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Agri-environmental policy in Germany: soil and water conservation

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AGRI-ENVIRONMENTAL POLICY IN GERMANY
- SOIL AND WATER CONSERVATION -

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SUMMARY

This paper is concerned with agri-environmental policy in Germany and focuses in particular on soil and water conservation. At first it discusses to what extent agriculture contributes to erosion and the pollution of surface waters and groundwater with nutrients and pesticides. Whereas erosion is a minor problem in Germany water pollution due to modern and intensive agriculture is of major concern.

In theory, a broad range of environmental policy instruments exists. In practice, agri-environmental policy in Germany is dominated by command-and-control-measures, whereas incentive-based measures are of minor importance. In this paper recent developments of the most important legal and institutional settings concerning soil and water conservation policies are surveyed with special emphasis on the Federal Water Act and the Implementation of the EU Nitrate Directive into German legislation by the Fertilizer Ordinance.

Since the Common Agricultural Policy (CAP) of the EU heavily affects farm structure, production intensity and regional specialization in agriculture, agri-environmental issues cannot be discussed without taking into account agricultural policy. Hence, the paper argues, that for different reasons the CAP is likely to become more environmentally friendly in future.

Furthermore, impacts of alternative water conservation policies are investigated by using a regionalized agricultural sector model. Information obtained by the model analysis cover the development of nitrogen balances, potential nitrate concentrations in the soil percolation water, potentially resulting costs and effects on the agricultural incomes in the former FRG on the county level.

ZUSAMMENFASSUNG

Im ersten Teil dieses Beitrages über Agrarumweltpolitik in Deutschland im Bereich des Boden- und Gewässerschutzes wird ein Überblick über den landwirtschaftlich bedingten Bodenabtrag und die Belastung von Oberflächengewässern und Grundwasser mit Nährstoffen und Pflanzenschutzmitteln gegeben. Während Erosion in Deutschland von geringer Relevanz ist, kommt der durch eine moderne und intensiv betriebene Landwirtschaft verursachten Gewässerverschmutzung eine erheblich größere Bedeutung zu.

In der umweltökonomischen Theorie existiert eine Reihe von umweltpolitischen Instrumenten. In der Praxis wird die Umweltpolitik in Deutschland von Ge- und Verboten geprägt, während anreizorientierte Maßnahmen nur selten eingesetzt werden. Der Artikel untersucht die wichtigsten rechtlichen und institutionellen Rahmenbedingungen im Bereich der Boden- und Gewässerschutzpolitik, wobei das Schwergewicht auf dem Wasserhaushaltsgesetz und der Düngeverordnung liegt, mit der die EU-Nitratrichtlinie in deutsches Recht umgesetzt wird.

Da die Gemeinsame Agrarpolitik der EU (GAP) die Betriebsstruktur, Produktionsintensität und die regionale Spezialisierung der Landwirtschaft beeinflußt, können Agrarumweltfragen nicht diskutiert werden, ohne die Agrarpolitik zu berücksichtigen. Aus verschiedenen Gründen ist es wahrscheinlich, daß die GAP in Zukunft etwas umweltfreundlicher gestaltet wird.

Mit Hilfe eines regionalisierten Agrarsektormodells werden die Auswirkungen alternativer Grundwasserschutzstrategien analysiert. Die Modellergebnisse erlauben für die alten Bundesländer Deutschlands auf der Ebene der Landkreise Aussagen über die Entwicklung von Stickstoffbilanzen, potentiellen Nitratkonzentrationen im neugebildeten Grundwasser, hierdurch potentiell hervorgerufene Kosten und Auswirkungen auf die Einkommen in der Landwirtschaft.

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LIST OF ABBREVIATIONS

µg	0.0001 milligram
billion	1,000,000,000
CAP	Common Agricultural Policy
FADN	Farm Accountancy Data Network
FEA	(German) Federal Environmental Agency
FRG	Federal Republic of Germany
GATT	General Agreement on Tariffs and Trade
GDR	German Democratic Republic
K	Potassium
LP	Linear Programming
MU	Manure unit
N	Nitrogen
NO_3	Nitrate
P	Phosphorus
pH	Pons Hydrogenous
RAUMIS	Regionalized Agricultural and Environmental Informationsystem (Regionalisiertes Agrar- und Umweltinformationssystem)
WHO	World Health Organization
WTO	World Trade Organization
WPA	Water protection area

1 INTRODUCTION[1]

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)[2] supported agricultural market prices at levels considerably above those prevailing at the world markets. The resulting intensification and specialization of agricultural production in fact was and still is one of the main factors contributing to water pollution and soil degradation.

