some positive results have been achieved, there are clearly limits to this approach.

- ✓ There can be uneasy trade-offs between the need to reach environmental standards and the social goals of sustaining farm incomes and employment. It was proposed that the use of incentives and compensation measures to obtain agricultural change should only apply once 'good agricultural practice' standards are reached.

- ✓ Farming can also have a positive role in shaping Europe's landscapes and in securing valuable wetland habitats. However, true integration of agriculture and environmental objectives requires a new approach. Further reform of the CAP is urgently needed to reduce the forces encouraging farmers to intensify production and hence their impact on water quality and quantity. A greater share of the CAP needs to be transferred to policy instruments such as agri-environment and sustainable rural development to support and strengthen the long-term implementation of the Water Framework Directive.

- ✓ The seminar strongly endorsed the need to plan measures to reconcile environmental objectives for water and agriculture at the river basin or catchment scale, as proposed by the forthcoming EU Water Framework Directive. Participants also identified a wide range of existing instruments related to EU legislation (e.g. the CAP and Strutural and Cohesion Fund reforms introduced in Agenda 2000, or the role of water pricingin the WFD) and national water and agricultural policies.

- ✓ The Water Framework Directive will offer a planning process that will help assess impacts and coordinate interventions and measures at the appropriate geographic and hydrological scale. The case studies point to the potential roles of many different actors in the development of solutions to agriculture and water conflicts. For example, initiatives by individual farmers, farming associations, private and public water suppliers, supermarket chains, organic associations and local authorities were cited during the seminar. In this respect, the requirement for a transparent, participative planning process, which enables stakeholders to influence decision-making, was seen as crucial.

- ✓ Several case studies showed that once a conflict between agriculture and water status is identified, there is a need to develop positive dialogue between those concerned, backed up by independent information on options for agricultural adjustment.

- ✓ In many cases, such as in CEECs, there is a need for training and capacity building in order to assist the adjustment of agriculture towards the market economy.

- ✓ As the policy impetus driving production-based agriculture begins to change, with public public opinion increasingly targeting environmental standards and food quality as key issues, we need to adjust from giving primary concern to farm income and recognise the environmental needs for improved agricultural practice and the limitations of water supplies.

- ✓ In many situations, a ‘system change’ in farming practice (e.g. from high-input, intensive agriculture, to low-input methods) is required to bring adequate and lasting benefits. This will require farmers to adapt their farming practices and hence will necessitate policy instruments that aim to integrate environmental and social objectives. Opportunities to develop a common interest through the promotion of sustainable rural development need to be seized within the current policy and economic framework. In particular, it was pointed out that the current low-input low-output agriculture of many CEECs offers a major opportunity to invest in sustainable rural development – and that analysis of the options at a macro-economic level show that this would better support farm incomes and the GDP than agricultural intensification, which is likely to result from accession to the EU.

- ✓ Innovation and experimentation play a crucial role in determining the most effective and sustainable solution to a given problem. Many of the case studies reported successful outcomes as a result of innovative approaches implemented in partnership by a range of stakeholders. However, further research and analytical efforts are required to clearly identify the key factors for success that would enable transfer to other locations and/or circumstances.

- ✓ Certain relevant issues were not fully discussed during the seminar, which had a limited time to address a very wide range of topics. Amongst the issues worthy of further attention are: the impact of drainage for agriculture on freshwater ecosystems (both in terms of loss of area and loss of functions and values); impact of cultivation practices (e.g. intensity of wet grassland management) on the biodiversity of freshwater ecosystems; and the impact of low river flows (due to abstraction of irrigation water) on freshwater biodiversity. Further exchange of information and experience would be required to ensure that these and other factors are adequately considered in the development of the river basin management plans of the WFD. Special attention should be given to ensuring that the experience, concerns and priorities of CEECs are taken into consideration in this respect.

Session 1:
Impacts of Agriculture on Water Resources

Review of the Impacts of Agriculture on Water Resources

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Summary

The contribution of agriculture to overall economic output in the EU is modest: 2.3% of GDP and 5.3% of employment. Value added in the agricultural sector grew by 10% in the period 1985 to 1995, a much slower rate of growth than in most other sectors (EEA, 1999a). Nevertheless agriculture is both a primary supplier of food and raw materials and a driving force exerting a major influence on the management of land and environmental quality. In many parts of Europe, agricultural activities will be the cause of water bodies failing to achieve the Water Framework Directive's environmental objective of 'good water status'. Thus, measures to control and decrease the adverse impacts of agriculture will be required. This paper illustrates, summarises and reviews the impacts of agriculture on Europe's water resources. It is based largely on published work undertaken by the European Environment Agency and its Topic Centre on Inland Waters.

1. Emissions from agriculture

In many areas of the European Union agriculture is based on intensive and large-scale production methods. This involves the use of artificial fertiliser (mainly nitrogen and phosphate) and the application of plant protection products such as herbicides, insecticides and fungicides. Crops do not necessarily take up all of these substances and certain amounts of fertiliser contribute to eutrophication of soil and water systems, whereas pesticides pollute soil, ground and surface water and air.

Intensive farm management practices are now considered normal. Since the 1940s, the area of ploughed land and the use of commercial inorganic fertiliser have increased dramatically. This, in conjunction with increased livestock densities, has resulted in the production and application of much greater loads of manure to cultivated land. Higher livestock densities also result in greater emissions of ammonia which, in turn, lead to greater atmospheric deposition of nitrogen to land and surface waters. Emissions from livestock also contribute to acidification and produce greenhouse gases.

Both increases in chemical fertiliser use, and in animal manure to be disposed of, constitute a potential source for run-off of nutrients to inland waters. Changes in arable farming practices have also increased the rate of soil erosion, with a related increase in phosphorus run-off. In many areas much of the agricultural land is drained and a large number of Europe's marshes, ponds and lakes have disappeared. This has considerably reduced the capacity of freshwater ecosystems to store and eliminate many contaminants, including nutrients and many pollutants.

Agriculture is a significant source of phosphorus pollution in many countries. Despite a reduction of 42% in the consumption of fertiliser phosphate in the15 Member States of the EU (EU15) since 1972, the phosphorus pool in the soil is still increasing. Agricultural surplus phosphorus (difference between input and output) has been estimated to be about 13 kg P/ha/year in the European Union (Sibbesen and Runge-Metzger, 1995), with the highest surpluses occuring in the Netherlands, Belgium, Luxembourg, Germany and Denmark. These annual surpluses provide considerable potential for loss of phosphorus from agricultural soils to the aquatic environment. Phosphorus losses from farmyards and runoff from animal manure spread during or before wet weather are also a significant source of phosphorus pollution. Erosion also contributes significantly in some regions.

Nitrogen pollution is usually dominated by diffuse sources, in particular agriculture (Figure 1). Nitrate is very mobile in soil and easily leaches to groundwater or surface water. In areas with little human activity, for example parts of the Nordic countries, the anthropogenic contribution to the nutrient load is relatively small, but only in the most sparsely populated regions such as northern Sweden can it be considered insignificant.

Nitrate leached from agricultural soils is a main cause of marine eutrophication. The total use of nitrogen in fertilisers and manure has increased in line with the intensification of agriculture, but far from all the nitrogen applied is removed with harvested crops. The non-harvested nitrogen may become a problem in the aquatic environment. Part escapes as harmless nitrogen gas (N_2) to the atmosphere as a result of denitrification, whilst some leaches, mostly as nitrate, to the groundwater or surface water.

A main determinant of potential leaching is the nitrogen balance, the difference between total inputs. From nitrogen balance studies on agricultural land in the EU15 countries it has been shown that the surplus (difference between input and output) varies from over 200 kg N/ha/year in the Netherlands to less than 10 kg N/ha/year in Portugal (Figure 2, Eurostat 1997). In general, there is an increasing surplus with increasing inputs, leading to increased potential for leaching. Many other factors are also important for nitrogen leaching. Soil characteristics, climate and agricultural practice (e.g. type of crop, amount and handling of manure, implementation of agri-environment schemes) are important in this respect.

In many regions point sources also contribute significantly to nitrogen pollution. The increased utilisation of modern wastewater treatment (Figure 3) may improve nitrogen removal if specific facilities for this purpose are included. It therefore appears likely that agriculture will be even more dominant as a major source of nitrogen pollution in the future. To reduce nitrogen pollution it is necessary to reduce the agricultural contribution significantly. Without such reductions many marine and coastal areas will remain in a poor ecological state.

Pesticides entering the aquatic environment may affect biological communities and limit the use of water for drinking water abstraction. The application of pesticides per ha of agricultural land varies widely between European countries (Figure 4). In 1985-1991 the application was lowest in the Nordic countries, intermediate in Eastern Europe and highest in Southern and Western Europe (EEA, 1995). The use of various types of pesticides depends on climatic conditions and crops grown. In Northern and Central European countries herbicides are the predominant category of pesticide, whereas the major types in Southern and Western countries are insecticides and fungicides.

The sale of pesticides, as measured by the amount of active substance contained within the pesticide, has generally decreased during the past ten years. Concurrently, new and more efficient pesticides have been developed with the same biological effect from a far smaller dose. Therefore, the observed decrease in pesticide sales does not necessarily indicate a decrease in crop protection efficiency, and the environmental impact may have been reduced less than the drop in sales figures suggests. Certain recently developed substances, however, are more selective in the organisms they target, and therefore have a lower impact on the environment in general. Research is also being carried out to replace pesticides by alternative agents that are less harmful to the environment.

2. Impacts on surface water quality

In undisturbed rivers total phosphorus concentrations are generally <25 µg P/l. Natural minerals may in some cases contribute to higher levels. Concentrations >50 µg P/l result from human activities and far more than half of all river stations (around 1,000 stations from 25 countries) exceed that level. Dissolved phosphorus concentrations over 100 µg P/l may allow saturation of the water body by algae and weeds that cause secondary organic pollution. The information also shows that only 10% of all river stations have mean total phosphorus concentrations of <50 µg P/l.

The lowest phosphorus concentrations are found in the Nordic countries, where 91% of stations have annual averages below 30 µg P/l, and 50% below 4 µg P/l, (Figure 5, EEA 1999d) reflecting nutrient-poor soils and bedrock, low population densities and high rainfall. High phosphorus concentrations are found especially in a band stretching from Southern England across Central Europe to Romania (and Ukraine). Western and Eastern countries exhibit very similar distribution patterns. The Southern countries show lower values than Eastern parts of the region, which may be due to the fact that for a relatively large proportion of the Southern European population, wastewater is discharged directly into the sea.

Phosphorus concentrations in European rivers have generally decreased significantly between the periods 1987-1991 and 1992-1996. During the 1990s, significant improvements were observed in Western Europe and for some countries of Eastern Europe. In the Nordic countries, rising concentrations have been observed, although levels are generally still low. In Southern Europe, the situation appears to be improving. This overall improvement is caused by a reduction in phosphorus emissions, in particular due to improved wastewater treatment (Figure 3) and reduced use of phosphorus in detergents. The reduced pollution from point sources, however, needs to be followed up by a reduction in the share originating from agricultural activity; a share that is becoming relatively more important.

Dissolved inorganic nitrogen, especially nitrate and ammonium, constitutes the bulk of the total nitrogen in river water. In pristine rivers, the average level of nitrate has been reported to be 0.1 mg N/l (Meybeck 1982), but because of high atmospheric nitrogen deposition the nitrogen levels of relatively unpolluted European rivers ranged from 0.1-0.5 mg N/l (EEA, 1995). Apart from the rivers in the Nordic countries, where 70% of the sites have concentrations below 0.3 mg N/l, 68% of the river stations in all European rivers have annual average nitrate concentrations exceeding 1 mg N/l in the period 1992-1996 (Figure 6, EEA 1999d). Peak concentrations exceeding 7.5 mg N/l are observed in about 15% of the sites. The highest concentrations are found in the northern part of Western Europe, reflecting the high intensity of agriculture in these regions. High concentrations also occur in Eastern Europe, whilst Southern Europe generally has lower concentrations.

Agricultural leaching is highly dependent on precipitation. Thus because of climatic factors, nitrate concentrations vary between years and the observed changes during the 1990s do not necessarily reflect changes in human activities. However, it appears that from about 1970 to 1985, nitrate concentrations increased at rates from 1% to 10% per year for between one-quarter and one-half of all river stations where measurements are available (about 1,500 stations from 30 countries). Since 1987-1991, the number of stations showing improvement in water quality has been balanced by the number of stations recording a worsening trend.

Though there is no clear trend for nitrate, the available data suggest that, after two decades of rapid increase, annual maximum concentrations are approaching a steady state, or even decreasing in some Western European rivers. At the same time, the minimum values have tended to increase in all European rivers, including Nordic countries (EEA, 1995).

3. Impacts on groundwater quality

Europe's groundwater is endangered and polluted in several ways. Some of the most serious problems are pollution by nitrate and pesticides (EEA, 1995, EEA 1999b).

Certain types of aquifer are more vulnerable to nitrate pollution than others because of differences such as hydrogeology and land use. Alluvial and shallow aquifers are particularly vulnerable to nitrate pollution, whilst deep or confined aquifers are generally better protected. The natural level of nitrate in groundwater is generally below 2 mg N/l. Elevated nitrate levels are caused entirely by human activities, particularly the use of nitrogen fertilisers and manure, although local pollution from municipal or industrial sources can also be important.

Figure 7 shows the results of monitoring of nitrate concentrations in groundwater for 17 countries. Four concentration bands are used. Concentrations up to 10 mg NO_3/l are considered to approximate natural concentrations. The guide level of 25 mg NO_3/l, and maximum admissible concentration of 50 mg NO_3/l laid down in the original Drinking Water Directive (80/778/EEC) define two further concentration bands. Of the countries providing data, it appears that Slovenia has the highest levels of nitrate in groundwater, with 50% of the sampling sites showing concentrations greater than 25 mg NO_3/l. In eight countries the level of 25 mg NO_3/l is exceeded in about 25% of the sites, and in one country (Romania), 35% exceed 50 mg NO_3/l.

Monitoring data reveal differing trends amongst Western European countries during the 1990s. In some countries there appears to have been no further increase in nitrate concentrations over this short period of time, but it is probably premature to conclude that the situation is stabilising.

Approximately 800 active pesticide substances are registered for use in Europe. However, only a small number of these account for most of the total quantity applied. Efficient monitoring of pesticide residues in the environment is complex and expensive. Although manufacturers supply analytical methods for their substances at registration, financial and analytical capacity in many countries are limiting factors for production of detailed quantitative information. Many pesticides are not found in groundwater simply because they are not looked for. Once a pesticide is looked for it is often found, though the concentration of a certain substance may be below the maximum admissible concentration of 0.1 µg/l specified in the Drinking Water Directive (80/778/EEC).

The most commonly found pesticides in groundwater are atrazine and simazine, with atrazine being found at concentrations greater than 0.1 µg/l in more than 25% of sampled sites in Slovenia, and between 5 and 25% of sites in Austria. Desethylatrazine was found at levels greater than 0.1 µg/l at between 5 and 25% of sites in Austria and Germany and in more than 25% in Slovenia (Figure 8). Atrazine, simazine and bentazone are broad-spectrum herbicides used extensively in agricultural, industrial and domestic situations. Their use is currently being either severely restricted or banned in many countries.

4. Impacts on water quantity

Freshwater resources are continuously replenished by the natural processes of the hydrological cycle. Precipitation is the primary source of fresh water. About 65% of precipitation eventually returns to the atmosphere through evaporation and transpiration; the remaining resource, or runoff, recharges the aquifers, streams and lakes as it flows to the sea. There is a wide spatial variability of freshwater resources, with annual average runoff ranging from over 3000 mm in Western Norway to 100 mm over large parts of Eastern Europe and less than 25 mm in the Spanish interior. In Europe, the average annual runoff is approximately 304 mm/year or 4560 m^3 per capita per year for a population of 680 million (EEA, 1995). At the continental scale, it would seem that Europe has abundant water resources but these are highly unevenly distributed, both in space and time (Gleick, 1993). Local demand for water often exceeds local availability, and problems of water stress and overexploitation occur frequently in areas of high population density and limited precipitation.

Surface water is the dominant source of fresh water in Europe, with two-thirds of countries taking over 80% of total abstractions from this source (Eurostat, 1997a and OECD, 1997). Most of the remainder comes from groundwater sources with only minor contributions from desalination of seawater (e.g. Italy, Spain and Malta). In Iceland, however, which has extensive underground reserves, 91% of water abstracted is groundwater. Groundwater abstractions are generally of superior quality to surface water abstractions, requiring less treatment and have historically provided a local and 'least cost' source of drinking water. In countries with sufficient groundwater reservoirs (Austria, Denmark, Portugal, Iceland and Switzerland) over 75% of the water for public water supply is abstracted from groundwater. This figure decreases to between 50% and 75% for Belgium (Flanders), Finland, France, Germany, and Luxembourg, and to less than 50% in Norway, Spain, Sweden, and the UK (Eurostat, 1997a). There are, of course, large variations in the use of groundwater across Europe, and in some countries, such as Portugal and Spain, agriculture is the predominant use of groundwater. Groundwater sources are therefore coming under increasing pressure with evidence of overexploitation in some areas.

On average, agriculture accounts for about 30% of total water abstraction in the EU15 (Figure 9, EEA 1999c). In countries where a significant proportion of the total agricultural area is cultivated by means of irrigation, this share rises to over 50% (Figure 10). Over the past decades the trend of agricultural water use has, in general, been upwards, because of increasing irrigation. However, it seems that more recently, in several countries, the rate of increase in area under irrigation has been diminishing. The intensity of irrigation in different countries obviously varies depending on the climate, the crops cultivated and the farming methods applied. The role of irrigation is completely different in Southern European countries, where it is an essential element of agricultural production, compared to Central and Western Europe, where irrigation is often merely a means to improve production in dry summers.

This is reflected by the consumption index of a country, which is the mean annual water consumption divided by the long-term average freshwater resource. 'Water consumption' is the amount of water not returned to the water cycle and lost principally by evapotranspiration. Irrigation accounts for most of the water consumed. Comparisons between countries in 1995 indicate large differences, reflecting variations in the principal use of water in those countries (Figure 11). Thus, countries with a high agricultural water use (with high consumption) such as Italy and Spain have large consumption indices, whereas the index is low for the Nordic countries (e.g. Finland and Sweden) where there is relatively low agricultural use of water. The indicator has been relatively constant over recent years in most of the countries for which information is available.

5. Impacts on the physical characteristics of water bodies

The modification of the physical characteristics of water bodies will also potentially affect ecological status. For example, dredging and river channelisation for drainage and intensive agriculture is particularly significant in Western and Central parts of the EU. Damming for public water supply and for irrigation purposes seems to be a typical modification in Southern EU countries. The over-abstraction of water from surface water bodies (perhaps for irrigation) will also significantly change natural flow regimes, and hence influence their ecological quality.

The impact of a drought depends on the combination of hydrological conditions and water resource pressures. The biggest impacts of the drought experienced by many countries in the early 1990s were in those regions where pressure on water resources were greatest, especially those with high irrigation demands. These are not necessarily the areas with the greatest hydrological drought. Low river flows and depleted reservoir stocks caused problems for irrigation over a large part of Europe, ranging from Hungary to Spain, where agricultural production was seriously affected.

Desertification is a problem in some areas of Europe, particularly semi-arid regions and areas of water scarcity in Southern Europe. The tendency towards desertification is commonly enhanced and accelerated by human activities. The overexploitation of water resources is liable to promote and accelerate desertification in semi-arid zones.

Over-abstraction of both surface and groundwaters is having serious impacts on associated terrestrial and aquatic ecosystems. Such impacts can be exacerbated during periods of low rainfall and river flow when there may also be increased pressures on supplies to meet urban needs, such as from watering gardens, and from irrigation of water-dependent crops. The excess of demand over supply leads to restrictions of uses (e.g. hose-pipe bans) during extended period of time in countries such as the UK.

6. Current status of Europe's water resources

The assessment of the current status of Europe's water resources given in the EEA's report on 'Environment in the European Union at the turn of the century' (EEA 1999a) indicated that there had been:

➢ A significant decrease in the number of heavily polluted rivers; organic discharges fell by between 50% and 80% over 15 years, mainly because of improved waste-water treatment.

BUT

- Nitrate concentrations in EU rivers showed little change since 1980, contributing to eutrophication in coastal waters;
- nutrient input from agriculture was still high;
- EU countries annually abstract on average 21% of freshwater resources, but with huge regional differences, including the triggering of water scarcity problems in Southern Europe.

➢ The overall, quality of EU rivers and lakes should continue to improve because of better waste-water treatment.

BUT

- The quantity of contaminated sludge from treatment processes will increase accordingly;
- water quality of rivers and lakes in intensively farmed regions is likely to remain a problem; and
- the total water demand is predicted to remain relatively stable until 2010.

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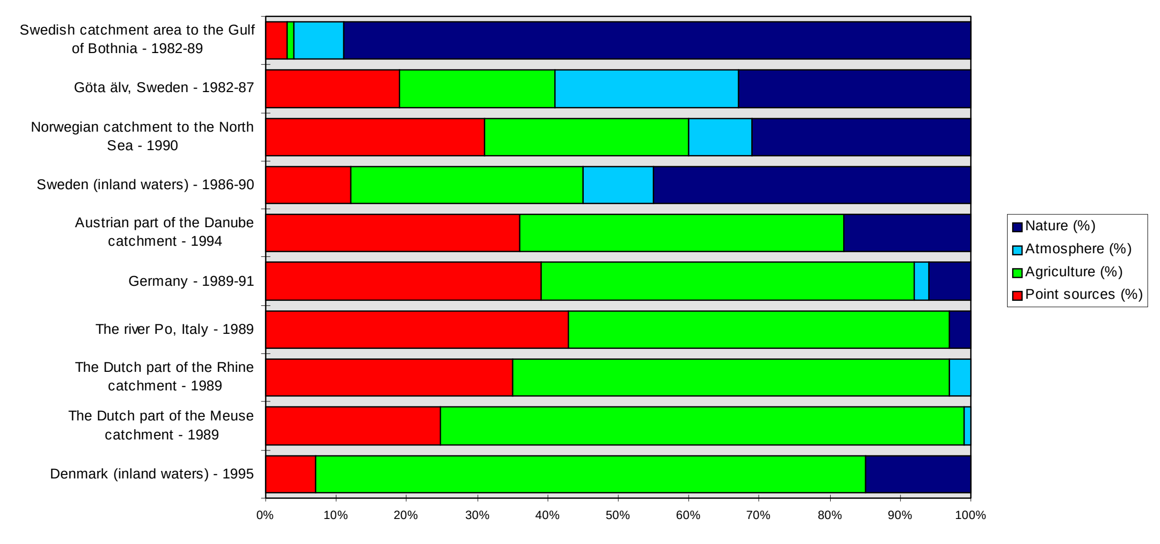
Figure 1. Examples of source apportionment of nitrogen load



Notes: Atmospheric precipitation only considered for some catchments. Natural load included in agriculture for the Dutch rivers. The lower bars have the highest proportion of agricultural pollution

Figure 2. Nitrogen balances for agricultural land in the EU in 1993 (Eurostat 1997)

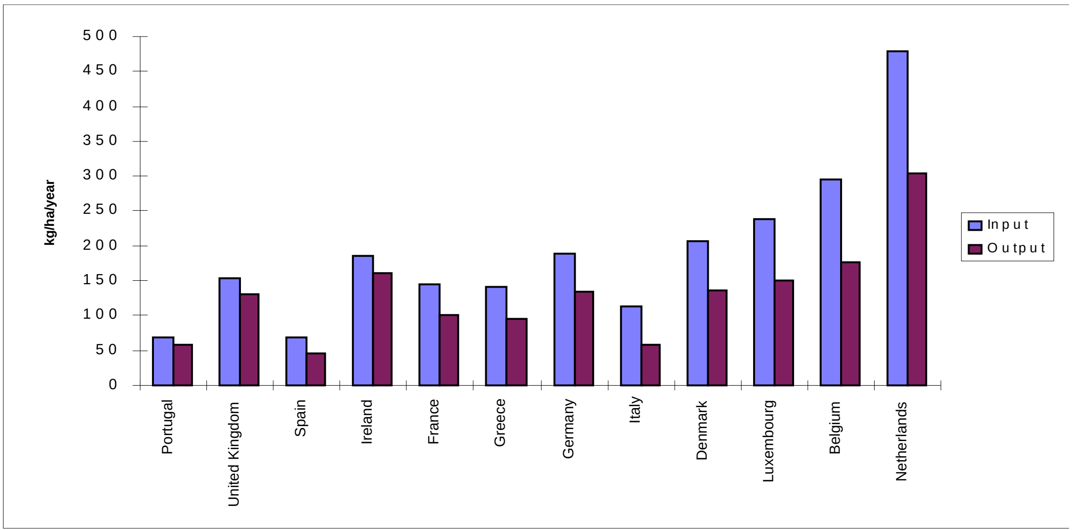


Figure 3. Waste water treatment in regions of Europe between 1980/85 and 1990/95. (Only countries with data from both periods included for the temporal change analyses, the number of countries in parentheses (Source: Eurostat (1995) and ETC/IW questionnaires).

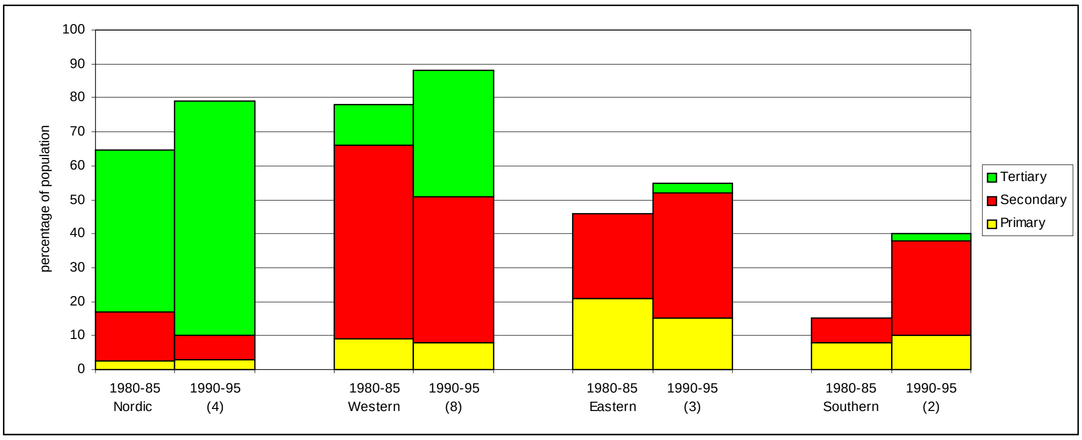


Figure 4. Pesticide usage per arable and permanent cropland (kg/ha) and the proportion of applied pesticide groups

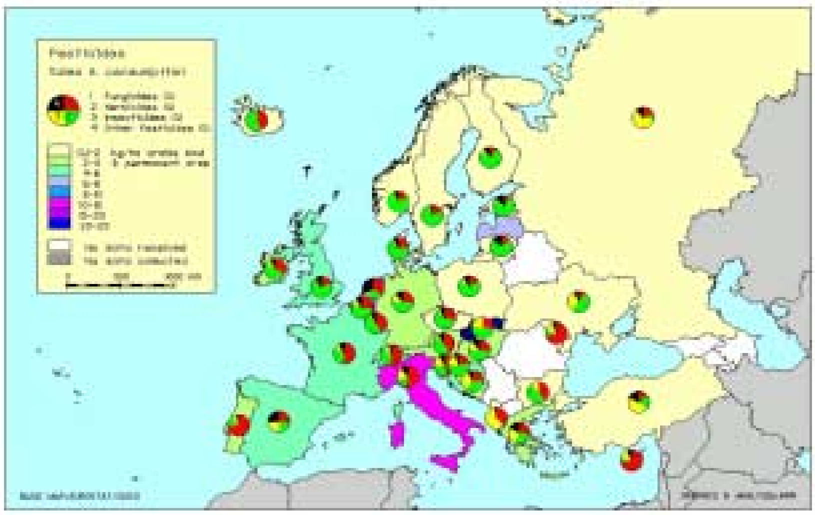


Figure 5. Annual average phosphorus concentration in rivers (1994 –1996)

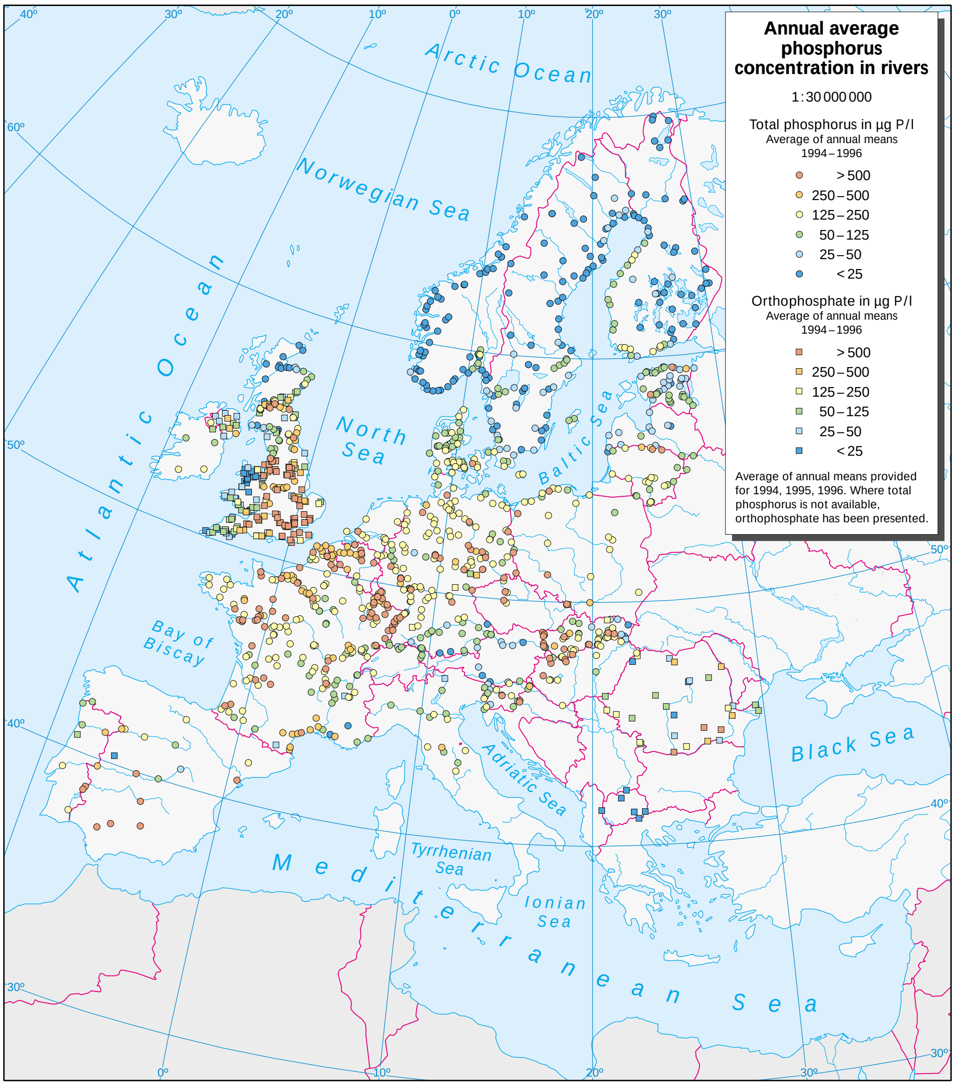


Figure 6. Annual average nitrate concentration in rivers (1994 –1996)

