acatech POSITION PAPER
Executive Summary and Recommendations

Sustainable Nitrogen Use in Agriculture

acatech (Ed.)

What form should agriculture in Germany take in the future? Scientists, policymakers and the general public are currently discussing this question intensively. Sustainable nitrogen use is an important aspect of this discussion, though it has received little public attention so far.

Nitrogen is an essential nutrient for all organisms. In agriculture, it is a component in fertilisers for crop cultivation and in livestock feed. However, crops and livestock do not use all of the nitrogen. In Germany alone, agriculture adds approximately 1.5 million metric tonnes of resource-intensively produced reactive nitrogen to the environment every year. Emissions from agriculture account for around two thirds of all nitrogen emissions in Germany; the remaining third comes from the industrial and energy sectors, transport, and wastewater/surface runoff. Nitrogen in the form of nitrites, nitrates, nitrosamines and as a component of particulate matter poses a risk to human health. Reactive nitrogen in the form of ammonium, ammonia, nitrous oxide, other nitrogen oxides and urea contributes significantly to climate change, biodiversity loss, as well as soil, air and water pollution. As a result, nitrogen inputs from agriculture into the environment are estimated to incur societal costs of between €30 billion and €70 billion a year.

These problems have been known for decades and extensive research has been performed in this area. However, measures implemented to date have not been effective, as indicated by the slow decline of nitrogen inputs from agriculture. This acatech POSITION PAPER takes a systemic look at the nitrogen problem along the entire agricultural value chain, up to and including consumers. The findings are the basis of recommendations for more efficient and sustainable resource utilisation and a reduction of nitrogen inputs into the environment. At most, only a slight drop in agricultural yields can be expected. Therefore, if these recommended activities are implemented, there should be

At a glance

- Nitrogen is an essential nutrient for all organisms. In agriculture, it is a component in fertilisers for crop cultivation and in livestock feed. As a result, approximately 1.5 million metric tonnes of surplus reactive nitrogen enter the environment in Germany every year.
- Why is this a problem? Reactive nitrogen in the form of ammonium, ammonia, nitrous oxide, other nitrogen oxides and urea is a significant contributor to climate change, biodiversity loss and soil, air and water pollution. Yet although this has been known for decades and extensive research has been performed, the measures taken to reduce nitrogen inputs have not been effective.
- This acatech POSITION PAPER looks at the nitrogen problem from a systemic perspective. Concrete recommendations are proposed for the entire agricultural value chain up to and including the consumer.
- The recommendations (see illustration) are geared towards more efficient and sustainable resource utilisation and a reduction of nitrogen inputs into the environment with at most only a slight drop in agricultural yields. They address sustainable management structures, the economic and regulatory framework, knowledge management and sustainable technology, and sustainable consumption.

acatech
NATIONAL ACADEMY OF SCIENCE AND ENGINEERING

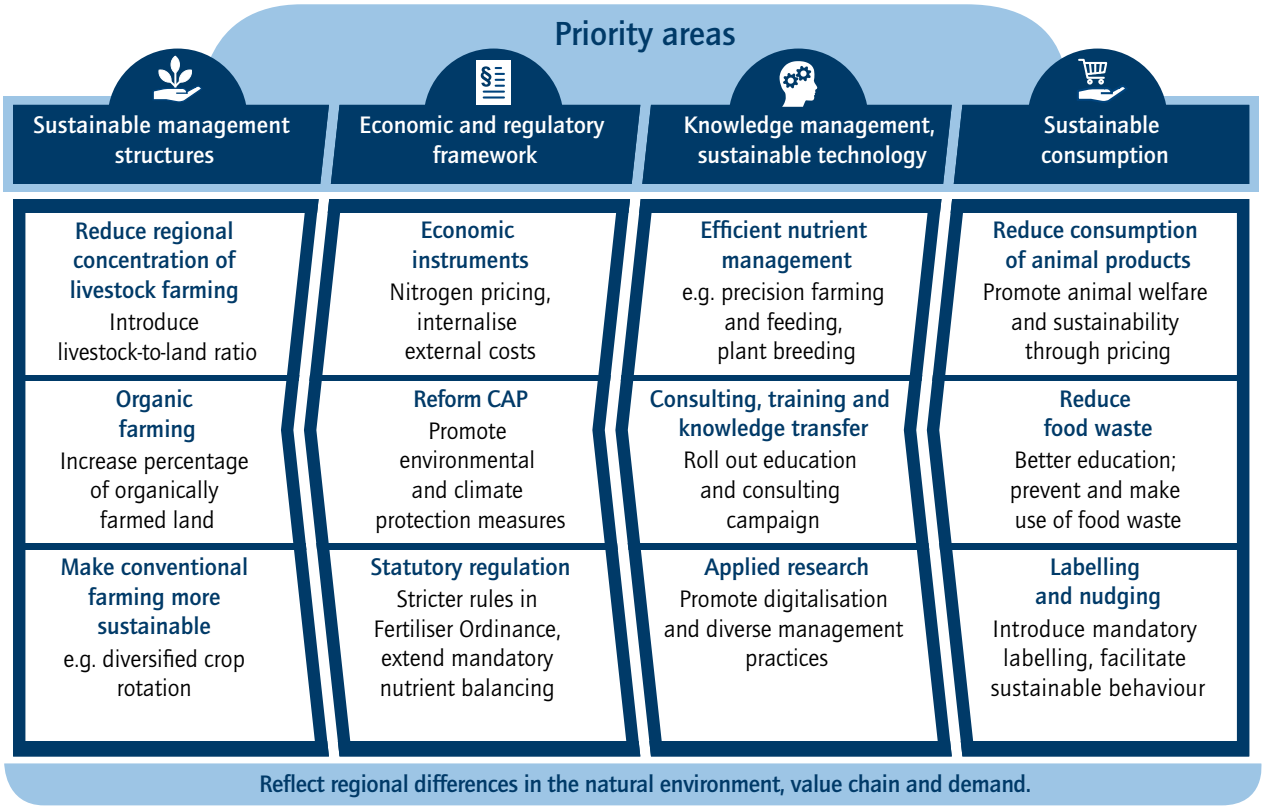
no negative impact on food security in Germany nor a need to increase imports to compensate for lower crop yield. The following measures are proposed for sustainable nitrogen use in the German agricultural sector:

