Manure

A valuable resource

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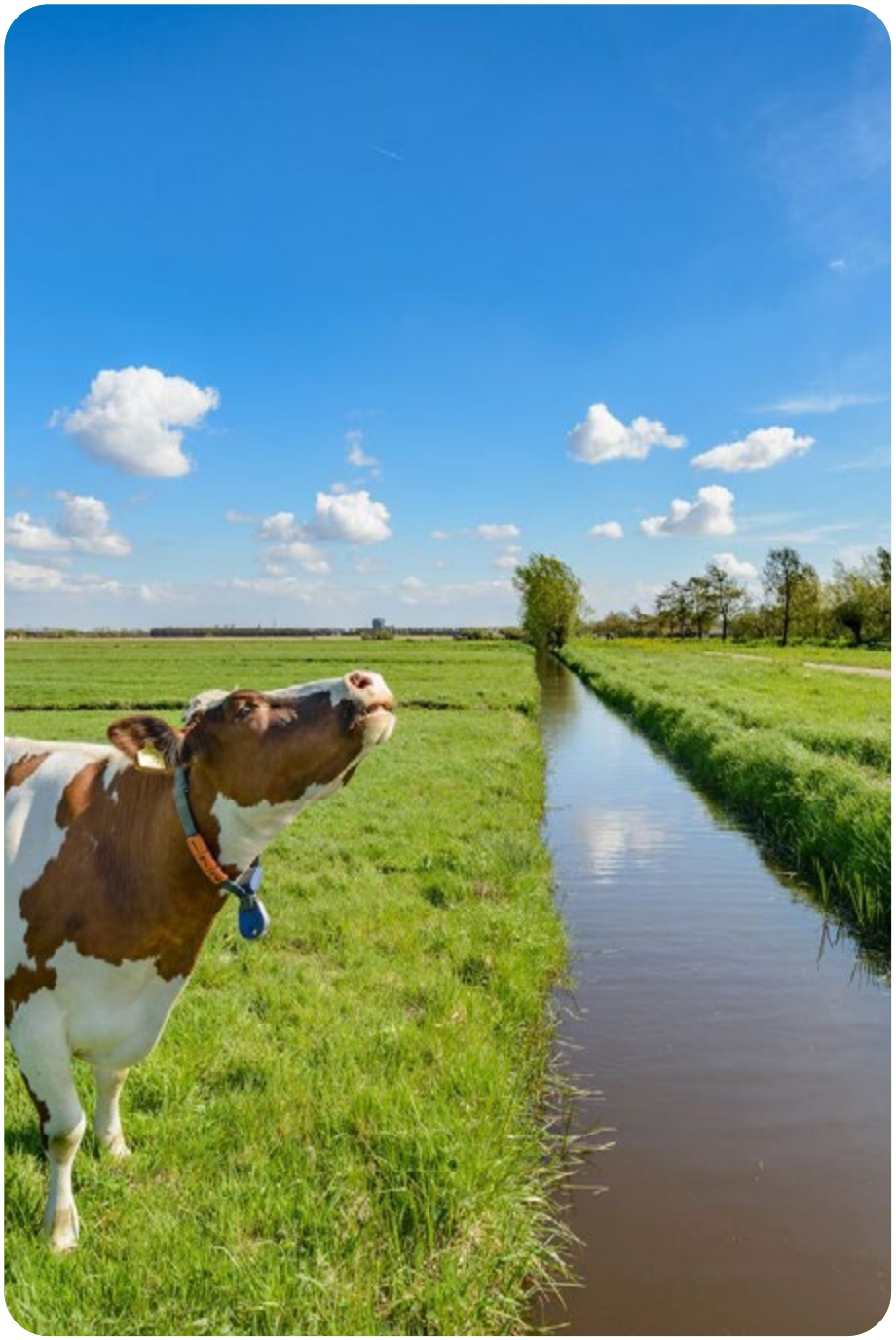