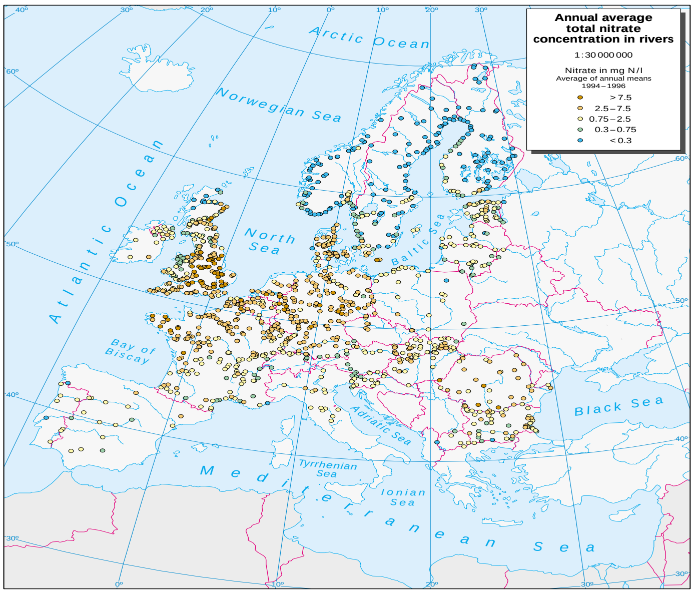


Figure 7. Nitrate concentration in groundwater (mg NO_3/l)

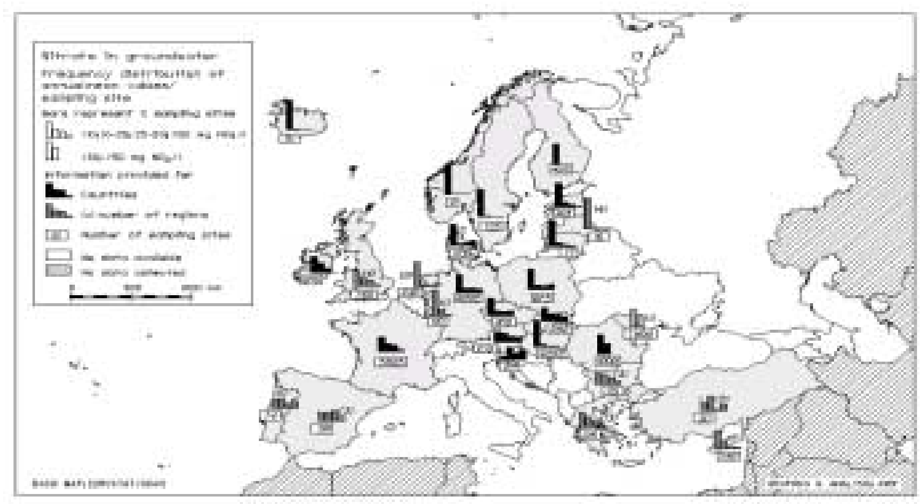


Figure 8. Percentage of sampling sites with concentrations of simazine, atrazine and desethylatrazine >0.1 µg/l

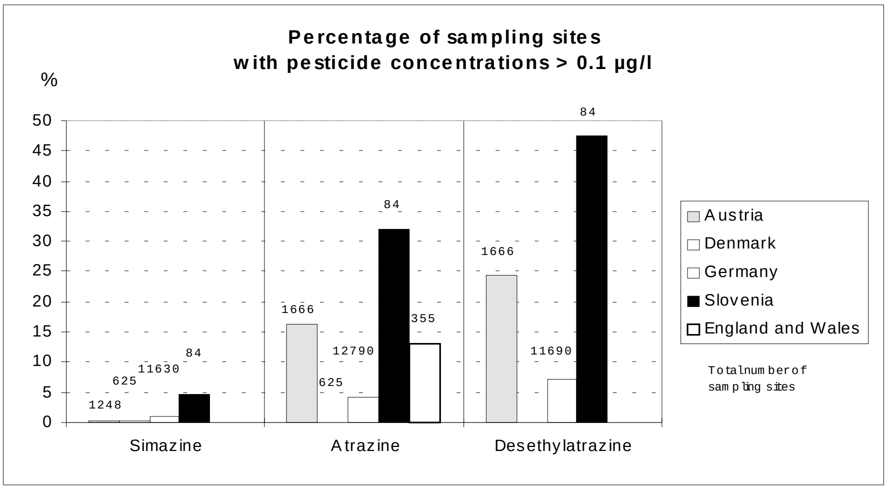


Figure 9. Sectoral use of water in EU15

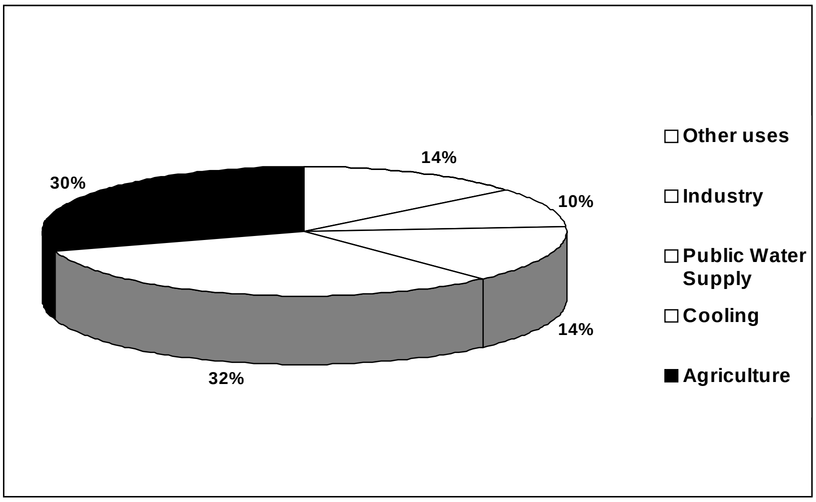


Figure 10. Sectoral water use in Europe in EU15 countries

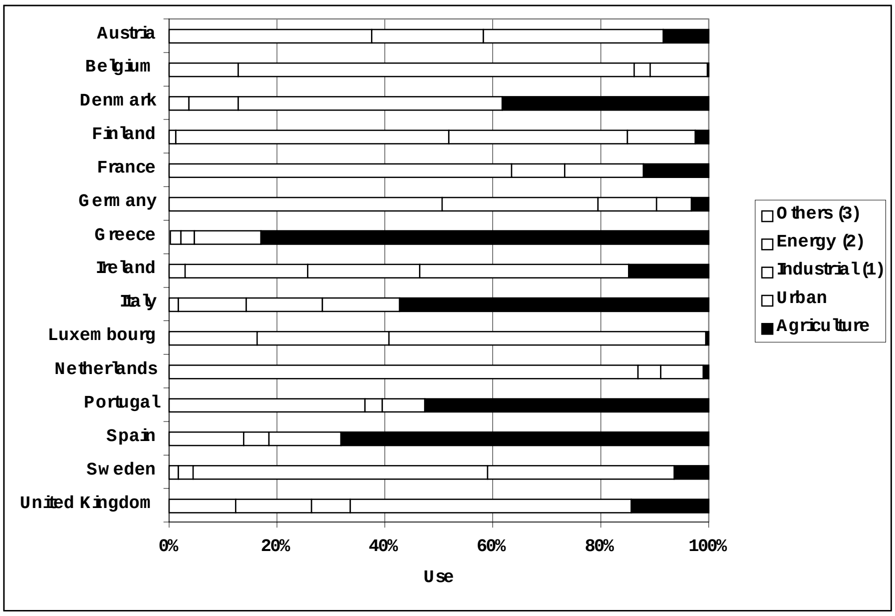
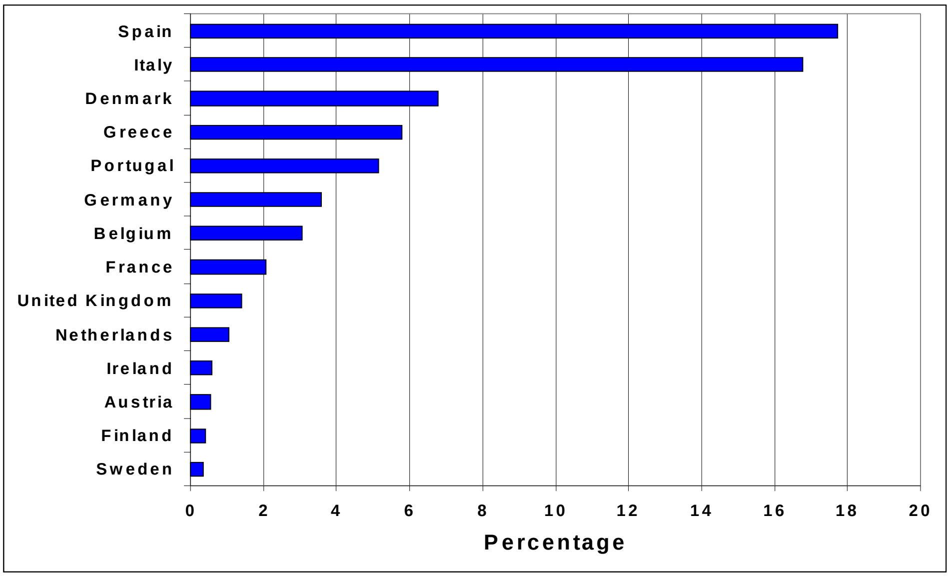


Figure 11. Consumption index of renewable water resources



Desertification and Salinisation in the Alentejo Region, Portugal

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Summary

The meaning of terms such as desertification, drought, land degradation, drylands, soil salinisation and sodisation and water quality parameters is presented and discussed. The causes of desertification in the north Mediterranean region are discussed, emphasising those such as intensive agriculture, irrigation, water quality and soil degradation by salinisation and sodisation. Methods of risk assessment are discussed, with reference to water quality limits in the draft EU Water Framework Directive. The specific situation of the Alentejo, in the south of Portugal, is described in relation to the desertification risk. The high risk of salinisation and sodisation of Alentejo soils is emphasised. The need for more and more irrigation water as a result of deteriorating water quality and the effects of clmate change, in turn leads to increased groundwater salinity and nitrate content. This degradation of freshwater ecosystems accelerates the desertification process.

1. Use of terms

To understand the desertification effects of intensive agriculture in dry sub-humid, semi-arid and arid areas (CCD, 1997), a good understanding of the terms used is required.

- *Desertification* – land degradation in arid, semi-arid and dry sub-humid (dryland) areas, resulting from climatic variations and human activities.
- *Drought* – where naturally occurring precipitation is significantly below normal recorded levels so that hydrological imbalances adversely affect land production systems.
- *Land* – terrestrial bio-productive systems that comprise soil, vegetation, other biota, and the ecological and hydrological processes that operate within the system.
- *Dry-land* – arid, semi-arid and dry sub-humid areas, i.e. non polar or sub-polar regions in which the ratio between rainfall and evapotranspiration (Penman method) is greater than 0.05 and lower than 0.65.
- *Land degradation* – reduction or loss of biological or economic productivity and complexity of rainfed cropland, irrigated cropland range pasture, forest and woodlands resulting from bad land-use management or from a process or combination of processes such as:

  - soil erosion by water or wind;
  - deterioration of physical, chemical and biological properties of soil *(salinisation* & *sodisation)*;
  - long-term loss of natural vegetation.

(a) *Salinisation* (Rowell, 1994) – a process that accumulates an excess of salts in the soil profile. All soils contain salts in soil solution, in adsorption complex and as precipitated salts. In saline soil the Electrical Conductivity of soil saturation extract (ECe) is greater than four decisiemens per meter (dS m^{-1})

Saline soil	ECe > 4 dS m^{-1}
Non-saline soil	ECe < 4 dS m^{-1}

(b) *Sodisation* (Rowell, 1994) – a clay swelling and hydraulic conductivity change (decrease) due to the increase of Exchangeable Sodium Percentage (ESP). Soils with more than 25% of sodium in exchange positions (ESP >25) have serious problems of clay swelling (dispersion) and hydraulic conductivity (a strong decrease of infiltration rate). For some authors there are problems when ESP > 5%.

2. Salty Soils

All soils contain salts, as precipitated salts, in the adsorption complex and in soil solution as shown below:

adsorption	-	+	
complex	-	+	
(negatively	-	+	adsorbed cations ⇔ soil solution ⇔ precipitated salts
charged	-	+	
colloid	-	+	
surfaces)	-	+	

Table 1. Classification of Salty Soils (US Salinity Laboratory, Riverside California; Richards, 1954): Diagnostic parameters

- ECe values are indicative of direct toxicities (of sodium, chlorine, boron, etc), of ionic imbalance in the plants, and of a reduction of the availability of water by lowering the osmotic potential (physiological drought).
- ESP values are indicative of the dispersion (soil permeability) problems.

	ECe 4dS m^{-1}	**ECe > 4 dS m^{-1}**
ESP 15%	Non-saline, non sodic soil	Saline soil
ESP > 15 %	Sodic* soil	Saline sodic* soil

* the term alkali is also used

The salinity could be ‘residual salinity’, resulting from the soil's parent material, such as former marine beds in an arid climate and in poor drainage conditions; or ‘secondary salinity’ (salinisation) resulting from the accumulation of salts in the upper layers of the soil caused by human activities, such as incorrect irrigation practices.

The main salt ions in a soil solution of a salty soil are the cations Na^+, Ca^{++}, Mg^{++}, K^+, and the anions Cl^-, $S04^{--}$, $HCO3^-$, $CO3^{--}$, $NO3^-$ with the predominance of Na^+, Cl^- and $S04^{--}$. Divalent cations are adsorbed more readily than monovalent cations and there is also a difference in adsorption preference between cations having the same valency. The order of adsorption preference is: $Ca^{++} > Mg^{++} > H^+ > K^+ > Na^+$. A significant Na^+ occupancy in exchangeable places is only to be expected when more than 50% of the cations in the solution consist of Na^+ (>80%).

3. Water quality

The criteria determining ‘irrigation water’ quality (Richards, 1954) are: low salinity, measured by Electrical Conductivity of the water (ECw) to prevent salinisation, low ratio of Na^+ to Ca^{++} + Mg^{++} (SAR: Sodium Adsorption Ratio) to prevent the development of sodicity, and the concentration of specific toxic ions such as sodium, chloride, boron.

The Sodium Adsortium Ratio is calculated by SAR = $[Na^{+}] / ([Ca^{++}] + [Mg^{++}])1/2$, where [ ] is the concentration in mmo l^{-1}. This is the best measure of the risk of sodisation caused by ‘irrigation water’ and is indicated by the increase of ESP in the soil. The most widely used classifications of ‘irrigation water’ quality systems are Ayers and Westcot (1985 – see table below) and the U. S. Salinity Laboratory Staff (Richards, 1954).

Table 2. FAO guidelines for the interpretation of water quality (from Ayers and Westecot, 1985)

Irrigation problem	**Restrictions to use**		
	None	Slight to moderate	Severe
Salinity			
ECw at 25°C (dS m^{-1})	< 0.7	0.7 – 3.0	> 3.0
Infiltration rate – Sodicity			
SAR* = 0-3 and ECw =	> 0.7	0.7 – 0.2	> 0.2
= 3-6 and ECw =	> 1.2	1.2 – 0.3	< 0.3
= 6-12 and ECw =	> 1.9	1.9 – 0.5	< 0.5
= 12-20 and ECw =	> 2.9	2.9 – 1.3	< 1.3
= 20-40 and ECw =	> 5.0	5.0 – 2.9	< 2.9
Specific ion toxicity			
Sodium ** (as SAR)	< 3	3 – 9	> 9
Chloride ** (mmol l^{1})	< 4	4 – 10	> 10
Boron (mg l^{1})	< 0.7	0.7 – 3.0	> 3.0
Nitrogen (NO_3^- -N in mg^{-1})	< 5	5 –30	> 30

* read across each line to obtain the ECw values, giving restrictions for each range of SAR values;
** the values apply to surface irrigation. Can cause damage with overhead irrigation.

The limits recommended by the United States Salinity Laboratory (Richards, 1954) are lower than those outlined above. For the electrical conductivity (salinity) of irrigated water (ECw): Low risk ECw $\leq$0.25 dS m^{-1}; Medium risk ECw 0.25 - 0.75 dS m^{-1};. high risk ECw 0.75 - 2.5 dS m^{-1} and very high risk ECw > 2.5 dS m^{-1}. For SAR, ‘irrigation water’ with more than 3 to 10 has a medium risk of sodisation, 8 - 18 has a high risk and 12 to 26 has a very high risk, depending on salinity.

However, the European Directive 75/440/CEE and the proposal for a Water Framework Directive only consider pH, salt content and nutrient concentration from the point of view of human consumption.

For human consumption, the Maximum Admissible Value for nitrate is 50 mg l^{1} and Maximum Recommended Value is 25 mg l^{1}, but for ‘irrigation water’ the limits are 30 mg l^{1} and 5 mg l^{1} respectively. There are no recommended sodium and SAR values in these Directives.

4. North Mediterranean characterisation

The North Mediterranean region (Glordano *et. al.,* 1992, Sequeira, 1998) is characterised by:

- Arid, semi-arid and dry sub-humid climatic conditions, with spring and summer droughts, very high annual rainfall and seasonal variability, sudden and high-intensive rainfalls;
- Poor and highly erodible soils, prone to develop surface crusts, on steep slops, thus with very high erosion risk;
- Past agricultural practices with high erosion rate;

- Current land abandonment with the deterioration of soil and water conservation structures;
- Unsustainable water resource exploitation (more than 50% of total water resources are used for agriculture), leading to chemical pollution, salinisation and sodisation of soils and exhaustion of aquifers;
- Coastal concentration of economic activities: urban growth, industrial concentration, tourism and irrigation for intensive agricultural activities.
- Poor or non-existent land-use planning.

5. Irrigation, salinisation and sodisation

Intensive agriculture based on irrigation increases the salt content of the soil through the salts carried in the 'irrigation water' (Rowell, 1994). The concentration of salts depends on water quality and also on the (salinisation effects of the) use of fertiliser. Land-use upstream, the effect of treated or untreated sewage from urban, industrial and agricultural uses, livestock and drainage of irrigated fields all affect the water quality.

All the salts carried in the 'irrigation water' stay in the soil or return in drainage water to the river downstream, increasing the salinity of the water. All the wastewater, from both domestic and agricultural sources, treated or untreated, increases the level of sodium, nitrogen and the SAR of the receptor water body.

Salt accumulation in soils is an obvious result of using 'irrigation water' in dry regions. The quantity of salt accumulation depends on the salinity of irrigated water. However, a less obvious effects is that as salts accumulate, the SAR of the soil solution increases above that of the irrigated water (Rowell, 1994) (Ca^{++} and Mg^{++} are more adsorbed than K^{+} and Na^{+}). Leaching is required to prevent both the salinisation and sodisation.

The Leaching Fraction (LF) is the extra water, above the amount of water needed to supply evapotranspiration, that is required to leach the salts out of the root zone. This maintains acceptable salinity and sodicity levels in the soil, expressed as a fraction of total water use.

The LF depends on the hydrological characteristics of the soil concerned (water holding capacity, field capacity, available water, drainage water), on soil-clay mineralogy (texture and clay type sensibility, expansive clays such as smectite which are more sensible), on water quality and on the sensitivity of the crops.

The relative solute (ion) transport velocities (leaching velocity) in the soil depends on the relationship between the quantity adsorbed in soil (mg kg^{-1}), and the quantity in the soil solution in equilibrium (mg l^{-1}). Thus the relative solute transport velocity depends on the distribution coefficient Kd = (mg kg^{-1})/(mg l^{-1}). The model used (Bolt, 1979, Christensen, 1985, Sequeira, 1992) is:

$$\mathbf{(Vs/Vw) = [1 + (p/\varepsilon)\,K\,C^{[l/n)-1))}]^{-1}}$$

where Vs is the velocity of the solute (ion), Vw is the velocity of water percolation, p is bulk density of the soil (kg dry soil dm^{-3}), ε is the soil porosity, n, K and C are the isothermic Freundlish parameters for adsorption of the ion in the soil.

In normal soil concentrations, it is possible to consider the adsorption as linear, then n=1, and the model changes to $(Vs/Vw) = [1 + (p/\varepsilon)Kd]^{-1}$. Thus, if Kd=0 (nitrate) the solutes move at the velocity of water (Vs/Vw) = 1. The movement of salts are inversely proportional to the adsorption (rate) and therefore the relative velocities of the movement of the cations in the soils are: $Ca^{++} < Mg^{++} < K^{+} < Na^{+}$.

The leaching fraction taking away the salts also causes the leaching of nitrates, which are highly mobile in soil. Leaching the nitrates out of the root zone decreases the nitrogen fertiliser efficiency and transports nitrates to the drainage water.

Both ground- and surface-water 'receptors' of run-off from agricultural fields that have been irrigated with bad quality water experience increased salinity and nitrate content. This effect depends on the (water) surplus of the hydrological balance, which, in turn, depends on rainfall, evapotranspiration rate and on water holding capacity.

Deep clay soils, especially vertisols, with high water holding capacity and field capacity, decrease annual water surplus, thus increasing salinity risk of the 'irrigation water' especially in a long drought period. The soils of smectite clay type, which exhibit greater swelling and dispersion at a lower ESP, accumulate Na^+ in the B horizon of the profile (about 0.5 -0.7 m deep), and Ca^{++} in the upper horizon, thus having an increased risk of sodisation.

6. South of Portugal, Alentejo region

6.1 Soils (Cardoso, *et al*, 1973 . Sequeira *et al.,* 1995):

Poor and highly erodible leptosols, cambisols and luvisols from shales are predominant soils at Alentejo. For the most part, they are shallow, stony and not suitable for irrigation. Arenosols and podzol sandy soils, without sodisation and salinisation risk, have very low buffer capacity and are located near the marine coast.

Gleysols, eutric planosols and albo-gleyic luvisols are not suitable for irrigation. Drainage increases suitability for irrigation but, at the same time, it also increases the risk of salinisation and, especially, of sodisation

Vertic luvisols and vertisols are the most fertile soils of Alentejo, but have a high risk of salinisation and, if they have no calcic layer, they are especially sensitive to sodisation. Some of the vertic luvissols are allomorphic soils with more than 20% Na^+ in the B horizon (30-60 cm depth), with a very low infiltration rate.

6.2 Groundwater (Anonymous, 1997, Macedo *et al.*, 1998)

Most parts of Alentejo aquifers show, at present, high level of nitrates and the same salinity and sodicity risks. An example is the Gabbric aquifer at Beja, in vertic soils: mean nitrate content (NO_3) was 62 mg l^{-1} (recommended value 25 and admissible value 50 mg l^{1}), the maximum value found was 143 mg l^{1}. This aquifer shows medium to high risk of salinisation (0.5-1.5 dS m^{-1}).

Another example is the Alvalade aquifer: the nitrate contamination is lower but 60% of the water samples exhibit high risk of salinity and medium to very high risk of sodicity (ECw from 0.75 to 2.5 dS m^{-1}, and SAR from 4 to 18).

This result from the low water surplus in the hydrological balance (high water holding capacity of the soil, high annual evapotranspiration) causes high concentration of salts in the percolated water. Agricultural intensification, with an increase of salts added to the soil by 'irrigation water' and the application of fertiliser causes an increase of salinity, sodicity and nitrate content downstream.

6.3 Dam water quality (Alvim & Nunes, 1984)

From the data on water quality of the dams of Southern Portugal, it is clear that the quality varies during the year and from year to year, depending on the present level of water storage. In spring and summer, evaporation rates increase the salt concentration. This effect depends not only on the evaporation rate but also on the relationship between the surface of the area exposed and the correspondent volume.

During the rainy seasons, autumn and winter, the salinity decreases with the rainfall. Salinity depends on rainfall, on the evapotranspiration rate and on the land use upstream.

Roxo Dam has the worst quality water, with an SAR from 2.0 to 4.0 (adjusted SAR from 4.0 to 9.0), and ECw from 1.3 to 2.3. According to the United States Salinity Laboratory (Richards, 1954) this water has a high to a very high risk of salinisation (but low risk of sodisation) because it comes from the drainage of good vertisols with intensive agriculture production and received waste water from Beja town.

Odivelas and Alvito Dams exhibit good water quality with an SAR of less than 2.0 and ECw from 0.3 to 0.45 with medium risk of salinisation and no risk of sodisation. Alvito, without any village upstream has better water quality than Odivelas

7. Necessity of modelling future water quality of Guadiana River

The Guadiana basin is home to more than 1.5 million inhabitants in Spain and more than 0.3 million in Portugal, upstream of Alqueva Dam.

There are also 27 dams in Spain (Anonymous, 1995), with a usable capacity of 7,106 hm^3. Over 22 of them will be constructed in the near future with a total usable capacity of 997 hm^3. In Portugal, there are only two dams: the Caia dam with a capacity of 203 hm^3 and the future Alqueva dam with a usable capacity of 3,150 hm^3.

The effects of the dams, the use of water for irrigation and the retention of treated or non-treated domestic waste water is not completely known because in Spain, the Serena Dam and its irrigation system are not yet fully functioning.

Comparing the natural regime with the modified regime at the border (Caia), the stream volume decreases more than 40%. This is because Spain has 300,000ha of irrigated land upstream and will have 380,000 ha in the future. The amount of water returned to the Guadiana from domestic use totals: in Spain about 50-60 hm^3, and in Portugal 20 hm^3. The corresponding figures for irrigation water are: in Spain more than 200 $hm^3$and in Portugal about 20 hm^3, depending on leaching fraction, irrigation efficiency, etc.

The evaporation at the surface of the dams corresponds to a loss of about 500 hm^3 in Spain and 300 hm^3 in Portugal once the Alqueva Dam is completed.

The quality of water returned from irrigated fields depends on the initial quality of the ‘irrigation water’, being worse as the initial quality decreases because it will then carry all the leached salts. The same happens to natural runoff (hydrologic surplus during winter) with a SAR greater than the original water (differential movement of the cations in the soil; Rowell, 1994): it carries the salts. The lag time effect depends on soil depth, soil organic matter content, clay content and clay type, and the quantity and efficiency of the irrigation system.

At present, it is not possible to develop a model of the future situation and/or to validate current work due to a lack of sufficient data. It is certain, however, that the quality of water decreases progressively at each dam downstream as a result of the pollution carried with domestic wastewater, the leaching of salts from irrigated fields (salinisation caused by fertilisers, by farmyard manure, etc.), and the concentration of the salts through direct evaporation and evapotranspiration.

Rainfall is too low to compensate for these effects.

8. Climate change

The probable increase of the evapotranspiration rate and the change in rainfall regime (Espiríto Santo, 1997) will lead to a decrease in runoff and therefore in the availability of water to recharge dams (Cunha, 1994). This, in turn, will increase the need for irrigation and decrease the quality of water given that:

more 'irrigation water' → more salts added → more needs for water (to leach the salts) → decrease in water quality downstream.

Whilst these effects are not assessed, the spring rainfall in Portugal has decreased significantly by about 50 mm between the periods 1930 to 1960 and 1960 to 1990 (Espirito Santo, 1997). This means that the knock-on effect of an increased irrigation period has led to a reduction in the quality of water and to ecosystem degradation, thus increasing the risk of desertification.

9. Conclusion

Intensive agriculture using irrigation based on a system of 'cascade' dams and having no regard for land use upstream leads to increased risk of soil salinisation and sodisation as well as degradation of water quality. This in turn directly accelerates the desertification process in the medium and long term.

Further research is needed to produce good and validated models to assess the risks involved, before political decisions are taken that will cause irreversible degradation of both land and water.

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Assessing Nutrient Inputs and their Impacts in Catchments

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Summary

Nutrient concentrations determine the extent to which water bodies are eutrophic. This paper describes an export model, which has been developed for the Environment Agency by Reading University, that predicts total nitrogen and total phosphorus loads from land use, stock headage and human populations. The model has been tested on 32 catchments in England and Wales and can been used to assess the effects of future land use changes and to establish baseline water quality against which change can be monitored. One of these catchments is the Broads, a wetland of international importance. In this catchment the model has confirmed the validity of phosphorus water quality targets and has highlighted potentially significant sources of phosphorus from rural populations and from the use of organic manures.

1. What is Eutrophication?

There are numerous definitions of eutrophication, but the Environment Agency, which is responsible for water quality in England and Wales, has adopted the following definition. *The enrichment of water by nutrients, stimulating an array of symptomatic changes, including increased production of algae and/or higher plants, which can adversely affect the diversity of the biological system, the quality of the water and the uses to which the water may be put*. These changes can be seen in many water bodies, but they are particularly pronounced in lakes where the most common problem is the production of excessive blooms of planktonic algae. The most well know of these are the potentially toxic blue-green algae (cyanobacteria) which pose a risk to the recreational use of water as well as to livestock and domestic animals. Other problems associated with planktonic algae include the reduction in the clarity of the water which can result in the disappearance of higher plants and a consequent reduction in biodiversity. This is a particularly important problem in shallow lakes, where plants normally occupy a substantial proportion of the open water. A good example of these changes is seen in the shallow lakes that form the internationally important wetland in Eastern England, know as the Broads.

Eutrophication of inland waters is recognised as a pan-European problem of major concern and the European Environment Agency has called for more effective and co-ordinated policies in this area (European Environment Agency 1999). The Environment Agency is proposing to tackle the problem of eutrophication by promoting measures to reduce nutrients losses to the water environment nationally, complemented by more stringent catchment-based actions for waters most at risk from or impacted by eutrophication.

2. Catchment-Based Approach

The concept of catchment management is not new in England and Wales. The Environment Agency and its predecessor organisation responsible for water management, the National Rivers Authority, have had catchment-based management plans for several years. These plans have recognised that the key to controlling eutrophication is the reduction of the amount of nutrients that can reach the water environment.