Nitrogen surplus reductions

- The German government's sustainability strategy includes a target of reducing the nitrogen surplus from its current level of over 90 kilograms of nitrogen per hectare of agricultural area to less than 70 kilograms by 2030. However, this target – which was set by policymakers – falls short of what is required. Even if it is met, some 1.2 million metric tonnes of nitrogen will still enter the environment every year, with all the above-mentioned consequences for people and nature. Consequently, the current nitrogen surplus target of 70 kilograms of nitrogen per hectare agricultural area should be reviewed and a lower, evidence-based target established. In some places, lower local targets will be necessary in order to reflect differences in local conditions, especially with regard to soil properties and climatic conditions.

Sustainable agricultural practices

- The concentration of livestock farming must be reduced and crop cultivation and livestock farming again spatially combined to a greater extent. These two measures would significantly diminish regional manure accumulation and are thus key to reducing nitrogen inputs into the environment. They are aimed at regions with high livestock densities and consequently very high nitrogen surpluses, and must be combined with measures to improve animal welfare. As with the nitrogen surplus target, livestock density targets should be determined on a regional basis in accordance with local conditions.
- Conventional and organic farming must go hand in hand and learn from each other. Adapted agricultural practices, especially species-rich crop rotation and demand-based fertilisation, are important for sustainable nitrogen use. Organic farming generally has low nitrogen surpluses and achieves high nitrogen use efficiency, while conventional farming enables high yields with comparatively lower land requirements. A major research and development goal should



Priority areas for sustainable nitrogen use (Source: authors' own illustration)

therefore be to combine the advantages of both systems to close the yield gap and avoid the need to devote more land to food production.

Economic and regulatory framework conditions

- The pricing of nitrogen inputs into the environment is a key instrument to promote both energy and resource efficiency as well as environmental protection. The recent development in mineral fertilizer prices along with sharply rising energy prices and a related decline in the amount of nitrogen used demonstrate the high effectiveness of this control measure. It also allows farms to choose their own individual strategy for reducing their nitrogen surplus. Pricing could be implemented in the form of a nitrogen surplus levy. A tax on mineral fertilisers and off-farm animal feed as a further option for implementing a price system is currently less effective, since it would affect agricultural inputs in general. Moreover, its effectiveness as an incentive to use fertiliser more efficiently has already been forestalled by the prospect of high long-term energy and fertiliser prices. Accordingly, the pricing system design should take the impacts on competitiveness and the effects of major fluctuations in the market price of agricultural inputs into account. Against this background, revenues from pricing should benefit agriculture in the form of a repayment to all farms or as a means of funding further measures to reduce nitrogen surpluses.
- Precise specifications for fertiliser application and on-farm nutrient balancing for almost all farms are key requirements for reducing nitrogen surpluses.
- The German government's current plans should be amended so that more funds are reallocated more quickly from the first pillar of the Common Agricultural Policy (CAP) – which largely comprises area-based direct payments – to the second pillar. This will strengthen the agri-environmental measures in the second pillar, some of which also help to reduce nitrogen inputs into the environment. At the EU level, area-based direct payments should be gradually replaced by payments rewarding environmental and climate protection measures that also aim to reduce nitrogen emissions.
- Measures to reduce the regional concentration of livestock farming must be supported by the relevant building and emission control regulations. Investments that have already been made and grandfather clauses must also be considered. In addition, political measures must ensure that no European or international competitive disadvantages arise. The goal is to prevent more goods with lower production standards from being imported, including from outside the EU.