In the meantime the public in Germany and in the EC has become increasingly aware of the fact that agricultural activities always influence the environment, and this 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 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 (FROHBERG ET AL. 1994).

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). To what extent agriculture influences soil and water quality is analyzed in section 2. Section 3 provides some general considerations on environmental policy instruments. The most important legislation and institutional settings concerning soil and water conservation in Germany are analyzed in section 4. In section 5 it is argued that the CAP of the EU is likely to become a slightly environmentally friendly in future. Using a regionalized agricultural sector model, the effects of alternative water conservation strategies are assessed in section 6. The paper ends with some concluding remarks.

2 AGRICULTURALLY INDUCED SOIL AND WATER POLLUTION IN GERMANY

2.1 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 (FROHBERG ET AL. 1994). The average soil loss per hectare of arable land is estimated to be 8.7 t/ha for the former FRG (WERNER ET AL. 1991). The corresponding figure for the former GDR amounts to 4.6 t/ha (WODSAK and WERNER 1994). The minor importance of erosion in the former GDR is largely a result of natural conditions: the topography of the former GDR is characterized by a relatively low relief. Rainfall is also very low. For an area of nearly 500,000 ha 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

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1 This Discussion Paper is mainly based on a contribution by WEINGARTEN and FROHBERG (1997a) to the Symposium on "Soil and Water Conservation Policies: Success and Failures", held on September 17-20, 1996, in Prague (cf. NAPIER ET AL. 1997a).
I would like to thank Prof. Klaus Frohberg for his critical comments on an earlier version of this paper and Dagmar Barth for language assistance. Of course, the responsibility for the content of this paper and remaining errors is still solely taken by the author.

2 In accordance with the Treaty on the European Union of 1992 (the Maastricht Treaty), the name of the European Community was changed to "European Union" in 1993.

of 1.1 t/ha and 0.5 t/ha respectively (DEUMLICH 1995). As illustrated in the soil erosion atlas of *Baden-Württemberg* (GÜNDRA ET AL. 1995, cited in STAHR and STASCH 1996), a hilly state (*Bundesland)* located in the South-West of Germany, 5.5 t/ha typical arable land are eroded per year in this state.

2.2 Water Pollution

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

2.2.1 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, on the 3rd International North Sea Protection Conference in 1990, the countries bordering the North Sea committed themselves 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 N-load will be reduced by only 25 %, i.e. half the required amount (PROJEKTGRUPPE NÄHRSTOFFEINTRÄGE 1994).

For 1989/91 the FEA estimated the total N-load of surface water in Germany to be 1.0 million t N (cf. Table 1), 61 % of which originated from nonpoint sources and 39 % from point sources. Most of the nonpoint 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 nonpoint source. According to the FEA 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 in 1989/91		**Phosphorus in 1987/89[1)]**	
	1000 t N	**kg N/ha[2)]**	**1000 t P**	**kg P/ha[2)]**
Nonpoint 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 nonpoint sources	**630**	17.7	**48**	1.35
Total point sources	**410**	11.5	**52**	1.46
Sum total	**1040**	29.2	**100**	2.80

[1)] For the former GDR the years 1991/92 were taken. [2)] Per hectare of the entire land area.

Source: PROJEKTGRUPPE NÄHRSTOFFEINTRÄGE (1994).

2.2.2 Pollution of Groundwater

2.2.2.1 Nitrate Pollution

Since agriculture is the most important nonpoint 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 (KÖSTER ET AL. 1988). More recent development calculations carried out with the "Regionalized Agricultural and Environmental Information System" (RAUMIS) (cf. section 6) indicate a significant reduction of the N-surplus from '1987' to '1991'[3] (85 as compared to 104 kg N/ha in '1987', cf. Table 2).

