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Potential of drinking water alliances to address nitrate pollution

Experiences from Germany

SOLAW21 Technical background report

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Deutsches Institut für Entwicklungspolitik

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by

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Abbreviations and acronyms

BDEW	Bundesverband der Energie- und Wasserwirtschaft (Federal Association of the Energy and Water Industry)
BMZ	Bundesministerium für wirtschaftliche Entwicklung und Zusammenarbeit (Federal Ministry for Economic Cooperation and Development)
BUND	Bund für Umwelt und Naturschutz Deutschland
FAO	Food and Agriculture Organization of the United Nations
Ha	Hectare
Mg/l	Milligram per litre
NLWKN	Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz
OECD	Organisation for Economic Co-operation and Development
WHG	Wasserhaushaltsgesetz (German Water Act)
WWF	World Wide Fund for Nature

Executive summary

This paper provides background to the *State of the World's Land and Water Resources for Food and Agriculture Report, Edition 2021 (SOLAW 21)* with an innovative governance approach to addressing non-point pollution sources originating from agricultural activities: alliances[1] between water utilities and farmers in designated water protection areas and drinking water extraction areas. The alliances revolve around the idea of balancing diverging targets such as maintaining drinking water standards and the viability and profitability of agricultural businesses.

While farmers can achieve high food production levels by using mineral and organic fertilizers and pesticides, these may have enormous side effects: nitrate and phosphate are transferred into surface and groundwater, impairing water quality and aquatic life. It may also result in the water no longer being usable as drinking water without special, costly treatment. These negative effects led to the establishment of voluntary alliances between water utilities and farmers (hereafter called 'drinking water alliances' or 'alliances') in the 1980s when the German government strengthened the threshold values for nitrate in drinking water from 90 mg/l to 50 mg/l. Water utilities, together with the regional (Laender)[2] governments, initiated alliances with farmers to adopt fertilization and land management practices in order to protect drinking water resources from nitrate pollution.

In such alliances, water utilities and farmers voluntarily agree to work together to achieve common objectives. Despite some differences, drinking water alliances across the German Laender have a number of common characteristics. They were established through a voluntary act; the parties involved have a self-interest in participating and self-regulating their affairs; water suppliers finance protective measures and advisory services on fertilization and land management practices, which are provided free-of-charge to the farmers.

Today, most drinking water alliances are found in Bavaria, Hesse, Lower Saxony and North Rhine–Westphalia, where the regional governments proactively supported their establishment in areas where water utilities withdraw raw water. In water protection areas, ordinances determine measures that often require a shift to alternative, sometimes new and not well-proven, and sometimes yield-reducing farming practices, which may create extra costs (e.g. for labour, machinery, manure storage facilities) and cause income losses. If farmers voluntarily conclude agreements with water utilities, fertilization and land management practices that go beyond purely regulatory action are financially supported and income losses are compensated. However, the major motivation driving farmers to conclude voluntary agreements is not so much financial gain, but rather the quality of the

[1] In German, 'alliances' are called *Kooperationen*. We have decided against using the direct English translation of this term because 'cooperation' in English denotes a process or action, rather than a type of organization.
[2] The Federal Republic of Germany, a federal state, consists of sixteen partly sovereign federated states known as Laender.

advisory services they receive, public recognition of their efforts to curb nitrate pollution, and the fact that the agreements allow them to avoid undertaking the non-tailored measures decreed in local water protection area ordinances.

Assessment studies show that alliances have successfully implemented water-protective measures resulting in reduced nitrate concentrations. The effectiveness of the alliances depends on whether a majority of farmers in water protection areas participate and whether the most critical areas are included. The conditions required for an alliance to produce positive effects are very demanding, both financially and institutionally. However, it is agreed by both the agricultural and water administrations that targeted, site-specific advisory services are key to solving the nitrate problem.

1 Introduction

In 2017, the European Commission (EC) initiated infringement proceedings against Germany for its failure to implement the European Union Nitrates Directive, which had been in force since 1991. According to the European Court of Justice, the German Fertilizer Ordinance of 2017 had been not been adequately implemented. Inputs of nitrate and phosphate into surface and groundwater had not been reduced jeopardizing the achievement of the drinking water quality target of N 50 milligrams per litre (mg/l) (European Commission, 2016). On 1 May 2020, most of the sixteen German Laender governments approved a revised Fertilizer Ordinance (Bundesrat, 2020).

Despite the EC action, nitrate values in groundwater improved slightly between 2016 and 2018 according to Germany's latest Nitrate Report 2020 (BMU and BMEL, 2020). Nitrate values have decreased, especially at highly contaminated groundwater measuring points, but they are still considered to be too high. The monitoring network of the European Environment Agency (EEA) determined that 65 percent of all measuring points showed no or only low nitrate values (nitrate content was between 0 and 25 mg/l. At 17 percent of the measuring points, nitrate content was between 25 and 50 mg/l and thus considered to be strongly contaminated. The remaining 17 percent of the measuring points contained significantly more than 50 mg/l nitrate. The main sources of pollution are agricultural activities.

At most of the monitoring sites on rivers (BMU and BMEL, 2020), nitrate concentrations decreased between 2016 and 2018 compared to the first survey period (1991 to 1994): a decreasing trend can be observed at about 94 percent of the sites monitored by the Federal-Laender Working Group on Water (LAWA[3]). Nitrate pollution is stagnating at about 4 percent of the monitoring sites, and pollution decreased at around 2 percent of the sites. The quality objective of the European Union Nitrates Directive (50 mg/l nitrate) was met during the reporting period 2015 to 2018 at all monitored river sites (BMU and BMEL, 2020; Umweltbundesamt, 2019, 2020). Despite these achievements, progress is considered to be too slow, particularly with regard to groundwater, and precautionary measures are needed in order to avoid long-term negative effects.

Since the 1980s, the governments and administrations of the German Laender with severe nitrate problems have promoted a local, site-adapted innovative approach: i.e. the establishment of alliances between farmers and water utilities in designated water protection areas and drinking water extraction areas to address nitrate pollution.