Knowledge management and sustainable use of technologies

- Efficient fertilizer management using digital technology, low-emission application technologies, precision farming and optimised fertilisers, and by growing varieties bred with specially adapted traits, promotes the sustainable use of fertilizers. A requirement here is the establishment of the necessary basic infrastructure, especially high-speed Internet. Access to finance for the deployment of efficient fertiliser technology and precision farming techniques is also essential.
- Nitrogen-minimised and needs-based precision feeding contribute to reducing nitrogen surpluses and ammonia emissions in livestock farming.
- Comprehensive training and consulting tailored to individual farms can help to change nutrient management practices and should be strengthened through government initiatives and funding.
- More funding needs to be made available for research that involves closer cooperation with farms as partners and demonstration projects, as this type of support advances technology development and promotes the more widespread use of innovative solutions in practice. This research should include key cutting-edge topics in fields such as plant breeding, precision farming and soil microbiome management.

Consumer policy

- Reduced consumption of animal products contributes to decreasing nitrogen emissions and also has benefits for human health, animal welfare and climate protection. Lower consumption can thus be justified on different levels. The task is to promote motive alliances, i. e. different motives and combinations of motives to encourage more sustainable dietary choices and consumer behaviours. Information on reducing the consumption of animal products can be communicated to specific groups.
- One possible approach would be to introduce a tax on animal products, supported by social policy measures, to better reflect the costs to society of livestock farming and the consumption of animal products.
- Behavioural policy instruments have a complementary effect, with the public sector leading the way. For instance, public sector canteens can offer a vegetarian menu as standard to make it easier for consumers to choose sustainably produced products and meals with less meat.
- Food waste along the entire value chain must be avoided or reduced. The less that is wasted, the less fertiliser that is

needed to meet demand for food. Food waste can be reduced by informing and educating consumers, organising the distribution of surplus food more effectively and adapting trading standards. As far as possible, the aim should be to create a circular food economy.

- The environmental impacts of producing animal and plant products must be immediately apparent to consumers. For people to make informed purchases and choose sustainably produced products, they need standard, independent and easily understood labelling that informs them about all the key environmental impacts, including those of nitrogen. This also calls for the development of comprehensive database structures containing product and sustainability information that can be easily accessed by the public.

Methodological approach

This acatech POSITION PAPER is the product of several years' work by a project group whose members from science and industry contributed expertise in a wide range of disciplines and areas of application. The findings and recommendations also draw on an analysis of publications, studies and position papers in this field. In addition, several experts contributed their knowledge through guided interviews and presentations to project group meetings. As a result, the input for this acatech POSITION PAPER reflects the views of representatives of NGOs, industry – including the farming, fertiliser and food industries – and various scientific disciplines. An extensive scientific review process led to the incorporation of additional content and details and the reappraisal and adaptation of the points of view expressed.

acatech – National Academy of Science and Engeneering, 2023

Munich Office
Karolinenplatz 4
80333 Munich | Germany
T +49 (0)89/52 03 09-0
F +49 (0)89/52 03 09-900

Berlin Office
Pariser Platz 4a
10117 Berlin | Germany
T +49 (0)30/2 06 30 96-0
F +49 (0)30/2 06 30 96-11

Brussels Office
Rue d'Egmont/Egmontstraat 13
1000 Brussels | Belgium
T +32 (0)2/2 13 81-80
F +32 (0)2/2 13 81-89

www.acatech.de
info@acatech.de

Committee of Board and Vice Presidents: Prof. Dr. Ann-Kristin Achleitner, Dr. Stefan Oschmann, Manfred Rauhmeier, Prof. Dr. Christoph M. Schmidt, Prof. Dr.-Ing. Thomas Weber, Prof. Dr.-Ing. Johann-Dietrich Wörner

Board acc. to § 26 BGB: Prof. Dr.-Ing. Johann-Dietrich Wörner, Manfred Rauhmeier

This executive summary is based on: acatech (Ed.): *Sustainable Nitrogen Use in Agriculture* (acatech POSITION PAPER), Munich 2023.
DOI: https://doi.org/10.48669/aca_2023-3. The original version of this publication is available at www.acatech.de.