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

	'1979'	**'1983'**	**'1987'**	**'1991'**
Chemical fertilizer	+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).

Regarding pollution by different farm types BROUWER ET AL. (1995) provide 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, cf. Table 3), while cereal farms have the lowest (96 kg N/ha).

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-surplus1)	**50 % of farms with medium N-surplus1)**	**25 % of farms with highest N-surplus 1)**	**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	2)	2)	224
Mixed farms	95	126	189	132
1) In the case of granivore farms every category covers 33 % of all farms. 2) No data given, due to sample size falling short of 15 farms.				

Source: BROUWER ET AL. (1995).

3 'year' is the abbreviated denotation for the three-year period investigated.

According to a study by NIEBERG and VON MUENCHHAUSEN (1996) 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.

WENDLAND ET AL. (1994) developed a model to trace nitrate flow in the groundwater in Germany at squares of 3 by 3 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.

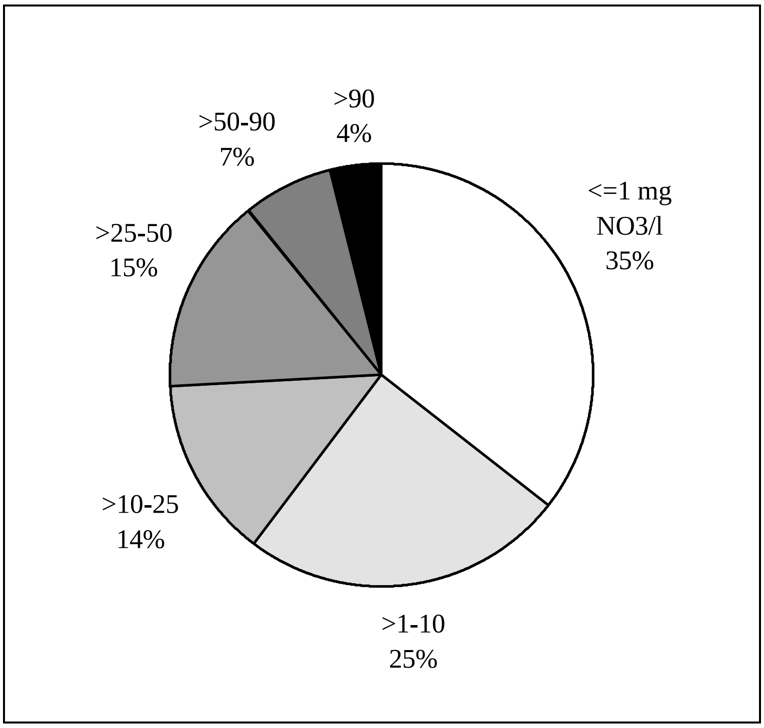
Based on the above mentioned N-surpluses for '1991' calculated with the model RAUMIS, WEINGARTEN (1996, 1997) assessed the potential nitrate concentration in the soil percolation water (cf. section 6). According to this assessment the potential nitrate concentration is less than 10 mg NO_3/l for 10 % 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 (cf. section 4.1). On average the potential nitrate concentration reaches 43 mg NO_3/l. In this assessment only the N-surplus originating from agricultural area 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.

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 (LAWA 1995). 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 surface near 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, 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 (cf. 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 the nitrate concentration has increased by 0.5 to 1 mg nitrate/l per year. However, in some cases nitrate concentration has also stabilized since the late 1980s (LAWA 1995).

Figure 1: Distribution of the analyzed nitrate concentrations in Germany in the early 1990s



Source: LAWA (1995).

2.2.2.2 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 (cf. section 4.1). 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 them the detected pesticide levels exceeded the limit of 0,1 µg/l (cf. Table 4) (UMWELTBUNDESAMT *1995*). 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 is 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 deregistered, atrazine might still be applied. In some of Gemany's neighboring countries farmers still are allowed to use it which makes it rather easy for German farmers to obtain this substance.