Nutrients can arise from many sources within a catchment. In general, catchments with a large proportion of their natural vegetation intact probably release lesser amounts of nutrients (Likens *et al*. 1977). However, in most of Europe where human activity has released more nutrients by introducing additional nutrient sources such as sewage effluents, or through the activities of agriculture, the degree of eutrophication has substantially increased

In inland waters, particularly lakes, it has generally been assumed that phosphorus is the potentially limiting nutrient for algal growth and most attention has been focussed on this nutrient. Point sources, particularly sewage treatment works, are the most obvious sources of phosphorus and over the last two decades there have been numerous examples where phosphorus removal has been introduced into the treatment process. In some cases this has produced significant improvements, while in others the response has been less effective. There are many possible explanations for this, but one of the most important is the recognition that until the phosphorus availability in the water body is reduced to a point where it can limit algal growth, any reduction in the supply of phosphorus will not result in a reduction in algal growth (Reynolds 1992).

Thus during the planning of any eutrophication control programme it is essential to establish both realistic target phosphorus concentrations, which are likely to produce a biological response and to identify all of the potential nutrient sources in the catchment.

3. Phosphorus targets

Target phosphorus concentrations can be taken from widely recognised threshold values (OECD 1982) or from a more detailed understanding of the ecological status of the impacted site. The latter approach is particularly important in shallow lakes systems where the classic view of a linear response to eutrophication by algae has been replaced by the concept of a series of threshold phosphorus concentrations at which abrupt changes in the ecosystem can occur.

Another approach to establishing appropriate nutrient concentrations is to reconstruct nutrient loads for a period when it is known, or can be assumed, that the habitat was in a good ecological condition. This is the approach that is being developed by the Environment Agency for lakes (Moss *et al*. 1996) and could potentially be applied to a wide range of aquatic habitats.

4. Reconstructing nutrient loads, Export Modelling

The approach being used is that of export coefficient modelling, a technique which provides information about changes in nutrient loads and the sources of these nutrients. It can thus be used to assess the degree of change in nutrient availability and to identify the most important nutrient sources within the catchment. Once established the model can also be used to evaluate future scenarios and is thus a valuable management tool.

Export coefficient modelling is a simple approach which calculates the total load of nitrogen or phosphorus arriving in a water body as the sum of the individual nutrient loads exported from each separate nutrient source in the catchment as a function of the rate of nutrient input to that source and the export potential of each land use type, livestock variety or people. The model once calibrated will provide estimates of the total nitrogen and total phosphorus load delivered to a water body annually which can be converted to predictions of mean annual total nitrogen and total phosphorus concentrations by the use of simple load response models (e.g. OECD, 1982). The precision of the model will depend on the spatial scale at which the data are collected. In developing the initial models the field was used as the basic modelling unit (Johnes 1996a), but to make the model more widely applicable with minimum cost a catchment scale version has been developed (Johnes *et al*. 1996), using regional sets of export coefficients.

The approach that has been used, is outlined in Figure 1. The model is initially constructed using data on land use and management in the catchment, the population, rates of nutrient inputs from atmospheric sources and nutrient inputs from fertiliser and livestock waste. These data are used to calculate the nutrient inputs to the catchment and using a set of export coefficients, initially selected from the literature from case studies with broadly similar land use, topography, climate and geology, the amount of nutrient exported to the water environment. The model is then calibrated by comparing the output with observed total nitrogen and total phosphorus loadings obtained from field monitoring.

The model is then run through a sensitivity analysis step to determine which model parameters have the greatest impact on output and the best fit obtained by varying the export coefficients within the range of published values. The model is then validated by comparing the predictions with observed data over a wider time period where land use, number of livestock and people in the catchment will have changed over the course of the catchment history. If the model output and observed data agree then the model can be considered to provide an accurate representation of the relative importance of the different nutrient sources and can be used to identify historic conditions (hindcasting) or to determine likely future responses to different proposed management strategies.

In England and Wales we are fortunate in having annual records of population, livestock and agricultural activity at a relatively small scale (parish 10-20 km^2) covering a period from 1866 to date. Population data are available at decadal intervals since 1851 and together with records of fertiliser use it is possible to generate catchment scale models wherever sufficient data is available for calibration and validation. The model predicts general system behaviour in an average year of flow and the output may underestimate phosphorus concentrations in very wet years or overestimate in droughts where flow from the catchment deviates markedly from the average response. However, although the model cannot simulate the extremes of the system it does provide a tool for predicting nutrient export in response to changes in catchment use. It has been used on 32 catchments covering a wide range of conditions in England and Wales and the close match between the predicted and observed total nitrogen and total phosphorus loads (Figure 2) demonstrates the robustness of the technique (Johnes *et al*., 1998).

5. Baseline conditions

Eutrophication is almost always an entirely anthropogenic phenomenon caused by alterations in the catchment. However, different catchments will have different natural levels of fertility, depending on rock type, topography and rainfall. In general upland hard rock areas will release less nutrients than lowland areas. Thus while lakes will change with time, they start from different initial states and without reference to historic conditions it is difficult to make valid interpretations about the current water quality.

There are several dates that might be used as a reference condition for lakes, but in the UK that most appropriate is the period from around 1920 – 1940, when agriculture reflected the natural topography and fertility of the area and was not influenced by intensive, subsidy driven systems. By using the export model approach nutrient loads can be estimated for this period and if contributions from the human population are removed from the model minimum sustainable loads can be generated. Alternatively the population can be included and, if records suggest that the water body was not exhibiting the symptoms of eutrophication, this might be used to establish an appropriate target for
restoration.

To facilitate this the catchment scale model, using the field as the spatial unit, has been simplified by applying the same export coefficients to catchments with broadly similar land use, management, soils, geology and climate (Johnes *et al*. 1998). A previous study demonstrated that while the catchment scale model explained 95% of the variability the modified model only reduced this to 89% (Johnes *et al*. 1996) and this approach has enabled the Environment Agency to produce baseline total nitrogen and phosphorus concentrations for any lake in England and Wales.

6. Application of the export coefficient model in the Broads

The Broads is an internationally important wetland area in Eastern England which consists of a series of interconnected shallow lakes surrounded by fen and alder woodland. Once dominated by aquatic plants these lakes have lost their submerged flora, replaced by phytoplankton or benthic algal mats. There has also been a decline in the fishery and a general loss of biodiversity as a result of the nutrient enrichment of the area. Analysis of diatom fossils from sediment cores suggest that changes in the ecology of these lakes started earlier than the 1930s, although at this time the lakes were still dominated by aquatic plants and records suggest that the lakes still contained a high biodiversity (Moss 1983).

Based on an analysis of Danish shallow lakes (Jeppesen *et al*. 1999) and supported by data from the Broads (Phillips *et al*. 1999) an appropriate restoration target for the Broads might be a mean total phosphorus concentration within the range of 50-100 ugP l^{-1}. Within this concentration range available evidence would suggest that these shallow lakes should be dominated by aquatic plants rather than phytoplankton and as a consequence be in a more sustainable ecological state. Running the modified export coefficient model for Barton Broad, the second largest lake in the Broads and currently the focus for a major restoration programme (Madgwick 1999), generates a hindcast total phosphorus concentration of 40 ugP l^{-1}. This value is close to the above range and confirms that after allowance for human inputs to the catchment that 50-100 ugP l^{-1} is an appropriate restoration target for these waters.

An export model using the field scale has also been developed for one of the Broadland river systems, the River Bure (Johnes 1996b). To generate the model a catchment survey was undertaken and farmers were asked to complete a questionnaire to identify more precisely their management practices and use of fertilisers. The model was calibrated and verified as described above and in addition comparisons were made with a neighbouring catchment, the River Wensum. The Broads area has an exceptionally flat topography and rivers a very low channel gradient. This in combination with low rates of discharge means that the rivers are very slow flowing with a high sediment trapping efficiency. As a result much of the nutrient load exported to the rivers is trapped in the bed sediments and only transported down steam during infrequent storm events. This applies not only to particulate phosphorus eroded as soil particles, but to soluble phosphorus from point sources such as sewage effluents which rapidly bind to this particulate material. The consequences of this are that routine water quality sampling, event carried out at weekly intervals is likely to underestimate the nutrient load and the export model may provide a more realistic estimate of the true load. Although sediment bound phosphorus may not be immediately biologically available, once deposited in the lake basin microbiological processes during the summer months can release this as soluble phosphorus available for algal growth (Phillips *et al*. 1999) and the export coefficient model may provide a more realistic estimate of the true load and thus the maximum potential rate of algal growth in the lake.

In general the model suggested that the headwater catchments receive a larger proportion of their phosphorus load from livestock waste than from human sources (Figure 3). In Norfolk there are many intensive poultry farms, many have little agricultural land attached and as a result poultry manure is often exported to neighbouring catchments. This is frequently applied as slurry to potato and sugar beet crops and in the headwater catchments this imported waste can make a significant contribution to the phosphorus load.

Further downstream human sources were more important and the model confirms the appropriateness of the restoration programme which has focussed on reducing phosphorus from significant sewage effluent discharges. Since 1980 phosphorus removal has been progressively installed at all of the major sewage treatment works discharging to the River Bure and its tributary the River Ant and this is reflected in the decreased contribution by people to the phosphorus load in this catchment. However, data extracted from the population census suggest that the increasing population, many living in rural areas not connected to these larger sewage works are potentially becoming significant in terms of nutrient loading.

Thus in this example the export coefficient model has confirmed the importance of human sources of phosphorus in the catchment but has highlighted areas of future concern relating to the disposal of agricultural wastes and the growth of rural populations. In other catchments livestock can be seen to be the dominant source of nutrients and it is suggested that export models provide a realistic and cost effective method of evaluation nutrient sources and of reconstructing the nutrient history of catchments.

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Figure 1. Export coefficient modelling procedure (based on Johnes *et al* 1998)

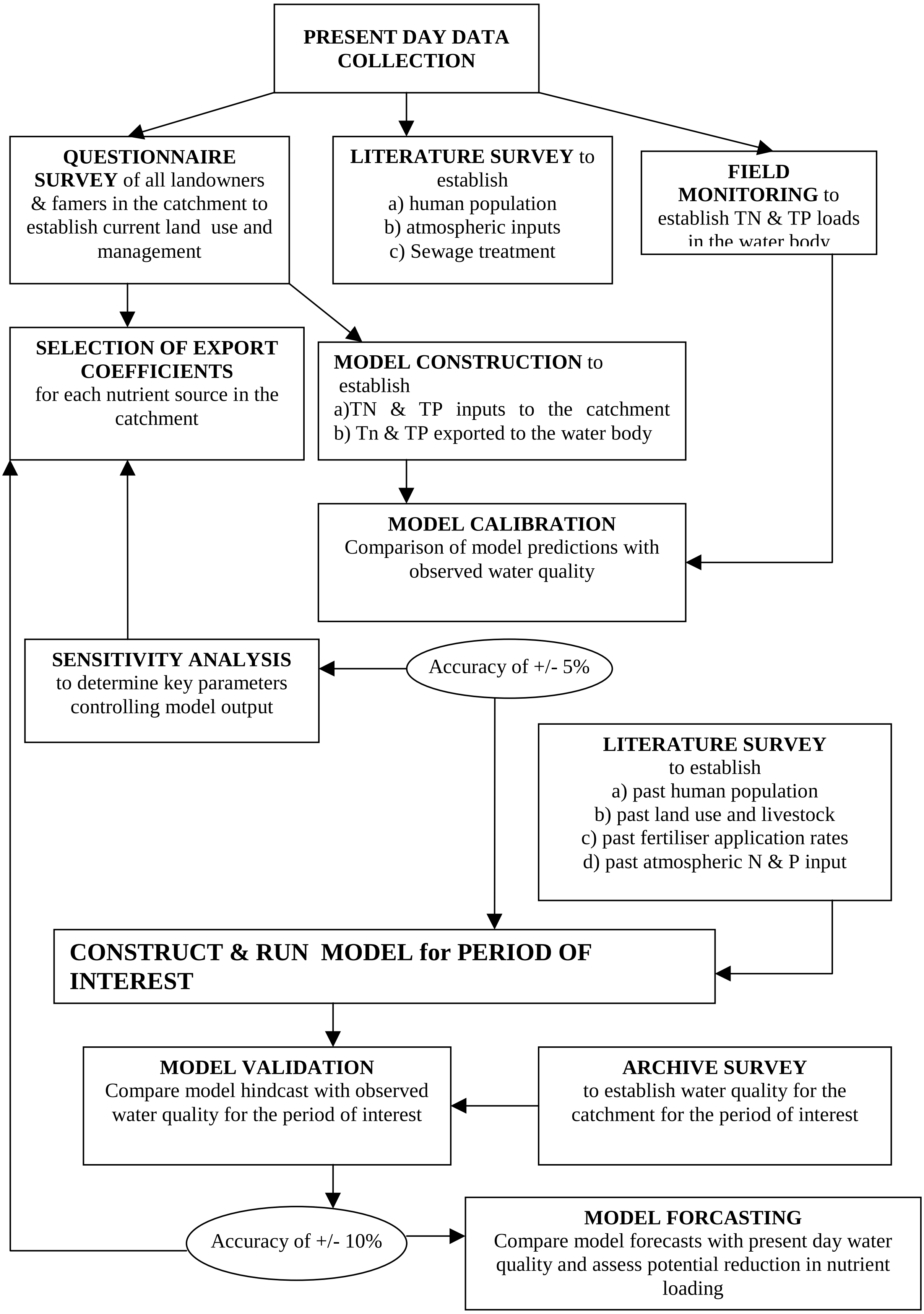


Figure 2. Observed versus predicted total phosphorus concentrations for thirty-four surface waters in the UK (Based on Johnes *et al*. 1999)

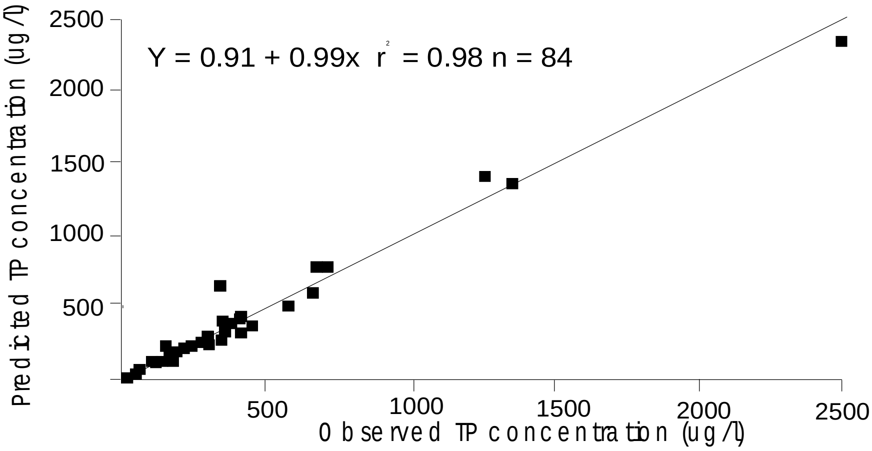
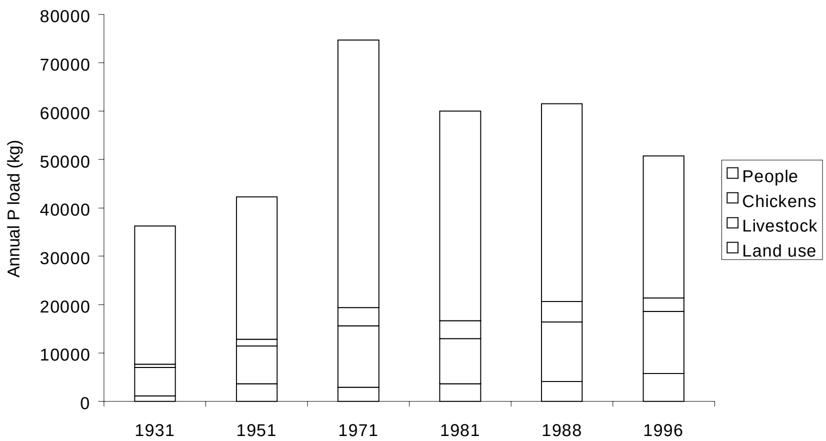


Figure 3. Changes in annual total phosphorus loads for a) a headwater catchment of the River Bure and b) the catchment upstream of Wroxham at the head of the tidal river



Impact of Agricultural Development Scenarios on Water Resources in Bulgaria, Hungary and Romania

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Summary

Agriculture is the single biggest sector responsible for nutrient pollution of the Danube River Basin. Results obtained from a recently completed Phare project on demonstration centres for sustainable agriculture in Bulgaria, Hungary and Romania suggest that organic agriculture and improved low-input agriculture have a positive effect on national agricultural production values and the potential to reduce nutrient pollution of surface and ground water. The economic benefits of these types of agriculture are even more pronounced when the environmental costs of nitrogen leaching are internalised in the production value. To enable development of sustainable agriculture in these countries, a three-track policy is suggested: improvements to the environmental and economic performance of current low-input agriculture; promotion of organic agriculture; and coversion of high-input regimes to integrated agriculture.

1. Introduction

In 1995, in order to examine the environmental and economic effects of low-input and organic types of agriculture in Bulgaria, Hungary and Romania, the EU-Phare programme funded a pilot project on setting up research and education demonstration centres for sustainable agriculture (EU/AR/301/91). The project's objective was to 'test' the feasibility of sustainable types of agriculture under agro-ecological and socio-economic circumstances of the three countries concerned. The project also had to draft a policy paper for conversion to sustainable agriculture in these countries. Education and research on water quality, biodiversity, market potentials and macro-economic feasibility represented a substantial part of the project activities (ended up in May 1999). The results obtained and experienced gained by this project are used in this paper as the frame for a wider discussion on the impact of agricultural development scenarios on water resources in the Danube countries.

2. Impact of agriculture on water resources in the Danube River Basin

Most agricultural operations, such as soil tillage, manuring, grazing, and irrigation, pose a serious threat to water quality. Agriculture is a substantial water user, and often the single biggest sector responsible for the pollution of European waters. In addition, agriculture threatens water habitats. Available data indicate that in many regions of Europe, agriculture alone is responsible for more than 50% of the total nutrient load carried by water (Znaor, 1999; VROM, 1998; IFEN, 1998; OECD, 1997). Many surface and groundwater resources are exploited beyond sustainable levels and agriculture contributes to this problem by drawing off a considerable volume for irrigation purposes.

Around 50% of nitrate and phosphate pollution in the Danube River Basin are attributed to agriculture. The '*Danube Integrated Environmental Study*' (Haskoning, 1994), a research project involving approximately seventy experts from eleven Danube countries concluded that:

- Agriculture is the major source of pollution by nitrogen (50%), phosphorus (53%) and pesticides, and contributes significantly to heavy metal (Cd, Cu, Zn), bacteria and virus emissions.
- Wetlands and related ecosystems still account for a substantial nutrient-removal capacity with a high economic value.
- Environmental problems related to water pollution are amplified by the consumption patterns of the Danube basin population, particularly the increase of animal protein consumption.
- The damage to the priority functions (drinking water, recreation, fisheries, ecosystem) of ground and surface water in the Danube basin and part of the north-western shelf of the Black Sea is estimated to be about +/- EUR 4 billion per year.

The findings of the Haskoning study were recently confirmed by another study (TG-MWRI, 1997). This study, too, found that more than 50% of N and P in the surface water of the Danube basin derive from agriculture. A study from VITUKI (1997) concluded that a 25% reduction of the nutrient loads (as compared to reference period 1989-91) is required to meet the environmental quality criteria for the Danube River, while a 40% N-reduction and 50% P-reduction scenario would be required for the Black Sea Basin. Experts from the CEE countries have suggested that such reductions (of about 50%) would be feasible if so-called 'Best Agricultural Practices' could be generally applied. Obviously, both Germany and Austria (Upper Danube) would have to contribute their share to this reduction as well.

The above data suggest that agriculture represents by far the most important sector for tackling nutrient pollution in the Danube basin. However, when calculating the amount of water pollution caused by agriculture, the pollution caused by agricultural practices are only part of the problem. Significant levels of pollution are caused by the agri-chemical industry that serves agriculture. It is a very substantial source of pollution. For instance, in Romania, a single fertiliser producer contributes 13.4% to the total Romanian phosphate discharge (60,000 tons) into the Danube river (Toma, 1999).

3. Low-external input: agricultural reality in the lower Danube countries

In Central and Eastern Europe, the sustainability issue in agriculture has two additional dimensions in comparison to Western Europe. The 'transition' process of economic and institutional reform, and the environmental 'opportunity' of current low-input reality in agriculture. Due to changes in the price of agricultural commodities and the high price of agricultural inputs, most of the farms in Central and Eastern Europe (CEE) are forced to practice low-input farming. Input levels have fallen to 10-30% of the input levels before 1989. In 1996-98, in most countries the agri-input levels have not increased above 10-50% of the 1989 levels: Bulgaria 10%, Yugoslavia 50%, Poland 50%, Romania 25%, Russia 12% (Kieft, 1999).

Even though this is a rather 'forced' agro-social experiment, it is very interesting to study its impact on agricultural production and water pollution in the Danube River Basin. The various data on inputs, outputs and water pollution show the potential to combine the objectives of agricultural production with environmental protection. Therefore, the reality of low input levels can be perceived also as an environmental opportunity for the region. Especially since a minimum 40-50% reduction in nutrient emissions is required to enable ecologically sound functioning of the Black Sea (VITUKI, 1997). This current situation is only an opportunity if agricultural production can be increased without increasing pollution again.

However, it is quite questionable whether this opportunity will be (fully) taken, since the official agricultural policies in most CEE countries aim at restoring agri-chemical inputs to the 1990 level (Kieft, 1999, Znaor, 1999) and offer relatively little support to environmentally-friendly types of farming.

Studies from some Danube countries (Kieft, 1999), as well as the results of the above-mentioned project indicate that by practising low external input agriculture, the reduction of yields is not proportional to the reduction of fertiliser and pesticide inputs. Even with relatively low levels of agri-chemical input, farmers in Bulgaria, Hungary and Romania can achieve interesting output levels, while at the same time reducing or avoiding environmental damage. Maintaining these output levels, however, requires improved farming practices including balanced nutrient management, improved manure handling, erosion control and crop rotations, based on low input techniques.

3.1 Bulgaria

Over the last decade, Bulgarian agricultural output declined by some 40%. The number of cattle also decreased from 1.4 large cattle units per hectare (LCU/ha) in 1989 to 0.7 LCU/ha in 1994. At the same time, price liberalisation increased the price of agricultural inputs and reduced purchasing power and the demand for food. While input prices (and sometimes retail prices) have almost reached international market levels, farm output prices lagged behind. Between 1990 and 1994, input prices in local currency went up 23 times, retail prices 22 times and output prices only 9 times (Beaumond and Montiel, 1995).

Due to this price development, most of the farms, including the state-owned farms, were forced into low input farming. The input of fertilisers and plant protection agents has dropped by over 60% since 1989. The statistics yearbook for 1993 shows that average N-fertiliser use is below 30 kg/ha, while the use of phosphate is around 7 kg/ha and potash around 1 kg/ha. The Bulgarian policy makers still seem to be insisting on achieving higher outputs through restoring the former policy of high input agriculture. Towards 2015, further increases in emissions are expected, unless mineral and organic fertilisers are effectively utilised.

3.2 Hungary

Under an interesting title '*Concern over low level of fertiliser use*', the review *'East Europe, Agriculture and Food'* (1995) presented two tables: *'Fertiliser Use in Hungary, 1989-95'* and '*Yields of Selected crops, 1986-95'*. For the current paper, these two tables have been integrated and summarised in Figure 1.

Fertiliser application dropped from an average of 206 kg/ha in 1989 to 30 kg/ha in 1992 (representing 17% of the level of 1985-89) and increased slightly to 66 kg/ha in 1995 (representing 32% of the 1985-89 level). With this fertiliser consumption in mind, it is interesting to look at the yields for a series of crops. The average 1992 yields show a production level of 66% (at a fertiliser level of 17%) in comparison to the period up to 1989. The average estimated yields in 1995 are at 88% of the 1985-89 levels, even though fertiliser use is only 32% of the former rate. Some crops (like soya bean, rape seed, and rye) even showed 1995 yields above the 1989 level. The article also indicates that "a drop of similar proportions has been recorded in pesticide and herbicide use".

As far as the Tisza river basin in Hungary is concerned, Olah J. and M. Olah (1996) link the recent drop in agricultural input levels to a clear drop in pollution of river water (*Editor's note*: this paper was contributed prior to the disastrous pollution of the Tisza, due to pollution from a Romanian mine, in January/February 2000). In a trend analysis over the years 1973-1993 they conclude that, primarily due to the high load from fertiliser, nitrate concentrations increased in the River Tisza from 1.5 ppm to 15.6 ppm. In recent years, they also noticed the decrease of nitrate concentration to 6.6 ppm, which is mainly the result of decreasing inorganic fertilisation from 617,000 to 124,000 tonnes of nitrogen per year. Based on this research, Figure 2 combines the three recent trends of N-fertiliser inputs, cereal yields and NO_3 pollution of river water for the Tisza River Basin in Hungary.

The data from Tisza River in Figure 2 clearly synchronise the *strongly reduced input levels* up to 1993, with only *slightly reduced output levels* but substantially *reduced nitrate pollution*. (A part of) this phenomenon might be explained by the micro-nutrients theory. According to this theory, in a situation of relatively well-balanced supply level of macro-nutrients (N, P and K), the yield-limiting factor is the availability of micro-nutrients and not macro-nutrients (Hekstra, 1999). This theory may also explain the current relatively low nutrient losses into surface water.

In the optimistic agricultural scenario, the maximum reduction in emissions will be reached only in 2015 (the recovery of economic activities is assumed to compensated by more environmentally friendly techniques), which represents a *status quo* scenario as compared to the situation in 1994-95. The pessimistic scenario predicts increasing loads as compared to the 1994-95 conditions (VITUKI report quoted in UNDP/HASKONING 1994).

3.3 Romania

Agriculture in Romania presents a rather dramatic picture in terms of the destruction of productive capital and of degradation of soil fertility (Romanian Ministry of Agriculture, 1997). Irrigation systems no longer function on 3 million ha (out of a total of 3.2 million ha). Erosion is occurring on 60% of the land area. There are very low fertiliser inputs – about 30-40 NPK kg/ha in 1995 compared to an average of 160 kg/ha before 1989 (Dumitru, 1996). There is also a serious lack of agricultural credit at farmer level. Organic fertiliser (manure) is scarce and available only to serve about 1 million ha of the 7 million ha of arable land. Calcareous modification would be required on 4 million ha. The current low yields mean that application of more than 50 kg of fertiliser per hectare is uneconomical. The agricultural impact on the environment has changed since the transition. Reduced inputs lowered eutrophication and decreased pesticide pollution of both surface and ground water. However, bad farming practices increased wind and water erosion rates, land-slides, and overgrazing and led to decreased soil fertility. Agro-environmental and nature protection have low political priority (European Commission, 1998).

In the national agricultural development scenarios (VITUKI 1997) a higher discharge into surface-water of nutrients is expected from the fertiliser industry. In the National Environmental Action Plan 1994-95 attention is given to reducing pollution from large animal-rearing facilities and to reducing soil fertility losses from erosion. Because of the lack of fertiliser, the agricultural sector may use waste water and sewage sludge because of its high content of nutrients. Waste-waters are suitable for irrigation but have a high polluting potential for the environment (Dumitru 1996). Careful application of minimum rates to provide the necessary nitrogen is advised. Excessive sludge application generate risks of nitrogen leaching into groundwater, Cu and Zn accumulation in soils and deterioration of food quality. Many water treatment plants for farm waste do not operate properly, so waste water continues to pollute the environment.

4. From problem to opportunity: careful farm management is the key issue

CEE’s 'forced' experience with low input agriculture was not the result of a designed policy for agricultural development but the consequence of a socio-political evolution from state economy to market economy. Nevertheless, this current reality can be a good starting point for designing more sustainable agriculture based on low input approaches with high input efficiency. The cases presented show that the level of production dropped much less than the level of external inputs of fertilisers and pesticides. However, this 'conventional-agriculture-without-inputs' is not an optimal form of low input agriculture and does not achieve the production levels which are possible with ‘improved low input’ or ‘ecological’ or ‘organic’ agriculture. It can be assumed that the production levels before 1989, especially of cereals, can also be achieved with well-managed ecological agriculture (Franke, 1999; Znaor, 1997; Elzakker, 1995). In the current period of scarce financial resources, these are important figures for deciding on the allocation of (governmental) investments.

Many experts from the region claim the bulk of CEE agricultural production is ‘ecological’, since little or no pesticide and fertiliser is being used. Although low-input farming inevitably results in declining agricultural output, from the environmental point of view this change might be desirable. But it cannot be taken for granted that this is the case. The reduction of agri-chemical inputs (or refraining from using them altogether) can, unless complemented by better management, degrade the environment. Low-input farming, as practised by a vast majority of farmers in CEE is not necessarily environmentally friendly (Znaor, 1999; Znaor, 1997) since it:

- does not pay sufficient attention to anti-erosion measures and promotes continuous soil erosion;
- can cause overgrazing, or more often undergrazing (which is frequently detrimental to biodiversity);
- does not pay sufficient attention to the replacement of soil organic matter, leading to bad soil structure and a decrease in overall soil fertility and soil water retntion capacity (more irrigation needed);
- leaves soil bare after a harvest, resulting in soil erosion and nutrient leaching;
- often has inappropriate manure management (storage and application), resulting in runoff, leaching and volatilisation;
- often practices narrow crop rotation or monoculture (e.g. maize, grain cereals, potatoes) that not only reduces soil fertility and allows the build up of pests and diseases, but also has a negative effect on biodiversity.

In short, agriculture in the CEE, although at a record low or even approaching zero input, is not sustainable either from an economic or environmental point of view unless it is accompanied by better management practices.

5. Macro-economic model study on three countries

Within the framework of the above-mentioned Phare project, a study measuring the macro-economic impact of sustainable agriculture in Bulgaria, Romania and Hungary was realised (Wit *et al.* 1999). Two development scenarios were designed for each of the countries:

- *conventional scenario:* arable land under low external input regime (ROM 80%, BG 60%, H 29.5%), or high external input regime (ROM 20%, BG 40%, H 70%) and no organic agriculture (H 0.5%) or low-input sustainable agriculture.

- *sustainable scenario*: close to low external input regime (ROM 77.5%, BG 60%, H 20%), and high external input regime (ROM 2.5%, BG 10%, H 50%), co-existence of some organic agriculture (ROM 10%, BG 10%, H 20%) and improved low – but sustainable – external input regime (ROM 10%, BG 20%, H 10%).

