AGRO-ENVIRONMENTAL POLICY IN GERMANY

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For a long time, agriculture in Germany was, or at least seemed to be, in a harmonious relationship with the environment. However, this harmony dwindled during the last two decades. In order to increase agricultural productivity and to ensure farmers a fair standard of living with its Common Agricultural Policy (CAP), the European Community (EC) supported agricultural market prices at levels considerably above those prevailing at the world markets. The resulting intensification and specialisation of agricultural production was, and still is, one of the main factors contributing to the serious problem of water pollution and soil degradation.

The public in Germany and in the European Community has become increasingly aware of the fact that agricultural activities always influence the environment, and often in a negative way. This public awareness developed after a considerable amount of damage had already been done. It was not only raised by the growing extent of soil and water pollution, but also by more sophisticated methods to detect traces of pollutants. Thus, today, amounts of pollutants can be measured that in many cases could not be discovered several years ago. In other words, the surveillance capability has increased to an extent that makes it possible to detect pollution problems that earlier would have passed unnoticed.

In order to reduce the negative impacts of agriculture on soil and water, various policy measures have been discussed and implemented in Germany as well as in the European Union (EU). This paper focuses on: the extent to which agriculture influences soil and water quality; general considerations on environmental policy instruments; the most important legislation and institutional settings concerning soil and water conservation in Germany; arguments for the fact that the Common Agricultural Policy of the European Union is likely to become slightly environmentally friendly in the future; the assessment of the effects of alternative water conservation strategies, using a regionalised agricultural sector model.

Agriculturally induced soil and water pollution in Germany

Soil erosion

The extent of soil erosion in Germany is not very well documented. This corresponds to the fact that soil erosion is no major problem in Germany.[1] The average soil loss per hectare of arable land is estimated to be 8.7 t/ha for the former FRG.[2] The corresponding figure for the former GDR amounts to 4.6 t/ha[3]. The minor importance of erosion in the former GDR is largely a result of natural conditions: the topography of the former GDR is characterised by a relatively low relief. Rainfall is also very low. For an area of nearly 500,000 ha of arable land located in the north-east of the former GDR, rather flat and with an annual rainfall between 470 and 570 mm, soil losses due to water erosion and wind erosion were assessed to amount to an average of 1.1 t/ha and 0.5 t/ha respectively.[4] As illustrated in the soil erosion atlas of *Baden-Württemberg*,[5] cited in Stahr and Stasch,[6] in a hilly state - *Bundesland*- located in the south-west of Germany, 5.5 t/ha of typical arable land are eroded per year in this state.

Water pollution

In many countries, as in Germany, modern and intensive agriculture causes several problems. In particular, the pollution of surface- and groundwater by nutrients, such as nitrogen (N) and phosphorus (P), and by pesticides has been a pressing issue.

Pollution of surface water

In the late 1980s the blooming of algae, which occurred at certain periods in the North Sea and the Mediterranean and which caused negative effects on ecology and tourism, placed eutrophication of surface waters on top of the political agenda. Thus, at the Third International North Sea Protection Conference in 1990, the countries bordering the North Sea committed them-selves to halving the nutrient stream into the North Sea by 1995 relative to 1985. According to a study by the German Federal Environmental Agency (FEA), however, Germany will only comply with this target with regard to phosphorus, whereas the nitrogen load - N-load - will be reduced by only 25 %, i.e. half the reduction required.7

For 1989/91 the FEA estimated the total nitrogen load of surface water in Germany to be 1.0 million tons of nitrogen (Table 1), 61 % of which originated from non-point sources and 39 % from point sources. Most of the non-point sources are affected by agricultural activities. With an estimated 0.4 million t N entering the surface water via groundwater, the latter is the most important non-point source. According to the FEA, in 53% of all surface waters N-pollution originated from agricultural areas. As regards the estimated load of surface waters with phosphorus, the corresponding figure amounts to 47%. Whereas erosion is of minor importance regarding N-levels, nearly one third of the total estimated P-load is effected by this source.

Table 1. Estimated load of surface water with nitrogen and phosphorus in Germany

	Nitrogen	**(1989/91)**	**Phosphorus**	**(1987/89)***
	1000 t N	kg N/ha*	1000 t P	kg P/ha*
Non-point sources				
Direct inputs	79	2.2	12	0.34
Atmosphere, litter	22	0.6	0.9	0.03
Drain	54	1.5	2.9	0.08
Erosion	73	2.0	31	0.87
Groundwater	400	11.2	1.2	0.03
Total non-point sources	630	17.7	48	1.35
Total point sources	410	11.5	52	1.46
Sum total	1040	29.2	100	2.80
*For the former GDR the years 1991/92 were taken **Per hectare of the entire land area				

Source: Projektgruppe Nährstoffeinträge (1994)[7]

Pollution of groundwater

Since agriculture is the most important non-point source of groundwater nitrate pollution and data on nitrate concentrations in groundwater representative for Germany are still lacking, N-balances are often used as a proxy for assessing the extent of pollution with this nutrient. In the former FRG, the average N-surplus increased from less than 25 kg N/ha in the 1950s to more than 100 kg N/ha in the early 1980s.[8,9] More recent development calculations, carried out with the Regionalised Agricultural and Environmental Information System (RAUMIS) indicate a significant reduction of the N-surplus from 1987 to 1991 - 85 kg N/ha as compared to 104 kg N/ha in 1987 (Table 2).

Regarding pollution by different farm types, Brower[10] provides information on N-balances. Based on the representative survey of farm types by the Farm Accountancy Data Network (FADN) of the European Commission their findings show that granivore farms have the highest average N-surpluses in Germany, 224 kg N/ha (Table 3), while cereal farms have the lowest, 96 kg N/ha.

According to a study by Niberg and Von Muenchhausen,[11] farm size, measured in ha or in standard farm income, is not correlated with the N-surplus. They surveyed 478 farms in the former FRG and 728 in the former GDR. In both parts, the differences in the level of N-surplus between regions are considerably higher than between farm size classes within one region.