Their experiences will be reported in this background paper to the *State of the World's Land and Water Resources for Food and Agriculture Report*, *Edition 21 (SOLAW 21)*. The paper is based on an intensive review of relevant academic literature, documents and websites of drinking water alliances, and on a number of qualitative, semi-structured interviews with public stakeholders, experts and members of alliances in Hesse, Lower Saxony and North

[3] LAWA (Bund-Länder-Arbeitsgemeinschaft Wasser) is a working committee of the Conference of the Environmental Ministers.

Rhine–Westphalia (see Annex: list of interviews). The paper benefited from previous work that was carried out as part of the research project "Implementing the water–energy–food nexus: incentive structures and policy instruments," funded by the Federal Ministry for Economic Cooperation and Development (BMZ) in 2016 (Richerzhagen and Scheumann, 2016; Dombrowksy *et al.*, 2016).

The paper is structured as follows: Chapter 2 introduces the challenges involved in reducing agricultural non-point water pollution sources. Chapter 3 is dedicated to analysing the characteristics of alliances in Germany, elaborating on their genesis, legal environment, and sources of financing. Their effectiveness and weaknesses are discussed in Chapter 4 while Chapter 5 discusses lessons learned and provides recommendations.

2 The specificities of nitrate pollution – why it matters and how to address it

By increasing production levels, the agricultural sector has made a major contribution to meeting growing global food requirements in recent decades. This has mostly been made possible by using high-yield varieties and applying plant nutrients (primarily nitrogen and phosphorus) and pesticides. However, it has led to a heavy influx of nutrients into surface and groundwater (nutrients in water transform into nitrate, ammonia or phosphate) in areas where they were applied at "a greater rate than they are fixed by soil particles or exported from soil profile or when they are washed off the soil surface before plants can take them up" (Mateo-Sagasta *et al.,* 2017, p. 11; Oenema, 2011; Velthof *et al.*, 2014). Although water pollution has decreased in Europe over the past two decades (European Commission, 2018), nitrate pollution from agricultural sources is still high and has remained a key problem in European and other OECD countries (Musacchio *et al.*, 2020; Wiering *et al.*, 2020; Parris, 2011; Grizetti, 2011; OECD, 2012). The intensification of agriculture and the intensification and concentration of animal production have detrimental effects on drinking water resources (Oenema, 2011; Velthof *et al.*, 2014).

There are quite a few non-trivial challenges to addressing the nitrate problem and applying the polluter-pays principle (Umweltbundesamt, 2006).

Origin. Nitrate pollution can originate from mineral fertilizers and animal feces. Certain crops (mainly legumes, such as clover and soybeans) are able to capture nitrogen from the air, particularly if they, entirely or in part, are incorporated into the soil. In addition, the type of crop and the timing of application is important. For example, some crops (such as asparagus, broccoli and lettuce) are supplied with nitrogen shortly before harvest when it can only be used by the plant to a limited extent – and, as a result, a large proportion may remain in the soil and enter water bodies. This also occurs in the cultivation of high-quality wheat where nitrogen is added to increase its protein content after vegetative growth has ended.[4] The expansion of biomass production, i.e. of energy crops such as maize and rape seed, has also led to nitrogen-intensive use of previously partly fallow land. Another source of nitrate pollution is the conversion of grassland into cropland where aerobic conditions in the soil reduce the organic matter and release *inter alia* nitrogen. Nutrient losses can also occur when organic fertilizers (e.g. stable manure or slurry, sewage sludge, bio-compost) are applied (WWF, 2008). Organic farming has a great potential to reduce nitrate leaching into water bodies, but only if water-protective measures are applied (Jäger *et al.*, 2004; Landtag Brandenburg, 2020).

Conflicts can arise between two user groups (e.g. farmers and water utilities) who rely in different ways on land and water resources within a landscape. Groundwater recharge takes place on agricultural land, and rivers and lakes are formed by precipitation/run-off on agricultural land. There, farmers use land as a basis for agricultural and animal production. Seepage water eventually enriched with nitrogen can impair drinking water

[4] A notable example is the so-called *water protection wheat* produced in Franconia, where farmers refrain from applying the last nitrogen dose.

resources (Nijkamp and Oltmer, 2004). Water utilities[5] use surface and groundwater as raw material to produce drinking water, whose quality is affected by fertilization and land management practices.

Nitrate pollution can be characterized as a negative externality affecting, *inter alia*, the production of drinking water by water utilities. In this respect, water utilities "are highly dependent on neighbouring policy fields to entice stakeholders (farmers) to take action" (Wiering *et al.*, 2020, p. 4). Economic instruments (e.g. pollution taxes in Denmark and Sweden, water-quality trading schemes in the United States of America) (Selman *et al.*, 2009) and regulatory command-and-control instruments can be applied to mitigate or reduce external effects (UBA, 2006; SRU, 2015). But implementation may be difficult due to institutional constraints or the high administrative costs associated with monitoring and enforcing measures (WWF, 2008; Selman *et al.*, 2009; Oenema, 2011), as well as for socio-economic reasons: since "agriculture is a classical competitive sector with a large number of small producers (they) cannot influence the producer price. This implies that pollution abatement costs cannot be passed on to the consumer" (Nijkamp and Oltmer, 2004, p. 4; WWF, 2008) which may result in income losses or even the abandonment of farm businesses.

There are quite a few non-trivial technical challenges to applying the **polluter-pays principle** which is a cornerstone of the European 1991 Nitrates Directive and its subsequent amendments, as well as the European Water Framework Directive (2000). Implementing the principle requires the identification of who is causing the pollution and to what extent. Whether negative effects occur depends on many factors, such as when and what is applied, the crops cultivated, the soil types and their denitrification potential, and climatic and hydro-geological conditions. Measured nitrate concentrations in raw water (specifically groundwater) do not allow robust conclusions about current cultivation practices because there are considerable time lags between the application of fertilizers on fields and the point when nitrate-enriched seepage water reaches groundwater layers. One possible solution is to legally prescribe a cap on the amount of fertilizer applications (see Box 1).

The polluter-pays principle requires that if inputs from agriculture lead to higher treatment costs for water utilities, farmers should implement measures to avoid negative impacts and bear the associated costs (WWF, 2008). Article 2[39] of the German Water Act (WHG) follows this logic, mandating that *agriculture must make adequate contributions*. But what is adequate? In this case, the agricultural interpretation of the 'polluter pays' principle is decisive. In 1999, the Council of the European Union decided that farmers must bear the costs that result from compliance with the rules of good agricultural practice. Farmers must only pay for the element of drinking water treatment costs that can be attributed to an insufficient implementation of good agricultural practices. If they take on obligations that go *beyond* good agricultural practices as decreed by regulatory law, they are to be compensated (WWF, 2008; Nijkamp and Oltmer, 2004).