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

Reporting period	Reported analyses		without pesticides		with pesticide detection: concentration < 0,1 µg/l		concentration > 0,1 µg/l		total number with pesticides	
until Dec. 90	49,736	100%	42,808	86,1%	3,999	8,0%	2,519	5,1%	6,783	13,6%
Dec. 90 - Dec. 91	77,673	100%	69,753	89,8%	6,104	8,8%	2,170	2,8%	8,038	10,3%
Dec. 91 - Dec. 92	68,219	100%	64,043	93,9%	1,592	2,5%	1,640	2,4%	4,203	6,2%
Dec. 92 - Dec. 93	75,472	100%	68,583	90,9%	6,858	10,0%	1,031	1,4%	6,889	9,1%
Dec. 93 - Dec. 94	60,564	100%	57,539	95,0%	2,674	4,6%	691	1,1%	3,363	5,6%
total	331,664	100%	302,726	91,3%	21,227	7,0%	8,051	2,4%	29,276	8,8%

Source: Own calculations on the basis of UMWELTBUNDESAMT (1995).

3 CONSIDERATIONS ON ENVIRONMENTAL POLICY INSTRUMENTS

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 (SIEBERT 1995). Thus, in order to protect soil and water efficiently it is necessary to at first define the desired degree of environmental protection by considering the 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 (SCHEIERLING 1996). Depending on the degree to which farmers' decisions are influenced by policies, these instruments can be arranged as follows: measures such as education and training, moral suasion, scientific research and technological development are voluntary. They cannot be used to force farmers to act in a specific manner. Instruments such as taxes (e.g. on fertilizer or pesticides) or subsidies (e.g. for environmentally sound farming methods) provide market-based economic incentives in order to change the farmers' behavior 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, e.g. 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 of the state managing the land use, e.g. 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 (SIEBERT 1995). 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. Pollution effects often occur over a long time horizon. Due to the diffuse sources and the complexity of the ecological problems the individual polluters are often difficult or not at all to be identified.

Besides setting instruments, policy makers also need to decide on the stage on which the instrument shall be at work (e.g. emission, agricultural commodity, production process), the addressee of the environmental measures (e.g. farmer, input industry), and the area affected by regulation. For the latter it is important to define the spatial extent, to which the same environmental measures are in force and to which polluters are allowed to divide their contribution to pollution abatement in a flexible manner (e.g. farm plot, farm, region, country) (SCHEELE ET AL. 1993).

Which environmental policy instruments relating to soil and water conservation are used in Germany in practice is described in the following section. Only the most important legislation and institutional settings will be discussed.

4 LEGISLATION AND INSTITUTIONAL SETTINGS

In the integration process of the EC and the EU respectively during the last decades, more and more decisions on agri-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, e.g. as subsidies for environmentally sound farming methods (cf. section 4.2.5). Only few European countries gained experiences with ecological taxes.[4] The dominance of regulatory measures and the minor importance of market-oriented economic measures have several reasons: in 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, e.g. nitrate leached into the groundwater, is not taxable, since it is not, or only with prohibitively high costs, measurable. If proxies for the pollution, e.g. chemical fertilizers, 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.

4.1 European Union[5]

In the EC 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 emphasized that environmental concerns need to be taken into account in the entire corpus of EC policies (WEINGARTEN and FROHBERG 1997b).

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, for pesticides to 0.1 µg/l for a single substance and to 0.5 µg/l of all pesticides together, had to be

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4 For example, chemical fertilizers were taxed in Austria and Sweden until their accession to the EU. The Netherlands will introduce a levy on nutrient surpluses, calculated on mineral book keepings, in 1998. In Denmark, pesticides have been taxed since 1996. In Germany, taxation of N fertilizer was often called for by some environmentalist groups, scientists and political institutions during the last ten years to internalize negative externalities, but never realized (cf. WEINGARTEN 1996). The impacts of a N-levy are analyzed in section 6.

5 A more detailled overview on water policies in the EU is provided by SCHEIERLING (1994).

met by 1985.[6] Whereas the nitrate limit is based on human toxic considerations and resembling that recommended by the World Health Organization (WHO), the pesticide limits follow the precaution principle in that almost no pesticide 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 the 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. The action 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 fertilizer. 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 recommending to design and implement a Framework Directive *on water resources* (cf. OLSEN 1996). 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 (OLSEN 1996).