Table 2. Nitrogen balances of the former FRG (in kg N/ha)

	1979	1983	1987	1991
Chemical fertiliser	113	117	131	117
Manure	101	109	109	105
Other N-input	35	35	35	34
Total input	249	260	275	256
N-removal with crops	-119	-125	-139	-138
Ammonia	-30	-32	-33	-32
Balance	100	103	104	85

Source: Weingarten (1996)[9]

Table 3. N-surpluses and distribution by farming types in the former FRG in 1990/91 based on FADN data (in kg N/ha)

	25% of farms with lowest N-surplus*	**50% of farms with medium N-surplus***	**25% of farms with highest N-surplus***	**all farms**
Cereal farms	73	94	115	96
General cropping farms	88	113	138	115
Dairy farms	101	127	163	129
Drystock farms	96	122	168	126
Granivore farms	172	**	**	224
Mixed farms	95	126	189	132
*In the case of granivore farms every category covers 33 % of all farms. **No data given, due to sample size falling short of 15 farms.				

Source: Brouwer et. al. (1995)[10]

Wendland et.al.[12] developed a model to trace nitrate flow in the groundwater in Germany at squares of 3x3 km. On the basis of hydrological, hydro-geological and agricultural data, maps with potential nitrate concentrations in the soil percolation water and in the spring water are drawn. It is demonstrated that variation of potential nitrate concentrations across the squares is more affected by different hydro- and hydro-geological conditions than by variation of N-surplus between agricultural areas. Nevertheless, this finding does not reduce the need for a general reduction of N-surpluses.

Based on the above mentioned N-surpluses for 1991, calculated with the RAUMIS model,[9] the potential nitrate concentration in the soil percolation water was assessed. According to this assessment the potential nitrate concentration is less than 10 mg NO_3/l for 10% of the total soil percolation water, between 10 and 25 mg NO_3/l for 21% and between 25 and 50 mg NO_3/l for 31%.

For the remaining 38% of the soil percolation water the potential nitrate concentration exceeded the maximum EU allowance of nitrate content in drinking water, which is fixed at 50 mg NO_3/l. On average, the potential nitrate concentration reaches 43 mg NO_3/l. In this assessment, only the N-surplus originating from agricultural areas is regarded as an input into the soil percolation water. Hence the figures quoted are likely to be even higher depending on the impact of other sources.

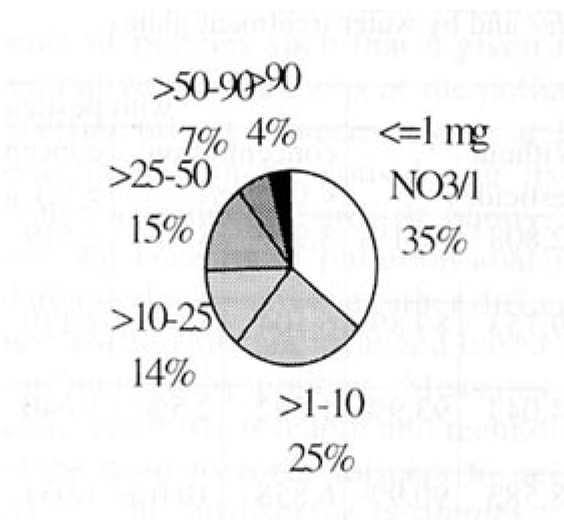

Figure 1. Distribution of the analysed nitrate concentrations in Germany in the early 1990s (LAWA, 1995)13

In 1995, a working group of ministries in the Bundesländer responsible for water management published a report on the quality of groundwater with regard to nitrate.[13] The report is based on some thousands of water analyses carried out in the last few years. It is, however, difficult to judge the representativeness of the results obtained. Some of the water samples originated from the surface near the groundwater while others were taken from groundwater in deeper aquifers. Some of the plots from which the samples were obtained, were located within areas intensively used by agriculture and some within areas where mainly naturally-caused nitrate inputs could be expected.

According to this report, more than one third of all water samples contained less than 1 mg nitrate/l and three quarters less than 25 mg nitrate/l (Figure 1). One quarter of the analyses showed significantly increased concentrations, caused especially by agricultural land use. The maximum allowance of 50 mg nitrate/l drinking water was exceeded by one tenth of all analyses, often correlated with using agricultural land for cultivating special crops, such as vegetables or fruit.

Although N-surpluses originating from agriculture have on average decreased in the last few years, increasing nitrate concentrations in groundwater are expected because of the actual N-storage in the soil and reduced capacities for denitrification in the aquifers. Thus, since the 1950s, in many water treatment plants, nitrate concentration has increased by 0.5 to 1 mg nitrate/l per year. How-ever, in some cases nitrate concentration has also stabilised since the late 1980s.[13]

Table 4. Number of pesticide detections in water reported to the Federal Environmental Agency by the Bundesländer and by water treatment plants

				with pesticide detection						
Reporting period	Reported analyses	Without pesticides		concentration < 0,1 µg/l		concentration > 0,1 µg/l		total number with pesticides	
Up to Dec. 90	49.736	42.808	86.1%	3.999	8.0%	2.519	5.1%	6.783	13.6%
Dec.90-Dec.91	77.673	69.756	89.8%	6.104	8.8%	2.170	2.8%	8.038	10.3%
Dec.91-Dec.92	68.219	64.043	93.9%	1.592	2.5%	1.640	2.4%	4.203	6.2%
Dec.92-Dec.93	75.472	68.583	90.9%	6.858	10.0%	1.031	1.4%	6.889	9.1%
Dec.93-Dec.94	60.564	57.539	95.0%	2.674	4.6%	691	1.1%	3.363	5.6%
Total	331.664	302.726	91.3%	21.227	7.0%	8.051	2.4%	29.276	8.8%

Source: Author's calculations on the basis of Umweltbundesamt (1995)[15]

Pesticide pollution

According to the EC Drinking Water Directive, established in 1980, the concentration of pesticides in drinking water is limited to 0.1µg/l of any chemical substance and to 0.5 µg/l of all substances together. In 8.8% of the 331,664 water analyses reported to the FEA between 1989 and the end of 1994, pesticides or their metabolites were found and in 2.4% of these analyses the detected pesticide levels exceeded the limit of 0,1 µg/l (Table 4).[15] However, the figures in Table 4 need to be interpreted with caution. It is not possible to draw conclusions from these figures on the overall pollution of both ground- and surface water with pesticides since the detection of, for example, 100 different chemical substances in one water sample is referred to as 100 reported analyses. Interestingly enough, although the use of atrazine has been prohibited in Germany since 1991, atrazine and its metabolites are responsible for three quarters of all pesticide detections. Several factors could cause this problem. Firstly, atrazine or its metabolites might still be stored in the soil and leached out into the groundwater. Secondly, regenerating polluted groundwater may be a long process. Thirdly, though de-registered, atrazine might still be applied. In some of Gemany's neighbouring countries farmers still are allowed to use it which makes it rather easy for German farmers to obtain this substance.