[5] Throughout this study, we use the term 'water utility' irrespective of the ownership structure.

However, the distinction between good agricultural practices (for which farmers must bear costs without being compensated) and additional measures that require compensation, is not easy to draw (Flaig *et al.,* 2020, WWF, 2018). Moreover, the definition of *good agricultural practices* has been subject to political decisions and subsequent regulations. The latest Fertilizer Ordinance (May 2020), which is the central regulatory instrument for controlling nitrogen use in agriculture, has significantly changed and tightened the criteria for defining *good agricultural practices* (see Box 1).

Box 1. Key features of the 2020 Fertilizer Ordinance

In red zones,[6] the following mandatory rules apply from 1 January 2021 onwards:
- an annual flat rate reduction of fertilizer applications to 20 percent per farm;
- a plot-related upper limit for the application of organic fertilizer (of animal and plant origin, including fermentation residues from biogas plants) to 170 kg total nitrogen per hectare and year;
- a ban on fertilization of winter rape, barley and catch crops in autumn that are not used for fodder;
- application of organic fertilizer on arable land to a maximum of 130 kg total nitrogen per hectare and year;
- a ban on nitrogen fertilization of summer crops if no catch crop was grown on the affected area in autumn;
- extension of the lock-up period for solid manure of hoofed or clawed animals and compost to three months from 1 November to 31 January;
- extension of the lock-up period for the application of fertilizers with a significant nitrogen content on grassland by four weeks from 1 October to 31 January;
- limitation on the application of liquid manure on grassland in autumn to 60 kg total nitrogen per hectare and year.

The following regulations apply to all areas regardless of whether they are affected by nitrate or not:
- The nutrient balance[7] has been abolished. Instead, farms must now document the quantities of nutrients (nitrogen and phosphorus) applied on each plot; these may not exceed the calculated fertilizer requirement.
- The riparian strips have been expanded.
- The application of phosphate-based fertilizers on arable land and grassland is banned from 1 December to 15 January.
- There is a lock-up period for compost and solid manure from 1 December to 15 January.
- Fertilizer containing nitrogen and phosphorus, including solid manure, may no longer be applied to frozen, flooded, waterlogged or snow-covered soils;
- The time during which liquid manure may be incorporated into uncultivated land has been reduced to one hour in order to reduce ammonia emissions.
- The application rate of liquid organic fertilizer on grassland and on land where perennial forage is cultivated in autumn is limited to 80 kg of total nitrogen per hectare and year.

Sources: Agrarheute, 2020; Landwirtschaftskammer Nordrhein-Westfalen, 2020

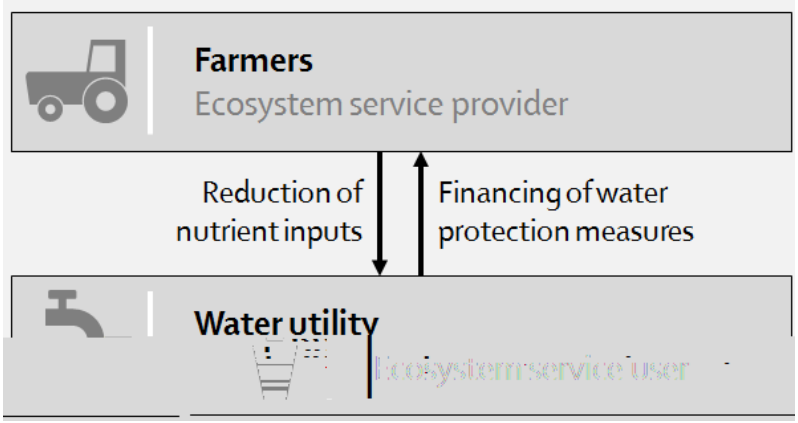
[6] Red zones refer to areas where the limit value of N 50 mg/l is exceeded. It is assumed that red zones will increase by 0.7 million ha to 2.7 million ha.
[7] The nutrient balance, also called field-stable balance or nutrient comparison, compares the nutrient supply and nutrient removal on the agricultural areas of a farm.

3 Voluntary alliances between farmers and water utilities: experiences from Germany

Drinking water alliances exist in European countries, mostly in Germany, and in the United States of America (Brouwer, 2003; Fletcher and Davis, 2005). Their growing popularity is attributed to common difficulties in implementing and enforcing environmental regulations (OECD, 2012; Heijden, 2012; Heinz, 2003b). European countries have opted for such alliances due to concerns about the administrative costs associated with enforcing regulations (Bressers *et al.*, 2001), while the lack of strong institutions able to impose and enforce regulations has also made them attractive as a means to reduce nitrate pollution in countries of the Global South (Segerson, 2013).

Alliances are a voluntary approach (OECD, 2003; Wiering *et al.*, 2020), and are considered to complement and even replace command-and-control approaches (Heinz, 2002). Alliances are concluded between farmers and water utilities, who voluntarily agree on water-protective agricultural practices in designated drinking water protection areas and drinking water extraction areas to avoid pollution. The water utility, as the beneficiary of these ecosystem services, finances drinking water protection measures that are implemented by farmers (see Figure 1) (Segerson, 2013).

Figure 1. Alliances between farmers and water utilities



Source: Richerzhagen and Scheumann, 2016.

In the following sections, we examine the origins and consider the characteristics of drinking water alliances in those German Laender (Hesse, Lower Saxony and North Rhine–Westphalia), where such arrangements are widespread.[8]

[8] Alliances are widespread in groundwater protection areas, since 69.1 percent of raw water comes from groundwater (as of 2016), 15.6 percent from surface water, 8.2 percent from bank filtrate, 7.0 percent from artificially enriched groundwater and 0.1 percent from other sources (Bundesumweltministerium und Umweltbundesamt, 2018).

