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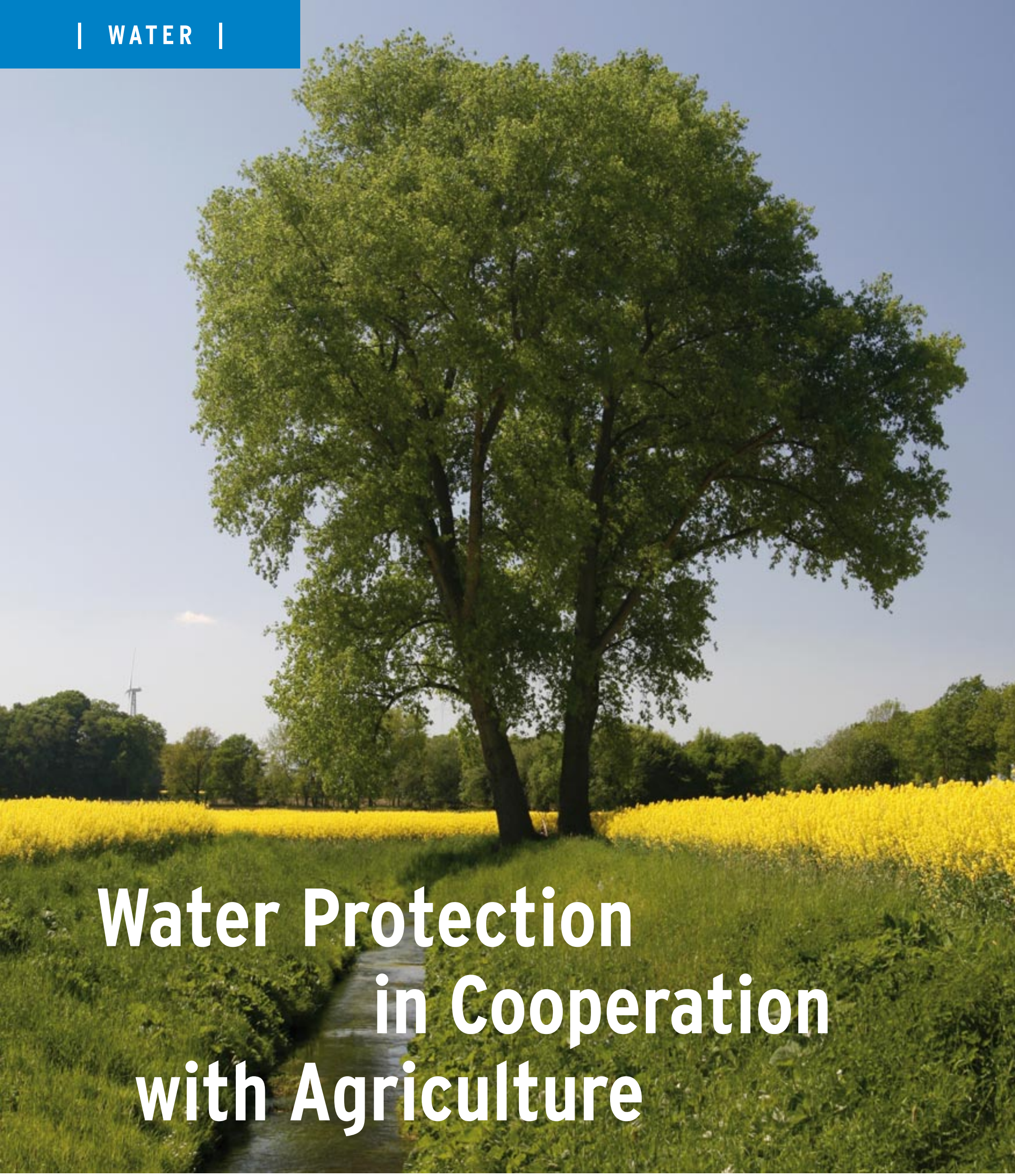

Water Protection in Cooperation with Agriculture

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1. Introduction

Germany's farmers are vital suppliers of numerous raw materials for the food and animal feeds sector, and hence a significant branch of industry. At the same time, the agricultural sector is the largest land user and, unlike other industries, most production takes place in an "open system". This poses a risk to the environment, since only part of the substances used, especially fertilisers and pesticides, are utilised, degraded and retained in soils and plants. A significant portion enters our waterbodies and neighbouring ecosystems, where it can cause major ecological damage. Over the past 30 years, innovations and improved management techniques have achieved notable success in reducing substance discharges into the environment, primarily in the case of emissions from production plants. However, as overall pollution levels have declined, diffuse sources now account for a growing share of emissions. This is particularly true in the case of nutrients, i.e. nitrogen and phosphorous compounds. Compared with other pollutant sources such as industrial facilities or sewage treatment plants that have implemented effective reduction measures, farmers' achievements have been comparatively modest: Between 1985 and 2005, discharges of nitrogen from agriculture decreased by only approximately 22 %. Meanwhile, phosphorous discharges have remained almost unchanged for 20 years, and agriculture has failed to achieve any tangible reductions here. It is fair to say that unless additional measures are taken by farmers, Germany will be unable to meet the targets set out in the EC Water Framework Directive (WFD) for achieving a "good status" of waterbodies.

There has been plenty of research into and much written about effective measures, particularly since the WFD was adopted in 2000, and findings and recommendations are therefore plentiful. Our task now is to ensure that these are consistently implemented.

In principle, experience has shown that *water protection can only succeed WITH agriculture, not AGAINST it.* Expert, competent advice to farmers is an important element of this approach. This brochure hopes to encourage the more widespread use of water-friendly measures and highlight the fact that water protection need not lead to a loss of earnings, and will ultimately benefit all the parties involved, as well as having a beneficial effect on all environmental media.

2. Statutory requirements governing water protection

Even experts find it difficult to get to grips with the extensive spectrum of statutory provisions designed to regulate the discharge of substances and prevent damage to waterbodies by agriculture. Since 2000, the *EC Water Framework Directive (WFD)* has been at the heart of European-wide water protection. It is the central control element with which all future measures must be aligned.

The Water Framework Directive calls for a "good status" of all waterbodies

The main objective of the Water Framework Directive is to achieve a so-called "good status" of all waterbodies (rivers, streams, lakes, coastal waters, groundwater). But what exactly is a "good status"? The basic concept behind this Directive is that although waterbodies may be influenced or modified by human use, this is only permissible to an extent which does not impair the functions of the waterbody, and does not significantly impair the biotic communities typical of that environment.

The WFD sets out in detail the requirements of good water quality for various types of waterbody. In the case of surface waters, these comprise both material as well as biological and structural properties, and in the case of groundwater, both material and quantitative criteria, designed to maintain groundwater levels in the long term.

The *EC Groundwater Daughter Directive* to the WFD sets binding EU-wide limits (the Directive uses the term "quality standards") of 50 mg/l for nitrate, and 0.1 µg/l (individual substances) / 0.5 µg/l (overall pollution load) for active pesticide ingredients

and biocides. These levels were derived from the *EC Drinking Water Directive*, and are therefore also reflected in the German *Drinking Water Ordinance.* The German *Groundwater Ordinance,* timetabled for adoption during 2010, will likewise incorporate these limits. These levels also serve as a basis for the licensing of active ingredients within the framework of European and German *pesticide licensing laws.*

EU expects more cooperation from governments and waterbody users

The WFD introduces several new principles of water protection: Integrated river basin district management, the specification of quality targets or environmental quality standards for all waterbodies, and the requirement for EU Member States to prepare programmes of measures and management plans with the involvement of the general public.

Also new is the concept of transboundary waterbody management. Most European rivers pass through several Member States. As a result, protecting the waterbodies and their river basins invariably necessitates cooperation between neighbouring countries. In concrete terms, the WFD requires the various different administrative bodies and national governments to cooperate more widely on the planning and implementation of reduction measures and hence on effective water protection.

The Member States were required to draft their programmes of measures and management plans for the river basin districts by the end of 2009, a task which Germany completed on time.

The WFD stipulates that a "good status" of European waterbodies is to be achieved by the end of 2015. Reduced targets are only admissible under very strictly defined conditions – for example, upon submission of proof that certain technical measures are impossible to execute. Before agreeing to a reduced target, the possibility of deadline extensions will be investigated, and may be applicable, e.g. on economic grounds.