The calculation showed that large-scale conversion to the sustainable scenario in these countries would result in gross national agricultural production values comparable to those obtained by the conventional scenario (Figure 3). When the external (environmental) costs of N-leaching are internalised into the price of the produce (Figure 3), by charging a shadow price of 1 per kg of nitrogen leached, the sustainable scenario showed even greater economic benefit. It resulted in net national agricultural production values of 5% (Romania),16% (Bulgaria), 40% (Hungary) higher than by the conventional scenario. At the same time, the sustainable scenario has substantially lower nitrogen leaching in comparison with the conventional scenario: 55% less in Romania, 66% in Bulgaria and 82% in Hungary. This nutrient emission reduction complies quite well with the targets set for nutrient reduction for the Danube River and the Black Sea (VITUKI, 1997; Haskoning, 1994).

However, the calculated scenarios have a rough and indicative value. Before basing policy on these data, a more in-depth analysis will be required for each country. Besides, it should also be noted that leaching represents only some 40% (on average) of the total loss of agricultural nitrogen to the freshwater ecosystems of the three countries concerned. Due to the lack of reliable data, nitrogen losses via erosion and run-off and direct discharge have not been taken into account in this calculation. As average erosion losses under ecological agriculture are substantially below erosion figures for conventional agriculture, this conservative estimate suggests that with improved farm management, further positive impacts on water quality are possible in practice. This would also result in a higher difference in net agricultural production values between sustainable and conventional scenarios.

6. Conclusions and recommendations

The current agricultural practices in Bulgaria, Hungary and Romania, although at a record low in terms of input levels, are unsustainable from both economic and environmental points of view, unless they are accompanied by better management practices. The present evidence and agronomic understanding suggest that both improved low external input agriculture and organic farming deserve serious places alongside conventional agriculture. A share of as little as 30% of these farming styles in the total agricultural production already exhibits benefits for the national economy and reduces the level of environmental degradation.

To enable development of sustainable agriculture in these countries, a three-track policy is suggested, namely to improve environmental and economic performance of the current low external input agriculture; to promote further development of pioneering organic agriculture; and to covert high external input farms to integrated agriculture. A mix of these three farming regimes represents a stepping stone for further development of sustainable farming systems in the Danube River Basin. Each of the regimes has its strong and weak points, which should be taken into account when setting the policy lines and targets. Table 1 summarises the performance of ecological agriculture, low input sustainable agriculture and integrated agriculture following five criteria (yield, environmental pollution prevention, biodiversity, employment and national income). It has been based on the results of several studies (Kieft, 1999), as well as the on-farm research evidence generated by the above-mentioned project.

Table 1. Performance comparison of ecological, low-input sustainable and integrated agriculture (after Kieft, 1999).

Agricultural system/aspect	**Ecological agriculture**	**Low-input sustainable ag. (= improved low input ag.)**	**Integrated agriculture**
Yield	+ + + +	+ + + +	+ + + + +
Environment	+ + + +	+ + +	+ +
Biodiversity	+ + + +	+ + +	+ +
Rural employment	+ + + + +	+ + + + +	+ + + +
National agric income	+ + + +	+ + + +	+ + + +

There is an important precondition for a lower input and/or ecological agriculture policy, however*: innovative extension* is required to enable good management practices which do not rely on high input levels, but *on efficient use of available farm resources and inputs*. It would also require formal support for documentation and research to adapt and develop those practices, in partnership with producers, in relation to the characteristics of specific locations.

The conclusion is that investments in agriculture should not be put into subsidising inputs but on developing and spreading knowledge of, and experience with, more sustainable and efficient farming techniques. It is on people – and therefore on institutions – that a strategy for sustainable agriculture should put its major emphasis and its scarce investments. Establishment of an international facility to support national teams in preparing and implementing this policy would enable a concerted and efficient action not only for these three, but also for other Danube countries.

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Figure 1. Relative yields and N fertiliser consumption in 1985-1995: averages of 9 major crops in Hungary. Reference year 1985.

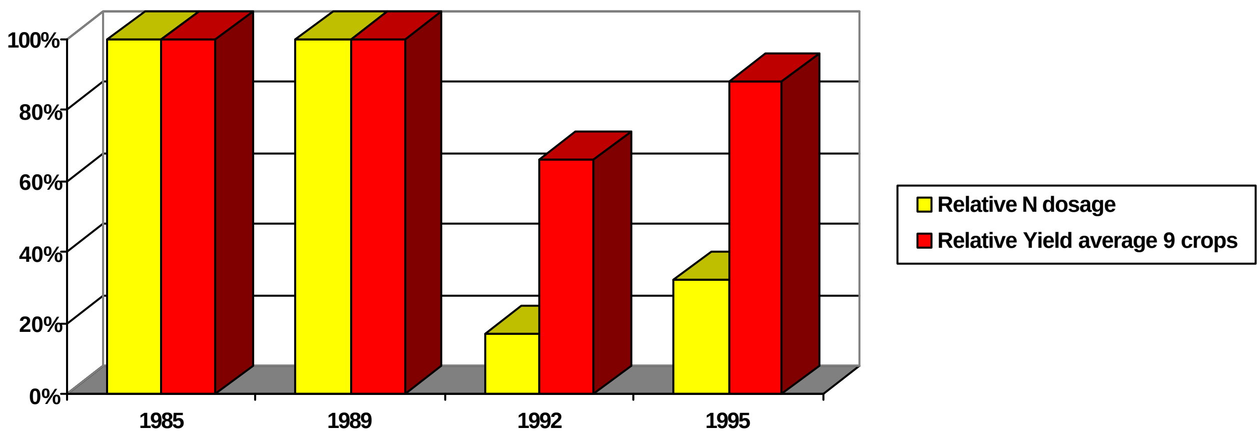


Figure 2. Trends in Cereal Production, Nitrogen fertiliser application, NO_3 concentration in River Tisza, Hungary, between 1973 and 1993 (modified after Olah and Olah, 1996).

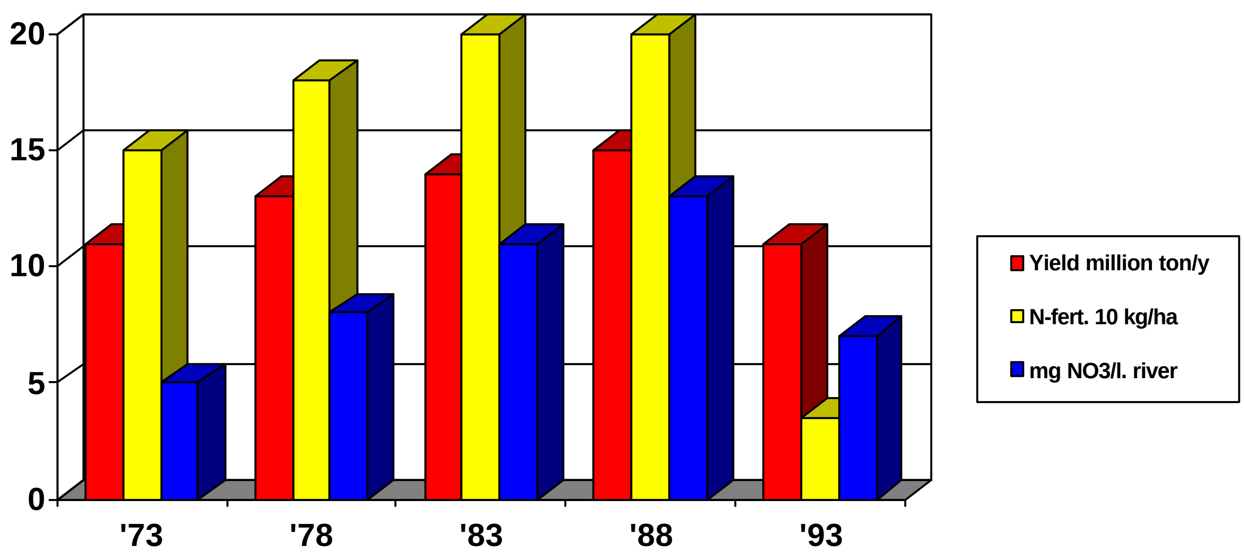
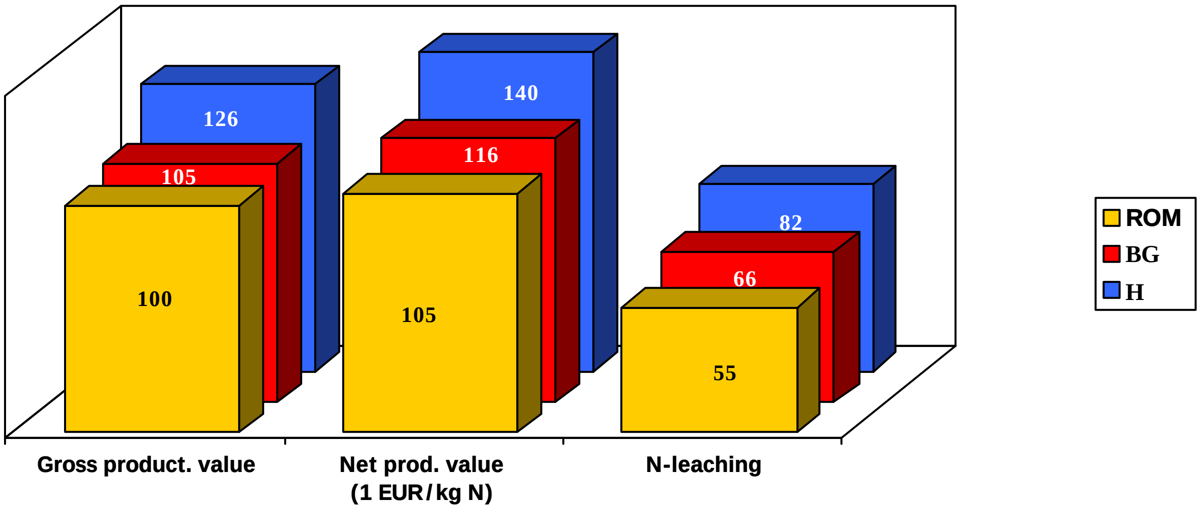


Figure 3. Sustainable scenario: relative figures for gross agricultural production value, net production value (corrected for 'shadow' price of 1/kg N leached) and nitrogen leaching as compared to conventional scenario (= 100) (modified after Wit, *et al.* 1999).



Session 2:
Measures for Integrating Water and Agriculture

Policy instruments to promote the integration of water and agriculture in the European Union

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The integration of the environment into sector policies is a key objective and priority of current European policies. In this context, specific attention is given to agriculture, as the impact of this sector on the environment is a major issue in many regions of Europe. In the case of water, existing levels of diffuse pollution and the over-abstraction of surface and groundwater resources by the agricultural sector stress the need to pursue both further integration efforts and specific environmental legislation concerning the interaction between water and agriculture.

Different instruments can be used for enhancing the environmental performance of agriculture, ranging from initiatives to introduce improved techniques and practices to economic instruments such as charging or incentive payments, regulatory approaches that limit pollution levels or improvement in the effectiveness of existing institutions. Many of these instruments have already been developed and promoted at different scales, i.e. local, regional, river basin, national and European Union. Further efforts are needed to improve and expand the effective use and implementation of these instruments, and also their effectiveness/efficacy in solving environmental problems in the field of water and agriculture.

Addressing the question of further integrating environmental requirements into the CAP and developing the effectiveness of policies concerning the relationship between agriculture and water would include the following question: where are we with the use and implementation of instruments incorporated in existing legislation? How to improve the effectiveness of instruments already in use? Which new instruments would further promote the integration of water and agriculture? For example, the integration of agriculture into the river basin management plans as promoted by the Water Framework Directive, along with the development of stakeholders' "discussion/negotiation platforms" including agriculture, could form key elements for a better integration between water and agriculture. Integrating environmental requirements into agricultural policies (whether at the National or EU levels) form an essential part of the overall approach in order to ensure that agricultural policies send the right signals to farmers with a view to encourage a more efficient use of water resources

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Groundwater Nitrate Reduction in the Styria Region (Austria)

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Summary

As a result of changes in agricultural land use during the 1980s, parts of the Austrian Province of Styria experienced significant water quality problems. Using the example of work carried out in the Leibnitzer Feld area, this paper reviews: (a) legal principles, based on the Water Act of Austria; (b) scientific methods to reduce nitrate in groundwater; (c) the situation of groundwater quality during the early 1980s; (d) the trends in groundwater quality since the early 1980s; and (e) the current situation resulting from the measures implemented to ensure protection of groundwater quality whilst maintaining the economic importance of agriculture.

1. Introduction

The study area depicted in Figure 1 is of special concern from the point of view of water quality because of:

- its role in providing water supply for more than 80,000 people – there are 4 communities or companies with 15 wells;
- its importance for agriculture – about 75 % of the region is used for agriculture with associated problems of manure, fertilisers and pesticides;
- its industrial development – problems derive from the use and handling of substances that pose a risk to water quality, as well as from the runoff of polluted surface water from roads etc;
- its important transport connections to south-eastern Europe – herbicides and salt etc. are used for treating roads and railway lines.

2. Legal framework for groundwater nitrate reduction

For a better understanding of all the measures taken, it is necessary to explain the quality principles of the Water Act of Austria, which are laid down in the paragraphs 30 to 32, 33f, 34, 48.

The most important points are that:

- ground water is kept clean in such way that it is possible to use it as drinking water (§ 30);
- adverse impacts (pollution) on groundwater must be avoided and in the event of a pollution incident all possible remedial measures must be taken (§ 31);
- each activity influencing groundwater requires a legal permit which is dependent on the rights of other water users not being reduced (§ 32).

For groundwater restoration § 33f is important. This paragraph was introduced into the Water Act of Austria in the amendment of 1990 and determines swell values for defined substances, which are related to the limits fixed for drinking water. The swell value is commonly 60 % of the drinking water limit. Should the swell value in a defined region be exceeded on more than 25% of all measurement dates, this region is defined as a 'groundwater restoration' area with corresponding restrictions on land use, e.g:

- defined rotation of crops;
- exclusion or reduction of defined crops;
- reduction of fertilisers;
- definition of periodic measures against nitrate deposition, such as maintaining vegetation cover after agricultural use (especially during the winter time).

§ 34 and § 48 of the Water Act define the protection areas and associated regulkations for drinking water plants. These are differentiated into '*Schutzgebiet*' (an 'inner protection zone' including the immediate surroundings of the plant) and '*Schongebiet*' (an 'outer prtotection zone' including wider areas or even the whole catchment of a drinking water plant). The 'inner zone of protection' is the most strictly protected zone and all land use is prohibited.

In the 'outer zone of protection' certain land use types are prohibited, whilst other require a permit. The application of organic fertilisers is strictly regulated, whilst crops (of particular types) must be grown year round to maintain vegetation cover. Maize and root crops, which need high rates of fertilisers during the growing season are prohibited, as are nitrogen-fixing leguminous crops.

3. Scientific investigations

Scientific investigations have been carried out in the following thematic fields:

- Water quality variation in time and space, (and consideration of influence of land use);
- Soil types and quality (important for calculating storage and leaching of nitrogen).

The investigation of land use methods and substance movement in the saturated and unsaturated zones were checked by lysimeter tests.

In the Leibnitzer Feld, between the late 1970s and late 1980s, there were significant increases of nitrogen and nitrate in groundwater. Consequently a programme was initiated to investigate all hydraulic parameters with a mathematical model. Important parameters were flow velocity, permeability and slope of groundwater table. Information about the annual recharge, evaporation, substance transport in space and time, and groundwater balance was also gathered.

The checking of all data was carried out at the lysimeter plant of Wagna, which is the most important plant to investigate the movement of substances within the unsaturated zone. The study examined the effects of different crop rotations and different rates of fertiliser application.

4. Development of groundwater nitrate concentration

Figure 2 shows the development of nitrate concentrations in relation to land use changes and the introduction of regulations under the Water Act of Austria at the drinking water plant of St. Georgen in the north-eastern part of the Leibnitzer Feld area, which was for a long time the most problematic.

Up to the mid-1980s, there was conventional land use with crop rotation, grassland and so on. This was followed by a switch to intensive pig breeding with a reduction in cattle and a move from crop rotation to maize monoculture. The problem of manure disposal increased significantly. There was insufficient storage space for manure and farmers were compelled to dispose of the manure at inappropriate times, for instance during winter months or on bare or saturated soil.

In 1988 the first water protection areas, with corresponding land use regulations, were designated. Because the success of nitrate reduction was not very high, new protection areas and new regulations were decided in 1990, since when there has been a continuous decrease of groundwater nitrate concentrations. This success is clear from Figure 3 which shows the concentrations of nitrate in groundwater at 17 wells within the Leibnitzer Feld. It is noticeable that nearly all wells had reached the target limit by 1996.

5. Conclusion

- A significant reduction of nitrate in groundwater was achieved;
- This reduction resulted from changing land use, the establishment and enforcement of regulations within the water protection areas, and intensive awareness-raising work for all potential 'polluters';
- All methods of new land use are scientifically tested and checked;
- Because of the respect of economic aims of agriculture there is a high acceptance of regulations within the population of the Leibnitzer Feld area which brings a high level of ground water protection and restoration of ground water quality;
- The study shows the importance and value of the partnership approach taken by the authorities, scientific researchers and farmers.

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Figure 1. Location of the study area

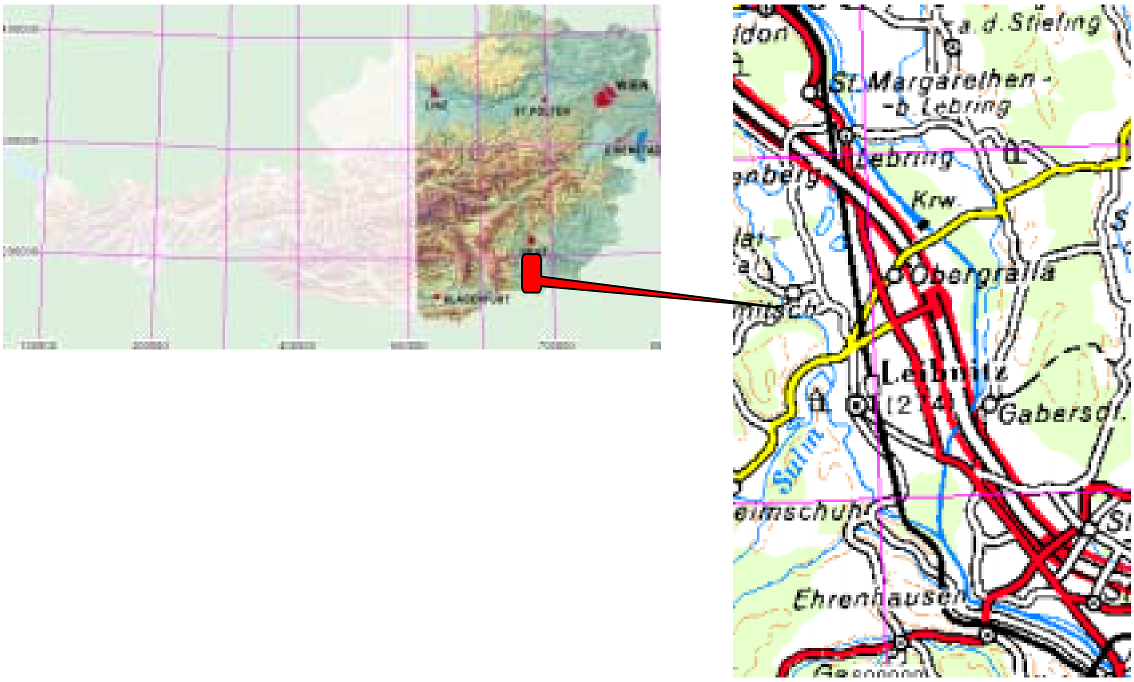


Figure 2. Development of nitrate concentration 1976-1998 due to the land-use changes and regulations

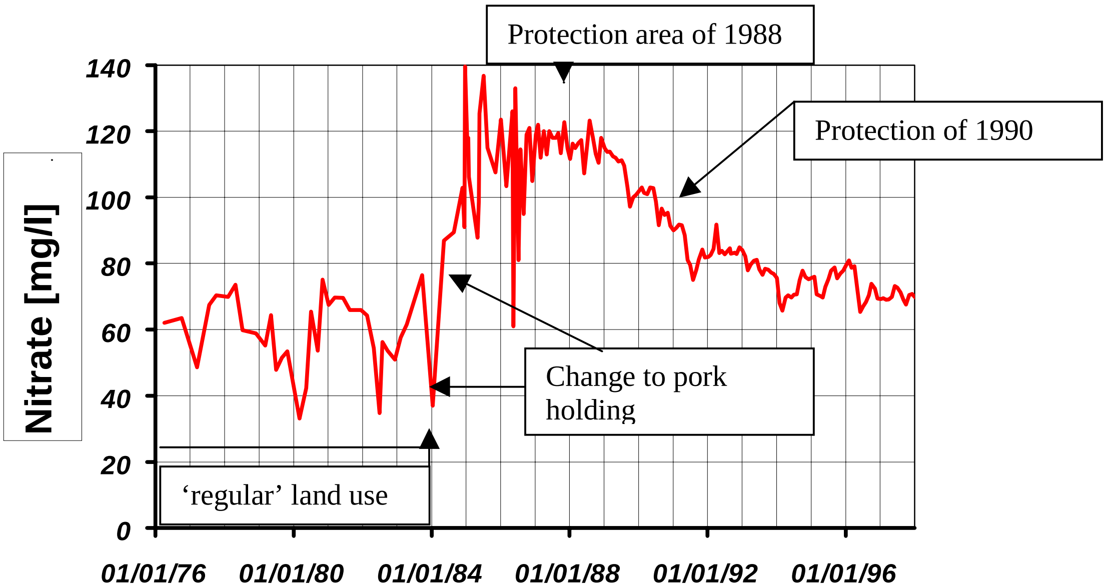
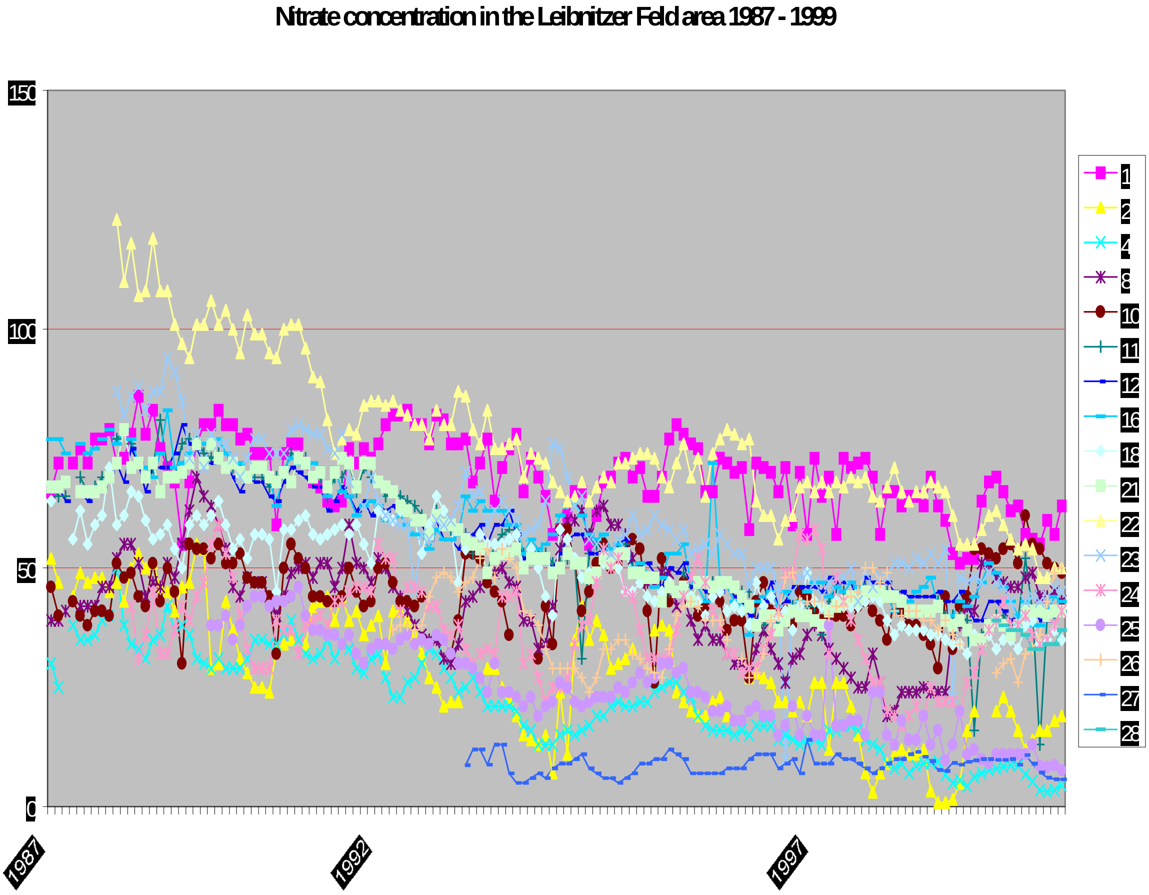


Figure 3. Development of groundwater nitrate concentration 1987-1999



The part played by forests in water management in mountainous water catchment areas: The experience acquired in the Autonomous Province of Trento, northern Italy

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Summary

The characteristic feature of the autonomous province of Trento, a typical alpine region in the north-east of Italy, is that more than 55% of it is covered by forests. Specialist agriculture and built-up areas, which occupy 14% of the province's land area, are concentrated almost entirely in the valley bottoms and on the lower mountain slopes. Forests therefore play an essential part in regional management and conservation, more particularly by regulating water courses and combating erosion. Analysing this role in the context of a catchment that has undergone profound land use changes (decline in agriculture, expansion of tourism and urban development) shows that prudent forest management, based on near-natural sylvicultural practices, has positive outcomes in terms of water course management and land conservation.

1. Introduction to Trento province

The Autonomous Province of Trento (Trentino) is a small region in north-eastern Italy covering roughly 621,000 hectares, or slightly more than one-fifth of Belgium's surface area. Since it is completely encircled by the Alps, it is typically alpine in character, while its altitude varies from a few metres above sea level to the high peaks of the Alps themselves.

Almost 70% of the Province is above 1,000 m altitude (Figure 1). This factor, linked with the slope of the valley sides has a decisive effect on land use: the limited amount of space available for intensive primary and secondary sector activities is concentrated in the valley bottoms or at medium altitude. Land stability and constant maintenance of water courses is thus required in order to defend and secure the quality of life in the most densely populated areas.

The Province of Trento has abundant water. During the first half of the twentieth century this resource was extensively used to generate hydroelectricity. This has had a considerable impact on the main water courses. More than 55% of the province is under forest cover, which in the mountains is unbroken; its forest-cover index of 75 ha/100 inhabitants, or in other words 0.75 ha/inhabitant is the highest in Italy. If one disregards the non-productive land at high altitute, the glaciers and the land under water, productive activities are concentrated within a restricted area. In addition, if one bears in mind that almost 7% of the region is covered by pasture and alpine meadows, only 11% and 3% of the land is left for agriculture and human settlements, respectively.

Since 1972, the autonomous status of the Province has conferred it with primary legislative powers concerning the environment and forestry. These powers have been widely used for environmental protection and restoration.

2. Sectors of the provincial economy with significant impacts on water

2.1 Agriculture

Agriculture (excluding pastoralism) is concentrated in highly specialised restricted areas where it may have significant impacts through demand for irrigation water and runoff of plant protection products.

In the past, stock-rearing was a major economic factor. For some years now the mountain pastures have been abandoned and the land has been subject to gradual, natural reforestation. Although this has had hydrological benefits, biodiversity is being lost.

2.2 Tourism

For a number of years, tourism has been a predominant force in both economic and environmental terms. This has given rise to an increase in water consumption and amounts of effluent. Rising consumption has been due not only to increased use in hotels etc. but also results from artificial snow generators used on more than 50% of the 470 km of ski slopes. At the same time, the expansion of ski runs and lifts has had an adverse impact on forested and other semi-natural areas.

2.3 Hydroelectric power

Larger and smaller installations can be found along all of the major water courses. Their main impacts are in terms of the flow of water released and retention of sediment.

2.4 Urban infrastructure

These have expanded considerably, often taking no account of the fragile natural balance of the region or of the risks to which new developments are exposed. Urban expansion has adversely affected the land formerly given over to agriculture, as well as those areas (wetlands, flood plains etc.) which used to form a buffer against natural disasters. Since most economic development is concentrated on valley floors and the lower slopes of mountains, which are also the areas where water flow is concentrated, runoff has been accelerated, therefore increasing the frequency of flood events in river beds.

3. The role of forests in regulating soil and water

The part played by forests in regulating water courses and protecting the soil has been amply studied and demonstrated (Verry, 1986). Nevertheless their activity is closely linked to the extreme variability of the weather and of the complex forest system. The theoretical impact of forests can be broken down into two main stages:

- regulation of surface soil/water interface:

  - via the tree and shrub cover which both absorbs and releases water, retaining on average one or two mm (Zinke, 1967) depending upon the species (and more in the case of snow). The water taken up is returned to the atmosphere by evapotranspiration. This effect is significantly reduced, or even zero, where there is intense or prolonged rainfall (more than 20-30 mm);

  - through the above-ground parts of plants acting as a brake on, and so reducing the speed and impetus of, raindrops and thus their impact on the soil. This limits erosion where water from the tree tops does not fall more than 8 metres (Chapman, 1948);

- by making the snow on the ground melt more slowly, therefore returning water to the collectors more gradually;
- by the amply demonstrated (Bosh and Hewlett, 1982), effect of vegetation cover on the volume and temporal distribution of run-off.

- regulation of sub-surface soil/water interface:

  - through the litter layer, high humus content and soil/root structure increasing the infiltration capacity for rainfall and meltwater;
  - by slowing down water flows liable to promote soil erosion;
  - by increasing the retention capacity within the soil profile, as the litter and underlying humus are able to retain 5% of rainfall (Waring and Schlesinger, 1985).

The two extreme situations are the virgin or primeval forests which regulate and combat erosion best of all, but which in practical terms no longer exist in Europe, and forests that have been highly degraded as a result of continuous exploitation (felling and grazing) leaving little vegetation cover, and where sloping ground is eroded by surface water flows.

Vegetation cover performs a variety of additional tasks, which are especially obvious close to water courses. It cleanses surface and underground run-off by:

- assimilating, converting and storing nutrients (especially those from agricultural land);
- promoting the deposition and retention of sediment (together with nutrients and pollutants adsorbed by the sediment e.g. phosphorus);
- sustaining metabolic activity of soil micro-organisms, particularly nitrate-reducing bacteria.

The high quality of water in forested areas is basically a function of the extremely natural type of environment in comparison with other forms of land use. At topsoil level, the clean-up is achieved by intercepting pollutants. At sub-surface level there is a filtering process which makes use of the chemical, biological and physical processes described above.