Environmental policy instruments - legislation and institutional settings

The problem of using environmental policy instruments consists in finding institutional arrangements or policies such that a given target of environmental quality is reached by the individual decisions of the polluters.[16] Thus, in order to protect soil and water efficiently it is necessary to at first define the desired degree of environmental protection by considering its interdependence with other goals of society, such as economic growth, equity, etc. Due to incomplete information on the costs and benefits of pollution abatement and various other problems, setting standards in this regard is a rather difficult task.[17]

Environmental policy instruments are arranged based on the degree to which farmers' decisions are influenced by policies. Measures such as education and training, moral persuasion, scientific research and technological development are voluntary. They cannot be used to force farmers to act in a specific manner. Instruments such as taxes - on fertiliser or pesticides - or subsidies for envi-ronmentally sound farming methods provide market-based economic incentives, in order to change the farmers' behaviour depending on their individual economic preferences. This is not possible in the case of command-and-control regulations, which are to be obeyed by farmers, i.e., to meet fixed standards for the maximum amount of animals per hectare or to spread manure only within certain periods of the year. The alternative to state management of land use - in nature conservation areas to protect the landscape or biodiversity - however, represents the strongest intervention in private decision-making.

Hence, since there is no single instrument which can solve all environmental problems, one of which is water pollution, it is important to combine appropriate measures. For evaluating instruments not only the ecological incidence but also a set of other criteria such as economic efficiency, information requirements, management costs, administrative, institutional and political practicability, and the time lag of incidence has to be considered.[16] What also needs to be kept in mind is the particular nature of agricultural pollution, which occurs mostly in large areas, varying over time - climatic influences - and space. The effects of pollution often occur over a long time horizon. Due to the diffuse sources and the complexity of the ecological problems, it is often difficult to identify individual polluters.

Besides setting instruments, policy makers also need to decide on the stage at which the instrument shall be at work - emission, agricultural commodity, production process - the addressee of the environmental measures - farmer, input industry - and the area affected by regulation. For the latter it is important to define the spatial extent in which the same environmental measures are in force and in which polluters are allowed to divide their contribution to pollution abatement in a flexible manner - farm plot, farm, region, country.[18]

A description of the environmental policy instruments relating to soil and water conservation in Germany follows. Only the most important legislation and institutional settings will be discussed. During the integration process of the EC and the EU over the last decades, more and more decisions on agro-environmental issues have been transferred from the Member States to the level of the EC and the EU. Therefore, an analysis of German soil and water conservation policies has to bear in mind also the relevant legislation and institutional settings on the EU level.

In Germany, similar to the EU, soil and water conservation policies are dominated by command-and-control regulations. Economic instruments are only chosen in some cases, such as subsidies for environmentally sound farming methods. Only a few European countries gained experiences with ecological taxes. The dominance of regulatory measures and the minor importance of market-oriented economic measures have several reasons: environmental policy regulatory measures have a longer tradition than incentive-based measures. The first have a higher ecological incidence and therefore they often meet with more acceptance in the political arena. One disadvantage of ecological taxes with regard to soil and water issues is that the pollution, i.e. nitrates leached into the groundwater, is not taxable, or only with prohibitively high costs, and therefore it is not measurable. If proxies for the pollution, i.e. chemical fertilisers, are taxed, the economic efficiency of incentive-based instruments decreases, since the proxies are only loosely correlated with the pollution. In any case, it is difficult to define the optimal tax rate.

European Union

European Commission environmental policy measures were initiated in the 1970s and led to the first of a series of five-year Environmental Action Programs in 1973. In the first program, the objectives and principles of the EC environmental policies and remedial actions were stated. In the following ones, the EC stressed the growing importance of environmental policies. The fourth program emphasised that environmental concerns need to be taken into account in the entire corpus of EC policies.[19]

Since the end of the 1970s, several measures for reducing and preventing water pollution were introduced, based primarily on a regulatory approach. The 1980 EC Directive on the quality of drinking water includes quality standards to protect human health, regarding, inter alia, nitrate and pesticides. These quality standards, which set the maximum level for nitrate to 50 mg/l and for pesticides to 0.1 µg/l for a single substance and to 0.5 µg/l for all pesticides together, had to be met by 1985.

Whereas the nitrate limit is based on human toxic considerations and resembles that recommended by the World Health Organisation (WHO), pesticide limits follow the precaution principle in that almost no pesticides should occur in drinking water. Hence, with the latter, the pesticide limits need not be differentiated with regard to their toxicity for humans or ecosystems, as done by the WHO. Since the nitrate content of groundwater still increased in many regions of the EC, agriculturally-induced water pollution was directly addressed for the first time in the Directive concerning the protection of waters against pollution caused by nitrates from agricultural sources in 1991.

This Nitrate Directive commits Member States to monitor waters and to identify zones vulnerable to nitrate. Codes of good agricultural practices need to be defined and implemented, on a mandatory basis within these vulnerable zones and on a voluntary basis outside these zones.

Additionally, action programs which aim at diminishing nitrate leaching are required for these zones. These programs must ensure that application of manure does not exceed specified limits - in general, 170 kg N/ha. The codes of good agricultural practices include rules concerning periods and conditions for applying manure and inorganic fertiliser. However, as in many other cases, not all Member States adopted the directive in time.

In 1996, the EC-Commission passed its Communication on community water policy. This communication sets out the principles for Community Water Policy, recommended to design and implement a Framework Directive on water resources[20]. From the Commission's point of view, such a Framework Directive would be an important step towards an integrated management of surface water and groundwater, taking into account both quality and quantity. Since this directive is aimed at replacing several existing ones, the EU water policy would become more transparent and coherent.[20]

Also in 1996, the EC-Commission proposed an action program aiming at integrating the protection and management of groundwater. Four main fields of action are suggested: (a) development of principles for an integrated planning and management of waters, (b) implementation of regulations concerning the quantitative protection of water resources, (c) establishing instruments to control groundwater pollution by non-point sources and, (d) implementing instruments to control groundwater pollution by point sources.