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 nonpoint 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, e.g. to remove the existing maximum allowance of 0.5 µg/l drinking water for all pesticides together (AGRA-EUROPE 1995a). 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 (FISCHLER 1996, BMELF 1996). The ongoing discussion on a revision of the CAP points towards an increasing need to put more emphasis on agri-environmental programs (cf. section 5).

6 In Germany, this quality standards were implemented via the Drinking Water Ordinance in 1986.

4.2 Germany

4.2.1 Federal Soil Act

The Federal Government aims at enacting a Federal Soil Act (*Bundes-Bodenschutzgesetz)* containing the most important regulations concerning the 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 (AGRA-EUROPE 1995b). Among others in § 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.

4.2.2 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 (e.g. 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 fulfill some criteria. These relate to the content of heavy metals and the pons Hydrogenous (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 meter 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 farm land is an overdoses of nutrients rather than heavy metals or other toxic particles.

4.2.2 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 authorized 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* (SCHEIERLING 1994).

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 of the Federal Water Act in 1986, the regulation about compensatory payments was discussed very controversially. The final wording adopted states 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 (N.N. 1995), 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 agricultural area 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 arable land located in a WPA. The main regulation imposed restricts the application of N-fertilizer to 20 % less than the usual rate. If the mineralized N in the soil exceeds 45 kg/ha in autumn, it is assumed that the farmer has not complied to this regulation.

Secondly, there is another approach implemented in Northrhine-Westfalia. In this *Bundesland* the government supports the cooperation 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/m^3 to 1,00 DM/m^3 in these nine *Bundesländer.*

4.2.3 Implementation of the Nitrate Directive by the Fertilization Ordinance

After more than four years of discussion, the Fertilization 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 farmers' interest, the Ministry of Environment with that of ecologists. An additional reason was the need to modify the German Fertilizer Act (*Düngemittelgesetz*) implemented in 1994 before enacting the Fertilization Ordinance in order to provide the necessary legal basis.

This ordinance defines codes of good agricultural practice with regard to using fertilizer. It comprises regulations concerning the application of fertilizer (§ 2), the peculiarities of manure application (§ 3), the calculation of fertilizer requirements and the obligation to record nutrient balances (§ 4).

In agreement with these regulations, fertilizer has to be applied in such a way that the nutrients can be used readily by plants in order to minimize nutrient losses. Furthermore, machines employed for spreading fertilizer have to function properly 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 Fertilization Ordinance also contained limitations regarding the application of phosphate and potash (K) which are, however, no longer included in the version currently enacted.

Maximum application limits are set to 236,1 kg N/ha for arable land (291,6 kg N/ha for grassland) in the case of slurry and dung water and to 283,3 kg N/ha on arable land (350,0 kg N/ha for grassland) in the case of solid dung (cf. 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 nitrogen contained in manure before application can be assumed to be unavoidable application losses. The ammonia emissions allowed for by the Fertilization Ordinance, however, exceed the critical load tolerated by many ecosystems (ISERMANN 1994).

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

	Arable land	**Grassland**
(1) Upper limit for manure application	170	210
(2) plus max. 20 % application losses	212,5	262,5
(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) Max. 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 Fertilization 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 Fertilization Ordinance. Fertilizer requirements (N, P, K) have to be calculated for each plot taking into account factors such as the type of crop to be planted and the nutrient availability in the soil. Since nutrient losses are to be minimized, it is prohibited to apply more (inorganic or organic) fertilizer 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 fertilizer requirements.

As an exception, however, soils with a high P or K content have no P or K fertilizer requirement. In order to allow farmers spreading 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 (1993) this exception would be valid for 27 % of arable land (12 % of grasslands) in the former FRG and 39 % (25 %) in the former GDR with a high phosphate content. For potash these shares are 26 % (40 %) for the former FRG and 53 % (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 criticized the Fertilization Ordinance for also regulating the application of P and K (LESER 1995). It is argued that the influx of P into surface water is caused by erosion rather than by fertilizing and that potash does not pose an environmental problem. 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 fertilizer application in the Fertilization 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 particular with respect to the experience made with the manure ordinances (*Gülleverordnungen*) and the fact that many regulations of the Fertilization Ordinance are defined rather ambiguously.