So which requirements of this Directive are relevant to agriculture? Any activities that significantly impact the water status are generally considered to constitute "water use". This includes discharges of nutrients such as nitrate and phosphate, pesticides, animal pharmaceuticals and other substances by farmers into surface waters and groundwater. Drainage measures, watercourse straightening and bank obstruction can also have major impacts on the waterbody status and are therefore covered by the Directive.

Fertiliser Ordinance places certain obligations on farmers

The WFD requires Member States to control discharges into and intervention in waterbodies on a polluter-pays basis, in order to ensure that a "good status" is achieved by 2015. To this end, the Member States already have a diverse range of control mechanisms at their disposal, whose effectiveness they are required to continuously review and adapt.

For example, the *EC Nitrate Directive* outlines a series of provisions aimed at reducing nitrate discharges from agricultural sources. It regulates good agricultural practice with respect to the application and storage of fertilisers, as well as for soil management, soil coverage, and the infiltration of nutrients and pollutants. The Member States are required to draw up action programmes with binding restrictions on usage and management.

Germany has implemented these requirements throughout its national territory with the *Fertiliser Ordinance,* which stipulates that actual fertiliser requirements should be ascertained, the application of nutrients carefully timed to meet the crops' requirements, and allowance made for the subsequent supply of nutrients from the soil during the vegetation period.

The Fertiliser Ordinance also contains provisions aimed specifically at water protection. For example, when applying fertilisers, a distance of at least three metres must be observed from the upper edge of the waterbody banks. Farmers must also ensure that fertilisers do not leach into overground waterbodies. They must not apply fertilisers if the soil is flooded, water-saturated or frozen, or covered in a continuous layer of more than five centimetres of snow. Blackout periods also apply to the application of fertilisers containing nitrogen. Machinery used in the application of fertilisers and soil improvers must comply with the “generally accepted rules of technology”. Farm manures of animal origin (slurry, liquid manure, solid manure) are also subject to an upper limit of 170 kg of nitrogen per hectare (kg N/ha). In isolated cases and subject to official approval, up to 230 kg of N/ha may be applied to grassland and fields. In order to minimise ammonia and odour emissions, on uncultivated arable land farm manures must be worked into the soil immediately. Farmers are required to prepare nutrient balance sheets for the land being fertilised. There are currently degressive upper limits in place for the admissible surplus. With effect from 2011, the nitrogen surplus according to an area balance sheet (excluding gaseous losses) must not exceed 60 kg N/ha.

Agricultural subsidies linked to water protection

EU agricultural law comprises a wide range of financial mechanisms to support farmers. Some of these agricultural subsidies are direct payments that are made to farm owners irrespective of the nature and extent of production. However, support is linked to certain conditions. The so-called *"cross-compliance" regulations* in the EU (implemented in Germany by the *Direct Payment Commitments Act*) stipulates that direct payments to farmers are dependent upon compliance with certain standards, which also include statutory guidelines and ecological criteria governing water protection: Examples include compliance with the EC Nitrates Directive and requirements relating to erosion prevention, the preservation of organic substance, the conservation of permanent grassland, and the storage of slurry. Farmers must maintain a storage capacity of six months for slurry, as regulated by the *Ordinances on installations of the Federal Länder (VAwS).*

The so-called *Health Check on EU Agricultural Policy* was adopted in January 2009. Its requirements for "good agricultural and ecological status" also include the creation of buffer strips on Waterbodies, and compliance with the licensing conditions for irrigation, e.g. regarding the admissible volume of water.

The Federal Water Act also applies to farmers

The *Federal Water Act (WHG)* sets out additional framework conditions for agricultural production. In Germany, the requirements of the Water Framework Directive were transposed into the Federal Water Act in 2002, and incorporated into the updated Federal Water Act in 2009.

The new WHG also contains licence restrictions for certain water uses, including the discharge of substances, and formulates requirements on waterbody maintenance. It also makes provision for usage restrictions in water protection areas, e.g. with regard to the application of fertilisers and pesticides. In March 2010, the creation of riparian buffer zones five metres wide in undeveloped areas became compulsory across Germany. Restrictions regarding the use of fertilisers and pesticides on these riparian buffer strips are still regulated by *Land law.*

3. How agriculture contributes to water pollution

For many decades, discharges of phosphorous compounds and, in particular, nitrogen compounds have posed a problem for groundwater in Germany and across Europe. However, nutrient emissions also pollute streams, rivers and lakes, as well as coastal waters and seas.

Agriculture operates in an open system. As a result, leaked pollutants are transported via complex routes in a variety of different environmental media and waterbody types. This can be readily illustrated using the example of nitrogen. It is a restricting nutrient in agricultural production, and the number one problem substance emanating from agriculture.

a) Nitrogen: The number one problem substance

In its gaseous form as N2, nitrogen makes up 78 % of the air we breathe. In its bound form, it is a component of proteins and other key biological molecules - in other words, an essential nutrient. Nitrogen in the air is inert and therefore harmless to the environment and waterbodies. In nature, only nitrogen-fixing bacteria or lightning can convert the nitrogen in the air into reactive forms. Ever since Haber and Bosch successfully produced mineral nitrogen fertilisers almost 100 years ago with a high energy input, agricultural productivity has increased continuously, but so too has the quantity of reactive nitrogen compounds in the environment. These are supplemented by nitrogen oxides from combustion processes, e.g. in power plants and engines.

There are substantial quantities of nitrogen in circulation in agriculture. It is found in mineral fertilisers and slurry. Only a small proportion of the fertiliser actually reaches the crops and is taken away with the harvest. A large proportion accumulates in the environment as a surplus, for example in the form of ammonia or laughing gas. The rest remains in the soil or seeps into the groundwater with rainwater in the form of nitrate. Nitrogen oxides from combustion processes are likewise used to fertilise soils and waterbodies.

What is more, nitrogen is present in many foodstuffs, and therefore occurs in substantial quantities in waste water. This sub-flow enters our rivers via sewage treatment plants. Nitrogen pollution in groundwater will end up in our rivers and lakes sooner or later, because groundwater generally flows into surface waters after a variable flow period. All pollution ultimately ends up in our coastal waters and seas. Surplus nutrient discharges lead to eutrophication in rivers, lakes and seas, which in turn causes substantial damage to the ecosystems (see box).

The impacts of past pollution still persist today

In previous decades, intensive farming underwent various developments which caused tangible pollution of our waterbodies that still exists today. These develop-

Eutrophication: Why algae "bloom"

Eutrophic means "well-nourished". Eutrophication is caused by human activity leading to the accumulation of nutrients such as phosphorous and nitrogen in waterbodies. Algae and water plants are then able to grow excessively and deprive other plant species and many organisms and fauna of life, either because massive accumulations of algae block the sunlight for water plants, or because the oxygen content of the water is reduced as a result of the biodegradation of the plant mass. In extreme cases, oxygen-free, inanimate profundal zones can form in lakes (for example, in many of the small lakes in northern Germany that have been overfertilised as a result of fish stocking and feeding) or in stratified regions of the ocean (e.g. in the Mecklenburg Bay of the Baltic Sea or in the Gulf of Mexico as a result of nutrient discharges from heavily farmed catchment areas). The anaerobic degradation of organic mass in these zones produces sewage gases such as hydrogen sulphide and methane. In this final stage, the waterbody is "spoiled".

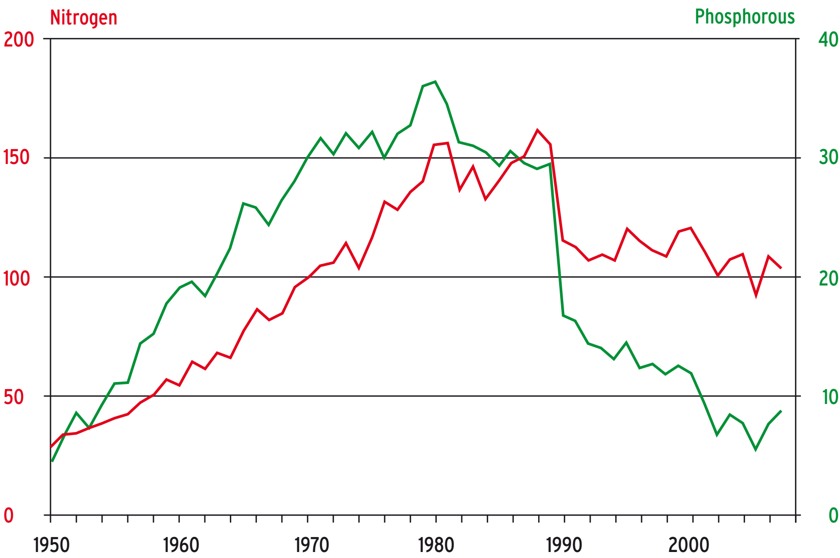
ments include the increased use of mineral fertilisers up until the end of the Eighties, regionally concentrated animal stocks with a high incidence of slurry, and the application of escalating quantities of pesticides.