3.1 Study of the Madonna di Campiglio water catchment area

A study was carried out in Trento Province in order to obtain quantitative data on the hydrological effects of changes in land use. It covered the Sarca di Campiglio basin, a well-known holiday resort (especially for winter sports) which experienced rapid development of urban and ski infrastructure especially between the 1950s and 1970s. The study concentrated on the phenomenon considered to be the most significant for that catchment area, namely flood peaks. A digital terrain model was developed on the basis of 25m x 25m units.

Land use documents for the period 1954 and 1989 show that development affected mainly former farmland areas at low altitude (below 1,800 m), spreading progressively to less and less suitable areas (in terms of environmental damage and risk).

During the same period, forested areas expanded very little. Nevertheless they have evolved well in qualitative terms owing to the near-natural sylvicultural practices employed. These have helped to increase the density and volume of forest cover.

The probable rainfall data (with different return times) were used for the hydrological analyses, together with a model applying the American Soil Conservation Services equation in order to calculate actual rainfall (% of rainfall contributing to flood peaks).

This revealed a significant increase in the volume of direct run-off and of flood peaks caused by the change in land use between 1954 and 1989. In the case of a catchment area with normal hydrological conditions, the increase in runoff and flood peaks is approximately 30% for rainfall events with a ten-year return period.

When the hundred-year flood event was analysed and the runoff of different parts of the catchment broken down according to land use, it was found that under critical hydrological conditions runoff is roughly 0.5 m^3/sec for forested areas and 6-8 m^3/sec for built-up areas. The latter are those which generate faster run-off, more particularly since most of them are in valley bottoms close to the hydrographic network.

3.2 Qualitative and quantitative changes to the Trentino forests

Around the mid-1950s the adoption of 'near to nature' forestry practices essentially included comprehensive sylvicultural activities that were intended to re-establish, maintain and highlight the natural characteristics of the forest plantations by fostering and supporting the natural changes taking place in the forest.

This choice, which challenged the concept of simplistic agronomy exclusively directed towards wood production, is based on maintaining diversity through moderate felling that is carefully distributed throughout the area and repeated over time. It has everywhere been accompanied by efficient cultivation in order to promote natural regeneration, to boost structural complexity and to promote species diversity; in other words, to introduce features of complexity as a guarantee of stability and continuity.

Action (generally via direct management) is taken on the basis of these principles, which have been codified in the form of prescriptive tools, in order to provide a positive response to the changes caused by centuries-old human settlement; alterations which are often still visible (e.g. impoverishment of flora, limitation of the biomass, simplification of structures).

This form of forestry has now been applied for more than 40 years. It has been vindicated by the initial results which have been more than positive, as witnessed by the biological indicators when compared with the situation in the mid 1950s. These include an increase in the surface area covered by woodland, essentially by acquiring marginal land that has been reforested naturally; significant expansion of tall-growth forest (+40% in terms of surface area, particularly following targeted action on coppice conversion, +90% in overall biomass, +34% per ha).

In the Trentino, sylviculture is a balanced activity that embraces farming and forest restoration. This diversity now has a positive spin-off in terms of environmental protection, defence against natural disasters and water control.

3.3 Intensive action along torrent beds

Alongside the extensive improvements to sylviculture, the Province of Trento, more particularly after the disastrous flooding in 1996, also carried out resolute action to upgrade the mountain water courses on the basis of a 30-year plan which defined the water protection needs of the catchment areas and beds of water courses.

This upgrading of water courses was also due to the need to protect inhabited areas, points of production and infrastructures which, in the view of the regional planning policy implemented, were often in risk areas. Water course upgrading affected roughly 22% of the hydrographic network in the mountains, extending to the smallest branches and was supplemented by action to stabilise and revitalise riparian areas vulnerable to landslips.

Experiments using an Austrian methodology (G. Kronfellner-Kraus, 1984) on hydrographic basins of various sizes pinpointed the direct relationship between the extent of basin upgrading (i.e. the level of completion and the effectiveness of the work done), the extent of forest cover, and the reduction in sediment transport. This reduction varied between 10% and 85% in comparison with basins that have not been upgraded.

The combined effect of water course management, re-establishment of vegetation in adversely affected areas, improvement of forest cover and restoration of natural land has thus been verified, particularly in terms of reducing erosion and sediment transport by water courses. However, the amount of run-off is a function of a wide range of weather and environmental factors which do not enable the above-mentioned effect to be established precisely.

4. Conclusions

The Trentino's rich natural wooded heritage which, almost throughout the area, is managed via the forestry policy described above and which provides for localised action in the most critical areas, has undeniably positive effects on water, sediment and nutrient flows which greatly help to prevent erosion and deterioration. Such action is even more appreciable given the basic fragility of the land in the Trentino and the Alps in general, where the climate, morphology and geology are significant factors in the stability of the hydrographic basins. It is against this background of instability that factors having contrasting effects are combined: first, the policy favouring natural-resource conservation pursued during recent decades; and secondly, mitigation of the adverse impacts that can be attributed to economic development in the area. Maintaining and increasing forest efficiency in terms of water protection and regulation must therefore constitute one of the primary aims of environment policy.

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Fig. 1 The Trentino in Europe
Le Trentino en Europe

Fig. 2 - Land use in the Trentino - Utilisation du sol dans le Trentino

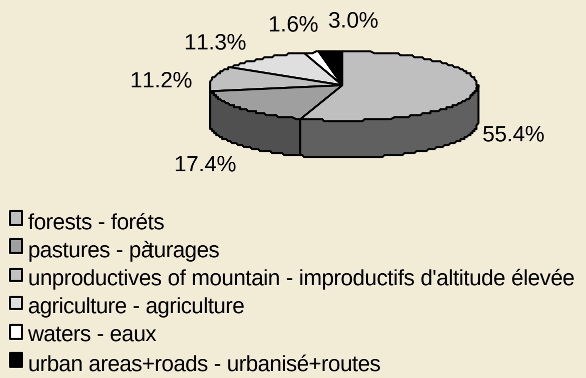


Fig. 3 - Growing stock changes in the high forests
Développement du volume sur pied dans les futaies

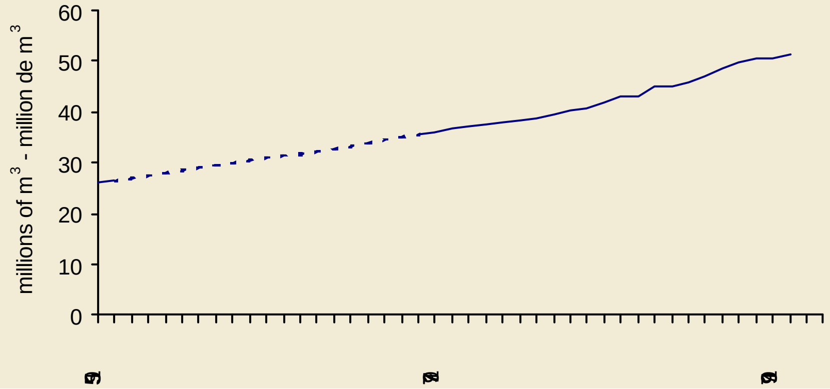


Fig. 4 - Current annual increment and annual yield development
Développement de l'accroissement courant et des possibilités volume

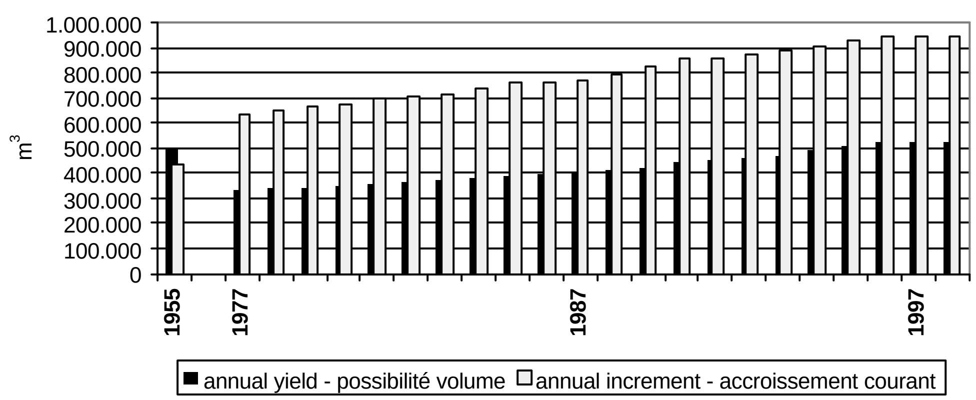


Fig. 5 - Percentage cover variation in the high forests
Variation de la densité de couvert en pour-cent dans les futaies

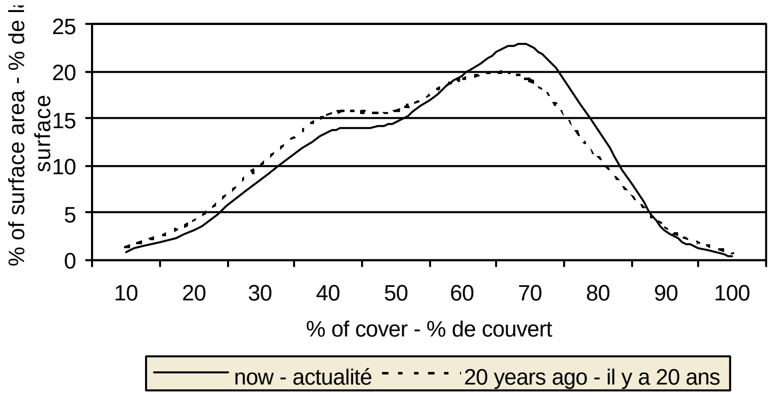
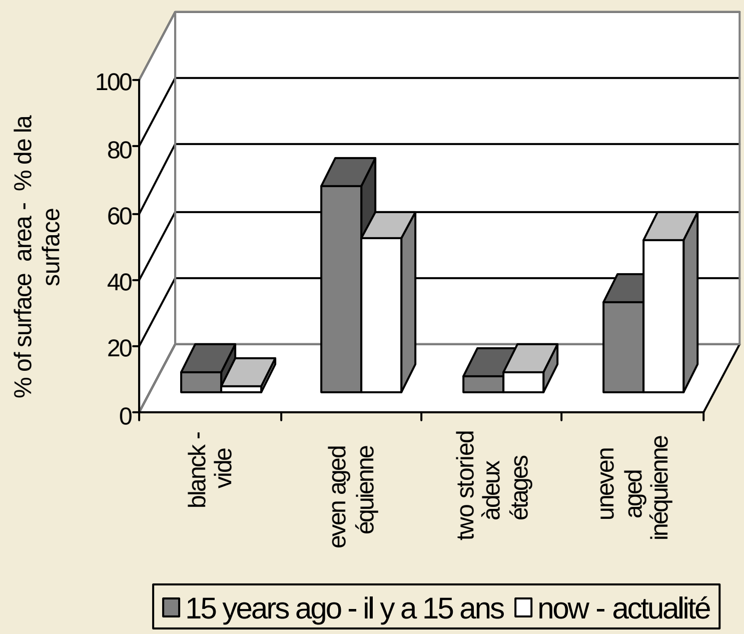


Fig. 6 - Changes in structure types in the high forests
Changement des types de structure dans les futaies



The Vindel River – Delta management at Ammarnäs

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Summary

The annual natural flooding of the free-flowing Vindel River in northern Sweden creates a spectacular and species-rich riparian landscape, maintained and enhanced by livestock grazing and hay cutting for winter feed. During recent decades, this valuable landscape has become threatened because of abandonment of cattle farms. In 1997, WWF started a project to reverse the negative trends. The results were appreciated not only by the farmers involved but also by neighbouring farmers, conservationists and the authorities. An enlarged project covering the entire river is presently being developed in order to maintain all valuable alluvial meadows along the river. The project is unique because it includes production of quality beef alongside a protected national river, resulting in enhancement of natural and touristic values, and offering livelihood opportunities (agriculture, tourism, food production) in an area which is characterised by emigration and unemployment.

1. Introduction

Seminatural grasslands, unfertilised meadows and pastures used by man and his companions – horses, cattle and sheep – for hay production and grazing, occupy a special place in the minds of most Swedes because of historic, natural, cultural and recreational values. Over the centuries, plants and animals have become adapted to the disturbance caused by scythes and grazing muzzles, and have formed one of the most species-rich habitats in northern Europe. Here, cultural and natural values are intimately connected and interdependent.

Nowadays, seminatural grasslands are rapidly decreasing as the number of livestock farms declines. As a consequence, the existence of unfertilised meadows and pastures and their biological and cultural values are seriously threatened.

1.1 History

About 4,000 years ago the first people started to cultivate the soil along the coast in northern Sweden and about 1,000 years later the first cattle farmers settled in the coastal zone, also growing barley, wheat, and oats. Much later, people started to colonise land along the large rivers.

It took until the 1500s for Swedish agrarian colonisers to reach the present village of Vindeln and not until the 1800s did they reach the small municipality of Ammarnäs, 400 km upstream from the coast. Many river valleys of northern Sweden became the natural routes for colonisers who entered the dark, forested western taiga. Floodplains along the northern rivers and delta land were particularly important because these areas were easy to cultivate when compared with adjacent unproductive forested areas. Grazing and cutting increased biological values by allowing for higher species diversity.

Sami people have lived as hunters along the Scandinavian mountain ridge for a very long time but they started to domesticate reindeer (*Rangifer tarandus*) only some five hundred years ago. During the last century some Sami people also begun to work as cattle farmers maintaining alluvial meadows along northern Swedish rivers.

2. The River

The Vindel River (*Vindelälven*) is one of four large free-flowing rivers left in Sweden. It has a length of 452 km and drains an area of 11,898 km^2. The river has its springs in the mountains of the borderland between Sweden and Norway. It follows the valleys shaped by the last glaciation on its way down to the coast. 30 km from the coast, the Vindel River joins the Ume River (*Umeälven*), the drainage basin's main river, now regulated by hydropower development.

At Ammarnäs, the river connects with one of its tributaries the Tjul River (*Tjulån*) in Lake Gautsträsk. The slowing down of water velocity when entering the lake results in deposition of sand and a spectacular delta landscape has evolved around the two rivers at the foot of the Scandinavian Mountain ridge. Today, Ammarnäs acts as the gateway to the alpine world with an interesting mix of reindeer husbandry, traditional agriculture, forestry and tourism. The delta area has been used for grazing and hay production for several generations.

At the municipality of Sorsele, the river forms the large Lake Storvindeln with natural water level fluctuations of 5 metres. Along the river, several alluvial meadows create a characteristic riverine agricultural landscape making the area unique in Sweden and in Europe. Today only some 50 farmers are active along the river, most of them close to the coast.

The Vindel River has been designated one of four Swedish national rivers by the Swedish Government and is presently suggested as an EU 'Natura 2000' area. Several nature reserves along the river as well as some spectacular rapids are already included in the Natura 2000 system, including one of the largest nature reserves in Europe, Vindelfjällens, covering 550,000 ha. Unfortunately, the delta in Ammarnäs is not yet included and WWF has therefore suggested it in its 'shadow list' of obvious future Natura 2000 sites.

2.1 Riparian hydrology and ecology

The Vindel River has an average water discharge of 174 m^3/sec but it varies from 16 m^3/sec during extreme low flows to as much as 1,651 m^3/sec during extreme high water following late spring snow melt; a ten-fold difference. The yearly natural flooding with increase in water level of between 2 to 5 times is unique among Swedish rivers. The flooding creates an optimal situation for a complex plant life. A characteristic zonation of vegetation is formed with as much as ten different vegetation zones from crustaceous lichens on rocks to lush riparian forests. The flora is considerably richer in the riparian zone compared to adjacent areas. The richest area has 138 plant species per 200 m transect compared to only 10-15 in adjacent transects above the highest water level. The annual flooding deposits both litter (mineral particles attached with fertilising organic material) and diaspores (seed and spores) explaining the high biodiversity along the rivers. Experiments have clearly demonstrated the dispersal ability of the floodwater, when seeds have been found to be carried far downstream and far away from the main stream. Typical alpine plant species are also found along the river. For example, alpine milk-vetch (*Astragalus alpinus*) mountain angelica (*Angelica archangelica*) and king carolus lousewort (*Pedicularis sceptrum-carolinum)*, are all commonly found along most of the river but can hardly be found outside the riparian zone. Typical tree species are alder (*Alnus*), birch (*Betula*), and pine (*Pinus*), The shrub layer is dominated by different willow species (e.g., *Salix myrsinifolia*, *S. phylicifolia*, *S. hastata*). One species of dandelion is endemic to the area (*Taraxacum crocodes*). Blueberries (*Vaccinium myrtillus*) mark the upper border of the riparian zone, because they can not survive being submerged by water.

The river harbours several fish species like the grayling (Thymallus thymallus), brown trout (Salmo trutta), and four species of whitefish (*Coregonus* spp.), pike (*Esox lucius*), perch (*Perca fluviatilis*) and burbot (*Lota lota*). Grayling is the most important species for angling tourists, while whitefish is important for local consumption. It is caught with gillnets during the autumn and eaten during the winter. The brown trout migrates between Lake Storvindeln and the rapids just downstream of

Ammarnäs to spawn and specimens of 10 kg are not uncommon. Lake Storvindeln also has an endemic whitefish species, (*Coreganus peled)* – although the *Coreganus* taxonomy is disputed. The arctic char (*Salvelinus alpinus*) is common in Lake Gautsträsk and is caught by jigging through the ice during winter and spring.

Salmon (*Salmo salar*) was formerly a very important commercial species. Today however, salmon and sea trout has only limited access through the large hydropower plant at Stornorrfors, in the Ume River, resulting in only a few fish reaching their spawning grounds in the Vindel River.

Among insect species, the abundance of black flies (Simuliidae), horse flies (Tabanidae) and mosquitoes (Culicidae) is noticeable and together with stone flies (Plecoptera), caddis flies (Trichoptera), and mayflies (Ephemeroptera) their larval stages make up a considerable part of the limnic biomass.

The forest and mountains along the river harbour several interesting mammals like brown bear, European lynx (*Lynx lynx*), wolverine (*Gulo gulo*), and Arctic fox (*Alopex lagopus*). The Norwegian lemming (*Lemmus lemmus*)), endemic to the Nordic Sub-Arctic, occurs with occasional high population peaks near the sources of the river.

Alluvial meadows (*raningar*, in Swedish) characterise the Vindel River and together with the delta in Ammarnäs they form the most species-rich areas. The lower parts of these meadows are flooded yearly shaping a productive habitat that makes annual hay cutting and cattle grazing possible. The delta harbours more than 100 vascular plant species, with *Carex aquatilis, Calamagrostis purpurea, C. canescens*, and *Deschampsia caespitosa* as dominating grass species in a succession from wet to dry areas. The alluvial meadows are important grazing grounds for ungulates like European elk (*Alces alces*), roe deer (*Capriolus capriolus*) and semi-domestic. Birds like whooper swan (*Cygnus cygnus*), lesser white-fronted goose (*Anser erythropus*), short-eared owl (*Asio flammeus*), great snipe (*Gallinago media*) can been seen around the meadows and in the mountains, golden eagle (*Aquila chrysaetos*) and gyrfalcon (*Falco rusticolus*) can be found.

3. The Problem – agriculture today

Today some 50 farmers are active along the river (Figure 1). 20 of them are dairy farmers producing altogether about 2,400 tons of milk annually and 30 are meat farmers producing some 120 tons of meat annually. Most of the farmers live close to the coast. In Ammarnäs three farmers are active, two old and one young, of whom two have cattle (partly traditional breeds) and one has sheep. Additionally, some 30 horses (Icelandic breed) are used for tourist cross-country riding. Earlier experiments to use horses in reindeer husbandry have unfortunately terminated.

A high sandy hill in Ammarnäs is used by the villagers for potato growing, and is therefore called the potato hill. The south-facing hill takes advantage of the midnight sun enabling potato growing in an area where it would not otherwise be possible.

Two Sami villages (Rahn and Gran) have their reindeer grazing land along the river (on alpine meadows during summer for grass and in the forested taiga during winter for lichen). Altogether, some 25 Sami families are involved in reindeer husbandry. During autumn the reindeers are separated and selected animals are slaughtered in corrals outside Ammarnäs.

The relation between the Sami people and locals is not uncomplicated because of interpretations of indigenous traditional rights concerning grazing, as well as hunting and fishing.

The number of farmers is rapidly decreasing; 15 years ago 100 were active and 25 years ago 150. It is mainly dairy farming that is declining – in Sweden about 3 farms are closed down per day, mainly in forested areas. The abandonment of meadows and pastures in northern Sweden results in the widespread colonisation of bushes (mainly willows, *Salix* spp) and hence degradation of biological values of the riparian agricultural landscape. In terms of area, these habitats can be considered as tiny islands in a sea of forested taiga, but they are very important for their landscape and biodiversity values.

The negative environmental effect of agriculture are very limited because of nutrient-poor river water and very low amounts of fertilisers on the few cultivated fields (70 kg N/ha). Pesticides are almost not used along the river. Grain production is limited to the coastal region.

3.1 EU Agri-environmental schemes

The new national management agreement programme for preserving the most valuable semi-natural grasslands started in 1995 when Sweden became a member of the European Union. It consists of three parts:

(a) Conservation of biodiversity, cultural heritage and maintenance of the open landscape in northern Sweden and in the forest regions;
(b) Protection of environmentally sensitive areas; and
(c) Promotion of organic production.

Until now, restoration of valuable unfertilised pastures has not been supported (however, it will probably be included within the next programme phase – see section 4.2).

The following compensation schemes are used along the river: open landscape, biodiversity – semi-natural grazing land/mowed meadows, least favoured area, conservation of traditional local breeds of animals, and organic farming. Production premiums received are: special beef premium, suckler cow premium, ewe premium, sustainable conventional agriculture, and perennial ley farming.

The three farmers in Ammarnäs receive a total of 220,000 SEK annually in EU support for 60 ha of land.

4. The Project

In 1997, WWF started a rural development project in order to reverse the negative trends in Ammarnäs. The goal (Table 1) was to restore and maintain the valuable delta and surrounding alluvial meadows, increase and sustain natural values, increase the attractiveness of Ammarnäs as the gateway to the mountain ridge, and to create living conditions for people involved with agriculture in sparsely populated areas.

The basic concept is quality meat production with conservation as an added value. By purchasing 'natural grazing meat' (Table 1) the customer not only pays for good quality but also for conservation and thus helps to maintain a living riparian agricultural landscape.

4.1 Initiation of the project – phase 1

The project started with visits to the area and its local stakeholders, (farmers, landowners, the local business association, tourist people), to discuss problems and get an idea of the rather complicated land ownership system, family relations, and, not least, to find out the aspirations of people involved.

Besides the usual problems of economy (including renovation of barns demanded by new EU regulations), milk collection in remote areas and age structure of farmers, one surprising problem that was revealed was the difficulty with land lease. The young farmer had difficulties to obtain grazing land, despite the fact that land was widely available.

An action plan was developed and rapidly implemented in order to show people that WWF interest was genuine. (Ammarnäs has experienced several investigations but few have been implemented). Therefore, tractors were supplied with double tyres for wetland driving and a start made on clearing overgrown alluvial meadows only two weeks after the initial visit.

To date, 15 ha overgrown alluvial meadows have been restored, an additional 25 ha have been fenced and are regularly grazed, giving a total of 75 ha being maintained (cut for hay production or grazed). The restoration process is often done with ordinary tools like rotating knives that cut bushes and even-out hair-grass tussocks, making efficient grazing possible. Debris from clearing has been collected, 4 km of electric fences have been put out. As a complement to fencing, some radio-telemetry equipment has been purchased to be enable the tracking of free ranging cattle – traditionally the cattle were called by singing or blowing horns. So far, no cattle have been lost to bears.

Educational discussions on cattle breeding and breed choice have resulted in a change from dairy cattle to beef cattle. The breeds used in the WWF 'Natural Grazing Project' are mainly light British breeds (Aberdeen Angus, Hereford, Scottish Highland), which have proven to be particularly efficient for conservation as well as for quality beef production (marbled meat). Castrated bulls, steers, and heifers are particularly well suited for quality beef production. Traditional dairy breeds are suitable for cross breeding with the above breeds in order to produce quality beef. Dairy farmers thus have an opportunity to earn extra by producing crossbreeds for beef production – since not all heads are needed for dairy recruitment.

In order to be able to produce 'natural grazing meat' the cattle must spend at least 50% of their time on unfertilised meadows and pastures; extra feed, deworming medicine, and hormones must not be given to the cattle when grazing in unfertilised pastures (see Table 2 for definition).

Suckling cows with calves, steers and heifers are most suited to graze effectively and thus are the best conservationists.

Ten new Aberdeen Angus cattle have been introduced to the project making the total number of grazing cattle 50. At the beginning of the project only a handful was grazing on the delta. The total area of available grazing pastures is around 100 ha making the required number of grazing cattle approximately 100. Almost all available meadows are nowadays maintained for winter hay.

The number of sheep is decreasing since no new farmers are willing to farm sheep.

To summarise, a plan for the development of quality meat is currently being implemented. The project has facilitated initial investments, solved land lease problems, restored and maintained most of the valuable alluvial meadows, given advice on quality beef production and on how to apply for EU support, as well as initiated biological surveys.

4.2 The project – phase 2

The project has attracted attention of other farmers along the river, as well as of the authorities and conservationists. Therefore, an enlarged project covering the entire river is presently being developed in order to maintain all valuable alluvial meadows along the river. The idea is to use the same main concept of quality beef production but also to include regional processing and marketing.

In cooperation with partner organisations (Table 3) the project has acquired EU support through the Structural Funds (Goal 6). During the first year, a feasibility study will be undertaken for submission of a proposal under the next round of Structural Fund allocations. Implementation will be programmed for the period 2001-2006.

In October 1999, a first information meeting has been held in the municipality of Vindeln and was attended by some 50 interested people. Of these, 15 cattle farmers have shown interest in a continuation and several of them have also been visited, and an overgrown alluvial meadow has been cleared outside Sorsele this winter.

There are approximately 800 cattle along the river today, but the majority are being kept indoors year round. The project aims to let these animals graze outdoors during the whole vegetation season. The goal is to have approximately 1,000 heads grazing some 1,000 ha of pastures, which will include all of the most valuable alluvial meadows along the river. The market for quality beef is primarily in the larger cities of Umeå and Skellefteå, but also restaurants and hotels along the river; thus, the project allows for regional consumption.

The project is unique because by producing quality meat with added conservation value along a protected national river, it will enhance biological, landscape and tourist values, and offer employment opportunities within agriculture, tourism, and food processing/sales – in an area that is characterised by emigration, unemployment and a darkening, overgrown agricultural landscape.

5. Conclusion

- The project has been successful because of a bottom-up approach during planning, and a rapid implementation giving fast visible results;
- The project has developed opportunities for cooperation among people;
- There is a market for green, regionally-produced quality products;
- There is a regional interest in cultural & biological conservation engaging many people;
- The project requires a continuation of EU support, as well as co-operation with state authorities for agriculture and environment.

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Thorssell, Stefan, WWF Natural Grazing Project, executant.

Thuresson, Ulrik, farmer in Ammarnäs.

Figure 1. Number and distribution of farmers along the Vindel River (Vindelälven)
Main municipalities, number of inhabitants, and distances (km)

Farmers:		3	2	4	1	1	2	2	←	35	→
		♦	90 km	♦	200 km	♦	60 km	♦			
.	AMMARNÄS		Sorsele	Vindeln	Umeå						
	250	3 500	6 500	100 000							

Table 1. Project goals

<u>Overarching goals</u>:
- Sustainable use of natural resources;
- Conservation of biological diversity;
- Increased knowledge, participation and involvement of the local stakeholders.

<u>The goal of the project</u>:
- Restore and maintain the unique alluvial meadows;
- Develop quality meat production with added conservation values;
- Create long-term sustainable agricultural enterprises;
- Disseminate project ideas among other local and regional stakeholders.

<u>Evaluation criteria</u>
- The area of restored and well-maintained alluvial meadows;
- Number of cattle produced;
- Positive development in the area's flora and fauna (through surveys);
- Attitudes among local stakeholders.

Table 2. Definition of the terms 'natural grazing pasture' and 'natural grazing beef'

<u>Requirement for a 'natural-grazing pasture'</u>
- Meadows and pastures with high biological values (flora & fauna) that have not been artificially fertilised, limed, irrigated, nor treated with herbicides.

<u>Requirements for 'natural grazing beef'</u>:
- Grazing outside during whole vegetation period;
- Grazing mainly on biologically valuable unfertilised pastures (not less than 50%),
- Deworming only when necessary but not when on unfertilised pastures;
- The winter-feed (hay) should mainly be produced on the farm or its neighbourhood,
- The animal should be at least 20 month old when slaughtered and the weight of the carcass 240-360 kg;
- The meat should come from heifers, steers, or young cows;
- The meat should be marbled.

Table 3. Partner organisations involved in the project's second phase

Partner organisation	Task
The Sorsele Alliance	Regionally owned company that specialises in administration of EU-funded projects
County Administrative Board	Regional state authority on among other things agriculture and environment
Norrlandskött	The regional part of Swedish Quality Meats, beef processing
LRF	The regional section of the national farmers association
ICA	Main Swedish food retailer & brand owner of 'Natural Grazing Meat'
Participating farmers	

Table 4. Plant and animal species mentioned in the text. Scientific name with an asterisk indicates a Natura 2000 species.