4.2.4 Pesticide Legislation

As regards 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.[7] One limits the periods for pesticide application and excludes some pesticides from use in specific areas, e.g. WPAs or national parks. The other ordinances require pesticide users to be licensed and machines used for pesticide application to be checked every two years.

4.2.5 Agri-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) (cf. WHITBY 1996, BROUWER and VAN BERKUM 1996). In Germany, for almost 5 million ha, i.e. 29 % of the total utilized agricultural area (AGRA-EUROPE 1996) farmers voluntarily adopt agri-environmental protection programs. These programs mainly include rules regarding the application of smaller amounts of chemicals or none at all, constraining the animal density to a certain level and the protection of the landscape as well as the maintenance of the country-side (cf. FROHBERG 1995). In some *Bundesländer* minimum tillage and underseeding row crops in order to reduce erosion and nitrate leaching are also elements which can be supported by these programs. 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 are likely to reach 826 million DM in 1996 (AGRA-EUROPE 1996). The money for the payments comes from three sources; the EC-Commission, the Federal Government and the government of the respective state.

5 COMMON AGRICULTURAL POLICY AND THE ENVIRONMENT

Since the CAP heavily affects farm structure, the intensity of production and regional specialization in agriculture, agri-environmental issues cannot be discussed 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 pro-

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7 These are the Plant Protection Use Ordinance (*Pflanzenschutz-Anwendungsverordnung*), the Ordinance Governing Specialist Qualifications in Plant Protection (*Pflanzenschutz-Sachkundeverordnung*) and the Ordinance Governing Plant Protection Products and Plant Protection Equipment (*Pflanzenschutzmittelverordnung*).

ductivity 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 problems (BROUWER and VAN BERKUM 1996). Due to increasing financial burdens on the EC-budget and the international pressure on the EC within the GATT-negotiations to liberalize the CAP, discussions on the formulation of agricultural policy became more frequent since the mid 1980s.[8]

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 the 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, oilseeds and pulses, 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 (WHITBY 1996) (cf. section 4.2.5). These practices include, in particular, a drastic reduction of fertilizer and pesticide application and of 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 fertilizer and pesticide applications. Whether the quasi-obligatory set-aside regulation has positive or negative ecological effects depends on the specific 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.[9] 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 fulfillment of environmental requirements in future. The more remote in time the price cuts of the CAP reform are, the lower the society's acceptance for today's acreage premiums will become. Besides, it is likely that the World Trade Organization (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 agriculture will influence the environment only to the degree desired by

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8 On overview of the development of the CAP since 1957 is given, for example, by HENRICHSMEYER and WITZKE (1994).

9 One reason for further adjustments of the CAP is the accession of Central and Eastern European countries to the EU, which is likely to take place in the next decade.

the society. Therefore, additional agri-environmental legislation and institutional settings or a stricter compliance with the existing ones are necessary. In the following section alternative measures to protect groundwater are analyzed.

6 Effects of Alternative Water Conservation Strategies

The effects of two water conservation strategies will be assessed and compared to a reference run which excludes any water conservation measure. The analyses are carried out with the model RAUMIS, which is briefly described in the following section (cf. WEINGARTEN 1996).

6.1 Overview of the Model RAUMIS (Regionalized Agricultural and Environmental Information System for Germany)

Commissioned by the German Federal Ministry of Agriculture, the model RAUMIS (WEINGARTEN 1995, HENRICHSMEYER ET AL. 1992, HENRICHSMEYER ET AL. 1996) was developed at the Institute of Agricultural Policy of the University of Bonn. RAUMIS 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 (HENRICHSMEYER ET AL. 1996).

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 of 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-maximizing behavior in these LP modules. For this purpose, empirical response functions were included into these LP modules.