The effects of past structural interventions into our watercourses likewise remain conspicuous today: Extensive farmland consolidation with straightening and deepening of watercourses, coupled with regular "waterbody maintenance", have permanently damaged the natural morphology of most rivers and streams.

Although a range of reduction measures have been adopted over the years – including the banning of atrazine (1991), and the amendments to the Plant Protection Act (1996) and the Fertiliser Ordinance (1996, tightened up in 2007) – to date these measures have only been partially effective.

Surplus nitrogen from agriculture is a pertinent example. Admittedly, German unification helped to bring down nitrogen surpluses, due to the drastic reduction of animal stocking in the new Länder. Furthermore, since the mid-Eighties farmers have been rather more circumspect in their use of fertilisers, so that the nutrients contained in slurry and manure are more effectively utilised. Despite these efforts, the surplus has seen only minimal reductions to date (Figure 1). Of nutrient discharges into Germany's surface waters, in the period from 2003 to 2005 over 70 % of all nitrogen discharges and over 50 % of all phosphorous discharges originated from agriculture.

Mindful of this problem, in 2007 the Fertiliser Ordinance introduced upper limits for tolerable nitrogen surplus levels which are gradually being reduced. However, one shortcoming of this approach is that farmers are only required to calculate the nitrogen balance of their arable land. Ammonia losses in the barns and during application, which are equally damaging to forests and waterbodies, are disregarded. Figure 1 illustrates the development of the overall balance sheet (also known as the "farm-gate balance”), which includes such losses.



Source: Federal Environment Agency (UBA), Gießen University (2009)

Figure 1: Nutrient surpluses in agriculture, 1950 to 2007

b) Contamination of groundwater

Groundwater in Germany is often contaminated with nitrate. The most recent data from measurements taken during 2008 indicate that the nitrate limit specified in the Groundwater Ordinance of 50 mg/l NO_3 was exceeded at almost 15 % of all monitoring sites. 36 % of monitoring sites indicated significantly to heavily increased nitrate levels. Nitrate levels of less than 10 mg/l, corresponding to a natural or only slightly modified status, were only found at around 49 % of all monitoring sites.

An investigation into the types of land use with low levels of nitrate pollution, and those with high levels, provides a clear insight into nitrate sources. If monitoring sites whose catchment areas are predominantly forest are compared with monitoring sites in the catchment area of arable land, the latter indicates significantly higher nitrate pollution levels of the groundwater (Figure 2). Monitoring sites in grassland also have higher nitrate levels than those in forests. Contamination levels in human settlement areas are even higher, although in such cases the discharges are generally due to leaking sewers.

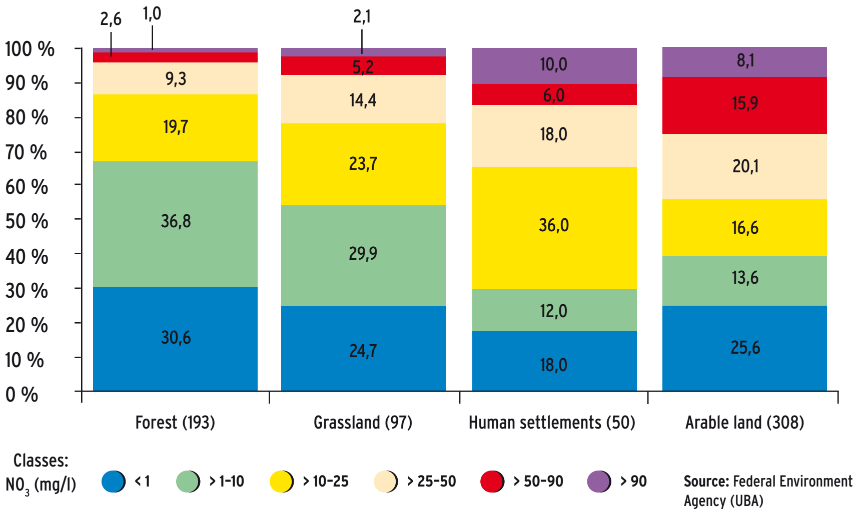
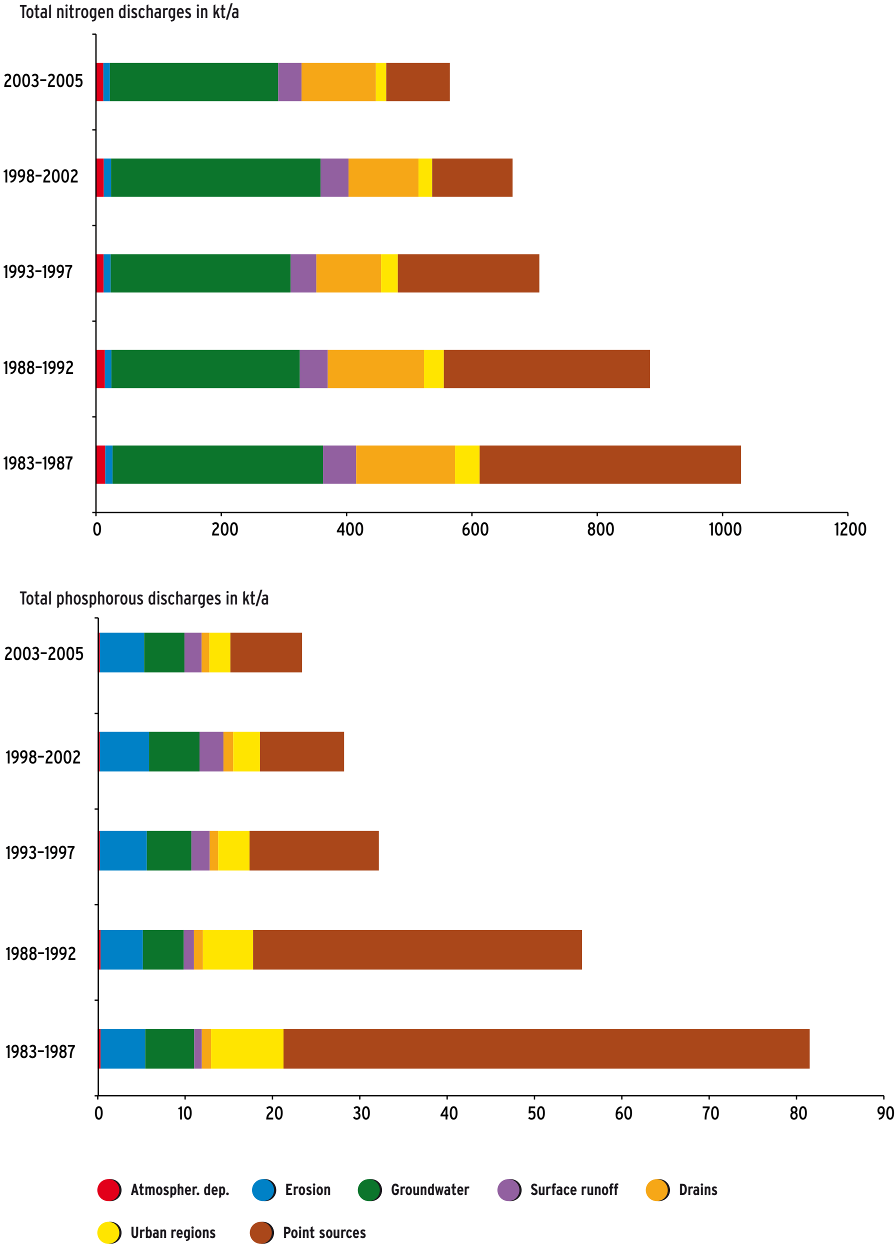


Figure 2: Nitrate contamination levels in forest, grassland, human settlements and arable land

c) Contamination of rivers and lakes

In recent decades, there has been a major shift in the principal discharge sources of nitrogen and phosphorous. In the Eighties, most nitrogen tended to originate from point sources, predominantly sewage treatment plants. Since the mid-Nineties, inflows via groundwater have been the principal source of nitrogen discharges into surface waters such as rivers and lakes. Groundwater contamination is particularly persistent, because water flows slowly underground. Today, nitrogen discharge levels from groundwater are more than twice as high as those from point sources (Figure 3).