Regarding pesticides, in 1995 the EC Commission proposed to amend the Drinking Water Directive, i.e., to remove the existing maximum allowance of 0.5 µg/l drinking water for all pesticides together.[21] Following the arguments of the Commission, this limit is deemed unnecessary because in the past an excess of this limit always coincided with an excess of the maximum allowance of 0.1 µg/l for a single substance. Furthermore, it is argued that controlling the maximum allowance of all substances together is not practicable.

Both the EC-Commission and some Member States argue for a growing need to integrate environmental and agricultural policies.22,23 The ongoing discussion on a revision of the CAP points towards an increasing need to put more emphasis on agro-environmental programs.

Germany

Federal Soil Act

The Federal Government aims at enacting a Federal Soil Act - Bundes-Bodenschutzgesetz - containing the most important regulations concerning soil. At present, such regulations are spread across different Acts. Currently, only a draft version of the Federal Soil Act exists aiming at protecting the soil from degradation.[24]

Among others, in Paragraph 22, it lists the principles for proper land stewardship by farmers. However, these principles are vaguely defined and open to broad interpretation. In general, it states that land has to be cultivated in agreement with site specific conditions. The quality of the soil structure has to be preserved or improved. Soil compaction and erosion are to be prevented as much as possible.

Ordinance on Sewage Sludge

With the Ordinance on Sewage Sludge - Klärschlammverordnung - the application of sewage sludge on agricultural and horticultural land is regulated. Sewage sludge to be applied has to meet different criteria concerning the content of heavy metals, i.e. less than 900 mg lead per kg dry matter sewage sludge and organic compounds. Also the land on which sewage sludge is to be applied has to fulfil certain criteria. These relate to the content of heavy metals and pH.

It is forbidden to apply sewage sludge on forest land, permanent grassland and within national parks. A minimum distance to surface waters of 10 meters is to be kept. The application of sewage sludge is limited to 5 tons dry matter per hectare within three years. Interestingly, current problems with applying sewage sludge on farmland is an overdose of nutrients, rather than heavy metals or other toxic particles.

Federal Water Act

Due to its federal structure, Germany has several institutions at various state levels which are involved in water conservation policy. While the Federal Government is authorised to enact so-called "framework legislation," the individual Bundesländer are required to enact specific laws. The Bundesländer further allocate responsibilities to institutions at various regional levels - Kreise, Regierungspräsidien. The way this is done differs between the Bundesländer.[25]

The Federal Water Act - Wasserhaushaltsgesetz - constitutes the framework for the individual laws specified by each of the Bundesländer. These regulations assign all surface and groundwater resources to public management. Hence, in Germany, there is no private ownership of water resources.

The most important items of the Federal Water Act for agriculture are the declaration of water protection areas (WPA), management restrictions and compensatory payments within these WPAs, as well as regulations concerning the storing of materials which are potentially dangerous to water bodies.

During the preparation of the amendment to the Federal Water Act in 1986, the regulation about compensatory payments was discussed very controversially. The final wording adopted by the states was that, although farmers have no property right to the groundwater, they need to be compensated if management restrictions within WPAs limit the "proper use of agricultural land" - ordnungsgemäße landwirtschaftliche Nutzung. The controversy arose due to the fact that these compensatory payments contradict the "polluter pays" principle. Moreover, no consensus has been reached on the definition of the "proper use of agricultural land."

Since the Bundesländer are responsible for implementing federal legislation, the water conservation policies differ between them. In particular, differences occur with regard to the size of designated WPAs, to establishing and implementing management restrictions and compensatory payments, as well as to financing these payments. According to a survey by the Federal Ministry of Agriculture,26 the proportion of designated WPAs in the terms of the total area of a Bundesland range from 1% in Schleswig-Holstein to 31% in Thuringia. The average for Germany is 10%; i.e. 3.7 million ha. An additional 1.5 million ha are planned to be assigned to a similar status. The extent to which this includes agri-cultural areas is not known.

Concerning the financing of the compensatory payments and the management restrictions imposed, two basic approaches can be distinguished: Firstly, one approach adopted by Baden-Württemberg requires water treatment plants to pay a levy on used water to the state government. This levy is used for transferring compensatory payments to farmers, which in general amount to 310 DM/ha of arable land located in a WPA. The main regulation imposed restricts the application of N-fertiliser to 20% less than the usual rate. If the mineralised N in the soil exceeds 45 kg/ha in autumn, it is assumed that the farmer has not complied with this regulation.

Secondly, there is another approach implemented in the North Rhine-Westfalia. In this Bundesland, the government supports the co-operation between water treatment plants and farmers. Both parties are required to negotiate management restrictions and compensatory payments to be paid to the farmers by the water treatment plant benefiting from these restrictions.

In nine of the 16 Bundesländer, water use is levied to different amounts depending on the regulation implemented in the individual Bundesland, the type of body the water is taken from - surface- or groundwater - and the purpose the water is used for. The levy to be paid ranges from 0,005 DM/m3 to 1,00 DM/m3 in these nine Bundesländer.

Implementation of the Nitrate Directive by the Fertilisation Ordinance

After more than four years of discussion, the Fertilisation Ordinance - Düngeverordnung - which implements the EU Nitrate Directive of 1991 in Germany, was finally enacted in 1996. Since the EU directive was to be implemented in 1993, at the latest, this means a delay of more than 2 years. It is not uncommon in the EU that EU directives are put into force by Member States considerably later than originally agreed. The main reason for the long delay was a disagreement between the German Federal Ministries of Agriculture and of Environment. The Ministry of Agriculture was more concerned with the farmers' interests; the Ministry of Environment with that of ecologists. An additional reason was the need to modify the German Fertiliser Act - Düngemittelgesetz - implemented in 1994 before enacting the Fertilisation Ordinance, in order to provide the necessary legal basis.

This ordinance defines codes of good agricultural practice with regard to using fertiliser. It comprises regulations concerning the application of fertiliser - Paragraph 2 - the peculiarities of manure application - Paragraph 3 - the calculation of fertiliser requirements and the obligation to record nutrient balances - Paragraph 4.