Plant		
Alpine milk-vetch	Fjällvedel	*Astragalus alpinus*
Mountain angelica	Kvanne	*Angelica archangelica*
King carolus lousewort	Kung Karls spira	*Pedicularis sceptrum-carolinum*
Grey alder	Gråal	*Alnus incana*
Downy birch	Glasbjörk	*Betula pubescens*
Scots pine	Tall	*Pinus sylvestris*
Dark-leaved willow	Svartvide	*Salix myrsinifolia*
Tea-leaved willow	Grönvide	*Salix phylicifolia*
Pale willow	Blekvide	*Salix hastata*
Jämtland dandelion	Jämtlandsmaskros	*Taraxacum crocodes*
Blueberry	Blåbär	*Vaccinium myrtillus*
Water sedge	Norrlandsstarr	*Carex aquatilis,*
Scandinavian small-reed	Brunrör	*Calamagrostis purpurea,*
Purple small-reed	Grenrör	*Calamagrostis canescens*
Wavy hair-grass	Tuvtåtel	*Deschampsia cespitosa*
Mammals		
Arctic fox	Fjällräv	*Alopex lagopus* *
Brown bear	Brunbjörn	*Ursus arctos* *
European elk (Moose)	Älg	*Alces alces*
European lynx	Lodjur	*Lynx lynx* *
Norwegian lemming	Fjällämmel	*Lemmus lemmus*
Reindeer	Tamren	*Rangifer tarandus*
Roe deer	Rådjur	*Capreolus capreolus*
Wolverine	Järv	*Gulo gulo* *

Birds		
Golden eagle	Kungsörn	*Aquila chrysaetos* *
Great snipe	Dubbelbeckasin	*Gallinago media* *
Gyrfalcon	Jaktfalk	*Falco rusticolus* *
Lesser white-fronted goose	Fjällgås	*Anser erythropus* *
Short-eared owl	Jorduggla	*Aseo flammeus* *
Whooper swan	Sångsvan	*Cygnus cygnus* *
Fish		
Arctic char	Röding	*Salvelinus alpinus*
Brown trout	Öring	*Salmo trutta*
Burbot	Lake	*Lota lota*
Grayling	Harr	*Thymallus thymallus*
Perch	Abborre	*Perca fluviatilis*
Pike	Gädda	*Esox lucius*
Salmon	Lax	*Salmo salar* *
Sea trout	Havsöring	*Salmo trutta f. trutta*
Whitefish	Sik	*Coregonus lavaretus*
Whitefish	Storskallesik	*Coregonus peled*
Insects		
Black flies	Knott	fam. Simuliidae
Caddis flies	Nattsländor	ord. Trichoptera
Horse flies	Bromsar	fam. Tabanidae
May flies	Dagsländor	ord. Ephemeroptera
Mosquitoes	Stickmyggor	fam. Culicidae
Stone flies	Bäcksländor	ord. Plecoptera

Role of Economic Instruments – Mediterranean Examples

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Summary

Options for applying economic instruments in the irrigation sector are discussed and evaluated in view of the empirical evidence and relative success. In particular, attention is given to pricing policies, water markets, water rights adjustments and incentives to adopt technologies or improve infrastructure. Three case studies from different regions of Spain are presented, with reference to additional examples in Italy and Portugal.

1. Introduction

1.1 Pricing policies

OECD (1999) provides broad evidence of the infrequent use of water pricing as a demand management instrument. The most advanced countries have succeeded in making irrigators responsible for the Operation and Maintenance (O&M) costs, and reduced water subsidies. In the Mediterranean, there are very few cases in which water pricing is given a prevalent management role. A number of reasons are identified to explain this apparent delay in pricing water:

- Water itself cannot be disentangled from the infrastructures used to 'generate' it. Thus, unless water is traded in open markets it is very difficult to dissociate the value of water from the costs of the physical facilities. This means that most efforts are directed towards better financing of the costs of supplying the water, which are usually high in Mediterranean countries. If fixed costs are high, the best pricing mechanism to recover them is via per hectare payments, a practice which deviates significantly from the standard notion of incentive pricing or demand management.

- Governments are still involved in Greece, Portugal and in Spain (to a lesser extent), in developing new irrigation areas, usually demanding large subsidies. It is difficult to expect that governments will promote incentive pricing, when at the same time they still subsidise new irrigation areas. This creates policy inconsistencies. In Italy and France, laws exist that promote full cost recovery prices, but in France the government has been subsidising farmers' irrigation equipment and thereby significantly increasing the demand for water in the last 5 years (Rainelli and Vermesch, 1997).

- Incentive pricing requires that individual or collective consumption be measured with some precision. While this is done with groundwater, it is not the case with surface waters, which accounts for about 60-70% of all irrigated land in the Mediterranean countries of the EU, except Greece (OECD, 1999).

1.2 Water markets

Allowing irrigators to sell or buy water rights is another important element of demand management. The many institutional problems related to water markets which are well covered by the literature (Easter et al., 1998). Spain has just passed a law, which will permit farmers to lease their water rights. This is likely to provide incentives to use water more efficiently, but significant doubts remain over issues such as the following:

- Large benefits accruing to rights-holders through the selling or leasing of water that is not theirs.

- Third-party effects and externalities may occur, which the basin agencies may not be able to anticipate.

- Water rights are far from perfectly defined. Hence, this may generate conflicts when return flows are used by downstream users, and upstream users trade water, thereby promoting more technical efficiency, and in turn reducing the return flow.

- The initial definition of rights prior to the initialisation of trade.

1.3 Water rights adjustments

Another means of demand management is revising the water allotments that farmers can use. Adjustments could be based on cropping patterns, best available technologies, the state of the conveyance network, and any other piece of evidence that could be advanced to show that a particular group of farmers do not need the amount of water they receive. While most water codes include provisions that allow official agencies to revise the allotments, this option has not been used frequently. Problems linked to potential arbitrariness, emergence of legal conflicts and various other reasons may explain why it has not been much used.

1.4 Incentives to adopt technologies or improve infrastructures

This option enjoys the widest support from most analysts. Improvement projects are approved and subsidised based on the ability to show evidence about significant water savings. In general, better water technologies help irrigators to use water more efficiently, but that does not necessarily imply that the whole basin will save water. In fact, Garrido et al. (1997) and Huffaker and Whittelsey have shown that under relatively normal assumptions better technologies could end up augmenting the total water uses.

1.5 A mix of the above

A balanced mix of the above instruments is not only desirable but necessary in order to help each individual instrument deliver the services it is meant to. The following serve as examples:

- Incentives to adopt better technologies without a proper revision of the wholesale water rights will result in farmers using a large resource base at the cost of downstream users that depend on return flows.

- Water markets without proper and universal pricing result in trade distortion and unreasonable market gains being made by those that hold water rights at subsidised rates.

- Water pricing with no water markets would put the least efficient users completely out of business. This might come associated with indirect costs in the form of rural decay, unemployment, reduction of the tax base or depopulation of marginal areas. The combination of the market mechanism and charging for water provides fair incentives to use less water and generate revenue to finance the charges imposed on the actual volumes consumed.

- Water markets without a fair initial distribution of water rights are likely to generate unequal and unjustified distribution of gains, social unrest and a negative perception of water trading.

2. Case Study I

This is the well-known case of the 'mini-trasvase' or mini-transfer Ebro-Tarragona. Although lawyers don't like to call it a 'market' exchange, economists tend to consider it a transaction. It shows that win-win solutions are available, and in addition demonstrates that a win-win solution does not necessarily mean water sellers cannot continue to be water users.

The arrangement entailed a transfer of a water right of 4 m^3/second from the two rice growers of the Ebro delta to the Water Consortium of Tarragona – a Catalonian city, and one of the largest chemical industry sites in Europe. Farmers agreed to 'sell' their water rights in return of the complete refurbishment and rehabilitation of their water networks – work that was financed by the Water Consortium. Since the 4 m^3/second flow given to the Consortium came entirely from the water savings generated by canal rehabilitation work, farmers have maintained their traditional paddies. In addition, the Natural Park of the Ebro Delta is managed jointly with the farmers' representatives to minimise the impact of chemical use on birds in the protected area. The Ebro River drains a vast catchment of 85,000 km^2 and its delta covers about 320 km^2. The delta is actually shrinking because the supply of sediments has been reduced or diverted by the construction of dams upstream.

The fact that water had to be transported out of the Ebro basin required the approval of the central government of Madrid and the promulgation of special legal measures to regulate all details and the rights and duties of all the three parties involved (the consortium plus the right-bank and the left-bank irrigators' communities).

The water charge paid by the Consortium has been raised by the government and used to recoup all the costs associated with canal lining, and other works. The Consortium operates as a wholesale supplier to other municipal and industrial retailers.

This arrangement is summarised as follows:

- Water applicant: cities, industries and tourists areas. All with great willingness to pay for water.
- Water seller (in legal terms, nobody), but the water transferred comes from the rights belonging to the farmers.
- Water transferred results from the savings achieved through refurbishment of the irrigation schemes.
- Farmers' implications: almost nothing; if anything benefits resulting from better conveyance systems. Farmers are not entitled to cash payment.
- Buyers' implications: they must pay a charge to cover the costs of the investments. The maximum transferable allotment is 4 m^3/second. Since it began to operate in the early 1980s only half of that flow has been used.
- Environmental effects:

  – positive as a result of the maintenance of a noted sanctuary for a great variety of birds, part of which has been declared a Wetland of International Importance under the 'Ramsar' Convention.

  – negative as the result of increasing salinity and water logging. Also, some bird populations have been affected by the spray of crop protection products.

3. Case Study II

This refers to the example of the Mula Irrigation district in Murcia (south-east Spain). It tells the story of a profound transformation of a very traditional irrigation district of about 2,000 hectares into one of the most advanced in the world. Presently, the irrigation district has 1,530 small farmers.

Farmers submit water applications from a teller-machine, and can also submit nitrogen applications. As with a normal bank operation, the petition is recorded in the farmer's 'water account' on which he can see his balance. In addition, the system is connected with the rural bank so that a charge is put on his cash account in relation to the amount of water and nitrogen ordered.

On the supply side, the system works by optimising three sources of water: farmers exploit an aquifer that is used only when the other two sources are insuffient, these other sources are limited water rights for waters from the Tagus-Segura aqueduct, and water rights from the Segura river. Water is sometimes bought from other users.

Both the demand and supply systems are integrated in an 'intelligent' scheme, in which detailed account of resources, finance, water reserves, individual consumption and power consumption is kept.

As a result of the system's sophistication, the district has managed to reduce water consumption significantly, delivering its farmers other important benefits and a great detail of transparency.

- Benefits accomplished from the project:

  (a) Farmers now irrigate automatically. Their life is much easier.

  (b) Supply costs reduced as a result of the optimisation of the district's supply sources.

  (c) Reduction of personnel costs.

  (d) Reduction of water consumption of 14%; allocation now set at 4,500 m^3/ha.

  (e) Farmers pay the full Operation & Maintenance costs.

The costs of the project were in the neighbourhood of EUR 6,000 per hectare, partly financed by several administrations.

- Lessons to be learned:

  (a) When rehabilitating an irrigation district, managers have to be very careful about the pace of reform. Some farmers might benefit earlier than others, but all will have to pay their share of those project costs which are not externally provided.

  (b) A full democratisation process has to put in motion, sometimes requiring the redistribution of land rights and water rights.

  (c) Transparency, security of rights and a great deal of communication are required to persuade irrigators of the benefits achievable from the modernisation of a very traditional and centuries-old irrigation district.

(d) Farmers accept the notion of volumetric and time-based pricing because they understand the notion of variable costs and perceive that their water supply schedule is upward sloping. More water implies higher costs, hence only those responsible for increasing demand must be made responsible for the entire costs incurred in servicing their needs.

(e) Water scarcity is clearly perceived by the fact that various sources have different costs and different guarantee levels. Reliable district sources, such as groundwater resources, are properly valued when farmers perceive its 'last-resort' nature, which can only be tapped when normal sources are insufficient.

(f) Irrigation districts can be persuaded to enter into large-scale reforms when external funds and management are available, but the final decision to proceed must be taken by the farmers. Persuasion is a condition for success.

(g) New technologies in water accounting, distribution and sharing require institutional changes in important areas such as water-rights tenancy, land tenancy, voting mechanisms, and financial provisions. The 'Mula' experience shows that success is partly explained by a consistent, gradual and democratic process of institutional reform.

4. Case Study III

This last case study is hypothetical, although it could become reality under the new water code passed in Spain in November 1999. For details, refer to Michelsen and Young (1993) and Fisher et al. (1995).

Its elements are:

- The city of Seville;
- A medium-size irrigation district (called El Viar of 12,000 hectares and more than 500 farmers);
- A permanent risk of drought.

The farmers have a very well-endowed water supply from a reservoir, which is managed independently by the district. The city of Seville suffered very severe droughts in the period 1992-1995 and is asking for permission to build a new reservoir in a site of recognised ecological value. It would only need the waters of this new reservoir in years of extreme drought. The Guadalquivir basin is subject to very unstable patterns of rainfall and run-off (see Figures 1 and 2).

The agreement would be to sign an 'option contract' between the farmers and the city. Under this arrangement, farmers would be entitled to a permanent payment from the city water company, but in cases of drought farmers would be obliged to transfer a certain amount of water to the city, but would be entitled to the option exercise price.

A large amount of documentation has been produced by the water company, and some contacts have already been made to initiate negotiations. The economics of the agreement are largely favourable. The incentives are there, but perhaps there are not legal instruments to sign a contract of such contingent nature.

This option is very interesting for areas that are subject to unstable precipitation regimes, because it allows welfare-improving transfer of economic risks among water users whose water dependency and perception of risks differ.

5. Other examples

Other examples are available from the Italian Capitanata Region. An ambitious new programme with three main components is now being implemented in the southern Capitanata Region. (Mastrorili, 1997). The first component of the programme seeks to improve the management of collective irrigation systems and extension services. The underlying objective here is to provide compensation to farmers for having their allotments standardised at the (relatively low) level of 2,050 m^3/hectare, by giving them broad advice on technical matters. The second component is the implementation of a two-part charging system that discourages water use levels which exceed the critical water need of a given crop. Besides being penalised for excessive consumption, those farmers who consistently exceed indicated water use levels also risk having their allotments completely cancelled. The third component of the programme seeks to increase waste water recovery, as well as the re-use of ‘unconventional’ waters.

In Portugal, agricultural water prices are levied by users’ associations, but in accordance with very complex mechanisms and formulae. The complexity arises because WUAs sometimes also supply municipal water, property sizes affect the water charges, and charges are combined with drainage fees in projects that require drainage. Between the passage of Decree 269/82 (in 1982) and new legislation in 1995, farmers were charged a two-pronged levy. The first was meant to recover the O&M costs of irrigation schemes, and was based on individual farm acreages. The second component was meant to reimburse the state over a fifty year period for the capital costs invested in projects. Project beneficiaries are required to pay a yearly set charge called TEC (‘Taxa de Exploração e Conservação’) which includes a selection of no more than three of the following components: (1) fixed charge per reclaimed or ameliorated hectare (ranging from US$ 18 to 270); (2) fixed charge per irrigated hectare (ranging from US$31 to 146); (3) volumetric charge per cubic meter, if metering is possible (ranging from US$ 0.01 to 0.028 per cm); (4) a drainage fee, when drainage of excessive water is required (ranging from US$ 19 to 67); and (5) a crop-based fee applicable for specific crops and projects (ranging from US$ 16.9 to 87.3) (Bragança, 1998).

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Figure 1. Run-off of the Guadalquivir basin (measure in the Tranco de Beas reservoir) Source: Garrido, Iglesias and Gómez-Ramos (2000)

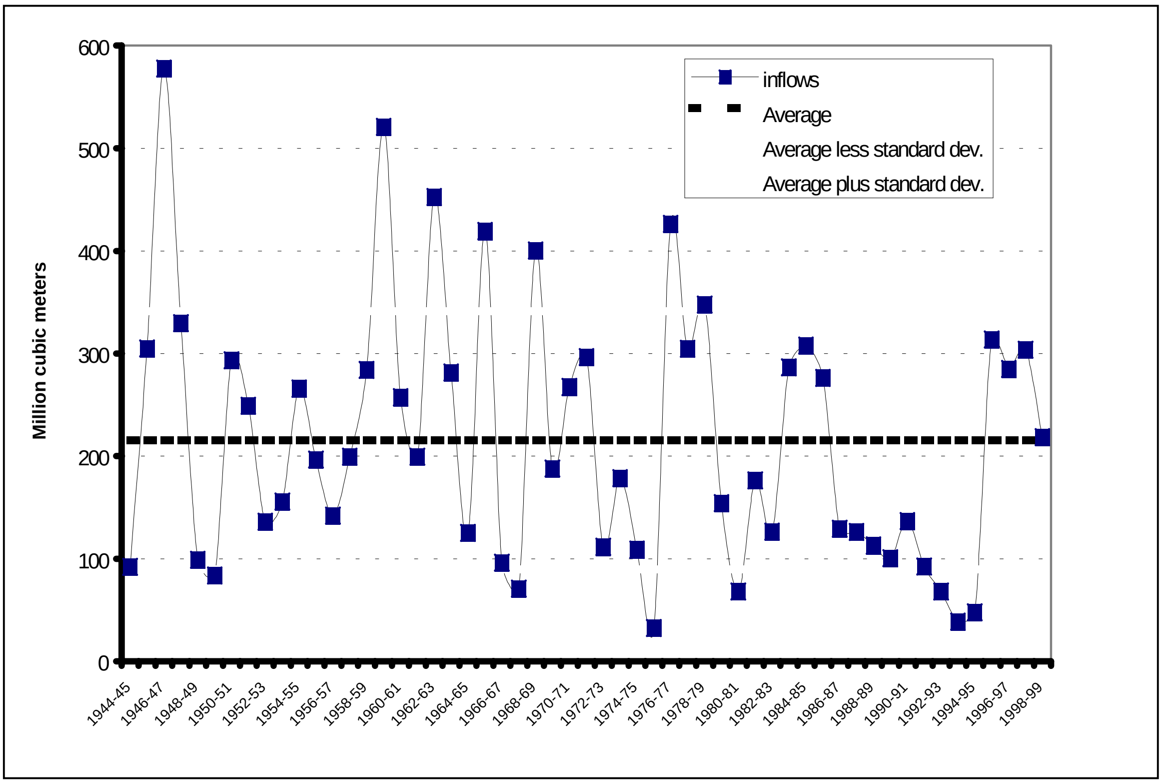
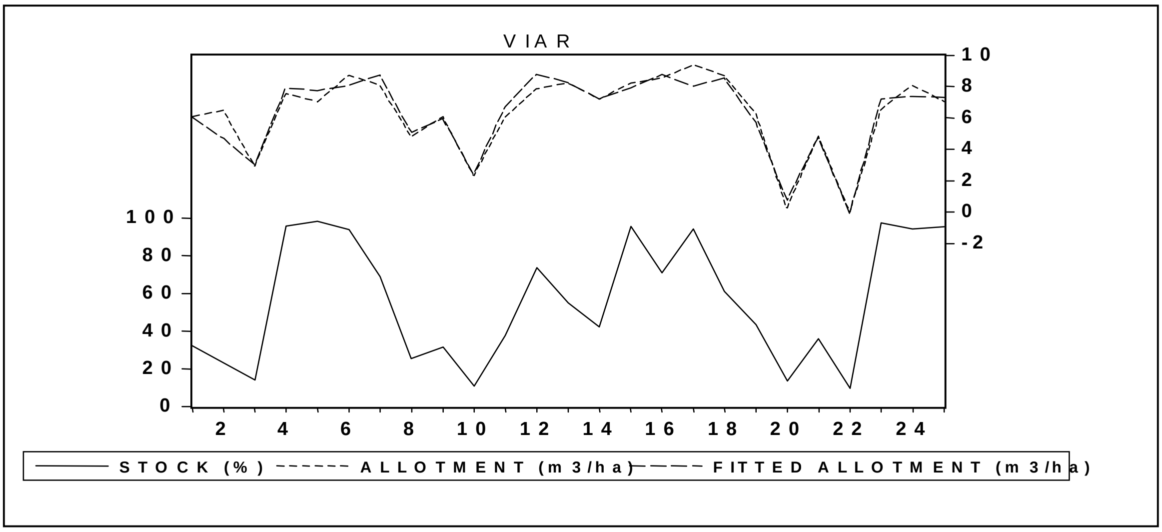


Figure 2. El Viar district (allotments, reservoir stock and predicted allotments). Source: Garrido, Iglesias and Gómez-Ramos (2000)



Session 3:
Integrating Water and Agriculture through River Basin Management: A Practical Exercise

The Proceedings for this session contain two case studies, each one consisting of an introduction followed by the perspectives of different actors

Case Study 1: Las Tablas de Daimiel – a protected area in the Upper Guadiana Basin Castilla-La Mancha, Spain

Introduction by:

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Summary

The wetlands of the Upper Guadiana Basin, Castilla-La Mancha, including 'las Tablas de Daimiel National Park', are recognised as internationally important freshwater ecosystems. In 1987 the Hydrographic Confederation for the Guadiana Basin, acting on the basis of Spain's new 1985 Water Act, provisionally declared Aquifer 23, on which the wetlands depend, to be over-exploited due to the expansion of irrigated agriculture. From 1991 onwards, it introduced restrictions on use of the aquifer, in the form of an annual abstraction plan. However, this scheme proved ineffective in practice. From 1993, a compensation scheme was introduced under EU agri-environment regulations. In response to ongoing concern over the future of the wetlands of the Upper Guadiana Basin, as well as in relation to socio-economic development and agricultural/agri-environmental policies, a committee of independent experts has been set up to draft a 'Plan for the Management of Natural Resources and for the Sustainable Development of the Upper Guadiana'. The initial report by this committee has highlighted numerous issues which require an integrated, coordinated approach in order to put such a plan into practice. (Note: see the following three papers for perspectives of J.R. Aragón, A. Olmedo and J.M. Sumpsi).

1. Introduction

The Upper Guadiana Basin extends across 16,000 square kilometres in the Castilla-La Mancha region, roughly in the centre of the Iberian Peninsula. As regards the natural environment, this area is notable for its wetlands of great ecological value, covering a total of around 250 square kilometres. These literally 'wet islands' in the midst of a semi-arid landscape provide much of the area's biodiversity. Since 1980 they have been on the UNESCO list of Biosphere Reserves under the name 'La Mancha Húmeda'.

The most significant wetland in the basin is 'Las Tablas de Daimiel' (or simply 'Daimiel') National Park, historically considered the most important wetland in the peninsula after Doñana National park. Apart from being a National park, Daimiel has been designated as a wetland of international importance under the 'Ramsar' Convention on Wetlands and as a Special Protection Area under the European Union's Birds Directive. Finally, it has been proposed as a Site of Community Importance (and candidate SAC) under the EU Habitats Directive.

The Daimiel wetland depends for its survival on one of the principal aquifers in the Upper Guadiana Basin, known as 'Aquifer 23' or 'La Mancha Occidental' aquifer. This aquifer covers approximately 5,500 square kilometres, with a population of around 270,000, of whom 44% work in agriculture which, like the National Park, depends heavily on the water from the aquifer, in this case for irrigation. The challenge is to resolve the current conflict between these two uses of Aquifer 23.

Over the past 30 years the Aquifer 23 area has witnessed a massive expansion of irrigated agriculture. Heavy public and private investments have transformed agricultural activity in the area, changing irrigated agriculture from a complement to the traditional three-year rotation between dryland cereals, vines and sheep, into a powerful sector of the economy producing important raw materials such as sugar beet and maize, two highly water-intensive crops. This transformation has been strongly promoted by both national and European agricultural policies, by means of investment in infrastructure, aid to improve farms and remove vines, and direct subsidies for growing maize, sugar beet, etc. It has also been the principal driving force for socio-economic development in the area.

This expansion of irrigation has had far-reaching impacts, both direct and indirect, on the wetlands in the area, particularly:

- Drainage and land conversion – in the last 30 years the area irrigated has quadrupled.
- Channelisation of major rivers and of their floodplains.
- Lowering of the flow rates of rivers and lowering of the water table as water is pumped from ever greater depths.

In the 1980s and 1990s the water table fell by over one metre a year. Numerous smaller wetlands disappeared, while Daimiel shrank sharply from 22,000 hectares to under 9,000 hectares. The threat now is that in drought years the wetlands could dry out almost completely. Abstraction of water from ever greater depths has also led to social conflicts, due to problems with public supplies.

Other factors affecting water resources and the natural environment in this basin are pollution of surface waters from industrial, agricultural and domestic sources and the political tendency to attempt to resolve water supply problems by means of major infrastructure engineering (for example, inter-basin transfers) instead of promoting sustainable management of water as a finite resource.

In 1987 the Hydrographic Confederation for the Guadiana Basin, acting on the basis of Spain's new 1985 Water Act, provisionally declared Aquifer 23 to be over-exploited. From 1991 onwards, it introduced restrictions on use of the aquifer, in the form of an annual abstraction plan. Under the 1995 plan, for example, farms of 5 hectares or less were allocated 4,278 hm^3/ha/year, whereas farms of 500 ha were allowed 1,112 hm^3/ha/year.

However, this scheme proved ineffective because of the problems encountered when the time came to put it into practice. These included:

- The large number of boreholes in the region which were unregistered and consequently evaded any rules on abstraction.
- Most boreholes in the area had no meters, consequently making monitoring of abstraction difficult.
- Resistance from farmers to schemes which could affect their income.

For all these reasons, over-exploitation of the aquifer continued and Daimiel had to be supplied with water transferred from the Tagus Basin. The situation was further exacerbated when the 1993-95 droughts reduced the supply to the headwaters of the Tagus resulting in rapid deterioration of the National Park.

In the early 1990s, the agri-environment programme under the Common Agricultural Policy (from 1992 under Regulation 2078/92) provided a way out of this *impasse*. In 1993, an income compensation scheme was introduced under this programme for the area covered by Aquifers 23 and 24, offering farmers the possibility of concluding a contract to reduce the volume of water used on their irrigated land by switching to less water-intensive crops. Starting from average consumption of 5,000 m^3/ha/year, there are three possible levels of reduction, with three corresponding rates of income compensation:

Reduction in consumption	Income compensation (1995)
• 100%	ESP 63 000/ha/year (EUR 380)
• 70%	ESP 45 150/ha/year (EUR 270)
• 50%	ESP 27 300/ha/year (EUR 164)

The compensation received by farmers fluctuates between approximately EUR 600 and EUR 240,400, depending on the option chosen and, above all, the surface area under cultivation. The total budget for the programme can be up to EUR 100 million. A large proportion of the irrigated land with legally registered boreholes is covered by the programme (in 1995 approximately 85,000 hectares out of the 120,000 hectares irrigated) resulting in a considerable reduction in water consumption (for example, 268 hm^3 in Aquifer 23 in 1995).

In this way, European Union funding has made it possible to apply the abstraction plans established under Spain's 1985 Water Act while maintaining farmers' incomes in a period of repeated droughts.

However, the income compensation scheme has been widely criticised on many counts:

- As a result of the droughts, in spite of the reduced abstraction Aquifer 23 is still far from restored and Daimiel is still under threat.
- Partly because of the droughts, but also because of their own historic over-exploitation of the aquifers, many farmers would have been forced to cut back on their water consumption over the last few years even without the income compensation programme, simply because the boreholes were running dry.
- The programme fails to address the problem of illegal boreholes.
- In effect, the programme compensates farmers for complying with the existing legislation – which runs against the spirit and letter of the current agri-environmental regulations.
- Growing of maize and sugar beet – two highly water-intensive crops – is heavily subsidised by the Common Agricultural Policy. Reform of the schemes for subsidising these crops could considerably reduce the area under them, without the high cost of the income compensation scheme.
- ‘Extensification’ of agriculture in the area, as an inevitable consequence of the switch to less-intensive crops, has brought with it heavy job losses. However, the authorities have been unable to introduce sustainable rural development programmes capable of generating jobs in other sectors, despite the substantial funding made available from the European Union's Structural Funds.

In response to widespread concern about the future of the wetlands of the Upper Guadiana Basin, about socio-economic development of the area and about agricultural and agri-environmental policies, a committee of independent experts has been set up with a view to drafting a Plan for the Management of Natural Resources and for the Sustainable Development of the Upper Guadiana. The initial report by this committee has highlighted numerous issues which require an integrated, coordinated approach in order to put such a plan into practice. Amongst others, these include:

- Coordination and cooperation between the different departments of the administration and between the administration and the individual stakeholders with a view to consensus-building.
- Development of a new model for (diversified, competitive and sustainable) agriculture for the area, backed up by environmental management of the natural ecosystems and their surroundings.

- Reform of the production subsidies from the CAP and of the agri-environment programmes in order to promote this new model (for example, reduction of the current differential between the support for irrigated and dryland agriculture).
- Development of new policy instruments to promote sustainable water management and consumption.
- Improvements to the current knowledge of the functioning of the hydrological system and wetland ecosystems.
- Development of an integrated, sustainable strategy for water resource management.

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Las Tablas de Daimiel: The case of a protected area in the upper Guadiana basin, Castilla-La Mancha, Spain

The perspective of:

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Summary

This paper examines a range of agricultural policy scenarios and analyses their likely impact on the status of Aquifer 23, farmers' incomes and public spending. All the simulated policy options work out cheaper than the present situation, while some of them produce better or similar results in terms of water saving. This suggests a certain wastage of public resources in order to attain the objective of reducing water abstraction from Aquifer 23. The other side of the picture is that compared with the current policy all the alternative policies simulated lead to a loss of income, which is greater in some cases than in others. (Note: for a general introduction to this case study, as well as the points of view of other stakeholders, see the three contributions by G. Beaufoy, and J. R. Aragón, and A. Olmedo).

1. Introduction

The measures adopted to reduce the volume of water abstracted for irrigation and attain sustainable use of 'Aquifer 23' ('La Mancha Occidental') have consisted of limits on abstraction for irrigation (Royal Decree on overexploitation of Aquifer 23) and financial compensation for farmers who give a voluntary undertaking to abstract less water (EU regulation 2078/92).

However, up until now no-one has considered the possibility of reducing water consumption for irrigation and attaining sustainable use of Aquifer 23 by means of alternative strategies, for example by making changes to the current Common Agricultural Policy (CAP) or simply by using the possibilities opened up for the Member States by the Agenda 2000 reform of the CAP. The objective of this paper is to attempt to simulate different agricultural policy scenarios and to analyse how they would affect the volume of water abstracted from Aquifer 23, farmers' incomes and public spending.

The results presented in this paper are from a broader study carried out by Professors Sumpsi, Blanco and Varela-Ortega from the Department of Agricultural Economics at the Universidad Politécnica de Madrid and financed by ADENA/WWF-Spain.

2. Method

The method used was based on mathematical models capable of simulating the effects of different agricultural policy scenarios on allocation of farmland between the different irrigated and non-irrigated crops grown in the area. In this way, the results obtained from the simulations make it possible to estimate the impact on water consumption for irrigation (abstraction from Aquifer 23), farmers' incomes and public spending.

The model operates on the level of individual farms. Four farm types representative of those found in the irrigable area of Daimiel (20,000 hectares), the site where the field work was carried out, were studied.

FARM TYPE	**1**	**2**	**3**	**4**
Size (ha)	8	24	30	70
Soil quality	Low	High	Average	Average and low
Type of crop	Vine	Fruit and vegetables & COP crops	Melon or beet (1/3), COP crops (1/3) and vine (1/3)	COP crops
Representativeness (% of total surface area)	22	19	28	31

The results for the entire irrigable area were obtained by adding together the results obtained for the four standard farm types and weighting them by the percentage of the total irrigable land in the area represented by each farm type.

One fundamental component of the method is the definition of the agricultural policy scenarios to be simulated, which are as follows:

2.1 Scenario 1 (E1): McSharry reform

Scenario E1 represents application of the McSharry reform, assuming no limits on water abstraction (Decree on overexploitation) and no income compensation (agri-environment programme). Since the technical and economic parameters for the model are taken from 1995, the product prices and direct aid for that marketing year have been taken as the reference values. This definition will be designated as the starting situation or baseline scenario, against which the results will be compared. In addition to the starting situation, scenario E1 allows the possibility of narrowing the differential between the direct CAP aid for irrigated and non-irrigated crops (simulations were carried out on four levels other than the current differential: a differential 25% narrower than the current level, a differential 50% narrower, another 75% narrower and, finally, with no differential between irrigated and non-irrigated crops).