Efforts to reduce nitrogen surpluses have achieved noticeable effects in Germany's rivers, but the river basins only respond to changes in pollution levels with a consider-



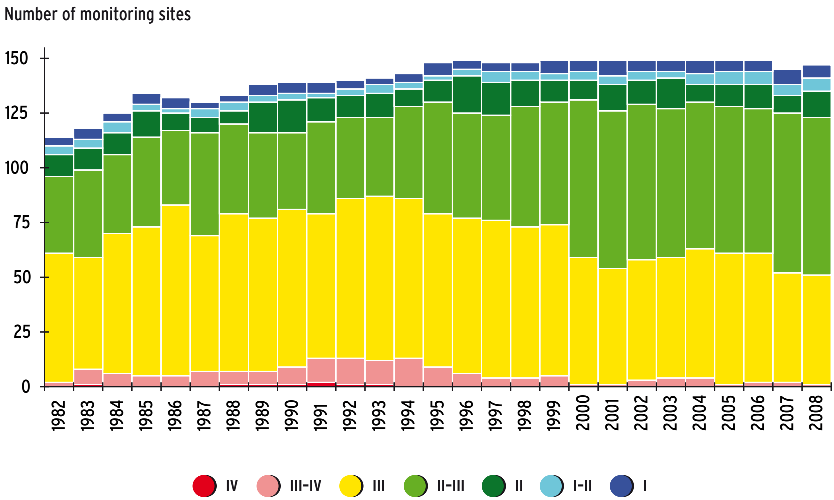
Source: Federal Environment Agency (UBA) 2009

Figure 3: Nitrogen and phosphorous discharges from point and diffuse sources into Germany's surface waters

able delay. Experts predict that reduced pollution levels will become apparent in the Rhine within two to ten years, but not for 20 to 30 years in the case of the Elbe.

Phosphorous shows a similar picture: Phosphorous levels in soil, and hence outflows, have actually risen on average, because surplus quantities are still entering the soils (Figure 1). Under certain conditions, the initially insoluble phosphorous can form water-soluble compounds. In acidic, oxygen-free or extremely sandy soils, phosphorous is also discharged into the groundwater. As a result, groundwater is responsible for approximately 20 % of phosphorous contamination in rivers and lakes.

Overall, it is true to say that the water quality situation in Germany remains unsatisfactory, despite some partial improvements. In 2008, only 16 % out of a total of 147 representative monitoring sites satisfied the requirements of quality class II or above with regard to nitrogen pollution (Figure 4), while 27 % satisfied the requirements of quality class II or above for phosphorous. Since 1998, however, the higher quality classes have exhibited a general increase; the proportion of class III is declining, while class II-III is increasing.



Source: Federal Environment Agency (UBA) from data supplied by the Working Group of Federal States on Water Issues (LAWA) (2009)

Figure 4: Quality classification for nitrate nitrogen (LAWA network of monitoring sites)

It is not just nutrients that are contaminating our waters, but also heavy metals and pesticides. Around 20 to 40 % of heavy metal discharges into surface waters originate from erosion or surface and drainage outflows from agricultural land. In the case of chromium, the figure is as high as 60 %. Here too, other pollutant sources, particularly those from industry, have been cut substantially, as a result of which the relative proportion of total pollution attributable to agriculture has increased.

The bulk of pesticide pollution originates from agriculture, from application to the fields, but equally from the cleaning of sprayers and other machinery. Of 38 pesticides considered relevant to water management, during the measurement period 2005 to 2007, only 20 substances satisfied the quality requirements for "aquatic biotic communities" and "drinking water" at all of the monitoring sites. In the case of a few substances that are banned or no longer licensed (e.g. atrazine), pollution levels decreased noticeably during the Nineties.

The current measurement network has only limited meaningfulness, because it only includes a few small streams and ditches in farmed areas. Impairments and damage to organisms arising in these waters as a result of pesticides are not generally recorded.

d) Contamination of coastal waters

Many readers will recall the alarming reports of algal infestation and seal mortality along the North and Baltic Sea coastlines during the early 1980s. This prompted the littoral states to adopt a number of pioneering resolutions, with the aim of halving pollutant discharges into both seas between 1985 and 1995. In the case of phosphate, this target was considered to have been met, since the introduction of phosphate-free detergents and the improved purification of waste water in sewage treatment plants had a rapid effect. By contrast, nitrogen levels have only been halved very recently.

Fertilisers and pesticides: Many routes lead to waterbodies

The substances used in agricultural production can enter the environment via a variety of routes. Mineral fertilisers and farm manures of animal origin, pesticides, animal pharmaceuticals and sewage sludge are particularly relevant to waterbody pollution. Such substances enter the environment in a variety of ways, firstly via the erosion and leaching of fertilised or sprayed soil particles, and secondly by elutriation due to improper or excessive use. The release of ammonia from livestock farming and from the storage and application of slurry likewise pollutes waterbodies.

However, material contamination is not the only problem. In the past, widening, deepening and straightening measures have been used to modify and standardise the appearance and course of natural waterbodies. Rivers and streams which retain their original course and natural vegetation are now a rarity in Germany.

e) Still a long way from achieving a "good status" of waterbodies

Back in 1991, the realisation that nitrogen pollution in many waterbodies originated from agriculture prompted the European Parliament to adopt the "Direction on protection of fresh, coastal and marine waters from nitrogen pollution" (91/676/EEC).

Since the adoption of the EC Water Framework Direction (WFD) in the year

2000, strategies and protection concepts have been aimed at achieving a "good status" of waterbodies by 2015 (see chapter 2).

The management plans for all ten German river basin districts indicate that agriculture is responsible for a large proportion of nutrient and pollutant discharges. Farmers are partly responsible for the fact that around half of groundwater aquifers, more than 80 % of rivers and streams, half of all lakes and almost all of Germany's coastal waters will fail to achieve a "good status" unless effective reduction measures are introduced. Agricultural sources are almost solely responsible for groundwater contamination. Almost half of groundwater aquifers are unlikely to achieve a "good chemical status" due to the high nitrate levels (Figure 5). For lakes and coastal waters, eutrophication as a result of nutrient discharges is by far the greatest problem.

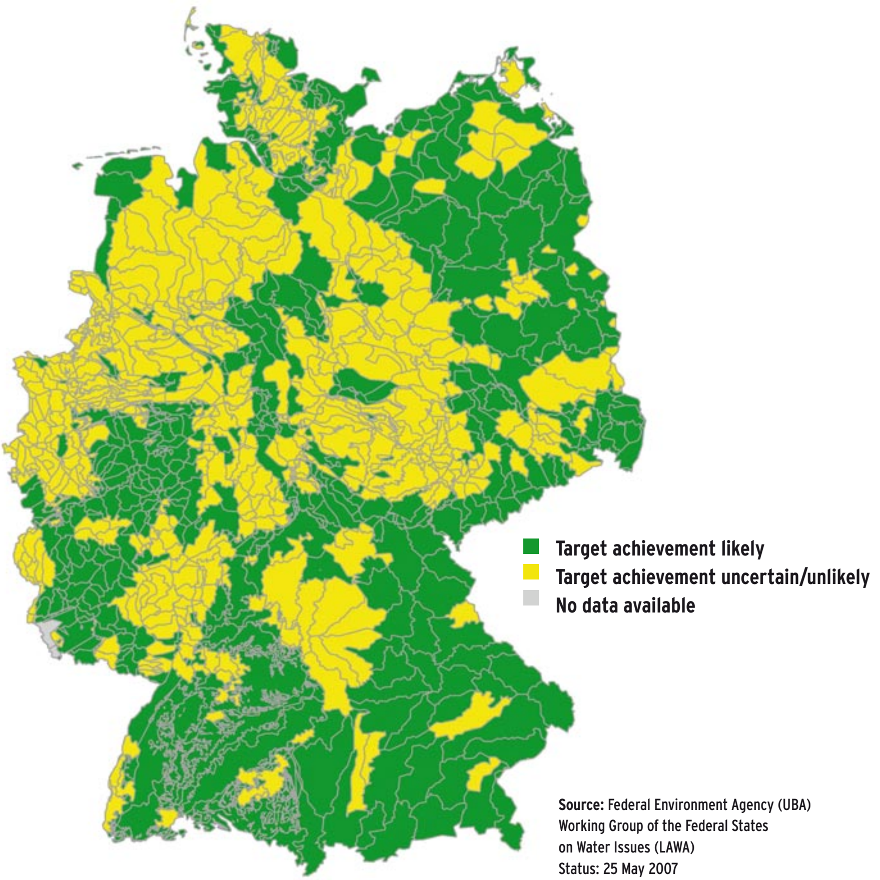


Figure 5: Target achievement by bodies of groundwater (chemical status)

Rivers and streams are damaged primarily as a result of morphological changes: In the past, waterbodies have been straightened, drained and deepened for agricultural use, as well as for hydropower and shipping purposes. Their beds are now trapezoid and uniform; natural structures have been prevented and removed[1].