Foreword

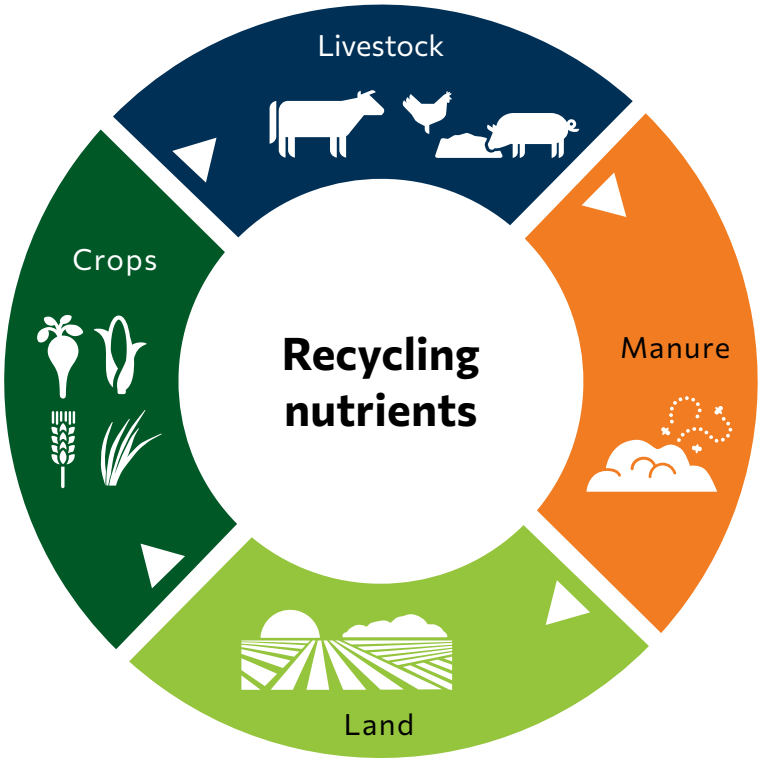
Manure – animal excrement – has been used in food production ever since people started keeping livestock, working the land and growing crops. It is an important source of nutrients for plants and essential for a healthy soil. Manure is also an energy source and contains valuable raw materials. This allows natural waste streams to be reused in agriculture.

After World War II, Dutch farmers began using synthetic fertilizers, which partially replaced livestock manure. This was an important change that coincided with the mechanisation of agriculture and had significant consequences. Farmers' and horticulturalists' efforts were rewarded with higher yields, allowing the Netherlands to provide large numbers of people with good, healthy food. Consequently, the country became a world leader in exporting agricultural products and expertise. However, synthetic fertilizers have a major drawback, in that they are produced using finite fossil resources. Today, we are once again recognising the value of livestock manure because of the benefits offered by the organic materials and trace elements it contains.
In current times, we understand how crucial it is to keep our soils healthy and maintain the quality of our water. To achieve that, we must prevent excessive use of both animal-based and synthetic fertilizers. And that is possible, as our understanding of the agricultural and ecological benefits of nutrients from livestock manure deepens. We also have the knowledge and technology to reuse or process components of this manure in a way that limits the negative consequences of its use. Manure and manure products and the effective use of livestock manure are vital elements in achieving circularity.

We strive to achieve circularity in nature and food systems and the efficient use of nutrients. One way to achieve this is to use natural resources or innovative technologies such as precision fertilization. Another is to design processes in a more intelligent way: surpluses on one farm can be used by others in the area to fertilize pastures and fields. By pursuing circularity more, we can more quickly and easily prevent harmful substances from contaminating water or air. Agriculture becomes less dependent on phosphate, potassium, natural gas and other scarce or finite fossil fuels.

This brochure offers an overview of manure policy over the years. With the current EU derogation coming to an end, farmers will be limited to 170 kg of nitrogen per hectare when applying livestock manure as fertilizer. This has created tension in the manure market, with farmers facing surpluses and sometimes having great difficulty disposing of their manure. In this brochure we outline the legal frameworks such as the Dutch Fertilizer Act and Soil Protection Act, as well as rules for transporting livestock manure and measures for processing it. You will find out why it is beneficial to use products derived from livestock manure that are known to effectively replace synthetic fertilizers. I hope it helps you make informed choices and inspires you to use as many sustainable products as possible – products that support both crop growth and nature.

Marten van den Berg
Director General DG Agro
Dutch Ministry of Agriculture, Fisheries, Food Security and Nature



Ministerie van Landbouw, Visserij, Voedselzekerheid en Natuur

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Introduction

Manure is an essential resource for our food supply and has served as the basis for agricultural production in the Netherlands for centuries. From an environmental point of view, manure has acquired a negative reputation over recent decades. However, there is a distinct relation between the agricultural benefits and the environmental risks of using manure. This has led to an extensive system of legislative framework for fertilizers in the Netherlands designed to minimize negative environmental effects.

The Netherlands is aiming for a situation where manure is a valuable product once again. A circular approach of agriculture is the strategy in the Netherlands and manure is a key factor in this. Optimization of the link between livestock and arable farmers can be achieved by minimizing losses of nutrients and meeting the demands of soil, crop and farmers.

Current situation

In certain regions of the Netherlands, intensive livestock farming results in local excess of animal manure. More manure is produced in some regions than can be used by local agriculture. Over-abundant use of fertilizer is harmful to the environment and nature. The Netherlands has therefore taken up the challenge of optimizing manure management based on the circular approach: manure is a valuable product.

Manure management

Optimizing the use of manure minimizes loss of nutrients and dispersion into the environment. An extensive knowledge infrastructure (research, education, management support) has stimulated farmers in the Netherlands to use manure as a valuable resource. And to be able to use manure where and when it is needed by the crop, manure may have to be transported. Volume reduction, by reducing the water content and manure processing to increase organic matter and nutrient content, makes distribution more effective.