2.2 Scenario 2 (E2): Agenda 2000

Scenario E2 corresponds to application of Agenda 2000. It starts with the baseline scenario, but changes the amount of direct aid and considers three hypotheses for future price trends for cereals, oilseeds and pulses (COP crops): the initial prices, prices 10% lower and prices 20% lower than the starting level.

It likewise studied the four levels of differential between CAP aid for irrigated and non-irrigated crops described in scenario E1, all of which are lower than the current level. It also considered attaching environmental conditions to the Agenda 2000 scenario, i.e. making payment of the direct aid subject to compliance with certain requirements. Since over-use of water from Aquifer 23 is the root of the environmental problems in Daimiel, the following environmental conditions were defined: farmers receive 100% of the CAP aid if annual water consumption on the farm is not more than 2,000 m^3/ha, 70% if they consume between 2,000 and 3,000 m^3/ha, 40% if they use between 3,000 and 4,000 m^3/ha and no CAP aid if water consumption on the farm exceeds 4,000 m^3/ha.

2.3 Scenario 3 (E3): Total disconnection of CAP aid

In this scenario all the direct aid is equal, which implies that the aid for maize will be the same as for the other irrigated cereals and will also be extended to crops such as sugar beet. The four levels of differential between direct aid per hectare for irrigated and non-irrigated crops and the environmental conditions defined above were also incorporated in this scenario.

2.4 Scenario 4 (E4): Radical reform of the CAP

The radical reform scenario consists of ending the direct CAP aid and applying the current agri-environment scheme to compensate for loss of income as a result of reductions in the volume of water abstracted. Three hypotheses for COP crop prices are also considered: original prices, prices 10% lower than the original prices and prices 20% lower.

3. Results

In the baseline scenario (E1), the results of the simulations show that water consumption would be fairly high on all farms: over 4,000 m^3/ha everywhere and up to 6,000 m^3/ha on some types of farm (type 2). All farms in the Daimiel area would be entirely irrigated. Adding the possibility of substantially narrowing the differential between the aid for irrigated and non-irrigated crops to this same scenario (1995 McSharry reform) would produce a marked fall in water consumption, to a smaller extent in farm type 2 (which would still use 4,000 m^3/ha) or more drastically on farm types 3 and 4 (which would use in the order of 1,000 m^3/ha and would switch to growing non-irrigated crops on most of their land).

In the Agenda 2000 scenario (E2), when the rate of aid is changed and cereal prices are reduced by 10 to 20% – a realistic hypothesis for the years ahead – water consumption falls by 40% and income by between 7 and 12%, compared with the baseline scenario and current situation in each case. Consequently, Agenda 2000 could result in a significant reduction in water consumption for irrigation in Daimiel, without any need to apply environmental conditions or to narrow the current differential between the aid per hectare for irrigated and non-irrigated crops.

The total disconnection of CAP aid – scenario (E3) – which implies taking the aid for maize down to the same level as for the other irrigated crops and introducing direct aid for beet to compensate for a reduction in the institutional price, produces very similar results to the Agenda 2000 scenario (E2).

Of the scenarios tested, the one which leads to the greatest reduction in water consumption with the smallest loss of farm income is Agenda 2000 with environmental conditions attached, especially if accompanied by a narrowing of the differential between subsidies for irrigated and dryland crops. This scenario has the advantage that the results obtained are not very sensitive to changes in agricultural prices, making this a very stable option in terms of water savings.

Radical reform (ending direct aid and considering the current aid under the agri-environmental programme for income compensation) is also a good solution, leading to a very strong reduction in water use with little loss in farm income. However, it must be remembered that the water consumption and farm incomes were compared with the starting situation or baseline scenario defined as the 1995 McSharry scenario, taking no account of either the limits on abstraction from the aquifer nor the income compensation programme (agri-environmental aid). If the radical reform scenario is compared with the real situation today (direct aid plus agri-environmental aid), the result would be a 30% reduction in water consumption instead of 74% and a 15% loss of income instead of 4%.

One final fundamental element to take into account would be the public spending under each agricultural policy scenario. In this case, the two extremes would be the direct aid plus agri-environmental aid scenario (current situation) with average spending of ESP 64,300 per hectare on the one hand, and the no direct aid and no agri-environmental aid scenario (abolition of all public aid) with no spending on the other. The baseline scenario (1995 McSharry reform without agri-environmental aid) lies between the two, with average spending per hectare of ESP 28,900.

In terms of public spending, savings are made compared with the baseline scenario only if the differential between the direct aid for irrigated and non-irrigated crops is narrowed or removed altogether. In the Agenda 2000 scenario with environmental conditions also applied, the spending remains similar to the baseline situation, while in the radical reform scenario, public spending rises from ESP 28,900 to ESP 44,600 per hectare due to the high rate of agri-environmental aid currently in force.

4. Conclusions

All the agricultural policy options simulated work out cheaper than the option currently taken in La Mancha Occidental, while some of them produce better or similar results in terms of water saving. This suggests a certain wastage of public resources in order to attain the objective of reducing water abstraction from Aquifer 23. The other side of the picture is that compared with the current policy all the alternative policies simulated lead to a loss of income, which is greater in some cases than in others.

Out of all the scenarios tested, the one which leads to the greatest reduction in water use for irrigation with the smallest loss of farm income is Agenda 2000 with environmental conditions, especially if accompanied by a narrowing of the differential between the aid per hectare for irrigated and non-irrigated crops. This scenario has the added advantage that the results obtained are not very sensitive to changes in agricultural prices, making this a very stable option in terms of water savings.

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Case Study 1: Las Tablas de Daimiel – a protected area in the upper Guadiana basin Castilla-La Mancha, Spain

The perspective of:

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Summary

The system established for groundwater exploitation with the purpose of converting over 100,000 hectares of dry land into irrigated land on the perimeter of the aquifer 'La Mancha Occidental' has raised incomes in the area but, despite the official designation of multiple protected areas, has seriously endangered the survival of the Biosphere Reserve 'La Mancha Húmeda', especially the wetland ecosystem 'Las Tablas de Daimiel'. Possible approaches to the problem are discussed, with the following two principal actions proposed (a) careful management of the aquifer for 20 years once over-exploitation has been overcome and its reserves and natural functions have been restored, (b) a change in economic management of the subsidies granted over the same period towards investment targeted at transforming the production system in the area. (Note: for a general introduction to this case study, as well as the points of view of other stakeholders, see the three contributions by G. Beaufoy, and A. Olmedo and J.M. Sumpsi).

1. Background

The Upper Guadiana Basin has low, irregular precipitation, flat, low-lying topography and extensive permeable surfaces which have formed an immature hydrographic network favouring replenishment of the aquifers of the La Mancha Natural Park, of which 'La Mancha Occidental' aquifer, better known as 'Aquifer 23', is the largest.

'La Mancha Occidental' is the largest natural hydrographic system in the Iberian Peninsula. A series of lateral aquifers are linked to it via the surface river network and via underground connections between the aquifer layers. Relevant features of the area include: the drying-out, as a result of river channelling works, of the floodplains of the principal rivers; the Ruidera lagoons; the loss of water from infiltration in the riverbeds, including the River Guadiana; the emergence of water in the Ojos del Guadiana due to discharges from Aquifer 23; outcrops of peat; Las Tablas de Daimiel wetlands; approximately 120,000 hectares of public and, for the most part, private irrigated farmland providing the basis for economic activity in the area; water supply for a total population of around 400,000 inhabitants and 'La Mancha Húmeda' lagoon complex which has been declared a Biosphere Reserve.

In La Mancha the lack of a permanent flow in the rivers led, historically, to exploitation of groundwater resources. This, together with river channelling works, affected the Tablas de Daimiel wetland, which dried out almost completely in 1986 and was damaged by fires in the exposed peat.

Prior to the 1986 entry into force of Spain's Water Act, private initiatives took precedence over hydrological management. In 1989, over 130,000 hectares were irrigated, while the wetlands have shrunk from 25,377 hectares in 1967 to less than one quarter of that today, leading to a structural water shortage that is difficult to solve, even in the long term.

The Hydrological Plan for the Upper Guadiana Basin – systems I and II – (161 towns; surface area of 22,948 km^2 and population of 555,000) shows the following general balance:

1995 (Date of adoption of the Plan):	Shortfall: 507.3 hm^3/year
Plan after 10 years	Shortfall: 461.1 hm^3/year
Plan after 20 years	Shortfall: 433.4 hm^3/year

Although the whole of systems I and II are affected, the shortfall is the result of over-exploitation of the water resources from Aquifer 23, the lowest point of which, in terms of altitude, coincides with the Tablas de Daimiel National Park, all of which overlies the aquifer.

According to the Guadiana I Hydrological Plan, the average rate of replenishment of Hydrogeological Unit 04.04 (Aquifer 23) is 340 hm^3/year, while the estimates for the year when consumption was highest (1989) showed that 598 hm^3/year were abstracted (568 hm^3 for irrigation and 30 hm^3 for public supply), giving an estimated cumulative deficit of 4,000 hm^3 by the end of the 1995-96 season.

2. The problem

This mounting shortfall has upset the hydrological balance, with serious consequences which culminated in an official declaration of over-exploitation of the Mancha Occidental and Campo de Montiel aquifers and imposition of a limit on the granting of concessions for water abstraction on the territory covered by Systems I and II.

In recent years, abstraction from the aquifer has fallen from a peak of almost 600 hm^3 in the 1980s to 245 hm^3 in 1994, as a result of the action taken to provide compensation for loss of agricultural income and measures taken by the water authorities. In the prolonged 1991-95 drought and again today, a drastic reduction in infiltration has ended replenishment of the aquifer from this source. By contrast, in the 1996-97 and 1997-98 seasons, precipitation was above the historic average, taking replenishment of the aquifer close to 1,200 hm^3.

Between 1993 and 1995 a number of emergency measures had to be taken to secure supplies for a large number of towns in the Upper Guadiana Basin. Despite these, over 100,000 inhabitants suffered severe restrictions. In 1988, 89, 90, 92, 94 and 96, water was transferred from the River Tagus Basin to the Guadiana Basin to restore the water supply to the Tablas de Daimiel National Park.

Since time immemorial, the natural water cycle has been altered in a bid to make immediate use of the resources. Once there is an awareness that water is a finite resource and that one use can affect others, or the environment as a whole, it becomes necessary to begin evaluating the consequences of any change in the cycle, amongst other reasons because water supports unique, fragile ecosystems which are interdependent and difficult to restore once destroyed. Wise use of water harmonised with other natural resources, together with conservation and restoration of the natural habitats affected, are all essential factors in order to avoid jeopardising future development.

Despite the official reports, the action taken on the aquatic environment in the Upper Guadiana Basin failed to evaluate the effects of transformation of the area and consequently failed to manage the process. This resulted in over-exploitation of the groundwater in La Mancha Occidental aquifer which has affected two major categories of user: socio-economic stakeholders and the natural environment.

In 1986 groundwater became public property with the entry into force of Spain's new Water Act, although resources already exploited remained privately owned. Since then, a significant number of regulations have been introduced to control groundwater abstraction in La Mancha and to restore the Tablas de Daimiel National Park. However, the deterioration of the water resources of the Upper Guadiana Basin is advanced and out of control.

The Guadiana I Hydrological Plan found that there were not enough indigenous water resources to satisfy the combined needs of public supply, irrigation and Daimiel National Park. Narrowing down the territory covered to the area of Aquifer 23 (La Mancha Occidental) and after identifying the external effects on the area, numerous consumers still remain, together with complex externalities. It is therefore necessary to simplify the problem further and focus on the critical externalities defining the problem:

The system established for groundwater exploitation with the purpose of converting over 100,000 hectares of dry land into irrigated land on the perimeter of the aquifer 'La Mancha Occidental' has raised incomes in the area but, despite the official designation of multiple protected areas, has seriously endangered the survival of the Biosphere Reserve 'La Mancha Húmeda', especially the wetland ecosystem 'Las Tablas de Daimiel'.

The current situation is that the environmental problem is stagnant, with high incomes based (to a large extent) on the subsidies received by agriculture in the area, but unsustainable, since it is based on over-exploitation of the groundwater resources in the area.

3. Approaches to solutions

To date the following initiatives have been taken:

3.1 Governing Board of Las Tablas de Daimiel National Park

At its meeting on 8 May 1996 the Governing Board of Las Tablas de Daimiel National Park adopted a report on the hydrological status of the park and future alternatives, which instructed a committee of independent experts to draw up a Plan for the Management of Natural Resources and Sustainable Development of Aquifer 23. As a first step, the committee of experts decided to draft a paper entitled 'Situation, Diagnosis and Proposals for Action' in preparation for a 'Plan for the Management of Natural Resources and Sustainable Development of the Upper Guadiana Basin', extending the area covered by the report and plan to the entire Upper Guadiana Basin.

This first paper describes the scenario on which the management plan could be based, so as "to reduce abstraction or to increase replenishment, preferably natural, with a surplus of 200 hm^3/year in order to restore the hydrological system to working order in 20 years". It considers that the management plan must take account of the fact that environmental recovery is the basis for restoration of the natural water cycle, the need to manage water resources, changes of mentality both on the part of the authorities and of the farming community, the need to set up a permanent coordinating body and to support all this with an economic model based on valuing nature. It also proposes that the management plan should set the following objectives:

- <u>Social objectives</u>: water pact between the authorities and interest groups and conversion of the agricultural development model (to rebalance the disproportionate incentives in favour of irrigation, to support dryland farming and to take natural resources into account);

- <u>Strategic or instrumental objectives</u>: progressive re-establishment of the natural hydrological function of the aquifer, monitoring of environmental and socio-economic indicators, restoration of the damaged ecosystems, increase in the profitability of dryland crops, bases for integration and implementation of the global pact and bases for the economic and financing plan guaranteeing the necessary resources.

3.2 Water authorities

The Hydrographic Confederation for the Guadiana Basin has proposed an action plan, which includes the action taken to date, based on coordination between the various public authorities concerned and with the following new lines of action: improvement of hydrogeological knowledge of the area; drafting of a specific environmental recovery plan for the rivers and wetlands; drafting of a specific programme to protect water quality in the area; establishment of a plan for joint exploitation of the surface water and groundwater resources based on maximum abstraction of not more than 200 hm^3/year from the La Mancha Occidental aquifer; preparation of a document defining legal bases appropriate to the problem and applicable specifically to the area of the aquifers; drafting of a plan to reorganise management of the areas where the water is used; drafting of schemes to increase participation by users, via the organisations representing them, in the management and monitoring tasks; establishment of a plan for raising awareness of the problem and disseminating potential solutions to the entire population.

3.3 General Irrigators' Community

In May 1997 the General Irrigators' Community for the La Mancha Occidental aquifer in turn proposed a hydro-agricultural plan with the following general objectives:

- Controlled recovery of the aquifer and of the associated wetlands;
- Regional socio-economic development by means of alternative projects;
- Sustainable development of the area.

4. Proposed solution

Restoration of the Tablas de Daimiel will entail restoring the flows into Aquifer 23 and improving the quality of the water received. At the current rate, it will take decades to balance the replenishment and abstraction rates. A general consensus has been reached on the need to restore the natural regulating functions of the La Mancha Occidental aquifer until a sufficient flow is restored through the 'Ojos del Guadiana' to supply the National Park.

Some of the irrigators using the La Mancha Occidental aquifer have accepted that the protected sites are a safeguard for them and understand that their disappearance could mark the first step towards desertification of the district.

Technically and theoretically there are various alternatives to the current situation which could solve the problem. We opt for the following, to be implemented <u>simultaneously</u>:

- Management of the aquifer for 20 years – the period covered by the hydrological plan – considering the uncertainties of the natural water cycle to give the maximum guarantees of recovery of the hydrographical balance of the aquifer once over-exploitation has been overcome and its reserves and natural functions have been restored.

- A change in economic management of the subsidies granted over the same period towards investment targeted at transforming the production system in the area. By the end of this period there should be no reduction in net annual income but only aid for agricultural activities and the rural environment that is common to other similar areas in the vicinity of Aquifer 23 would be maintained.

It is fundamental to adequately inform all concerned and potentially interested of the magnitude and scale of the problem, following a detailed analysis and evaluation of the origins and consequences. It is also essential to seek proposals from stakeholders, to hold a wide debate, to build consensus around coherent, respectable and responsible solutions, and to involve everyone concerned in implementing these solutions.

This is the starting point for putting into action a development plan allowing a **satisfactory solution**. Public support will allow changes to the regulations, ensure that they are observed and help to secure the necessary funding.

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Las Tablas de Daimiel: The case of a protected area in the upper Guadiana basin, Castilla-La Mancha, Spain

The perspective of:

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Summary

In 1987, Aquifer 23 in the Castilla-La Mancha region of Spain was officially declared as over-exploited. The first phase of a coordinated action plan, based on compensation for reduced irrigation, led to a significant reduction in the rate of lowering of the water table. The river basin authority has set abstraction levels for other users. This paper presents the perspective of the 'General Community of Users of Aquifer 23'. The association believes that the initiatives taken to date are insufficient for the long-term sustainability of Aquifer 23. Proposals are presented for a hydrological research project, a hydro-agricultural sustainable development plan and an afforestation programme. The importance of full participation of user groups is emphasised. (Note: for a general introduction to this case study, as well as the points of view of other stakeholders, see the three contributions by G. Beaufoy, and J. R. Aragón, and J.M. Sumpsi).

1. Introduction

Over the last twenty years the area occupied by La Mancha Occidental aquifer ('Aquifer 23') has been suffering from the problem that abstraction has been outstripping the annual rate of replenishment. The aquifer was declared over-exploited in 1987.

In 1993 a coordinated action plan was established in the form of a five-year income compensation programme cofunded by the European Union, the Spanish Ministry of Agriculture and the Environment and the Regional Department of Agriculture for Castilla-La Mancha. In 1998 this was extended for a second period of equal duration.

The first phase of this programme (1993-97) yielded total water savings of 302 hm^3 and covered a total area of 85,834 ha.

The immediate result was a marked slowdown in the lowering of the groundwater table, except in the severe 1994-96 drought, when the abstraction/recharge rates were balanced.

At the same time the Hydrographic Confederation for the Guadiana Basin (river basin authority) adopted an abstraction plan setting abstraction levels for other users not covered by the income compensation programme.

However, both these programmes remain short-term solutions, particularly since the commitment given by users is for just five years, which is too short for a definitive recovery, and the abstraction plan limits farm incomes.

Consequently, any new plans to achieve sustainable development of the Aquifer 23 area (co-existence of the environment with abstraction of groundwater) must take account of the programmes which the General Community of Users has prepared for the public authorities to implement and support financially. These are:

- A hydrological research project on Aquifer 23 (to acquire knowledge of the aquifer, its behaviour and characteristics).
- A hydro-agricultural plan for sustainable development of the Aquifer 23 area.
- A programme for definitive recovery of Aquifer 23 with the aid of a specific afforestation programme.

Obviously all these projects are essential in order to reduce water consumption and restore Aquifer 23, together with reorganisation of land use and the administration with a view to coordinating the different authorities and Irrigators' Communities, bringing up to date the water register and catalogue of private users, ensuring mandatory compliance with the annual abstraction plans and requiring installation of water meters at all abstraction points or boreholes.

2. Hydrological research project on Aquifer 23

Aquifer 23 is constantly being talked about in a wide variety of circles – universities, authorities and other stakeholders – with speakers sometimes even seeking to give listeners the impression of an in-depth, exhaustive knowledge of the subject. Nothing could be further from the truth.

Claims have been made that, for example, the Tablas de Daimiel wetland will never recover, or that the state of the aquifer is irreversible. The truth, however, is that the income compensation scheme for farmers who cut their water consumption, the action taken by the Irrigators' Communities (public bodies set up recently) to provide information and training for their users and the modest efforts by the water authorities have slowed down the lowering of the water table and even – in years with a favourable weather conditions – raised the level; an outcome which many experts considered inconceivable.

Without unfounded triumphalism, the conclusion which must be drawn from the foregoing is that Aquifer 23 is a great unknown quantity. We do not yet know how it behaves, where the water bodies are, how the flows or currents work, how it is linked to and affects other aquifers, etc. In short, we do not know what is there.

The Hydrographic Confederation for the Guadiana Basin, like the university, insists that studies have been conducted on the aquifer. However, none of these have reached the General Community of Users.

A knowledge of the aquifer and of the existing water resources is indispensable for any water policy or management. By way of example, it will never be possible to turn the water bank envisaged in the recent reform of the Spanish Water Act into reality for irrigators and users of Aquifer 23 unless it is known exactly which resources exist and could be made available. Aquifer 23 cannot wait any longer. Detailed knowledge of the aquifer is essential to meet the requirements of agriculture, irrigators and, more importantly, of the Community water policy framework, particularly the environmental side which cannot be forgotten under any circumstances.

3. Hydro-agricultural plan for sustainable development of the Aquifer 23 area

Basic principles:

- The rural world cannot be sustained by agriculture alone. It needs to diversify its economic activities, for example into agro-industry, agri-tourism, hunting and other leisure activities, services, construction, etc.

- Farmers are slowly learning the painful lesson that securing sufficient water supplies for irrigation is not the end of the problem but that the crops must then be sold at a profit. Selection of alternatives adapted to the water supply, farming and climate conditions and openings on the markets are skills yet to be learned in areas such as La Mancha, with little tradition of irrigated agriculture.

- Without doubt, water is one of the factors limiting regional development. Generally, the concept of profitability per hectare should be replaced by profitability per cubic metre of water.

- Development of channels for marketing and promoting quality produce is essential to make agriculture profitable.

- The environment must be considered not as a cost to be paid but as a real economic asset which, if managed properly applying appropriate business criteria, can and must offer significant profits.

Finally, it is important to stress the need to be able to offer farmers a series of sufficiently attractive alternatives, before embarking on a policy to limit production. Some conversion schemes have been unduly painful because of the failure to plan alternatives before starting the conversion.

Objectives:

- Controlled, progressive recovery of the aquifer itself and of the wetlands affected, if necessary reducing the irrigated area currently cultivated to acceptable, sustainable limits.

- Regional economic development by means of alternative projects for diversifying economic activity in the rural environment.

- To attain sustainable development of the area by means of harmonious use of its natural resources, with particular reference to agriculture and water, and to change the objective from maximising production per hectare to optimising farmers' income and making it sustainable over time.

One important point to note is that the interaction between the three objectives is so close that failure to attain any one of them could call into question attainment of the others.

4. Afforestation programme

The only way to establish a definitive system totally restricting water consumption is to abandon irrigation once and for all and compensate farmers for the loss of income.

The programme proposed by the General Community of Users of Aquifer 23 includes measures which could be considered environmental at a critical time for our planet, when destruction of nature is making giant strides (report by ADENA/WWF-Spain), with inestimable losses of forest cover throughout the world and a steady increase in demand for food from a constantly rising population (which multiplied by 2.6 in the second half of the twentieth century), resulting in ever-greater tracts of land being taken over for food production at the expense of forests.

Nor can we ignore the importance of the nitrogen content in the environment (UNO's Geo-2000 report) and in the soil as a result of indiscriminate use of nitrogenous fertilisers, which are degrading the natural habitat of flora and fauna.

Finally, there is the unremitting worldwide demand for water, with estimates showing that 20% more water than is available will be needed for the next 25 years.

The programme drawn up by the General Community of Users is a contribution to solving all these dramatic problems facing mankind in the short term, by cutting water consumption, creating woodland where none exists at present, and avoiding use of nitrogenous fertilisers. Added to this, the restoration of plant cover with indigenous species which have virtually disappeared today will lead to regeneration of the soil in the short term.

Consequently, it is a comprehensive programme looking, from different perspectives, at development of a particularly degraded area suffering from serious erosion, desertification, water pollution and over-consumption of nitrogenous fertilisers and which will result, with the aid of a single programme, in the creation of a natural environment more in tune with the future needs of agriculture in the area.

The plan proposes definitively ending irrigation of 40,000 hectares over a 20-year period (20,000 hectares in the first year, 10,000 hectares in the second year and 6,000 hectares in the third year) – with the aim of creating natural habitats in the future. This is clearly in line with the current trend in the European Union.

Finally, the lack of support for the Irrigators' Communities from the water authorities must be stressed. Any solution must be initiated by the stakeholders most affected, who are the users. This was the intention of the reform of the Spanish Water Act recently published in the light of the European framework, which considered it appropriate and established the possibility to conclude collaboration agreements between the water basin authorities and user communities for performance of specific functions, giving user communities the requisite economic and technical support.

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Voluntary Agreements for Water Protection: the case of Organic Farming in Weser-ems, Lower Saxony, Germany

Introduction by:

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Summary

This case study focuses on a rural region of north-west Germany, which forms part of one of the most intensive meat-producing areas in the world. The massive import of nutrients into the agricultural system has led to a steady nutrient surplus, which, combined with the area'' sandy soils has led to severe nitrate pollution of groundwater used to supply drinking water. Since buying and afforesting land to protect water supplies was not a practical option, one drinking water company began entering into voluntary land use agreements with farmers, focusing on the application of organic farming methods in its water protection areas. From 1993, the company tested the impact on groundwater quality of conversion to organic farming methods in one of its water protection areas. Nitrate levels in the groundwater underlying the fields fell from 125 mg/l in 1993 to 18 mg/l in 1997. The trial area is now part of a 100 ha certified organic farm. (Note: the following two papers – by H. Seul and G. Peek – present the perspectives of the consultancy company engaged to work with farmers, and of one of the farmers concerned).

1. Introduction to the study area

With its tendency to deeply interfere with natural water and nutrient cycles, agriculture often proves a difficult partner for water operators. Even more so, since during the last three decades, the search for unpolluted water resources has led drinking water suppliers to turn their backs on rivers and to rely more and more on groundwater in rural regions. This development has been especially pronounced in Germany. Here, water suppliers are asked to go beyond the quality standards of the EU drinking water directive for two reasons. Firstly, the minimisation principle in the German drinking water law requires them to supply the best possible water. Secondly, German consumers generally expect that the water supplied at the tap should be naturally pure and free of pollutants.

This case study concentrates on a rural region in the north-west of Germany, in the state of Lower Saxony. The area is located between the rivers Ems in the west (which is the border with the Netherlands) and the Weser in the east. Here, life and landscape are dominated by agricultural activities. The lowlands, often former bogs, have been turned into fertile grain fields. The German north west has also developed into one of the most intensive meat-producing regions of the world. It has made use of its proximity to the sea: animal fodder from Thailand and Brazil can be transported to the farms cheaply via rivers and shipping canals.

The massive import of nutrients into the agricultural system has led to a steady nutrient surplus, much of which was shed as slurry on the region's farmland – 2.7 million cubic metres in 1987. Together with a rapid increase in the use of fertilisers over decades, the capacity of soils and plants to absorb and recycle these nutrients was far exceeded. The situation is aggravated by the nature of the soils in the region: mostly sandy soils with little or no capacity to retain nutrients. As a result, nutrients have been washed into the groundwater, raising nitrate concentrations to extremely high levels.

2. Impacts of agriculture on groundwater abstraction

Water operators who are relying 100 per cent on groundwater in this region, had to abandon the topmost layers of groundwater and turned to strata 30 to 50 metres deep. However, the nitrates quickly moved into these deeper strata, and observing the 50 milligrammes per litre drinking water standard became increasingly difficult. With no other resources to turn to – the next deeper levels of groundwater not being sufficiently plentiful – it was obvious that the agricultural practices in the region weren't compatible with suppyling clean drinking water.

One water supplier in the region suffering heavily from increasing groundwater nitrate levels is Ostfriesisch-oldenburgische Wasserversorgungsverband (OOWV). It is owned and controlled by the municipalities of the region and serves about 850,000 people. It supplies about 70 million cubic metres of drinking water per annum which makes it the largest water supplier in the region. OOWV has committed itself in its company principles to protect the regional groundwater in order to secure long-term supply from this resource. In some cases, it has resorted to actually acquiring and afforesting the land around its wells to avoid further agricultural pollution.

However, to effectively protect its wells, OOWV would have to buy more than a quarter of the total land surface in the region – an impossible strategy. The only viable option is to change farming patterns to make them compatible with the supply of wholesome drinking water. However, in a region so entrenched in farming, changing agricultural practices on a large scale encounters considerable resistance.

It is obvious that change first needs to happen where the impact of agriculture on drinking water resources is most pronounced. These are the areas in the direct vicinity of the wells – the so-called *water protection areas*. Under German law, only limited human activities are allowed in water protection areas. Consequently, wherever possible, they are located in natural or forested areas. However, in the Weser-Ems district, where OOWV operates, 84,000 ha (59%) of the 143,000 ha of water protection areas are in agriculture use. Some of the water protection areas around OOWV's wells are actually located in the midst of the intensive meat producing area of Süd-Oldenburg. Even the strict legislation applying within the water protection areas has not impeded massive inputs of nitrates into groundwater. In 1989, the OOWV wells around Holdorf contained 144 milligrammes of nitrate per litre. Outside water protection areas, levels as high as 600 milligrammes per litre were regularly found in drinking water wells.

This rise in nitrate levels is due partly to inappropriate legislation, but also to a lack of official control. The legal limits set for the use of fertilisers and slurry are difficult to monitor. With water and agriculture authorities suffering from decreasing state funds, an efficient control system cannot be maintained and water suppliers complain that authorities do not adequately protect their water resources. The situation is aggravated by the wider developments in the EU Common Agricultural Policy. New incentives for further intensification of agricultural production were and are continually created by falling product prices, and the farmers in the Weser-Ems region naturally reacted to the changing situation.

Politically, water supply is clearly treated as secondary to agricultural production, and for years, the suppliers found virtually no support in the government. The situation changed in the mid-1980s when environmental NGOs launched major campaigns on the deteriorating state of drinking water resources. The antagonism between some forms of agricultural production and the supply of wholesome drinking water came to the attention of the general public through the NGO campaigns. Initially, not all water suppliers supported these campaigns because they feared for the good reputation of their water. Meanwhile, however, they realised that public awareness is a necessary precondition for changes in the political arena.

It is difficult to say how much pressure the NGO campaigns actually created, but the adoption of the Nitrates Directive (and also the Directive on the Placing on the Market of Pesticides) occurred at the time of maximum campaign activities. Both directives improve the protection of groundwater and surface water resources. The preferred strategy of the farming lobby, namely to lower the standards for drinking water, particularly for pesticides, has so far been fended off not least with the assistance of NGOs.