Similarly, farmers today are more efficient and eco-friendly in their handling of chemical substances and agents than they were 15 or 20 years ago. Despite this, most German waters will fail to achieve a "good status" as defined by the WFD by 2015. To this end, measures are needed to cut surplus nitrogen to approximately 50 kg N/ha (as an area balance) per annum. This figure is roughly equivalent to the sustainability target of 80 kg/ha (farm-gate balance). The Fertilisers Ordinance, which introduced more stringent limits in 2007, will likewise fall short of this target. For the nitrogen surplus area balance, an average of the years 2009 to 2011 and later an upper limit of 60 kg/ha is to be adhered to. However, if around 30 kg/ha of additional gaseous nitrogen discharges are also taken into account, it seems unlikely that the target value for 2010 (80 kg/ha farm-gate balance) will be met.

[1] Further details may be found in a brochure published by the Federal Environment Agency, „Gewässer pflegen und entwickeln – Neue Wege bei der Gewässerunterhaltung", 2009

4. Water-friendly approaches to farming

In order to minimise the pollution of Germany's waters, some areas require measures above and beyond the current legal requirements. All farmers nationwide are obliged to observe the principles of good agricultural practice - for example, fertilisers and pesticides are to be used in a requirement-based, efficient and low-loss manner. In order to achieve a "good status" of waterbodies, as required by the EC Water Framework Directive, we need to establish practices above and beyond these obligatory measures to facilitate the best possible water protection without adversely affecting agricultural earnings.

Water-friendly management techniques have been the subject of research and trials for many years. In the meantime, a "state of the art" has emerged which has yet to be applied on a wide scale. There is an extensive range of technical and organisational measures available for use in agricultural production. The main rule of thumb is that activities that help to conserve our waters also benefit other protected commodities such as soil and air. In this way, they also support environmental objectives in the areas of climate protection, landscape protection, nature conservation and soil conservation.

4.1 WAYS OF MINIMISING WATER POLLUTION

In agriculture, there are four main ways of reducing water pollution by adopting a modified approach to farm and land management:

a) Nutrient balance assessments and fertiliser management
b) Crop rotation and location-appropriate land use, riparian buffer strips
c) Plant protection
d) Eco-friendly waterbody maintenance.[2]

a) Nutrient balance assessments and fertiliser management

The Fertiliser Ordinance provides the statutory basis for the use of fertilisers. Water-friendly practices are designed to reduce nutrient surpluses and minimise elutriation and leaching of fertilisers into the groundwa-

[2] Further details may be found in a brochure published by the Federal Environment Agency, "Gewässer pflegen und entwickeln – Neue Wege bei der Gewässerunterhaltung", 2009

To this end, comprehensive fertiliser planning is needed. Such plans must make allowance for the farm manure generated, and also any fermentation residues arising (where applicable), based on an up-to-date calculation of nutrient requirements, and results of soil and plant analyses. Farmers can significantly improve their fertiliser management by using field databases and field balance assessments after actual fertilisation, and based on realistic yield expectations. Accredited experts, agricultural advisors, IT programs and Internet portals such as ISIP offer support in this regard.

Nitrogen
In quantitative terms, nitrogen is the most significant of all nutrients in agriculture. However, nitrogen and its chemical compounds can damage waterbodies and their flora and fauna, for example, by contributing to eutrophication. Measures aimed at water-friendly farming must therefore target this nutrient, because it is the area where the greatest positive effects can be achieved.

Generally speaking, the application of nitrogen fertilisers should aim to minimise or avoid nitrogen surpluses and accumulation. There are various ways of achieving this:

- The greatest reductions can be achieved with demand-based, location-appropriate fertiliser application (see box).

- A good humus balance is important for preserving soil fertility. Excessively high humus contents should be avoided, since increased mineralisation of the organic substance releases nitrogen, which in turn increases the risk of unwanted nitrogen outflows into waterbodies.

Approaches to demand-based fertilisation

The greatest potential for reducing unwanted nitrogen discharges is by adopting fertiliser practices that have been adapted to the crops' actual needs and the local conditions. Nitrogen quantities should be based on the optimum financial yield, not the maximum yield. Wherever possible, farmers should aim for less than the maximum tolerable levels of surplus nitrogen according to the area balance. Preparation of a farm-gate balance provides additional insight into the actual volume flows. It is important to coordinate the analysed nitrogen absorption with the subsequent supply of nitrogen from crop residues and soil. In sensitive areas, fertiliser application should be based on location-typical yields over many years.

In order to estimate the outflow potential, the Nmin values in autumn and, where applicable, spring should be recorded, and allowance made for the residues in fertiliser planning. Additionally, fertiliser application should be carefully timed in such a way that nitrogen availability is optimally adapted to the nutrient requirements of the crops. To this end, where necessary, the black-out periods should be extended beyond the provisions of the Fertiliser Ordinance in order to minimise the risk of surplus supply in autumn and spring.

Dispensing with the application of nitrogen fertilisers after straw rotting and after harvesting until January of the following year (except in the case of autumn crops with a corresponding nitrogen demand) also contributes to water protection, as does minimising periods with no crop vegetation in order to bind nutrients and water in the soil and minimise elutriation.

- The management of farm manures must be supplemented by suitable measures in livestock farming, in the pigsty or cowshed, and in the storage of slurry (see box).

- Selected application techniques such as the drag-hose, drag-shoe or slit-injection technique can help to prevent direct discharges. Precision sprayers facilitate an even spray pattern and exact application e.g. along water-bodies and paths.

- The effectiveness of measures should be monitored and controlled by careful record-keeping of nutrient surpluses. From the viewpoint of water-body protection, we advise farmers to keep a "farm-gate balance" which includes all nutrient flows into and out of the farm. The field-based area balance as required by the Fertiliser Ordinance is also important, as it indicates whether the nutrients have been evenly distributed among the farm's fields.

Water-friendly measures in livestock farming

There are also various measures in livestock farming that can benefit water protection. In order to ensure the timely and targeted use of slurry, for example, the statutory storage capacity of at least six months should be kept available. The upper animal stocking rate limits per unit of area should also be observed. As a general principle, the animal stocking rates should be in a balanced ratio to crop cultivation, i.e. they should not exceed the actual demand for organic fertilisers. By adapting feed to protein requirements, excretion of nitrogen can be reduced by between 5 and 20 %, depending on the animal species, with no loss of performance. An analysis of feed, together with professional control and ration planning, will avoid unnecessary wastage during feed purchasing and storage, as well as preventing surpluses of raw protein.

Other pollutants

Phosphorous

For phosphorous, farmers should aspire to a supply level equivalent to soil content category C in land cultivation, corresponding to balanced fertilisation and maintenance rates. Higher supply rates should be minimised by reducing the nutrient doses. Any erosion protection measures will likewise help to minimise phosphorous discharges into waterbodies (see following section).

Heavy metals

The Fertiliser Ordinance prescribes upper limits for heavy metals in mineral fertilisers in order to limit discharges of heavy metals into our soils. The same applies to the upper limits stipulated in the Sewage Sludge Ordinance. Furthermore, the addition of copper and zinc to animal feeds and the use of disinfectants containing copper in the cowshed or pigsty should be limited by means of suitable alternative measures (regular hoof care, use of suitable mats). If the soil contains excessive levels of bound heavy metals, erosion protection measures will help to minimise their discharge into waterbodies. (see following section).

b) Crop rotation and location-appropriate land use, riparian buffer strips

Optimum crop rotation and location-appropriate soil cultivation will have a positive effect on water quality, because they increase the content of organic substance in the soil, and improve its fertility, structure and water-retaining capacity. In this way, they reduce nitrate elutriation, minimise erosion, and reduce the surface outflow of nutrients. The principal measures are as follows:

- Structuring crop rotation in such a way that humus levels are at least balanced and elutriation losses, surface runoff and soil erosion are avoided as far as possible. Widespread location-appropriate crop rotation increases yield reliability and reduces the use of fertilisers and pesticides.