The interdependencies between agriculture and the environment are modeled using environmental indicators, of which the N-balance is the most important one (cf. section 2.2.2). On the input side, chemical fertilizer, manure, symbiotic and asymbiotic N fixation and input of the atmosphere are taken into account. Removal rates of N from fields vary according to the crop planted. Ammonia emissions are calculated endogenously. The N-balance represents that amount of N 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, accumulation of N 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/m^3 groundwater raised are calculated for groundwater with a potential nitrate concentration in the soil percolation water between 10 and 25 mg NO_3/l. If the potential nitrate concentration amounts to 25 to 50 mg NO_3/l, 0,20 DM/m^3 are assumed. Given a potential nitrate concentration of more than 50 mg NO_3/l, this figure raises to 0,70 DM/m^3 (cf. BÜTOW and HOMANN 1992). In order to facilitate the assessment of the monetary value of the 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.

6.2 Water Conservation Strategies

Depending on the objective pursued, water conservation strategies are to be designed differently. Using the model RAUMIS two water conservation strategies were investigated (WEINGARTEN 1996, 1997). 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. Details of restriction on farming imposed and compensation payments provided are listed in Table 6. Within WPAs farmers have to limit their fertilizer application and are restricted on ploughing up of grassland. They are compensated 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 fertilizer and slurry surpluses are introduced and the ploughing up of grasslands is forbidden (cf. Table 6). Farmers get the revenues of the N-levies paid by them refunded on a uniform basis per hectare.

Table 6: Analyzed 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

1. Maximum utilization of N-fertilizer (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

2. Maximum livestock density: 1.0 manure units (MU)/ha (i. e. the equivalent of 120 kg N/ha)
3. Prohibition of ploughing up grassland
4. Regionally differentiated compensatory payments

STRATEGY 2 (Blanket coverage of groundwater conservation policies)

1. Nitrogen levy on chemical fertilizer: 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 utilized agricultural area according to N-levy revenues

Source: WEINGARTEN (1996).

6.3 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 (cf. 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 strategy 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 policies of strategy 2 were implemented. The latter reaches a surplus of 50 kg N/ha.

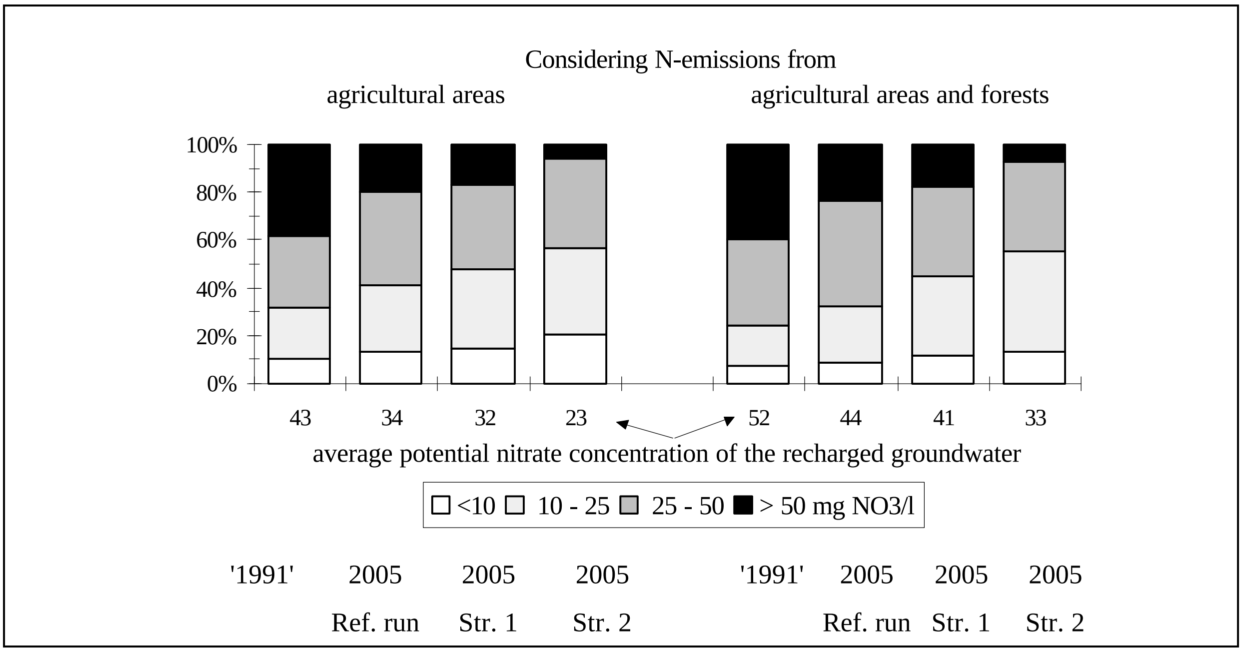
The potential nitrate concentration of the soil percolation water averages 34 mg NO_3/l in 2005 (reference run) as compared to 43 mg NO_3/l in 1991 (cf. the left side of Figure 2). Since the measures of strategy 1 restrict farming only within WPAs, the potential nitrate concentration of the entire soil 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 percolation 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 (cf. the right side of Figure 2).