3.1 Why promote drinking water alliances?

At the beginning of the 1980s, the news captured the headlines that nitrate pollution was starting to accumulate in groundwater, with serious implications for drinking water quality.[9] On 22 May 1986,[10] the German government passed an amendment to the Drinking Water Ordinance that lowered the limit values for nitrate from 90 to 50 mg/l, which was believed to be sufficiently conservative to not endanger the health of consumers, particularly infants and pregnant women (WHO, 2011).[11]

This was the starting point for the alliances as it became clear that meeting the new drinking water threshold would be a challenge, particularly in the intensively-used water protection areas, where about 6,000 water utilities extract drinking water for almost 100 percent of the population. As of 2002, the year of the first survey on alliances issued by the University of Dortmund, there were 113 alliances in North Rhine–Westphalia, 44 in Hesse and 112 in Lower Saxony (Heinz, 2002). In the meantime, alliances have spread throughout the regions mentioned.

Why would water utilities initiate drinking water alliances? Why have water and agricultural administrations promoted the alliances and why do farmers participate?

Water utilities and end consumers

Water utilities must comply with the threshold values mandated by the Drinking Water Ordinance. Water utilities could merely trust in the enforcement of regulations as determined in local water protection area ordinances (see 3.3), but did not, because of insufficient administrative monitoring and enforcement capacities (Interviews No. 13, 14).

Although nitrate pollution was not a serious problem throughout Germany, water utilities, particularly those producing drinking water in heavily polluted areas, assumed that nitrogen inflows would increase in the years to come, given the intensification of agriculture (i.e. the cultivation of maize and bioenergy crops, and the growth and concentration of animal production); the long-term effects of nitrogen inputs; and the largely exhausted denitrification potential of soils. If nitrate values were to increase, drinking water costs could rise by 55 to 75 cents per cubic metre, a price increase of 32 to 45 percent. A four-person household would then have to pay up to EUR 134 more per year (Umweltbundesamt, 2017a; BDEW, 2017a).

The water utilities are allowed to determine for themselves how they will achieve the N-target value of 50 mg/l. Approaches could be the introduction of advanced treatment technologies such as ion exchange and reverse osmosis (Grolleau and McCann, 2012). Biological treatments are also feasible, but these require many personnel, consume a large amount of energy, require the use of chemicals and produce large quantities of wastewater (BUND, 2019). Water utilities can purchase land to lie fallow, relocate and/or

[9] In 1985, the Sachverständigenrat für Umweltfragen (SRU) diagnosed a growing threat to the drinking water supply due to rising nitrate levels (SRU, 1985).
[10] The Drinking Water Ordinance dates from 10 March 2016, with the latest revisions made in 2021.
[11] Nitrate is suspected of transforming into carcinogenic nitrosamines.

deepen their wells and blend nitrate-laden water. The option chosen depends on local circumstances and costs.

A study by the Federal Environment Agency in Lower Saxony estimated the costs of different strategies (preventive, technical and reactive) for dealing with undesirable nitrate concentrations in raw water (Umweltbundesamt, 2017b; Oelmann *et al.*, 2019). In a significant part of the regions affected (36 percent), preventive measures – which are at the heart of drinking water alliances – would be sufficient to reach the nitrate target values in seepage water.[12] Hence, the alliances are perceived as being attractive for water utilities since they may make expensive investments unnecessary.[13]

Water and agriculture administrations

Farmers who cultivate land in designated water protection areas must, in principle, comply with the restrictions imposed by so-called local ordinances. Implementing the ordinances requires area-wide monitoring and control efforts, and the penalization of infringements, however the authorities lack the capacity to monitor and enforce the ordinances and because the farmers and their lobbies often refuse to cooperate (Interviews No. 10, 13, 14). The water and agricultural administrations are also not able to provide adequate advisory services that are tailored to individual farm conditions (Flaig *et al.*, 2002). As a result, Laender governments supported the establishment of alliances over purely regulatory action. However, the ministries hold the final voice in deciding whether alliances can replace or supplement local water protection area ordinances (Interviews No. 3, 4, 5, 6).

In North Rhine–Westphalia, the establishment of alliances was accelerated within a larger reform agenda. When the Ministry for Food, Agriculture and Forestry of North Rhine–Westphalia was reorganized in 1985 as the Ministry for the Environment, Regional Planning and Agriculture, protecting water resources and supporting agricultural production was headed by one ministry. This worked in favour of the 'Twelve-point programme' adopted in 1989 by the Laender government and representatives of the water and agriculture administrations, which laid the foundation for establishing alliances (BDEW 2021). Furthermore, overall support came from the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety and the Federal Ministry of Health who encouraged water utilities to cooperate with farmers (Umweltbundesamt, 2019).

Farmers

Farmers must incorporate mandated fertilization and land management practices into the everyday operations of their farms in ways that do not jeopardize their economic viability. Investments in storage capacities for manure and specialized machinery to spread manure

[12] Seepage water replenishes groundwater.
[13] Previous studies calculated that the cost of alliances and drinking water treatment are not far apart. The value-added of alliances would be the application of the precautionary principle: while technical options exclusively aim to achieve drinking water quality, preventive water protection measures also contribute to water, soil, nature and climate protection (WWF, 2008; Bach *et al.*, 2006).

are required, although these may have a negative impact on a farm's profitability (Landtag Brandenburg, 2020; Landwirtschaftskammer Nordrhein-Westfalen, 2020).

From the perspective of the farmers that participate in the alliances, the greatest advantage is the opportunity alliances offer them to flexibly react and adapt to widely differing local circumstances and cultivation conditions (Landtag Brandenburg, 2020; Flaig *et al.*, 2002; Heinz, 2002; Interview No. 9). They perceive use restrictions from 'above' as limiting their autonomy. They often do not comply because mandatory restrictions require a shift to new, unproven farming practices, entail extra costs in labour and machinery, and require a heavier workload (Flaig *et al.*, 2002; Interviews No. 9, 12)

By joining an alliance, farmers benefit from free advisory services that are provided and financed, either fully or partly, by water utilities. They have access to credit at lower interest rates and share costs. Early surveys in Hesse (Bach *et al.*, 2006; Bach *et al.*, 2007) and across Germany (Flaig *et al.*, 2002) show that the major motivation driving farmers to join alliances was not so much financial gain, but rather the quality of advisory services, public recognition of their efforts to curb nitrate pollution, and the fact that it allowed them to bypass non-tailored measures decreed in local water protection area ordinances (Interview No. 9).