- Land management based on conservation tillage techniques. Mulch sowing techniques (plough-free, shallow, non-turning tillage) and direct sowing techniques (which do not till the soil at all) inhibit nitrogen mineralisation by extending the fallow period and avoiding harmful soil compaction. In conjunction with adequate year-round soil coverage with intercropping and undersowing, nutrients are bound and erosion processes inhibited. (See box).

- Flower strips, conservation strips or riparian buffer strips along waterbodies or in areas at risk of erosion can help to avoid direct discharges of nutrients into surface waters. The effectiveness depends on the adjacent use, the width of the strip, and the angle of slope. The strips must be seamlessly connected over an adequate length, otherwise elutriation will simply flow around them. Nevertheless, erosion protection must take place in the land. (See box).

Intercropping and undersowing helps to bind water and nutrients

Intercropping and undersowing prevent nitrate elutriation in winter and (in the case of winter-hardy varieties) into spring, because they provide interim storage of nitrogen and reduce the volume of leachate. Planting during low-vegetation periods will help to minimise erosion and reduce the surface run-off of nutrients, provided there is an adequate supply of water. In regions with low summer precipitation, intercroppping and undersowing can help to stabilise the soil humidity. Undersowing is more difficult to integrate into farming practices. Sowing must be carefully timed and must use the right technique to facilitate rapid growth after the main crop has been harvested. The potentially increased use of herbicide is acceptable from a water protection viewpoint, since reduced elutriation and erosion also help to minimise herbicide discharge.

Measures to prevent surface run-off and erosion

An optimum sequence of main and interim crops will shorten the period with no soil coverage. Conservation tillage with mulch sowing or direct sowing can selectively reduce surface run-off of nutrients and minimise the risk of erosion. Although crop rotation with conservation tillage often necessitates the more extensive use of herbicides, this is tolerated from a water protection viewpoint, because overall herbicide discharges are lower. Feed crops, mixed cropping and undersowing likewise help to reduce erosion. It is also important to avoid and remove sludgy deposits and harmful soil compaction, and to preserve a good soil structure and location-typical humus content. Other important measures against erosion include buffer strips and filter strips on the land and along waterbodies, together with soil cultivation at right-angles to the slope.

- Ploughing up permanent grassland leads to extreme nitrate elutriation, because humus that has accumulated over a period of years or even decades is removed within the space of a few months. For this reason, it is advisable to avoid ploughing up grassland in areas particularly at risk of erosion and flooding, as well as in water meadows and drinking water abstraction areas, and to practice grassland renewal without ploughing. In many cases, this is a statutory requirement.

- Grassland use and grazing management should be practised as extensively as possible (average stocking levels of less than 1.4 grazing livestock units (GLU) per ha). No grazing should occur after 15 October. Water-friendly grazing management requires appropriate fertilisation, grazing changes in line with pasture maturation, and the preservation of a comprehensive grassland sward to avoid concentrated areas of nitrate elutriation.

- As a general principle, areas that perform ecological equalisation and dilution functions such as fallow land and priority ecological land should likewise be preserved.

Integrated land use also comprises coordinated water management in agricultural cultivation areas. Preserving wetland areas and small ponds helps to support natural waterbody structures and retain nutrients. Individual farmers are not always able to carry out certain measures, since this requires the support of the managers and owners of arable land and grassland, as well as cooperation with the public administration. Such measures include:

- Renaturation of developed watercourses

- Removal of drainage installations that are no longer required.

- Rewetting of water meadows and peatlands, especially where it is necessary to restrict or discontinue agricultural use for water protection purposes.

SUMMARY:
All forms of management that retain water and nutrients in the land and conserve the soil help to protect waterbodies!

c) Plant protection

Good agricultural practice includes the principles of integrated plant protection, which are considered minimum requirements from a water protection viewpoint. All measures above and beyond this that reduce the volume of pesticides used are recommended.

- Wider use should be made of preventive measures, such as mechanical maintenance measures. Use should be made of the full range of techniques available (biological, biotechnical, horticultural and cultivation methods), and we also recommend targeted individual plant control and nest treatment.

- By observing the harmful threshold principle, the volume of pesticides used can be reduced to an essential minimum.

- Varied cropping reduces the risk of infestation.

- In order to avoid runoff and spray drift, distance regulations and application requirements must be observed, by maintaining a distance of at least 5 m from the upper edge of the waterbody.

- Spraying equipment should be cleaned in the field and modernised where necessary.

- Residual quantities and cleaning fluids should be disposed of properly. Rinse residues should be disposed of in the field or as special waste. Discharging into farm drains or public sewers is a violation of good agricultural practice.

4.2. HOW CAN WE IMPROVE THE (ECO-) POLITICAL FRAMEWORK CONDITIONS?

European and national requirements and regulations under agricultural and water protection legislation provide a framework for action by individual farmers. Statutory and policy instruments need to be coordinated with one another and improved if we are to reduce water pollution by the agricultural sector.

For effective political control, we recommend a combination of European requirements with valid, European-wide minimum standards and supplementary, regionally adapted measures. This is the most effective way of ensuring that water protection is anchored in agricultural policy. Examples of regionally adapted measures, which could be financed from the so-called "second pillar" of the Common Agricultural Policy (CAP), include training courses, agro-environmental programmes, and river basin management plans. Efforts to improve water quality must be stepped up across all areas.

Minimum ecological standards for good agricultural practice

We should consistently aim to anchor minimum soil and water protection standards into good agricultural practice with legally binding effect as a key component of eco-friendly farming. The objective should be to reduce agricultural discharges of pollutants by stipulating appropriate techniques and standards in livestock farming and crop production. In this respect, area-wide implementation throughout all EU Member States should be the priority, rather than restricting measures to at-risk or sensitive areas.

Demanding and promoting environmental efforts

In order to create a uniform European standard, we must develop and stipulate cross-compliance requirements in the interests of water protection. To this end, we must create an interface to the EC Water Framework Directive. Based on the other EU analysis requirements governing regular random sampling within the framework of the integrated administration and control system (InVeKoS), compliance with the WFD-relevant provisions of cross-compliance should likewise be monitored in at least 1 % of farms.

The so-called "second pillar" of the EU's Common Agricultural Policy (CAP) needs to be strengthened so that further incentives can be offered to farmers to use eco-friendly, water-conserving production and management techniques . Within the framework of agricultural subsidies under the CAP, the Second Pillar is being extended via the instrument of modulation, and will be gradually increased from its previous level of 5 % to 10 % by 2013. Modulation means cutting direct payments based on the size of the farm, and redirecting the funds thereby released into rural development. The next reform of the CAP (probably for the period from 2014 onwards), however, should include clear budgets for the two pillars with a pronounced shift in weighting in favour of the second pillar, in order to meet the "new challenges" such as water management, climate protection and conserving biodiversity. However, this must not be allowed to occur at the expense of existing activities to promote rural development. The required funding top-up would come from budget cuts in the "first pillar", eliminating the need for modulation, i.e. the retrospective redirection of funds from the 1st to the 2nd pillar depending on farm size allocation.

The European Agricultural Fund Regulation[3] provides the statutory basis for rural development funding, and also constitutes the platform for agricultural and environmental programmes by the Federal *Länder*. The Federal Government is involved in this via the "Joint Task for the Improvement of Agricultural Structures and Coastal Protection" and the related framework plan.

Germany uses a range of agricultural and environmental programmes to integrate supplementary agricultural measures into management plans as stipulated by the EC Water Framework Directive.

Alongside the voluntary measures offered within the context of agricultural and environmental programmes, the EAFRD Regulation also envisages the option of compensation for compulsory measures and related management restrictions/increased expenditure associated with implementation of the WFD. For water protection purposes, the Federal *Länder* must apply the EAFRD Regulation accordingly and enforce compulsory measures in the event of high pollution levels.

Take advantage of agricultural and environmental programmes!