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 fertilizer	+117	+112	+106	+70	+80
Manure	+105	+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).

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



Source: WEINGARTEN (1996).

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 Map 1. 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 characterized by N-surpluses above the average and/or a quantity of soil percolation water below the average. The potential nitrate concentrations are below the average especially in hilly regions where N-surpluses are relatively low and the quantity of soil percolation water is large due to high precipitation.

Map 1: Potential nitrate concentration in the soil percolation water considering N-surpluses from agricultural land (Assumption: 50 % of the N-surpluses leach into groundwater)

Grafikname:
Erstellt in:
Erstellt am:

'1991'

Grafikname:
Erstellt in:
Erstellt am:

2005, reference run

Grafikname:
Erstellt in:
Erstellt am:

2005, Strategy 1, *within WPAs*

Grafikname:
Erstellt in:
Erstellt am:

2005, Strategy 2

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 (cf. Table 8, considering N-emissions from agricultural land). The potential costs are lowest if strategy 1 is realized (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 groundwater) **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 percolation water**	
	Land from which N-emissions are considered			
	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).

To obtain an estimate of the financial costs caused by the nitrate pollution of the entire groundwater, hypothetical costs were calculated, assuming that the entire soil percolation water would be treated similar to water used for drinking purposes. Based on the N-surpluses of '1991', hypothetical costs of 17 billion DM per year were estimated (cf. Table 8). The reference run 2005 results in hypothetical costs of 12 billion DM. Since the WPAs cover not more than 15 % of total agricultural area, the farming restrictions induce only a slight decrease in the hypothetical costs. In contrast, the hypothetical costs are cut into half 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 their 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, one has to keep in mind that, according to the model results, labor input declines by 40 % in 2005. Therefore, income per full time equivalent of farm labor decreases not as much as the total income does.

If one compares the decrease in the potential costs for water treatment plants with the payments to compensate farmers for losses occurred and the loss in agricultural income respectively, and also takes into account the (minor) change of other subsidies, strategy 1 results in a plus of about 0.3 billion DM (cf. 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 valuing 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 done in this analysis. Furthermore, transaction costs of various amounts caused by the two strategies and impacts of the strategies on environmental resources other than groundwater also have to be taken into account.

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

	2005 Reference run	**2005 Strategy 1**	**2005 Strategy 2**
(1) Compensatory payments induced by strategies	-	+0.40	±0[1]
(2) Other subsidies	-	-0.02	-0.05
(3) Agricultural income [2]	-	±0	-1.54
(4) Interim sum [= -(1) - (2) + (3)]	-	-0.38	-1.50
(5) Potential costs of water treatment plants (extracted groundwater)[3]	-	-0.71	-0.43
(6) Hypothetical costs soil percolation water[3]	-	-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

[1] The compensatory payments (612 million DM) are financed by the farmers paying the N-levy, which for this reason are excluded here. [2] The change of the agricultural income (Net value added in factor costs in the agricultural sector) includes the change of the compensatory payments and of the other subsidies. [3] Cost variant A, only considering N-leaching from agricultural areas.

Source: WEINGARTEN (1996).

7 CONCLUSIONS

The analysis of nitrogen balances at county level reported in this paper indicates reductions of nitrogen 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 Fertilization Ordinance on water pollution critically depends on how precisely farmers calculate fertilization 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 that used as drinking water shall be protected. The welfare change depends heavily on this question.

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