3.2 What exactly are drinking water alliances?

Drinking water alliances are best described as coalitions of farmers and water utilities that formally agree to work towards common objectives. Alliances aim at preventing or reducing nitrate pollution of water bodies by implementing water-friendly fertilization and land management practices to ensure that raw water extracted by water utilities does not exceed concentrations of N 50 mg/l.

Alliances are established in local drinking water protection and drinking water extraction areas, where agricultural use negatively affects water quality to the extent that restrictions on farm practices become necessary. In Hesse, most alliances exist in designated Class C water protection areas[14] (Interview No. 4); while in Lower Saxony, they can be found in water protection areas where ordinances require restrictions as well as in drinking water extraction areas without ordinances (Interviews No. 6, 13) (see Table 1). In water protection areas, alliances may, with the consent of the Laender Ministry of Environment, replace or modify management restrictions laid down in local ordinances (Interviews No. 3, 5, 6; DVWG, 2013). If restrictions on management practices go beyond those required by law, water utilities must compensate farmers for any loss of income (see Chapter 3.4). Changes to regulatory law could mean that such compensation payments for practices that have become mandatory can no longer be made. A case in point is the Fertilizer Ordinance of 2021, which made the N_{min}-analysis mandatory in nitrate-sensitive areas if compared to the Fertilizer Ordinance of 2017; the measure on 'reduced N fertilization' can also no longer be

[14] In Hesse, protected areas are divided into Classes A, B and C depending on the level of nitrate concentrations in the raw water extracted. Restrictions in Class C are stronger than in Classes A and B.

compensated, as the nitrogen applications in these areas must be reduced by 20 percent (see Chapter 3.3).

Table 1. Table 1. Alliances in brief

Region	Alliance area	Financial sources	Legal status
Hesse	Water protection areas (96 alliances in Class C areas)	Water service charge	Anchored in Water Act (2009, §33 [2])
Lower Saxony	Water protection areas, drinking watersheds	Water extraction charge	Anchored in Water Act (2010, §28)
North Rhine–Westphalia	Water protection areas and drinking watersheds	Water extraction charge	12-Point Programme (1989, 2012, 2021) and Water Extraction Charge Act (2004, §8)

Alliances need to react quickly and flexibly to new circumstances whether because of changes in regulatory law or because the state of water resources makes such changes necessary. Having alliances is a clear advantage in these circumstances, given that changing ordinances in water protection areas is often a lengthy, costly and conflict-laden process that involves not only farmers many other user groups (Interview No. 5). Since the designation of protected areas ends with a political decision, political interests may also find their way into this process.

Framework agreements between representatives of water utilities (namely the German Association of Energy and Water Industries, BDEW) and farmers (the Chambers of Agriculture) support the establishment of alliances and encourage their members to participate. One example is the North Rhine-Westphalian Framework Agreement concluded in 1991 and renewed in 2012 and 2021 (BDEW, 2021).

Alliances in the German Laender do not have a uniform organizational structure (Interview No. 14). Nevertheless, members of an alliance are always the elected representatives of farmers and water utilities. Alliances have statutes that define objectives as well as obligations and rights of their members; these are officially approved by the relevant ministries. Alliances have advisory boards with representatives of all stakeholders. The advisory board of the Höxter alliance in North-Rhine Westphalia, for example, consists of six representatives of agriculture and five representatives of the water utilities. By statute, the board decides by majority vote, but favours consensual decisions.

In annual general meetings, all participating farmers negotiate and decide on a catalogue of measures, which has to be notified by the European Union Commission (Interview No.

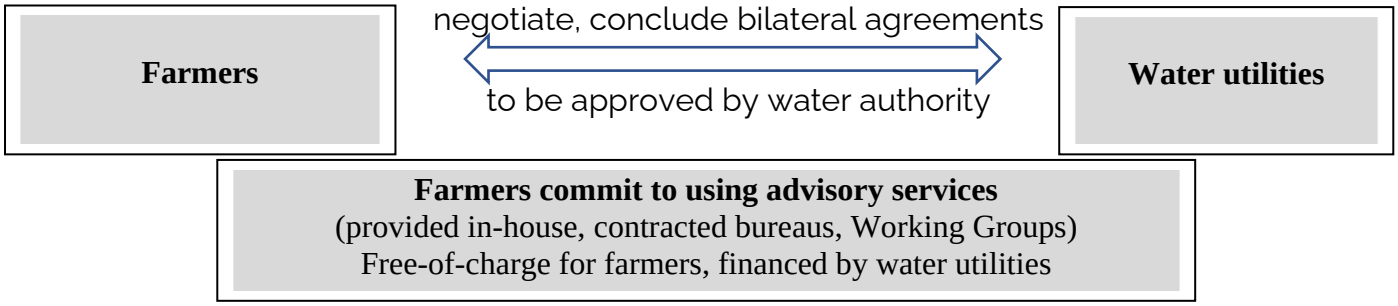
8).[15] Representatives of water utilities, the chamber of agriculture, and the water authority attend the annual meetings as observers (Interview No. 6, 8). The agreed measures reflect local situations and determine the maximum amount of compensation payments (Interviews No. 8, 5; NLWKN, 2021).

Farmers with land in water protection areas and drinking water extraction areas are free to participate and to decide which measures from the official catalogue of measures they want to implement. Parties to the binding contracts, so-called voluntary agreements, are individual farmers and water utilities.

The voluntary agreement is considered fulfilled when the agreed measures have been implemented (Interview No. 8). If farmers do not implement the agreed measures, their compensation payments can be reduced or cancelled; as a last resort, the agreement can be terminated. Independent consultants or agricultural engineers employed by the water utilities monitor compliance (Interviews No. 13, 8; NLWKN, 2021). Only a few cases are known where farmers deliberately breached the voluntary agreement (Interview No. 9).

The provision of site- and farm-specific advisory services is a core component of every alliance. Water utilities employ either in-house consultants or externally contracted bureaus (Interviews No. 9, 14), or the advisory services are provided by so-called Working Groups (Hesse, North-Rhine Westphalia). In North-Rhine Westphalia, the Chamber of Agriculture contracts independent advisors to improve credibility rather than relying on advisors contracted by water utilities (Interviews No. 2, 9, 12). This, so the reasoning goes, ensures that the advisors work for the benefit of farmers rather than for the benefit of the water utility. In any case, the water utilities fund advisory services (see 3.4).