In agreement with these regulations, fertiliser has to be applied in such a way that the nutrients can be used readily by plants in order to minimise losses. Furthermore, machines employed for spreading fertiliser have to function prop-erly with regard to spreading and evenly distributing the amount intended. The application of manure is quantitatively restricted and allowed only in certain periods. With the exception of solid dung, using manure on arable land after harvest of the main crop is only permitted under specific conditions. If manure is applied to uncultivated land, it must be worked into the soil immediately. Between November 15 and January 15, manure application is generally forbidden.

For manure, in general, the application per farm is limited to an average of 170 kg N/ha for arable land - without set-a-side - and 210 kg N/ha for grassland. A former draft of the Fertilisation Ordinance also contained limitations regarding the application of phosphate and potassium, K, which are, however, no longer included in the version currently enacted.

Maximum application limits, in the case of slurry and dung water, are set to 236,1 kg N/ha for arable land and 291,6 kg N/ha for grassland. In the case of solid dung, limits are set to 283,3 kg N/ha on arable land and 350,0 kg N/ha for grassland (Table 5). These differences arise from storage and application losses, which need to be taken into account. For example, in the case of slurry and dung water, 10% of the N contained in the excrement can be considered as storage losses. For solid dung this proportion amounts to 25%. In addition, a maximum of 20% of the nitrogen contained in manure before application can be assumed to be unavoidable application losses. The ammonia emissions allowed by the Fertilisation Ordinance, however, exceed the critical load tolerated by many ecosystems.27

Table 5. Limits for the application of manure according to the German Fertilisation Ordinance (kg N/ha on farm average)

		Arable land	Grassland
(1)	upper limit for manure application	170	210
(2)	plus maximum 20% application losses	215.5	265.5
(3)	plus 10% storing losses for slurry and dung water (solid dung: 25 %) = maximum allowed N from animal excrement	236.1 (283.3)	291.6 (350.0)
(4)	maximum allowed "losses" for slurry and dung water (solid dung) [(3)-(1)] (= ammonia emissions)	66.1 (113.3)	81.6 (140.0)

Source: Weingarten (1996)

The upper limits for manure application in the Fertilisation Ordinance are less restrictive than those of the manure ordinances - Gülleverordnungen - which existed in some of the Bundesländer, and which have been substituted by the Fertilisation Ordinance. N, P and K fertiliser requirements have to be calculated for each plot taking into account factors such as the type of crop to be planted and soil nutrient availability. Since nutrient losses are to be minimised, it is prohibited to apply more inorganic or organic fertiliser than necessary. This implies that manure application is not only restricted by these upper limits in the ordinance mentioned above but also by the case-specific fertiliser requirements. As an exception, however, soils with a high P or K content have no P or K fertiliser requirements. In order to allow farmers to spread manure, its application to these soils may amount to the equivalent of the nutrient extraction by plants, if it can be expected that this will not lead to water pollution. According to an evaluation of the soil quality by Isermann,[28] this exception would be valid for 27% of arable land and 12% of grasslands with a high phosphate content in the former FRG, and to 39% and 25%, respectively, in the former GDR. For potassium, these values are 26% and 40% for the former FRG, and 53% and 57 % for the former GDR. These figures indicate how important these exceptions are.

Being afraid of possible disadvantages for their competitiveness as compared to the farmers in other EU-Member States, the German farmers' association has criticised the Fertilisation Ordinance for also regulating the application of P and K.[29] It is argued that the influx of P into surface water is caused by erosion rather than by fertilising and that potassium does not pose an environmental risk. In addition, it is pointed out, that in accordance with EU legislation, covering P and K is not necessary. Nevertheless, the attempt to define codes of good agricultural practice related to fertiliser application in the Fertilisation Ordinance is to be seen in the light of its positive impacts on water conservation to be expected, if the regulations will be adhered to. This latter precondition, however, raises some doubt as regards the efficacy of the Ordinance, in particu-lar with respect to the experience made with the manure ordinances - Gülleverordnungen - and the fact that many regulations of the Fertilisation Ordinance are defined rather ambiguously.

Pesticide legislation

Regarding pesticides, a number of regulatory policies exist in Germany for controlling pesticide use. The most important regulation, covered by the Plant Protection Act - Pflanzenschutzgesetz - is the registration of pesticides, which is a precondition for their legal application. In order to ensure their proper application, the government issued three ordinances.

The first limits the periods for pesticide application and excludes some pes-ticides from use in specific areas, i.e. WPAs or national parks. The second and third require pesticide users to be licensed and machines used for pesticide application to be checked every two years.

Agro-environmental programs

The accompanying measures of the 1992 CAP reform offer Member States the opportunity to promote ecologically sound farming methods - EC Directive 2078/92.[30,10] In Germany, for almost 5 million ha, i.e. 29% of the total utilised agricultural area,[31] farmers voluntarily adopt agro-environmental protection programs. These programs mainly include rules regarding the application of smaller amounts of chemicals or none at all, constraining animal density to a certain level, and the protection of the landscape and the maintenance of the country-side.[32]

In some Bundesländer, these programs support minimum tillage and underseeding row crops, in order to reduce erosion and nitrate leaching. In 1994, payments for ecologically-sound farming methods, granted to farmers who signed up for these programs, amounted to 417 million DM, in 1995 to 705 million DM and were projected to reach 826 million DM in 1996.[31] The money for the payments comes from three sources; the EC-Commission, the Federal Government and the governments of respective states.

Common agricultural policy and the environment

Since the CAP heavily affects farm structure, the intensity of production and regional specialisation in agriculture, agro-environmental issues cannot be dis-cussed without taking into account agricultural policy. In the 1957 Treaty of Rome, which laid the foundation for the EC, the objectives of the CAP are formulated. Its main objectives are to increase agricultural productivity and to ensure a fair standard of living for the farmers. Environmental objectives are not listed. In order to achieve the main objectives, the EC pursued a farmers' income-oriented price support policy, which stimulated intensive agricultural practices and production and contributed to the rise of environmental prob-lems.[33] Due to increased financial burdens on the EC-budget and to the interna-tional pressure on the EC within the GATT-negotiations to liberalise the CAP, discussions on the formulation of agricultural policy became more frequent since the mid 1980s.