3. Voluntary agreements between water suppliers and farmers

In view of the sobering experiences with implementation of existing water legislation in Germany, water suppliers prefer not to rely on the complete and timely implementation of the Nitrates Directive alone. Many suppliers throughout Germany have decided to take improvement of water protection into their own hands. They began to enter into negotiations with farmers. This was the beginning of *voluntary agreements* between water operators and farmers – though it must be said that they aren't quite as voluntary on the part of the water operators. After all, they are obliged by law to meet the requirements of the drinking water directive, yet the political circumstances mean their sources are inadequately protected.

Many different forms of cooperation between farmers and water operators have been on test throughout Germany, with hundreds of voluntary agreements in existence today. They concentrate on the most vulnerable groundwater resources in the water protection areas and basically always aim at lowering the farming intensity on the respective land. In exchange, farmers are paid an agreed sum to compensate for eventual economic losses. The money comes from either the supplier itself – and hence finally the water consumers – or from the state. Most German Länder (states) have introduced levies on the extraction of groundwater which in turn are used for protective measures in water protection areas. Measures range from zero agricultural activity on the respective land to minor changes in land use.

OOWV decided to focus on the application of organic farming methods in its water protection areas. The decision was the result of encouraging field trials with organic farming on the typically sandy soils of the region. From 1993, OOWV tested the impacts on groundwater quality of conversion to organic farming methods in one of its water protection areas (Thülsfelde). Nitrate levels in the groundwater underlying the fields fell from 125 milligrammes per litre in 1993 to 18 milligrammes per litre in 1997 (pesticide levels also fell). The trial area is now part of a 100 ha certified organic farm.

The next step may seem a rather bold one. OOWV focused on the most difficult area, the district of Süd-Oldenburg with its intensive meat production and conservative farming community. If organic agriculture makes it there, it makes it anywhere. Statistics show that organic farming is under-represented in the Weser-Ems region, with only 0.25 per cent of the farming area compared to 0.81 per cent in the whole of Lower Saxony and more than 2.0 per cent in Germany. These figures reveal a major potential for organic agriculture in the Weser-Ems region, especially since German organic farmers cannot yet satisfy the EUR 2 billion domestic demand for organic produce.

The difficulty that OOWV had to overcome – and it is here that it asked CREAM consultants to assist them – is that organic farming methods are difficult to apply to voluntary agreements. The main reason is that farmers normally only enter into voluntary agreements with a fraction of their land. Changing part of the farm to organic practices is unattractive, because to be able to use one of the recognised organic labels, organic farming methods must be applied on the entire farm. Many farmers still shy away from the decision of total conversion.

The Biopool project started by CREAM and OOWV in 1997 focused on 54 farms in 11 different water protection areas. It aimed to create incentives for farmers with land in water protection areas to convert to organic methods. The following papers present a novel and successful strategy for water suppliers to reconcile the specific difficulties of voluntary agreements and the potential of organic farming. This promises to show not only the way forward for clean water, but also for improved environmental and food quality.

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Voluntary agreements for water protection: The case of organic farming in Weser-Ems, Lower Saxony, Germany

The perspective of:

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Summary

Owing to the adverse impacts of increasingly intensive farming within a water protection area, a programme was initiated to encourage and enable farmers to make a transition to ecological farming practices (see also introductory paper by K. Lanz and following paper by G. Peek). This paper summarises the development of the programme from a pilot phase in 1993 to widespread implementation in the Weser-Ems region at the beginning of 1993. The joint approach to problem-solving and the development of a four-stage transition process for conversion to organic farming are highlighted as key factors favouring the success of the programme.

1. Introduction: the impact of intensive farming on groundwater

The water protection areas in the 12 rural districts within the Weser-Ems administrative district of Lower Saxony, Germany, cover an area of roughly 143,000 hectares. Of this a total of 59% (84,000 ha) are used for agricultural purposes.

Here, more than 40 water suppliers abstract drinking water, almost 90% of this from groundwater. Supplying an area of 7,534 km^2 the Oldenburg-East Frisian Water Association (OOWV) is the supplier serving the largest area in the region and is one of the major water suppliers in rural Germany. The roughly 50 million m^3 extracted by the OOWV each year meet the water consumption needs of one million people.

Since its water protection areas are in a region with the highest cattle population per hectare in Germany – the ‘South Oldenburg’ intensive farming region – some of the OOWV's waterworks lie within one of the most important agricultural regions in the country. Roughly 6% of the farms rear every second battery chicken, every third laying hen and every fifth pig in Germany on 5.62% of its land area.

Thus, in 1987, in the Vechta rural district alone, 871,000 m^3 of liquid cattle manure, 1,412,000 m^3 of liquid pig manure and 484,000 m^3 of liquid chicken manure and 12,000 t of poultry dung were produced and then disposed of on agricultural land.

However, the predominantly light, sandy soils can only retain limited amounts of nutrients in their upper layers. In the 1980s this led to increasing nitrate pollution of the groundwater near the surface and also in the untreated water from extraction sources, including those of the OOWV that has caused some concern. An investigation in 1987 revealed residual nitrogen contents of, on average, 155 kg/ha of N. In some areas there were even more than 250 kg/ha N. However, in order for groundwater concentrations not to exceed the threshold of 50 mg/l of NO_3 a residual nitrogen content no higher than 35 kg/ha N would be needed. Thus, the nitrate content of the groundwater forming beneath agricultural land calculated for the winter of 1987/88 was 220 mg/l.

2. Cooperative efforts by the water and farming sectors

In spite of the seriousness of the problems outline above, a reversal proved to be possible in the 1990s as a result of close cooperation between the water industry and agriculture. A decisive factor in that success was the dialogue principle and that of reconciling practical cultivation practices.

A further, new, instrument here is ecological agriculture, which had been defined legally throughout the EU by Regulations 2092/91 and 1884/1999. By dispensing with the use of chemical pesticides, quick-dissolving mineral fertilisers and stock rearing that depends upon farm surface areas, this makes a practical contribution to preventive groundwater protection.

The OOWV had established the effectiveness of this approach in a pilot project between 1993 and 1997. The OOWV converted a 30 ha test area to ecological agriculture in the 'Thülsfelde' WCA, and recorded the sequence of nitrate values in the percolating water. In addition, the horticultural and economic potential of ecological farming in water-extraction areas was examined. Since the 1993 conversion, the nitrate values constantly fell from 125 mg/l (1993) to 18 mg/l (1997) – see Figure 1. The previous project areas now form part of a biofarm covering roughly 100 ha.

However, these ecological achievements only influenced a very small area. So far ecological agriculture, accounted for only 0.25 % of the land surface area in the Weser-Ems region (as compared with 0.81% in Lower Saxony and 2% in Germany as a whole).

3. The Biopool Programme

With support from the Lower Saxony Ministry for the Environment and the Weser-Ems district administration, the Oldenburg-East Frisian Water Association (Brake) and CREAM Consultants (Oldenburg) have developed a tool that has persuaded local farmers working land in water abstraction areas to opt voluntarily for ecological farming.

Answers were sought to three core questions:

- Can farmers with land in water conservation/priority areas be made interested in converting to ecological agriculture?
- Can a viable design for conversion be developed for the use of ecological agriculture in water conservation/priority areas?
- Is there adequate market potential for the resultant products?

The Biopool programme was developed and tested by CREAM consultants. It successfully enabled interested farmers be motivated and qualified for the ecological farming of water conservation land.

Three aims were thereby achieved:

- raising interest and commitment to groundwater conservation via ecological agriculture;
- making a gradual approach towards conservation possible;
- generating competence in production technology and market strategies.

The programme used a practical offer in order to reach conventional farmers operating in water conservation areas. A total of 54 farms in 11 water protection areas were advised on ecological farming in such areas by six water suppliers. During the pilot stage a total of 13 farms converted 415 ha of water conservation land to ecological farming (265 ha EU, 170 ha EFC). In addition, five out of the 11 small-scale food processors/companies in the food industry having received advice were certified to produce/process ecological products. The Weser-Ems regional administration introduced Biopool throughout the region on 1 January 2000. Since then, roughly

20 water suppliers have declared involvement in the programme. At the moment 690 ha are under ecological farming. In addition, the Biopool principle has been included in a new EU co-financed support Directive adopted by the Lower Saxony Ministry for the Environment. This is currently before the European Commission for approval. If the latter gives the go-ahead for this Directive all farmers in water conservation areas in Lower Saxony will in future be able to enter into contracts with the water suppliers for ecological farming of water conservation land.

In addition, the Biopool programme implements the "improvements to agricultural advice concerning the conversion to ecological agriculture" and "increased support for ecological agriculture by means of cooperation agreements between farming and water management" recommended throughout the Federal Republic of Germany by the Federal Environment Agency in the action plan entitled 'Sustainable water management'.

The Biopool programme functions in four stages, as shown below:

The 'Biopool' conversion and advice programme

Stage 1
Information – Motivation – Advice

▼

Stage 2
Conversion of water abstraction areas
to ecological farming

▼

Stage 3
Introduction of market cooperation

▼

Stage 4
Farm conversion to EFC standard

Initially the farmers affected are informed and advised on the spot. This concerns the general inter-relationships, strategies and Directives applying to ecological agriculture, and prominence is given to farm planning and economies. First of all the amount of groundwater conservation taking place is given precedence in the practical conversion to ecological farming of individual pieces of land in water abstraction areas. Moreover farmers are only exposed to low risk when gaining their initial practical experience. Thus, as enshrined in the regulation, land management quality is monitored by State-appointed inspectors. Furthermore the farmers involved gain an insight into the markets for bioproducts from further training courses. The aim of this is to provide practical contacts and cooperation with partners in the market. Produce complying with EU Directives will thus be sold exclusively to the processing industry and not to the final consumer. The practical work that they themselves do within ecological farming, together with outside advice given, are specifically intended to foster self-help among those involved; the farmers involved may – wherever permitted by their operating conditions – extract more value from their farms and secure more lucrative distribution outlets by joining supra-regional associations and brands such as recognised ecological farming associations (Bioland, Biopark, Demeter, Gäa, Naturland, etc.) or by availing themselves of the new standardised Federal 'eco-label'. Thus, in 1999, farmers selling Biopool ecograin earned incomes that were between 30 and 100% higher than those from conventional products. The conversion of all farmland – including that outside water conservation areas – to ecological farming concludes a further positive development.

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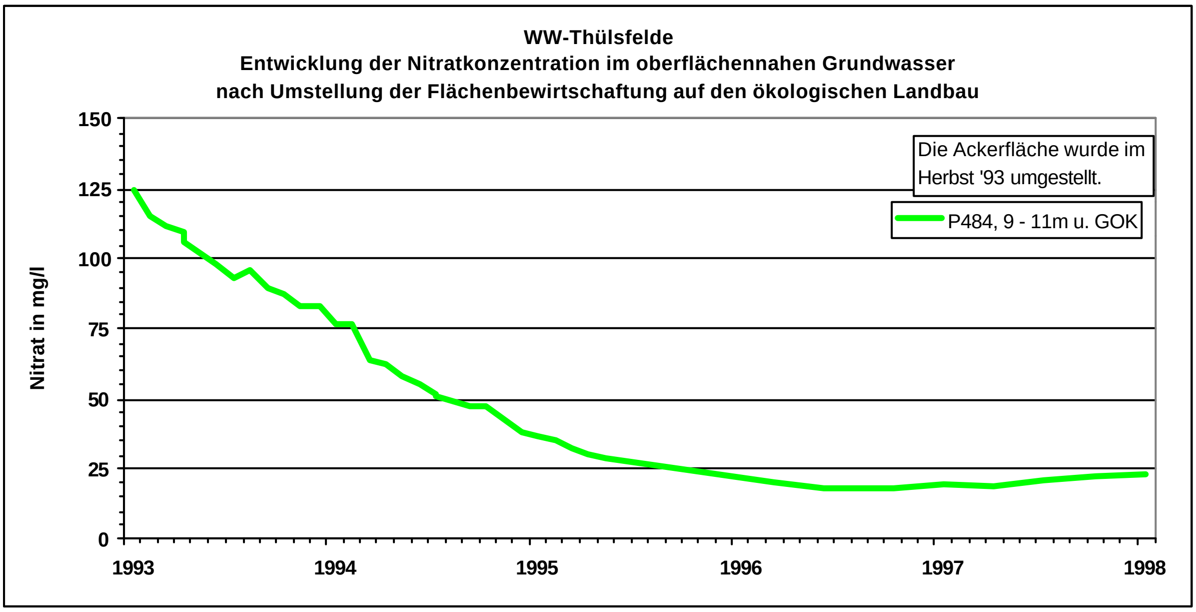
Figure 1. Changes in the nitrate concentrations in sub-surface groundwater following 1993 land-use conversion to ecological farming



Voluntary agreements for water protection: The case of organic farming in Weser-Ems, Lower Saxony, Germany

The perspective of:

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Summary

Owing to the adverse impacts of increasingly intensive farming within a water conservation area, a programme was initiated to encourage and enable farmers to make a transition to ecological farming practices (see also preceding paper by K. Lanz and H. Seul). This paper presents the experience of one farmer who has participated in the programme. The importance of a phased transition, which enables farm income to be maintained without undue risk, is underlined.

1. Introduction

After an agricultural apprenticeship and two years at the vocational school, I took over my parents' farm in Molbergen-Grönheim, a small locality near Cloppenburg in Weser-Ems (Lower Saxony, Germany) in 1990.

The farm consists of 70 hecatres of arable land in the Thülsfelde water conservation area (WSG). I took over mixed farming with sow-rearing, bull and pig fattening.

However, the market forced us to specialise. In 1992, for cost reasons, we gave up the rearing of 40 breeding sows in favour of pig fattening. As a result of the EU's Common Agricultural Policy (CAP, 1992) this was constantly expanded up to 1996/97. This was achieved by building or leasing new fattening facilities.

In 1995, we gave up bull fattening, despite the 110 animals involved, in order to intensify further. Those operations had caused our arable farming to become very intensive, which then became a cause of conflict with the water supplier. The crop rotation included a very high proportion of silage maize, but this was later replaced by winter grain.

In the early 1990s the nitrate values measured around the farm were constantly rising. This had even become a problem for agriculture.

At the time, the water supplier was increasingly emerging as a competitor for land, buying it up in order to remove it from intensive agriculture and convert it into woodland. This pushed rents upwards. It then became almost impossible for farms such as mine to lease further land and expand their pig stocks.

Because of the situation in which the agricultural economy found itself, farms had to be operated intensively and grow in size. Conversely, the water situation required extensification to protect groundwater – an almost insoluble dilemma.

The inevitable consequence was conflicts of interest between farmers and water suppliers.

2. Conversion to organic farming in the framework of the Biopool Programme

In 1993, this situation led to close cooperation between farmers, rural district councils, administrative-district authorities and the water industry. It was intended that a consensus would then be found concerning an agricultural practice that met the requirements of both agriculture and the water industry. I myself represent agriculture as part of the cooperation in our water conservation area in Thülsfelde.

In 1998, I became familiar with the Biopool Programme through the water supplier. CREAM Consultants were developing that programme on behalf of the Lower Saxony Ministry for the Environment. Its purpose was to examine whether the positive effect of ecological agriculture on nitrates could be a practical vehicle for its widespread adoption and use in water conservation areas, and if this were the case, how it could best be achieved.

I then took part in Biopool tenders from early 1998 onwards, thus for the first time coming into contact with ecological agriculture. This meant that for the first time I became aware of the principles and potential of ecological agriculture.

Biopool made it possible for me gradually to approach the ecological management of my water conservation areas.

In their directives the German ecological agriculture associations categorically require conversion of the entire farm as the first stage.

However, that was completely impossible in my case since my farm needed every inch of space to continue being viable for intensive pig-fattening. Conversion of the entire farm would have entailed an enormous, unthinkable risk.

Nevertheless I wanted to acquire more specialist knowledge and above all my own practical experience in ecological farming.

Through a four-stage plan, the 'OOWV' (water-supply board) provided scope for initially converting only some of the land within the WCA to ecological production, thereby enabling the operational risks attached to my entry into ecological farming to be reduced considerably.

Thus in addition to my pig-fattening operation, I have been able to farm some hectares of arable land in the Thülsfelde water conservation area in an ecological manner.

Biopool gave me advice and support, via production techniques, from the seed procurement stage right up to the marketing stage. I was in this way able to acquire initial impressions and experience of ecological farming at low financial risk.

The result amazed us since, even in the first harvest after conversion the yield from the ecologically farmed land was considerably higher than from my conventional arable land.

A further advantage of the Biopool Programme is that, once initiated, I myself can now determine the rate of my further conversion.

This will then become meaningful for both myself and several of my colleagues if this can be substainable in farm management terms.

3. Future developments

However the background conditions applying to my conventional operations have become less and less favourable. Conventional pigmeat prices are falling. There is no prospect of any improvement in the immediate future. However, since I have now been specialising in pig-fattening, the way is clear for improved earnings from those operations. However, the scope for expansion is very limited in view of the small land surfaces available. Furthermore, the environmental directives arising from the Thülsfelde WCA's regulatory procedure are being made still more stringent.

Because of the above I am currently considering transferring all of my land area to the Biopool Programme and for several months I have been discussing various conversion and operational options with CREAM Consultants. Together we have already conducted various calculations for various scenarios.

The gradual conversion of my entire farm could be as follows:

- Reducing my pig stock from 2,000 to 1,200;
- Dispensing with the leased sties;
- Using a paid contractor to dispose of surplus slurry;
- Ecological farming of all arable land;
- Reducing conventional pig stocks during conversion and cessation of conventional pig-fattening;
- Building up ecological pig stocks following conversion and the commencement of ecological pig-fattening.

In order to market the ecologically-grown products, especially grain, in an optimum manner, I would like to invest in a grain store with drying facilities, since only optimum marketing can secure long-term profits.

If the developments proceed as planned these will lead to specialised biopig fattening, fully compatible with location in a water conservation area, in contrast to the adverse location of the former, conventional operation.

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Annex II. Seminar Programme

Thursday 10 February 2000, 9:00 - 17:30

9:00-9:30	**Registration and coffee**	
9:30-10:00	**Welcome and introduction to the water seminar series**	Julian Scola, WWF European Policy Office Tony Long, WWF European Policy Office Helmut Blöch, European Commission
	Introduction: Context and purpose of the Water and Agriculture seminar	Jane Madgwick, WWF European Freshwater Programme

10:00-12:45	**SESSION 1: IMPACTS OF AGRICULTURE ON WATER RESOURCES**		
10:00-11:00	**Summary overview presentation**	Review of the impacts of agriculture on water resources	Steve Nixon, European Environment Agency-Topic Centre on Inland Waters
	Case study presentations	Desertification and salinisation in the Alentejo region, Portugal	Eugenio Sequeira, Liga para a Protecção da Natureza, Portugal
		Assessing nutrient inputs and their impact in catchments, UK	Geoff Phillips, Environment Agency, UK
11:00-11:30	**COFFEE**		
11:30-12:45	**Case study presentations (ctd.)**	Impacts on water resources in view of agricultural change scenario upon accession in Bulgaria, Hungary and Romania	Henk Kieft, ETC Consultants, The Netherlands
	General discussion		**Chair**: Helmut Blöch, European Commission

12:45-14:15 **LUNCH**

14:15-14:25	**Synthesis by Rapporteur of Session 1**	Annali Bamber Jones, WWF European Agriculture and Rural Development Programme

14:25-17:20	**SESSION 2: MEASURES FOR INTEGRATING WATER AND AGRICULTURE**		
14:25-15:05	**Summary overview presentation**	Policy instruments for integrating water and agriculture	European Commission
	Case study presentations	Groundwater nitrate reduction in the Styria region, Austria	Günther Suette, State Government of Styria, Austria
15:05-15:35	**COFFEE**		

15:35-17:20	**Case study presentations (ctd.)**	The role of forestry in mountain-river basin management: The experience of the Trento autonomous province, Italy	Mauro Confalonieri, Trento Regional Authority, Italy
		Vindeläven river delta management at Ammarnäs, Sweden	Ola Jennersten, WWF European Agriculture and Rural Development Programme
		Role of economic instruments - Mediterranean examples	Alberto Garrido, Universidad Politécnica de Madrid, Spain
	General discussion		**Chair**: Tony Long, WWF European Policy Office

20.00-23:00 **DINNER**

Friday 11 February 2000, 8:30 – 16:00

8:30-8:40	**Synthesis by Rapporteur of Session 2**	Pierre Strosser, European Commission

8:40-12:40	**SESSION 3: INTEGRATING WATER AND AGRICULTURE THROUGH RIVER BASIN MANAGEMENT: A PRACTICAL EXERCISE**		
8:40-10:25	**Case study 1 practical session** Las Tablas de Daimiel: The case of a protected area in the upper Guadiana basin Castilla-La Mancha, Spain	Format	Julian Scola, WWF European Policy Office **Chair**: Josefina Maestu, Mediterranean Water Network, Spain
		Introductory note	Guy Beaufoy, ARPA, Spain
		Speakers, presenting the point of view of the different stakeholders	Jose María Sumpsi, Universidad Politécnica de Madrid José Ramón Aragón, Confederación Hidrográfica del Guadiana Araceli Olmedo, Comunidad General de Usuarios del Aquífero de la Mancha Occidental
		Questions & general discussion	**Chair**: Josefina Maestu, Mediterranean Water Network, Spain
10:25-10:55	**COFFEE**		

10:55-12:40	**Case study 2 practical session** Voluntary agreements for water protection: The case of organic farming in Weser-Ems, Lower Saxony, Germany	Format	Julian Scola, WWF European Policy Office **Chair**: Hilmar von Munchausen, WWF European Agriculture and Rural Development Programme
		Introductory note	Klaus Lanz, International Water Affairs, Germany
		Speakers, presenting the point of view of the different stakeholders	Heinrich Seul, CREAM Consultants, Germany Gerd Peek, organic farmer, Weser-Ems, Lower Saxony, Germany
		Questions & general discussion	**Chair**: Hilmar von Munchausen, WWF European Agriculture and Rural Development Programme

12:40-14:10 **LUNCH**

14:10-14:35	**Synthesis by Rapporteurs of Session 3**	Guy Beaufoy, ARPA, Spain Klaus Lanz, International Water Affairs, Germany

14:35-15:50	**SESSION 4: PRESENTATION OF MAIN POINTS AND DISCUSSION OF A SYNTHESIS NOTE FOR THE SEMINAR**	**Chair**: Gordana Beltram, Ministry for the Environment and Spatial Planning, Slovenia Facilitator: Tim Jones, TJEnvironmental, Switzerland

15:50-16:00	**CLOSE**	Helmut Blöch, European Commission Jane Madgwick, WWF European Freshwater Programme

Annex III. Water and Agriculture in Poland

The following paper was contributed as an addendum to the Seminar Proceedings by three Polish participants: ***Dorota Chmielowiec*** *representing the Lower-Silesian Foundation for Sustainable Development (NGO),* ***Wieslaw Dembek****, of the Department of Nature Protection in Rural Areas, Institute for Land Reclamation and Grassland Farming (IMUZ); and* ***Marta Kaczynska****, Regional Environmental Centre for Central and Eastern Europe (REC)*

The opinion given below was formulated by the three Polish participants in consultation with a number of experts on agriculture and water issues.

1. Polish water policy

The situation with regard to water policy in Poland can be characterised by the following key points:

- Poland belongs to those European countries which are not rich in freshwater resources (1,600 m^3 of surface water/person, which is 1/3 of the European average);
- The limited amount of fresh water and a significant level of water pollution are the cause of regional problems which may limit further economic development;
- Although the amount of pollution discharged into rivers has decreased within the last few years, significant improvement in water quality has not been achieved;
- Compared to other European countries, water management in Poland is inefficient, water is wasted and the situation is unlikely to change much in the near future;
- The main obstacle to effective water management (according to the Polish Parliament's Commission on Environmental Protection) is the lack of a National Strategy (currently in preparation) and lack of adequate updates to the Water Law; the last changes made to the Water Act (1997) were of minor significance and did not refer to an integrated water management approach;
- Several components of the Water Act (regulating management of water resources) presented by the Ministry of the Environment were criticised by both members of the Parliamentary Commission and a group of consultative experts. Neither the Water Act nor the National Strategy on Water Management have been open to public consultation;
- The lack of a National Strategy on Water Management has resulted in quick decisions on strategic investment plans for the two biggest rivers – Oder and Vistula – being made by the Polish Minister of the Environment.

Negotiations on EU Accession should include discussions on how to avoid instances of inappropriate decision-making in situations when there is a lack of information or a gap in the national law. According to EU legislation, such instances require a formal procedure including: consideration of all possible options; assessment of economic and social consequences; an environmental impact assessment; and public consultation. It is important that EU Accession countries adhere to EU rules before formal integration into the European Union.

2. Specifics on Polish agriculture

Characteristic features of Polish agriculture which relate to environmental protection, including the impact on water resources, include:

- Agricultural land with settlements covers nearly 70% of the total area of Poland;
- Rural communities make up a significant percentage of Polish society: 23.3% of the population are employed in approximately 2 million individual farms (1998), while 29.9% of people are connected with agriculture (1996). Thus farmers form a strong interest group which is able to lobby and influence political decision-making in the country;
- Lower average intensity of agricultural production in Poland than in the EU: e.g. cereal harvests per hectare are now equivalent to that in France or Germany at the end of the 1960s. Agricultural production depends on natural soil fertility (see table):

Soil Class	Soil Quality	% of land area
I	excellent	0.4
II	very good	2.9
IIIa	good	10.0
IIIb	good	12.3
IVa	medium	22.4
IVb	medium	17.4
V	poor	22.7
VI	very poor	11.9

- Complexity and liability of ownership: following the collapse of the cooperative farm system, 92.3% of agricultural areas belong to private owners (including 83.7% as individual farms), while 7.7% of the area is owned by the state (1999);
- A significant amount of relatively small, privately owned farms: the majority of small farms are less than 5 ha in size, with an average farm size of 7.7 ha (1998). The size of farms may have both positive and negative implications: while the ownership structure is more 'environmentally friendly' compared to EU in that it creates a rich landscape mosaic of fields, at the same time this makes environmental protection more complicated and difficult to achieve. Agriculture characterised by the big number of small farms is a specific feature of land use in Poland, quite different from other post-communist countries and the EU. However, over the last few years the trend in development in agriculture has been following the EU pattern, with the number of farms decreasing and the average size of farm growing;
- A diversified level of development as a result of historical and cultural processes: farming is traditional in the western part of the country (similar to western countries), but is much less practised in the eastern part;
- Abandonment of agricultural areas: areas of poor quality soils or agricultural land in remote locations are being abandoned by farmers because of low income from crop production, particularly in north-east Poland;
- Economic difficulties: following the regression of agricultural production in the 1990s, the use of pesticides and fertilisers has been 2-3 times lower than in EU countries, resulting in much lower nitrogen levels and average pesticide loads on arable land;
- Ineffective use of fertilisers: this has resulted in high levels of nutrient leakage from fertilisers; e.g. the effectiveness of nitrogen use from artificial fertilisers does not exceed an average of 13%, meaning 1.3 million tons of nitrogen per year wasted, polluting water and air (1997);
- Problems with the quality of drinking water, particularly in rural areas: e.g. about 35% of the people living in the catchment of the Vistula River (which covers more than 50% of Poland) are supplied with water from wells located in their households, 50% of which do not meet Polish standards of water quality or sanitation;
- About 95% of rural households do not have appropriate facilities to collect and store stable and liquid animal manure;
- In rural areas, 70% of dumping sites are so-called 'wild waste dumps' – unauthorised dumping grounds which can contaminate surrounding land and water;

- Areas of extensive farming (owned by individual families) are the richest in terms of natural features and biodiversity: these areas, mainly in the eastern part and in uplands, are very little fertilised, but unfortunately often on the verge of bankruptcy, in either economic or biological terms;
- Unusual diversity, in the European context, of hydrological types of grassland, related to climatic and geo-morphological zones in Poland;
- A significant physiological diversity of agricultural areas, rich in relief from seashore depressions to great valleys, to upland meadows;
- Very poor water and sewage treatment facilities and management, particularly in extensive farming areas which are potentially rich from a nature and landscape point of view;
- Irrigation systems in very bad condition: 36.2% of agricultural areas are drained; 48% of wetland habitats are partly drained; 80% of drainage is caused by regulation of rivers and the construction of channels and ditches. Irrigation of land in Poland hardly occurs, resulting in very high losses of water through passive run-off through drainage systems.

3. Agriculture and water resources

1) From an environmental perspective, the situation in Poland's agricultural sector is better than the average found in countries of the European Community, including impacts on water resources; and Poland's rich water ecosystems have not been as severely damaged by deterioration and regulation as has occurred in Western Europe. The EU policy toward Poland and other accession countries should ensure that in the process of integration, the situation will not change for the worse. The Water Framework Directive should enable implementation of policy and economic instruments in terms of agriculture and water resources protection. Extensive and organic agriculture and the maintenance of a diversity of wetland types and areas instead of the construction of large water reservoirs should be priority areas.

2) There is a lack of the 'polluter pays' mechanism in Poland's national water and agriculture policy and legislation, in particular in terms of agricultural impact on surface water resources. Agricultural interests are not legally responsible for damage caused to water resources. For example, it is estimated that agriculture is responsible for 40-70% of the pollution flowing into the Baltic Sea (at present there is no inventory or monitoring of sites and pollution flows in water catchments). Most of the pollution comes from agricultural companies and large farms, neither of which are obliged to cover the costs of building water purification or protection systems. The Precautionary Principle should be a priority in water resources management. One of the main tools for prevention should be an economic mechanism by which the user pays for exploiting and destroying resources.

3) Integrated water management within catchments is still not practised in Poland. The competencies of the different institutions overlap and are not clear; e.g. government agencies are only responsible for riverbeds, while other bodies take care of riverbanks or the areas between the two. Decisions made by local or regional authorities are not complementary. There is no coordination of activities within catchments. An integrated approach to water management within catchments is needed as quickly as possible (before formal integration with the EU). There is also a need for obligatory strategic environmental impact assessments for such catchment plans; at present, individual environmental impact assessments are carried out only for some local initiatives/investment schemes, such as dams.

4) With 23.3% of the Polish population employed in approximately 2 million individual, mostly small farms, in order to minimise the negative impact of agriculture on water resources, it will be necessary to develop rural employment policies as well as agri-environmental schemes which help

farmers adapt to new situations and to generate income from other activities (e.g. tourism, organic farming, and small business ventures).

5) In view of the high number of people (farmers) who have a direct impact on the quality of the environment, education in environmentally friendly agricultural practices, organic farming, storage and use of natural and artificial fertilisers must be a priority in Poland.

6) Agricultural waste is produced mainly in farms, and the major source of pollution is inappropriate storage and use of animal manure. However, it must be stressed that in spite of problems in the quality of water, from an environmental perspective Polish agricultural products are still of a high quality. This results from the low use of artificial fertilisers, the high percentage of organic fertilisers in the total amount used, and the still popular Polish traditional methods of farming. These approaches and behaviours should be maintained.