Figure 2. Farmer – water utilities relationship in alliances



Farmers who do not participate in alliances are bound by the requirements of water protection area ordinances, which are controlled by the relevant water authorities. However, these authorities are usually "unable to fulfil this task, or only to a very limited extent, due to a lack of expertise and personnel" (Interviews No. 13, 14).

[15] The catalogue of measures is drawn up by the respective ministries of the environment with the cooperation of, for example, the chambers of agriculture. Examples of measures included in the catalogue are time restriction or renunciation of the application of animal manure; water-friendly application of liquid manure; crop rotations that protect water; extensive grassland management; conversion of arable land into extensive grassland, and reduced N-fertilization (NLWKN, 2021).

3.3 The legal environment

Alliances operate in a regulated environment (Table 2; Brower and Zabel, 2003). The Drinking Water Ordinance of 1986 and its amendments set the limit value of nitrates (50 mg/l nitrate) to which water utilities must adhere. The Federal Water Act (2009), which implements the European Union Water Framework Directive (2000), and the European Union Groundwater Directive (2010) have implications for the protection of water bodies, not only in designated water protection areas but in all watersheds.

The German Federal Water Act (WHG) requires the implementation of, among others, the Drinking Water Ordinance and the Fertilizer Ordinance, which aim to protect water resources from nitrate and other pollution sources (Oenema, 2011, Wiering *et al.*, 2020). The 2020 Fertilizer Ordinance is a major instrument for implementing the European Water Framework Directive and is the central regulatory instrument for controlling nitrogen use in agriculture. It determines the criteria for good agricultural practices in terms of fertilization and land management (Meergans and Lenschow, 2018), and prescribes uniform rules that apply throughout Laender, including in areas that may not be affected by nitrates (see Box 1).

The Federal Water Act rules that Laender may establish drinking water protection areas and issue site-specific ordinances to protect drinking water sources by imposing restrictions on farm operations. In these areas, stricter requirements apply. These involve the precautionary protection of drinking water resources and go beyond normal area-wide water protection. The act delineates three zones where actions that endanger water quality can be prohibited and where the owners of land are obliged to take specified measures to protect water sources. In Zone I, no use is allowed and access is prohibited. In Zone II, restrictions aim to protect the water source against contamination by pathogenic microorganisms and in Zone III, use restrictions apply to e.g. the spreading of liquid manure, the application of sewage sludge and use of pesticides (BMU, 2012). The designation of water protection areas is by decree of the competent government units and foresees the formal participation of all affected stakeholders, not only farmers. However, as mentioned previously, alliances may modify and even replace ordinances in water protection areas with the consent of regional authorities but, of course, these replacement agreements must not jeopardize the protected status. Last but not least, alliances are legally anchored in the regions' water acts.

Table 2. Major legal instruments

Drinking Water Ordinance (1986) (threshold value is N 50 mg/l)	Binding for water utilities
Federal Water Act (WHG 2009)[16] **Groundwater Ordinance**[17] **(2010) Laender Water Acts**	Universally binding
Water protection areas (WHG §52) Site-specific ordinances	Binding for land users (agriculture, horticulture, livestock) and water users
Fertilizer Ordinance (2020)	Binding for land users (agriculture, horticulture, livestock keepers)

It should be noted that the effects of the Fertilizer Ordinance may not always be beneficial. Agricultural advisors, consultants (Interview No. 9) and farmers (especially in Brandenburg) have strongly criticized the 2020 Ordinance for not taking account of regional contexts: while some Laender have only a local nitrate problem, in Lower Saxony and North Rhine–Westphalia the N-problem is nearly ubiquitous. In Brandenburg, by contrast, the N-surplus is 30–35 kg/ha/year on average, whereas the permissible limit is 50 kg/ha/year (Landtag Brandenburg, 2020).

Critics argue (Interview No. 9; NLWKN, 2012) that the 2020 Fertilizer Ordinance would demotivate farmers who have participated in drinking water alliances for years because it introduces mandatory measures that can no longer be compensated. Furthermore, the Ordinance establishes excessive applications of nitrogen as good fertilization practice, although these are above the levels actually needed by some crops. The Fertilizer Ordinance prescribes a reduction by a flat rate of 20 percent in nitrate-polluted areas (known as red zones). While this would be an appropriate average reduction for winter cereals and rape, it is excessive for summer cereals, root crops and maize. Furthermore, the periods when organic fertilizer can be applied in spring and when it can be applied on slightly frozen soil have been shortened. Fertilization is thus postponed far into the vegetation period, reducing the N-efficiency of organic fertilizer. Nitrogen released from organic fertilizer is only available after harvesting, with the result that it enters the groundwater. Critics insist that the nitrate problem can only be solved if actual N-fertilizer applications are calculated as accurately as possible and based on robust scientific findings rather than on fixed reduction rates.

To conclude, local ordinances for water protection areas and the Fertilizer Ordinance are key instruments that bind farmers with regards to their farm operations. If alliances are established and bilateral voluntary agreements are concluded, they can replace local water protection area ordinances, given the consent of the Laender water authorities.

[16] An amendment to the Federal Water Act incorporates the EU Nitrates Directive.
[17] Bundesministerium der Justiz und Bundesamt für Justiz, 2010. Grundwasserverordnung vom 9. November 2010 (BGBl. I S. 1513), geändert am 4. Mai 2017 (BGBl. I S. 1044) (Anhang 2: NO3-Schwellenwert ist 50mg/l).

3.4 Financing alliances

If water protection area ordinances restrict the use of private land, farmers are entitled to compensation payments (WHG §52[4]) which the beneficiaries – water utilities – are obliged to pay (WHG §97[1]). These payments compensate farmers for economic disadvantages caused by measures that go beyond normal agricultural practice. This applies particularly to the use of fertilizers and chemical pesticides in water protection areas (BMU, 2012).