The agricultural and environmental programmes of the Federal *Länder* are generally designed to reward management forms and production-related measures that aim to make agricultural production more eco-friendly. In the current funding period (up until 2013), a growing number of measures will be targeting sites at risk of erosion and elutriation and offering measures eligible for support connected with implementation of the EC Water Framework Directive.

The majority of *Länder* support measures aimed at reducing nutrient discharges, preventing erosion and facilitating land use, such as intercropping or undersowing, the creation of flower strips, flower zones and riparian buffer strips over a period of several years, the application of mulch or direct sowing, and the use of eco-friendly slurry application techniques. Some *Länder* also offer support for the semi-natural development of waterbodies, improvements to water ecology, and the sustainable development of wetlands in conjunction with agricultural activity.

In future, we would recommend linking support more closely to results, so that the actual environmental relief achieved can be rewarded directly.

[3] EAFRD: European Agricultural Fund for Rural Development. The relevant Regulation was recently amended (now: Regulation (EC) No. 74/2009).

Communication and training

Incorporating conservation and water protection aspects into the education and training of farmers helps to foster an understanding of water protection, and improve specialist knowledge of eco-friendly production techniques. Targeted information and advice can encourage the spread of voluntary measures and their implementation at farm level, so that eco-friendly practices are integrated into everyday agricultural life in the long term.

Additional support should be dependent upon the farmer attending water protection consultations and advanced training programmes.

Cooperative water protection agreements at *Land* and river basin level both within and outside of water conservation areas also help to foster water-friendly farming practices. For this reason, we should actively communicate the experiences of existing programmes in selected Federal *Länder* and the results of pilot projects to implement the EC Water Framework Directive in the agricultural sector, with the aim of initiating follow-on projects.

Strengthening organic farming

Organic farming is considered a particularly sustainable form of production, although of course even organic farming is not emission-free. Because organic farming refrains from using mineral-based nitrogen fertilisers, its N surpluses are lower, and the risk of nitrate elutriation is reduced. Furthermore, it does not use chemical/synthetic pesticides, and this in turn eases pressure on the environment.

In certain cases, organic farming can be used specifically to ensure a good groundwater quality and thereby safeguard water supply to large towns and cities. This occurs on a cooperative, i.e. contractual basis with compensatory payments, for example, in the Mangfall mountain range (water supply to the city of Munich) or at the Canitz water reserves near Leipzig (water supply to the city of Leipzig).

As part of its sustainability strategy, the German Government has set itself the target that 20 % of agricultural land should be farmed according to organic principles. At the moment, however, this figure is only 5 %. Consumer demand for organic produce significantly outstrips domestic production, leading to rising imports. Our aim should therefore be to provide financial support for farmers wishing to go organic, and make it so attractive that the bulk of Germany's demand can be met from domestic production.

5. Challenges for the future

In a globalised world, production conditions are changing rapidly. This is equally true of agriculture. The globalised agricultural market poses brand new challenges for farmers. Reforms of and changes to agricultural and environmental policy exert a direct influence on its day-to-day practices. As if that were not enough, agriculture – like other industries – is also exposed to external influences.

Below, we cite some examples of recent developments that affect agriculture in a variety of ways. They all share one thing in common – namely, that farmers are both players and affected parties in equal measure:

a) Climate change and adaptation strategies
b) Opportunities and risks associated with bioenergy

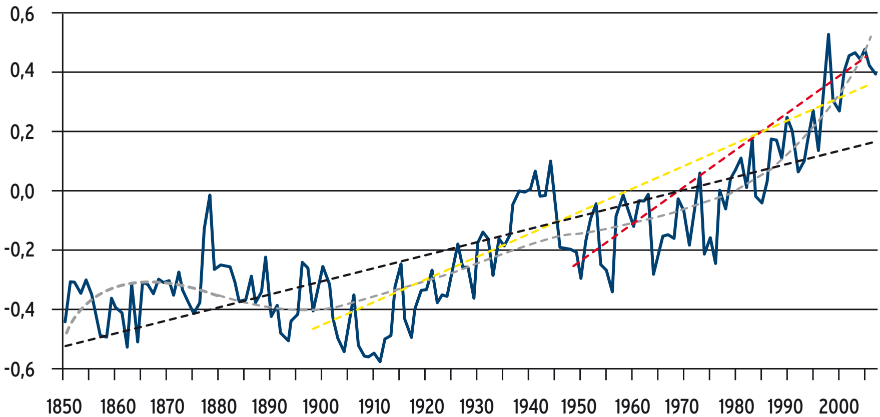
a) Climate change – Consequences and adaptation strategies

There can be almost no other industry that relies as heavily on the weather as agriculture. As a result, climate change is a particularly important issue for this sector. The facts are well-known. Over the past 100 years or so (1901–2006), the average air temperature in Germany has risen by just under 0.9°C. The Nineties were the hottest decade of the 20th century. For Germany as a whole, climate researchers are expecting the temperature to rise again by the end of this century. The rise in summer could be more pronounced than in winter.

The quantity and distribution of precipitation is already changing, although at present, annual fluctuations and regional differences make it difficult to establish clear correlations with global climate change. In all probability:

- Average annual precipitation will increase in the west,
- It will become even drier in the east of Germany,
- Precipitation will shift over the course of a year,
- Summer rains will decrease,
- Winter rains will increase,
- More rain will fall, and less snow,
- Particularly in winter, heavy precipitation will become more frequent and more intensive.

Higher temperatures and changing precipitation affects the entire water balance. As a result, the agricultural sector is directly affected by the consequences of climate change. Despite the many uncertainties, it seems clear that precipitation is shifting from summer to winter, in direct contradiction to the requirements of agricultural crop production. Inadequate precipitation, excessively high temperatures and the increase in extreme weather events (storms, hail, periods of drought) may prompt more pronounced fluctuations in crop yields and quality, and even failed harvests. On the other hand, with a moderate rise in temperatures and an adequate water supply, we can expect an increase in yields for many types of crops.



This diagram shows the global development of average temperatures between 1850 and 2005 (blue line). The linear trend since 1850 (black line), since 1900 (yellow line) and since 1950 (red line) is becoming ever steeper. The trend curve (polynomial adaptation of the time series) reflects the dramatic increase since the late Seventies (grey curve).

Source: German Weather Service, Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

Figure 6: Average temperatures, 1850–2005

Adaptation measures are unavoidable: Even if mankind were to put an immediate stop to all climate-relevant emissions, the climate would still continue to change over the next few decades, due to the greenhouse gases already released.

How to make agriculture "climate-proof"

Firstly, adaptation measures help to minimise the agricultural risk. Secondly, a modified approach to land management and efficient water use can help to significantly ease the pressure on water resources.

Soil- and water-conserving production methods are at the forefront of this approach. They reduce water loss from evaporation and minimise the risk of erosion. Conservation tillage and comprehensive soil coverage have a positive impact on the soil's seepage properties, and increase its ability to absorb water, and therefore aid water retention in the land. What is more, these forms of management help to reduce discharges of nutrients and pollutants into waterbodies. In the future, this will be highly significant for water protection, since periods of low precipitation in conjunction with low water levels are likely to occur more frequently than in the past, as climate change progresses.

Riparian buffer strips help to minimise diffuse discharges of nutrients and pollutants. They also restore land to the waterbodies where natural flora and fauna and even riparian forests are able to develop. Improved waterbody structures also offer a retreat for flora and fauna, e.g. in the event of low water levels in summer.

It is essential to select suitable varieties and to adapt crop rotation in line with climate change. Heat-loving and drought-resistant varieties and species are recommended, since these will offer sufficiently high yield levels even under altered climatic conditions. Sowing spring cereals earlier could potentially increase yield, thanks to the higher soil humidity in spring, and minimise the risk of drought stress. At the same time, however, there may also be an increased threat of damage due to late frosts.

As a general rule, therefore, robust varieties with a high climate tolerance and minimal susceptibility to pests should be given preference over sensitive, high-performance varieties. Extending the crop rotation spectrum can reduce the risk of harvest failures caused by climatic extremes.

Last but not least, agriculture can make an important contribution towards improving the water balance if land reclamation measures that are no longer required are reversed, and rewetting of land is permitted. Given the possibility of precipitation shifts into the winter months, water retention and the efficiency of irrigation systems in general should be improved. The abstraction of water for agricultural irrigation should always be practised prudently; it must not be allowed to cause a lowering of groundwater levels or damage to terrestrial ecosystems.

b) Renewable energies – Opportunities and risks associated with bioenergy

Bioenergy is one of the principal components in the future energy mix, since it reduces the emission of greenhouse gases, while at the same time reducing our dependency on energy imports. The use of bioenergy has also led to the emergence of interesting development alternatives in rural regions, where farmers are turning to plant operation as well as raw material production.