In 1988, the EC introduced programs for extensive agricultural production and for arable land to be set aside. However, the goal of these programs was primarily to reduce production surpluses. Protecting the environment was not high on the agenda. Since these policies did not show the effect expected and, due to the ongoing negotiations in the Uruguay Round, another, but this time major, reform of the CAP was introduced in 1992. The basic change of this reform, which was still not driven by ecological concerns, was a cut in price support for major commodities like cereals and oilseeds, and to compensate farmers for income losses by acreage premiums for these crops, coupled with set-aside requirements. Support for livestock husbandry by headage payments was made depending on the livestock density. Within the framework of the so-called "accompanying measures" of the CAP reform, financial support is provided for environmentally sound farming practices and afforestation.[30] These practices include, in particular, a drastic reduction of fertiliser and pesticide application and a reduction in livestock density, as well as organic farming and a long-term set-aside of arable land for environmental purposes. Farmers can participate in these accompanying measures voluntarily.

It is too early to comprehensively assess the ecological impacts of the 1992 CAP reform, which was fully implemented only in 1996. Positive impacts, however, can be expected. Price cuts for agricultural commodities diminish the economic incentives and lead to less intensive production practices, i.e. to reduced fertiliser and pesticide applications. Whether the quasi-obligatory set-aside regulation has positive or negative ecological effects, depends on the spe-cific natural conditions of the arable land affected. The accompanying measures will certainly have positive effects on soil and water conservation. However, due to limited financial support and because the farmers' participation is voluntary, these accompanying measures cannot lead to a sustainable agriculture. It is worth mentioning that the CAP reform puts more emphasis on environmental issues than former agricultural policies. However, this dimension of the reform is still of minor importance. It may gain in priority in the future, as, for different reasons, policy-makers are considering a further adjustment of the CAP. Both the EC-Commission and the governments of some Member States argue for a growing need to integrate environmental and agricultural policies. It is likely that the existing acreage premiums will become more closely connected with the fulfilment of environmental requirements in the future. The more remote in time the price cuts of the CAP reform are, the lower society's acceptance for today's acreage premiums will become. Besides, it is likely that the World Trade Organisation (WTO) will no longer accept these premiums in the next round of trade negotiations, which is scheduled to start in 1999, since these premiums are still stimulating agricultural production. Hence, although the CAP may in fact become slightly "greener," this alone will not be sufficient to ensure that agri-culture will influence the environment only to the degree desired by society. Therefore, additional agro-environmental legislation and institutional settings, or a stricter compliance with the existing ones, are necessary.

Effects of alternative water conservation strategies

The effects of two water conservation strategies will be assessed and compared to a reference which excludes any water conservation measures. The analyses are carried out with the RAUMIS model (Regionalised Agricultural and Environmental Information System for Germany).[9]

Overview of the RAUMIS model

Commissioned by the German Federal Ministry of Agriculture, RAUMIS was developed at the Institute of Agricultural Policy of the University of Bonn. It is designed for quantitative analyses of agricultural and environmental policies. It is currently used by the Institute of Agricultural Policy, the Federal Ministry of Agriculture and the Federal Agricultural Research Center.[32,35,36]

RAUMIS depicts the main interdependencies between agriculture and the environment. It consists of several modules, the most important of which is a system of Linear Programming (LP) modules at the county level. Since RAUMIS is designed for the former FRG, it consists of 240 such LP modules. Together, they depict the agricultural sector in consistence with the Economic Accounts for Agriculture. Restrictions of data availability explain the chosen time differentiation. Thus, ex post RAUMIS is based on the model years 1979, 1983, 1987 and 1991. The target year of the comparative-static simulation analysis of water conservation strategies is 2005.

In RAUMIS, agricultural production is divided into 29 crop and 12 animal activities. For the ex ante analysis, flexibility constraints are used to control the scale of adjustment. The intensity of chemical application is determined by profit-maximising behaviour in these LP modules. For this purpose, empirical response functions were included into these LP modules. The interdependencies between agriculture and the environment are modelled using environmental indicators, of which the N-balance is the most important one.

On the input side, chemical fertiliser, manure, symbiotic and asymbiotic N fixation and atmospheric input are taken into account. Nitrogen removal rates vary according to the crop planted. Ammonia emissions are calculated endogenously. N-balance represents the amount of nitrogen which will be denitrified, leached out into the groundwater, or accumulated in the soil. Assuming that the N-storage in the soil is in a long term equilibrium, N accumulation is neglected in the RAUMIS analysis.

On the basis of the regional N-surplus and the regional soil percolation water, potential nitrate concentrations of the soil percolation water are assessed on the assumption that 50% of the N-surplus leaches into groundwater. A second assessment includes not only N-leaching from agricultural land but also from forests - 30 kg N/ha. Depending on the potential nitrate concentration and information about groundwater raising, potential costs associated with treating the nitrate-polluted groundwater for drinking purposes are estimated. Figures on the costs of treating nitrate pollution per additional cubic meter groundwater available in the literature differ widely.

Hence, two variants of cost figures were used in the original analysis. However, in this paper only the scenario with the more likely one is reported. 0.01 DM/m3 groundwater raised are calculated for groundwater with a potential nitrate concentration in the soil percolation water between 10 and 25 mg NOV/l. If the potential nitrate concentration amounts to 25 to 50 mg NO3/l, 0.20 DM/m3 are assumed. Given a potential nitrate concentration of more than 50 mg NO3/l, this figure rises to 0.70 DM/m3.

In order to facilitate the assessment of the monetary value of nitrate pollution in the soil percolation water, hypothetical costs are estimated on the assumption that the entire soil percolation water would be conditioned as groundwater used for drinking purposes.

Water conservation strategies

Using the RAUMIS model, two water conservation strategies were investigated.[9,13] Strategy 1 aims at protecting groundwater as a resource for drinking water. Thus, water protection areas are defined where groundwater is used for drinking purposes.