Alliances are commonly funded either from water service charges or water extraction charges (see Table 1). In Hesse, the water utility finances alliances and channels the costs to consumers through water service charges. In North Rhine–Westphalia and Lower Saxony, water utilities can offset the costs of alliances against the water extraction charges they pay to the treasuries. There are no additional costs to consumers because the extraction charge is part of the water price.

At the end of the 1980s, water extraction charges were introduced in Germany and, after reunification in 1990, these also appeared in the new Laender, where they are paid by all water utilities – both private and public – for the extraction and use of groundwater and, sometimes, surface water. As of 2019, most of the German Laender has levied an extraction charge as mandated by the Water Framework Directive.[18] The charge was introduced as an economic incentive to reduce the pressure on water bodies, but it is also an instrument for financing the implementation of the Water Framework Directive (Gawel, 2014). Levying a water extraction charge has been justified on the grounds that individual water users benefit from using a common good (Gawel, 2014).[19] Both financing schemes – the water service charge and water extraction charge - are broadly criticized invalidating the polluter-pays principle (Nijkamp and Oltmer, 2004; Römer, 2019; Interview No. 11).

The Laender handle the use of the water extraction charges in different ways (Römer, 2019). In some, they are strictly earmarked, and only finance measures that improve water quality.[20] The laws of Lower Saxony and North Rhine-Westphalia provide the possibility of offsetting expenses for measures to protect water, either partly or fully. Cost-sharing schemes are applied in some alliances for cultivating intercrops, soil sampling and for developing fertilizer plans (Interview No. 12).

In some alliances, revenues from the water extraction charges are sufficient to finance voluntary agreements as well as to allow the purchase of specialized technical equipment, while in others, the costs of supporting the alliances are higher than the revenue from the water extraction charges. Since the amount of the revenue from charges depends on the

[18] Hesse abolished the charge in 2003 and Thuringia in 1999. The non-uniform regulation has been criticized by the Taxpayers' Association of Baden-Württemberg, environmental organizations and the Association of Municipal Enterprises (Römer, 2019, WWF, 2008).
[19] In some German Laender, agricultural water users are exempted from paying the charge because of the insignificant amount of water extracted, insignificant impacts on the respective water body or to support the agricultural sector.
[20] For an overview, see Umweltbundesamt, 2017: 186-190 (Table 49) and BDEW, 2017b, 2018.

amount of raw water extracted, large water suppliers have an advantage. For this reason, smaller utilities have merged into regional units.

4 Effectiveness, weaknesses and limits of the voluntary approach

In the following sections, we examine whether alliances are effective or not, and whether they can be regarded as an alternative to a purely regulatory approach.

4.1 Effectiveness

In 2003, Andrew and Zabel (2003) assessed the achievements of alliances with positive results. Since then, a number of studies have evaluated their performance, although it is difficult to reach consistent conclusions because the studies have applied diverse target systems, varying methodologies and indicators for measuring success. The studies also cover different time periods and long-term effects could not be observed for relatively new alliances (Vidaurre and Schritt, 2021).

A factor that complicates the assessment of the alliances' performance is that members are free to decide on the measures they apply. Even within a single alliance area, the measures may vary from farm to farm, which makes it difficult to assess their combined nitrate reduction potential (Vidaurre and Schritt, 2021; Interviews No. 1, 2). In addition, measures taken by agri-environmental programs and implemented in ecological priority areas can contribute to positive impacts irrespective of the measures applied by alliances.

The ultimate criterion by which the success of alliances can be measured is whether nitrate concentrations in raw water have decreased or are decreasing. Because of the special nature of the nitrate problem (see Chapter 2) and locally varying hydro-geological conditions, the application rate and the N_{min}-content of the soil water are evaluated after the harvest has taken place. The analysis of the N_{min}-content (i.e. the mean mineral nitrogen in kg N/ha) at the end of the growing season in late autumn is a proven method for evaluating whether nitrogen-reducing water protection measures have had an effect (Vidaurre and Schritt, 2021).

A number of studies provide more recent information on the performance of alliances.

Cooperative agreements in agriculture as an instrument to improve the economic and ecological efficiency of the European Union water policy: national report (Heinz, 2002) was the first assessment of drinking water alliances in Germany. According to the report, "nitrate concentrations (were) sinking or stay on the same level" in Bavaria (Heinz, 2002, p. 79). In Lower Saxony, "significant reductions of the nitrate content (were) observed in almost all areas with voluntary agreements concerning soils in autumn and seepage water; particularly intercropping resulted in an average reduction of N_{min}-values" (Heinz 2002, p. 93). In North Rhine–Westphalia, "a significant positive change (was) observed in a first trend analysis (…). 120 water utilities reported sinking nitrate values in raw water, 70 reported that nitrate values were rising, and 180 found that values stagnated" (Heinz 2002, p. 92). In Hesse, "a noticeable reduction of nitrate concentration in the soil" (Heinz 2002, p. 81) was observed.

Evaluation of the cooperation between agriculture and water management in Hesse (Bach et *al.*, 2006; Bach *et al.*, 2007) was commissioned by the Hessian Ministry for the Environment, Rural Areas and Consumer Protection and covers a period of ten years (1996–2006). The report found that, out of 40 alliances that had been active for at least two years, 64 percent showed a decrease in nitrogen applications, 16 percent showed no change, and 19 percent showed an increase.

Drinking water protection cooperations in Lower Saxony. Basics of the cooperation model and presentation of the results (NLWKN, 2019) was commissioned by the Lower Saxony State Office for Water Management, Coastal Defense and Nature Conservation. The study covers the period from 2000 to 2016. The Lower Saxony alliance model comprised 374 drinking water extraction areas (with and without protection status) covering 293,000 ha of agricultural area (this corresponds to 11 percent of Lower Saxony's agriculturally used area) (NLWKN, 2019). Success could be proven against almost all control parameters. Between 1998 and 2016, the N-surplus balance decreased from 95 kg N/ha to 55 kg N/ha. During the same period, the N_{min}-values measured in autumn decreased. The nitrate contents on the monitoring sites with nitrate concentration of more than 5 mg/l decreased from 68 mg/l in 2000, reaching 60 mg/l in 2016. This reduction was active until 2008, while nitrate levels have stagnated since then. Nitrate levels in water monitoring sites with a nitrate concentration of more than 5 mg/l decreased slightly from 25 mg/l in 2000 to 23 mg/l in 2016.