In recent years, the amount of land used to cultivate energy crops has increased at a rapid rate: At present, energy crops are cultivated on more than 14 % of Germany's arable land. The two dominant crops, rape (as a raw material for biofuels) and maize (as a substrate for biogas generation), have seen a particularly sharp rise (Figure 7).

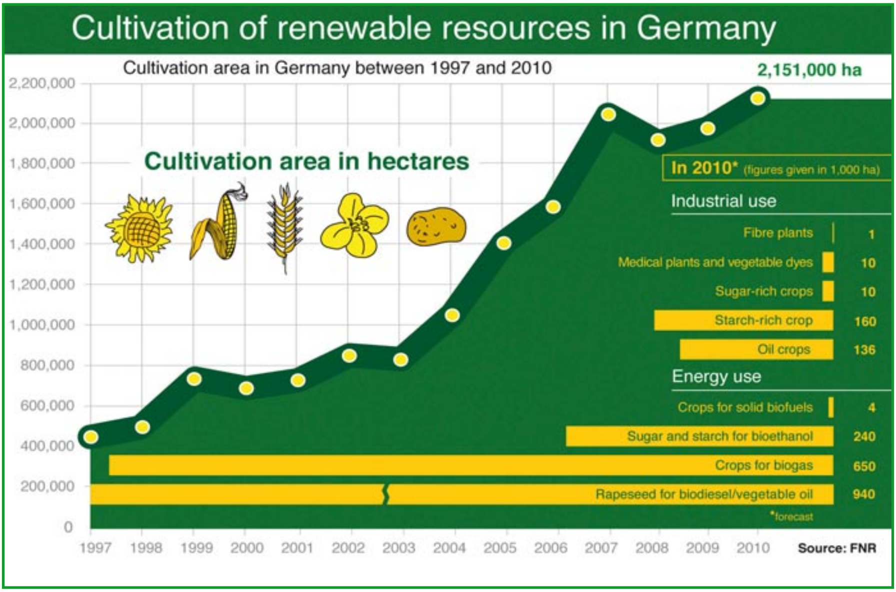
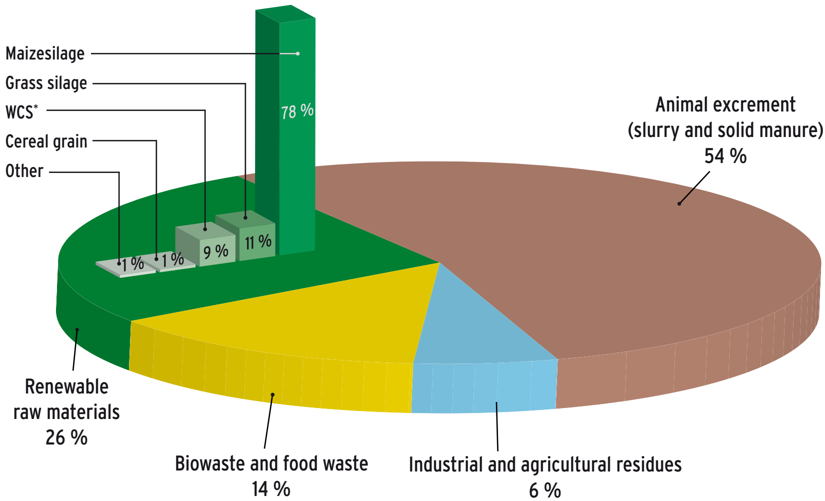


Figure 7: Cultivation of renewable raw materials in Germany

However, rape and maize are problematic crops from a water protection viewpoint, as they require comparatively high volumes of fertilisers and pesticides. Maize is also one of the most erosion-prone crops. Yield-oriented production, close crop rotation with high proportions of rape or maize, and expanding cultivation areas, coupled with regional concentration, exacerbate these problems.

Biogas production is also linked to various problems affecting water. The fermentation residues produced are used as fertilisers, due to their high nutrient contents, whereby the nutrients and constituent ingredients are determined to a large extent by the original substrates. As illustrated by Figure 8, in Germany slurry is the main original substrate used in biogas extraction. Among renewable raw materials, maize is the dominant choice.

Fermentation residues can be difficult to define and control, which increases the risk of crop- or location-inappropriate application. What is more, fermentation residues increase the amount of fertilisers produced by the farm itself, with the associated risk of an oversupply to nearby agricultural land.



* WCS = Whole Crop Silage

Source: German Biomass Research Centre, 2009

Figure 8: Original substrates for biogas extraction

Recommendations for water-friendly bioenergy

As we have seen, impairments to waterbodies can be caused both by the cultivation of energy crops, and by the return of fermentation residues onto agricultural land.

For the first time, the Sustainability Ordinances adopted in 2009 imposed certain environmental and management standards on the cultivation of energy crops in the electricity and biofuels sector. From a water protection viewpoint, however, the criteria are insufficient, especially as the requirements do not extend beyond good agricultural practice and the cross-compliance regulations. Instead, the principles of location-appropriate, water-friendly management must be applied to energy crop cultivation as well (see chapter 4.1).

Farmers should also utilise every opportunity to structure their crop rotation to counteract one-sided cultivation structures and minimise the risk of water pollution. Using energy crops can extend the spectrum of species on arable fields, for example via the introduction of new crops such as sorghum, silphium perfoliatum or topinambur.

Mixed cropping and duoculture systems likewise offer opportunities for the water-friendly production of energy crops. Both techniques promise to reduce diffuse nutrient discharges, thanks to the reduced use of fertilisers and pesticides, although their use in practice has thus far been limited.

The use of grassland for agricultural purposes should be avoided, especially at locations which are at particular risk of erosion and discharge, since the requisite tillage causes the mineralisation and release of large quantities of nitrogen, and large quantities of carbon stored in the soil additionally escape into the atmosphere.

The use of fermentation residues plays a central role in the operation of biogas plants. In this regard, the relevant provisions governing the application and storage of farm manures are inadequate. If fermentation residues are applied as fertilisers, they must be incorporated in their entirety into the calculated application rate of 170 kg N/ha. In this regard, allowance must be made for the entire volume of nitrogen, and not just the portion originating from animals. Fermentation residues contain various original substrates, and their nutrient contents may therefore vary significantly. Farm- and plant-specific analyses are necessary for eco-friendly horticultural use, in order to ensure that application reflects the local requirements.

The targeted and precisely timed application of fermentation residues presupposes the availability of adequate storage facilities, possibly beyond the six-month deadline. Application after harvesting and in the autumn should be reduced to a bare minimum or avoided altogether, to prevent the relocation and elutriation of soluble nitrogen.

6. New collaborative forms – Cooperation and participation

Implementation of the EU Water Framework Directive and the requirements for adaptation to climate change have clearly shown that water conservationists and farmers need to collaborate more closely to resolve existing problems.

The EC Water Framework Directive adopts an integrative approach which calls on those responsible for waterbody management at various different levels to coordinate their efforts: The status of waterbodies is assessed on the basis of river basins, the contours of which follow the natural geographical conditions rather than the imposed administrative structures and national borders. Those responsible for water pollution, and the general public, are explicitly consulted during the decision-making processes and urged to become involved.

The realisation that the regulatory requirements, which are anchored in environmental and agricultural legislation, are not in themselves sufficient to reduce diffuse discharges of nutrients and pollutants into waterbodies to an acceptable level, is hardly new. Cooperation between water suppliers and farmers, which in some Federal *Länder* is an important instrument for safeguarding the drinking water supply, clearly shows that acceptance for essential measures can be achieved faster and more easily by means of informal exchange and the involvement of various interest groups, and by adopting a coordinated approach. Some of the programmes of measures and management plans under the WFD follow on from these cooperative experiences. The Federal *Länder* and Government authorities are developing models for integrated, coordinated action concepts in order to achieve the Directive's objectives in the field of agriculture and water protection.

The cooperation and decision-making structures that have emerged to date are not always perfectly organised, and institutional cooperation between the various players often leaves scope for improvement. Nevertheless, the coordinated cooperation between various different policy-making areas is a step in the right direction, and the challenges of the future cannot be resolved without it.

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