Table 6. Water conservation strategies

Strategy 1: Regionally differentiated groundwater conservation policies
1. outside water protection areas: no farming regulations and no compensatory payments 2. inside water protection areas: farming regulations and compensatory payments Maximum utilisation of N-fertiliser (in kg N/ha): Winter wheat 110 · Sugarbeets 150 Rye, winter barley 85 · Winter rape 135 Winter and summer maslin 85 · Summer rape 90 Oats 95 · Grassland 140 Summer wheat, summer barley 75 · Silage maize 140 Grain maize 120 · Mangel-wurzel 150 Potatoes 120 · Legumes 0 Maximum livestock density: manure units (MU)/ha - the equivalent of 120 kg N/ha Prohibition of ploughing up grassland Regionally differentiated compensatory payments
Strategy 2: Blanket coverage of groundwater conservation policies
1. Nitrogen levy on chemical fertiliser: 0.66 DM/kg N at current prices 2. Nitrogen levy on slurry surpluses (slurry-N) exceeding 1.5 MU/ha: 0.66 DM/kg slurry-N 3. Prohibition of ploughing up grassland 4. Uniform compensatory payments per hectare utilised agricultural area according to N-levy revenues

Source: Weingarten (1996)[9]

Details of restrictions on farming imposed and compensation payments provided are listed in Table 6. Within WPAs, farmers have to limit their fertiliser use and are restricted on the ploughing of grassland. They are compen-sated by regionally differentiated payments so that they do not suffer any income losses. Outside the WPAs, no regulations for applying special practices exist.

Strategy 2 is designated to protect groundwater everywhere, because of its functions within ecosystems and in the water cycle. Hence N levies on chemical fertiliser and slurry surpluses are introduced, and the ploughing of grasslands is forbidden (Table 6). Farmers get the revenues of the N-levies paid by them refunded on a uniform basis per hectare.

Table 7. Nitrogen balances of the former FRG for 1991 and 2005 (in kg N/ha)

	1991	2005			
		Reference Run	Strategy 1 Total Land	Strategy 1 WPA Land	Strategy 2
Chemical fertiliser	117	112	106	70	80
Manure	150	82	79	65	79
Other N-input	34	33	33	33	33

Total input	256	227	219	168	192
N-removal with crops	-138	-131	-128	-113	-121
Ammonia	-32	-24	-23	-19	-21
Balance	85	73	67	36	50

Source: Weingarten (1996)[9]

Impacts on ecological and economic characteristics

Based on the assumption of a continuation of current policies up to 2005 and on other specifications of the model, the results of the reference run indicate a further decline in the average N-surplus (Table 7). The reduction amounts to 73 kg N/ha by 2005. This is mainly due to a decrease in manure application, a higher efficiency in plant uptake of manure-N and a considerable reduction of N-application on grassland. Restrictions on farming practices as specified in Strat-egy 1 lead to a substantial lowering of N-surplus in WPAs, amounting to 36 kg N/ha. The average for all of the cultivated land equals 67 kg N-surplus/ha, which is only 8% lower than that in the reference run, but 34% higher than if the poli-cies of Strategy 2 were implemented. The latter reaches a surplus of 50 kg N/ha.

The potential nitrate concentration of the soil percolation water averages 34 mg NO_3/l in 2005, in the reference run, as compared to 43 mg NO_3/l in 1991 (Figure 2). Since the measures of Strategy 1 restrict farming only within WPAs, the potential nitrate concentration of the entire soil percolation water is only slightly lower than in the reference run. However, the potential concentration of the groundwater extracted is drastically reduced to 19 mg NO_3/l on average. Strategy 2 reduces the average potential nitrate concentration in the soil percola-tion water to 23 mg NO_3/l. If an assumed 30 kg N-surplus per hectare forest is taken into account in the calculation, the potential nitrate concentrations are always higher than the figures mentioned above (Figure 2).

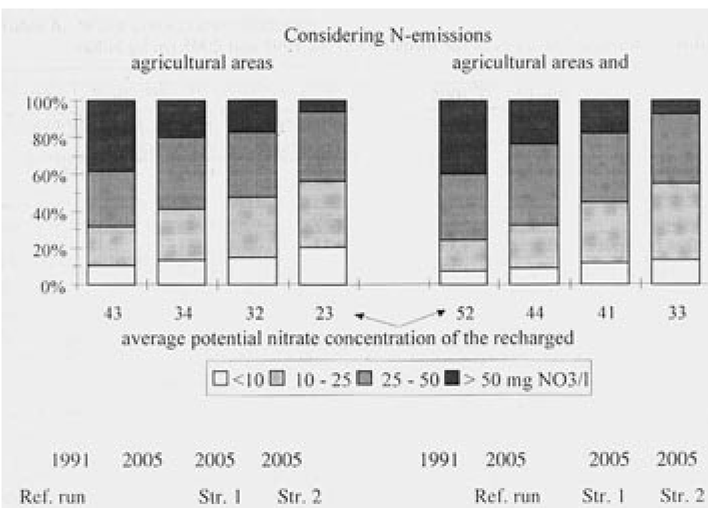

Figure 2. Potential nitrate concentration of the soil percolation water in 1991 and in 2005 under different scenarios

Source: Weingarten (1996)[9]

Insights into the regional variation of potential nitrate concentrations in the soil percolation water and their changes between 1991 and 2005, as well as into the effects of the two strategies are provided in Figure 3. The figures immediately below the bar charts indicate the proportions of the total 240 counties considered belonging to the corresponding concentration classes. The regions with the highest potential concentrations are characterised by N-sur-pluses above the average and/or a quantity of soil percolation water below the average. The potential nitrate concentrations are below the average especially in