A study by the North Rhine–Westphalian Ministry for the Environment, Agriculture and Nature and Consumer Protection in 2021 – *Review of the effects of cooperative water protection* – analysed 18 alliances operating in 20 water protection areas. In two of the areas, drinking water is extracted from dams; in all others it comes from groundwater. Reduction effects were found in alliances where compensation payments were based on the level of N_{min}-values, and not simply on whether measures were applied. For the measure 'advisory services,' a reduction effect of 21 kg N/ha was found in only one water protection area. There, the reduction effect depended primarily on the intensity of the advisory services provided (Vidaurre and Schritt, 2021).

Additional studies of alliances in North Rhine–Westphalia are available; all reveal positive results (i.e. the Stevertal alliance, the Bergisches Land alliance, the Minden-Lübbecke alliance, the Herford-Bielefeld alliance, the Höxter alliance, the Aachen South and Nordeifel alliance, and the Bocholt alliance). Furthermore, the Wahnbach Dam Association's annual water quality reports always reflect on the successful work of the Working Group (Wahnbachtalsperrenverband, 2020).

4.2 Weaknesses and limitations

There are a number of factors that account for the weakness and limitations of the alliances.

Voluntary membership is a major challenge. In fact, it has been characterized as a 'design fault' (Interview No. 13). Farmers are free to both decide to join an alliance and to choose the measure(s) they are willing to apply. As a result, the alliances may not be sufficient to

have overall positive effects on water quality if critical areas are not included in their coverage. In Lower Saxony, for example, measures are implemented on less than 50 percent of the area where they are needed (Interview No. 13; Meergans *et al.*, 2020).

Incentives for farmers. One of the most important motives for farmers to join alliances is the free-of-charge, high-quality advisory services offered (Interviews No. 6, 7). Nevertheless, compensation payments for loss of income provide a major incentive to join. Tightening regulatory law might be seen as politically necessary, but the downside is the loss of incentives for farmers to conclude voluntary agreements (Interview No. 9). Without voluntary agreements, the authorities are required to enforce restriction but often lack the human and financial resources to do so (Interviews No. 13, 14).

Sanctioning non-compliance. Sanctioning mechanisms exist, and farmers can be sanctioned for not complying with the terms of voluntary agreements: compensation payments can be withheld or suspended based on monitoring that is carried out by independent consultants or agricultural engineers employed by the water utilities on a random basis. However, it is mostly social pressure (the fear of losing reputation), rather than sanctions, that compels farmers to comply (Interview No. 9).

Political and economic conditions. Alliances do not operate in a vacuum. They can reach their limits when agricultural policies promote the intensification of crop production, when the intensification and concentration of animal production produces a high nutrient surplus, or when corn production for biogas plants causes an increase in nitrogen applications. Moreover, if prices of mineral fertilizers are low, manure can be dumped at low cost, and if these cost components are not significant when compared with prices of other inputs, farmers have little economic incentive to join an alliance (Interview No. 2).

4 Key messages

While the experiences of the alliances studied for this report are not universally applicable given the fundamental differences between countries, there is a major finding of common interest: the capacity of administrations to monitor compliance, enforce regulations and sanction infringements is limited, even in developed countries. In this respect, the alliances provide clear advantages.

Alliances provide benefits for all stakeholders

Water utilities have promoted alliances because of the advantages they expect (no or lower costs for providing clean drinking water). Their interest coincides with that of the consumers in keeping drinking water prices low. For farmers, this means above all that they can maintain the productivity and profitability of their businesses, receive financial compensation in case of income losses, and technical support for changing their fertilization and land management practices. For the Laender governments and their administrations, alliances help support the implementation of the European Union Water Framework Directive and the European Union Nitrates Directive.

Alliances rely on an established legal environment

Alliances act within a comprehensive legal framework, namely the designation of water protection areas, drinking water standards, and the Fertilizer Ordinance, which has become an integral part of Germany's water legislation. Furthermore, legal claims for compensation payments have supported the establishment of alliances, not only in Germany but other European countries. The legal framework should promote alliances, as long as they aim to prevent or reduce nitrate pollution of water bodies and avoid establishing disincentives.

Alliances rely on suitable financial models

The alliances can only be effective if adequate financial sources are available to support them. Approaches to financing drinking water alliances are diverse. Some alliances are financed through water service charges, others through deductions from the water extraction charge paid by water utilities. In addition, Laender treasuries provide financial resources to varying degrees and for various purposes; financial contributions from the Laender budget have been important as start-up financing in the early phase of an alliance's existence.

Alliances require political support, and the collaboration between the water and agricultural sectors

The Federal as well as the Laender governments have promoted the establishment of the alliances analysed in this study. The experience in Hesse, Lower Saxony and North-Rhine Westphalia shows that the intersectoral collaboration between actors of the agricultural and water sectors is an essential condition for the successful work of the alliances.

Key stakeholders must have a voice

Along with representatives of water utilities, farmers and their representatives (either elected or appointed) must play a central role on an alliance's board. Their role and modes of participation should be laid down in an alliance's statute.

Collaboration must be based on trust – and on monitoring compliance

If farmers trust in the quality of advisory services provided, their motivation to participate increases. Farmers also tend to participate more actively if the advisors or consultants have an agricultural background, and 'speak their language'. Even if, as reported in the case of Hesse, few breaches of voluntary agreements are observed, on-site monitoring and sanctioning schemes must be in place and enforced.

Performance depends on site-specific measures

Taking due consideration of site- and farm specific issues is key to gaining the farmers' acceptance and, consequently, solving the nitrate problem. Individual, flexible, site-specific measures based on new robust scientific findings as well as on local experience must be developed in close collaboration with agricultural advisors.

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Annex: list of Interviews

Respondent category	Interview number
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Academia	2
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Water utility	13
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Water utility	15

This paper provides background to the State of the World's Land and Water Resources for Food and Agriculture Report, Edition 2021 (SOLAW 21) with an innovative governance approach to addressing non-point pollution sources originating from agricultural activities: alliances1 between water utilities and farmers in designated water protection areas and drinking water extraction areas. The alliances revolve around the idea of balancing diverging targets such as maintaining drinking water standards and the viability and profitability of agricultural businesses.

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