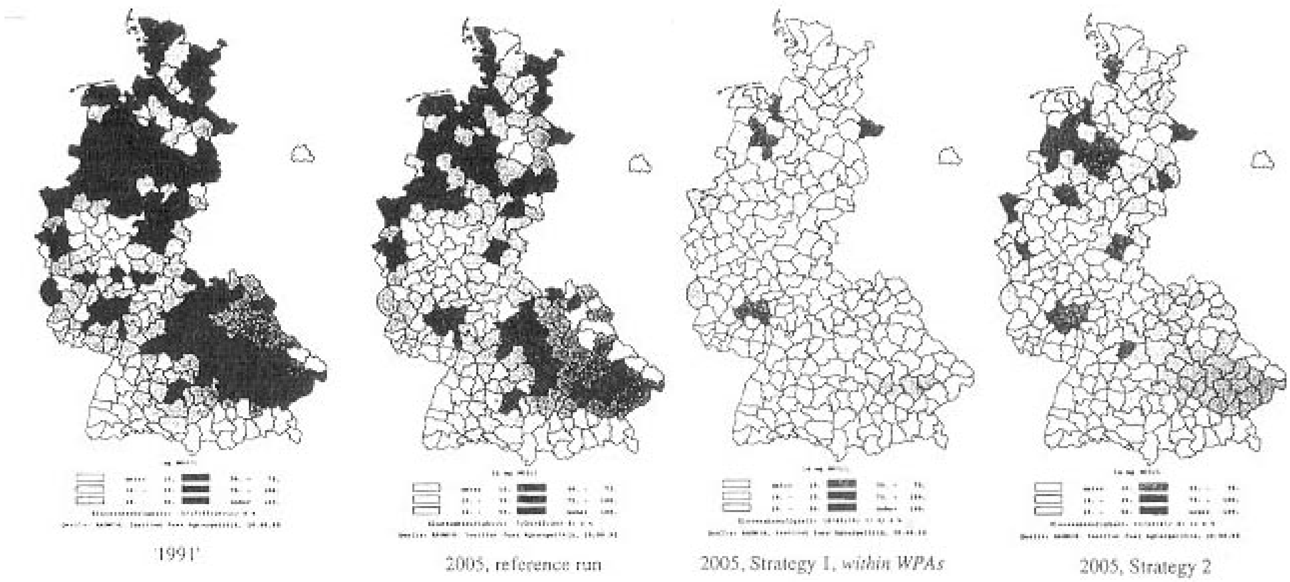

Figure 3. Potential N-concentration in soil percolation water considering N-surpluses from agricultural land (assumption: 50% of the N-surpluses leach into groundwater) hilly regions where N-surpluses are relatively low and the quantity of soil percolation water is large due to high precipitation. Due to lower potential nitrate concentrations, potential savings for water treatment plants at current prices are also lower in 2005. Whereas the potential costs based on the N-surplus of 1991 are estimated to amount to 1.2 billion DM per year, the corresponding figure for the reference run in 2005 equals 0.9 billion (Table 8), considering N-emissions from agricultural land. The potential costs are lowest if Strategy 1 is realised - 0.2 billion DM. This figure, however, does not cover compensatory payments for farmers. Strategy 2 halves the potential costs of the reference run.

Table 8. Potential costs of water treatment plants caused by nitrate (in extracted ground-water) and hypothetical costs (caused by nitrate in soil percolation water) for 1991 and 2005 (in billion DM per year for prices as by 1991)

	Extracted	groundwater	Soil perco-	lation water
	Agriculture	Agr. a. forest	Agriculture	Agr. a. forest
1991	1.24	1.61	17.24	21.08
2005				
Reference run	0.90	1.35	11.51	18.01
Strategy 1	0.19	0.56	10.08	16.32
Strategy 2	0.47	0.85	6.25	10.45

Source: Weingarten (1996)[9]

To estimate the costs of groundwater nitrate pollution, hypothetical costs were calculated, assuming that soil percolation water would be treated like drinking water. Based on the N-surpluses of 1991, hypothetical costs of 17 billion DM per year were estimated (Table 8). The 2005 reference run results in hypothetical costs of 12 billion DM. Since the WPAs cover at most 15 % of total agricultural area, the farming restrictions induce only a slight decrease in the hypothetical costs. In contrast, the hypothetical costs are halved in Strategy 2.

In the reference run, agricultural income at current prices, measured as net value added at factor costs, decreases in 2005 as compared to 1991 by nearly 50% to 10.1 billion DM. The decrease is mainly due to lower output prices and a reduction in meat production. If farmers were to be compensated for income losses resulting from the farming restrictions imposed within WPAs, an additional 0.4 billion DM would have to be paid. Although the levies on nitrogen - 0.6 billion DM - are refunded to farmers, in Strategy 2 the net value added at factor costs still decreases to 8.5 billion DM. However, according to the model results, labour input declines by 40 % in 2005. Therefore, income per full time equivalent of farm labour decreases less than total income does.

Table 9. Impacts of water conservation strategies on economic indicators compared to the reference run without conservation measures (in billion DM/year for 1991 prices)

	2005 Reference Run	2005 Strategy 1	2005 Strategy2

(1) Compensatory payments induced by strategies	-	0.40	0*
(2) Other subsidies	-	-0.02	-0.05
(3) Agricultural income **	-	0	-1.54
(4) Interim sum [= -(1) - (2) + (3)]	-	-0.38	-1.50
(5) Potential costs of water treatment plants (extracted groundwater)***	-	- 0.7 1	-0.43
(6) Hypothetical costs for soil percolation water***	-	-1.43	-5.23
(7) Total effect considering the potential costs (extracted groundwater) [= (4) - (5)]	-	0 32	-1.06
(8) Total effect considering the hypothetical costs (soil percolation water)[= (4) - (6)]	-	1.05	3.78
*The compensatory payments (612 million DM) are financed by the farmers paying the N-levy, which for this reason are excluded here. **The change of the agricultural income (Net value added in factor costs) includes the change of the compensatory payments and of the other subsidies. ***Cost variant A, only considering N-leaching from agricultural areas.			

Source: Weingarten (1996)9

If one compares the decrease in the potential costs for water treatment plants with loss-compensations to farmers and with the loss in agricultural income respectively, and also takes into account the change of other subsidies, Strategy 1 results in a plus of about 0.3 billion DM (Table 9). In this partial analysis Strategy 2 induces a welfare loss of about 1.1 billion DM. Considering the hypothetical costs as an indicator for evaluating the agriculturally-induced nitrate pollution of the entire soil percolation water, Strategy 1 causes a welfare increase of 1.0 billion DM and Strategy 2 one of 3.8 billion DM per annum. However, these figures should be interpreted with caution. This comparison is not a complete cost-benefit-analysis. Additional aspects would have to be taken into account, such as using shadow and not market prices, as in this analysis. Furthermore, transaction costs of various amounts and impacts of the strategies on environmental resources other than groundwater also have to be considered.

Conclusion

The analysis of N-balances at the county level reported in this paper indicates reductions of N-surpluses beginning in the second half of the 1980s. This is a result of changes in the CAP of the EU and a growing awareness of farmers with regard to protecting the environment. Any further adjustment of the CAP is likely to strengthen this development.

During the last years, additional restrictions on farming were also imposed. This increased the intensity of control measures applied to agriculture. The impact of the Fertilisation Ordinance on water pollution critically depends on how precisely farmers calculate fertilisation requirements for crops and grassland and how strictly they follow these constraints. The two water conservation strategies presented on imposing restrictions on nitrogen use show how important it is to clarify whether the entire groundwater or only drinking water shall be protected. The welfare change depends heavily on this question.

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