Manure policy

The Dutch government has specifically stimulated and facilitated these developments. Partnerships between government, industry, NGOs and science have become increasingly common, resulting in widely supported and practically applicable solutions with long-term perspectives. The strategy embraced by consortia is to start at the demand of the end user (crop farmer) and to adapt the manure producing chain in such a way that the demand will be met.

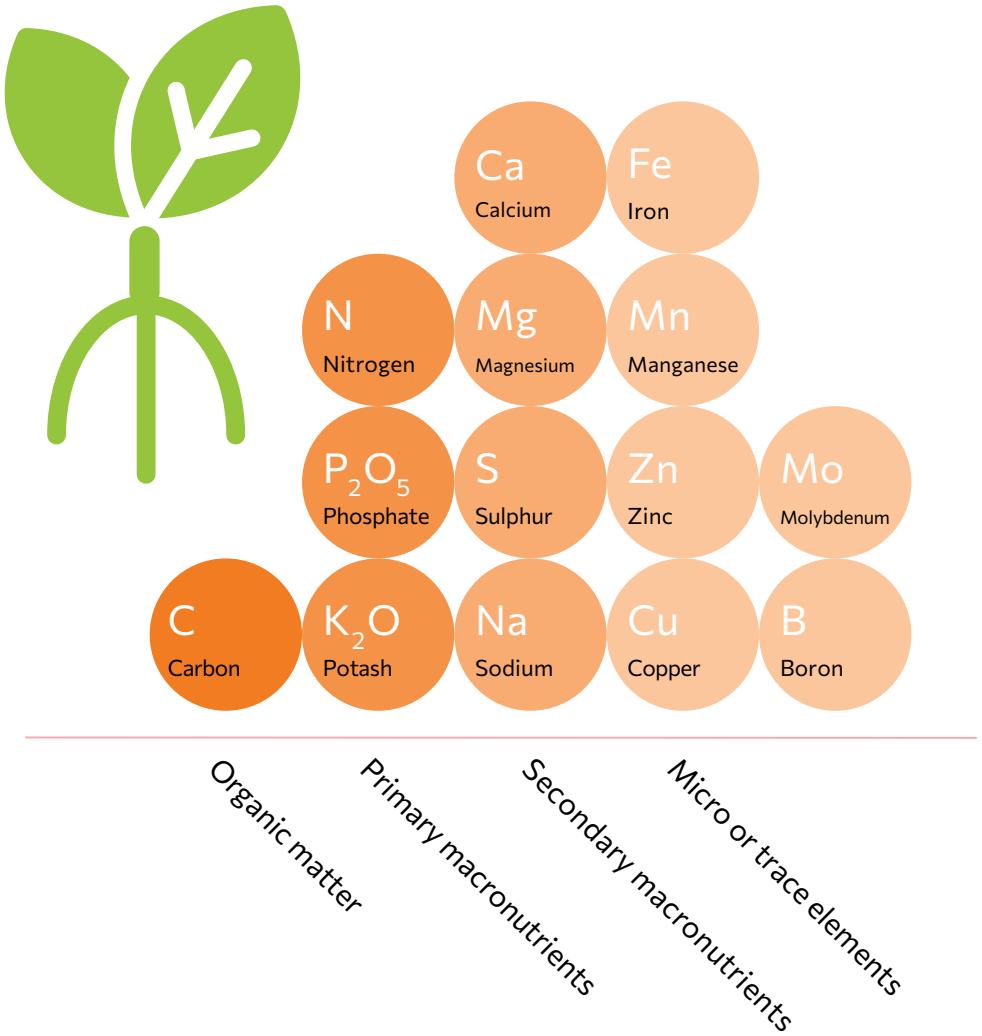
This brochure shows how the Netherlands prevents the dispersion of nutrients into the environment and optimizes the value of manure. The Dutch manure policy and technology could potentially be an inspiration for manure management in other countries.

Manure is not waste. It is valuable nutrition for plants and soil, and a source of energy and other substances.

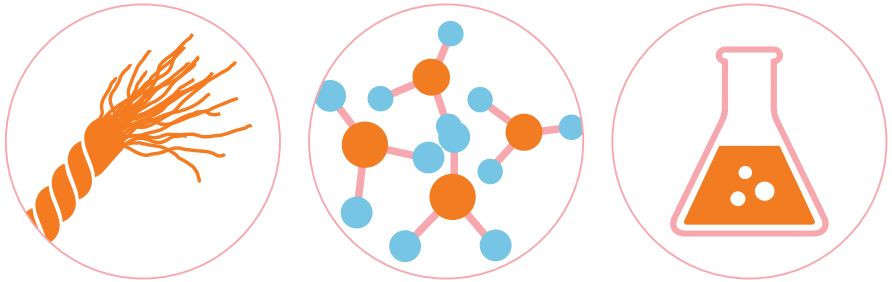
Manure is valuable in many ways

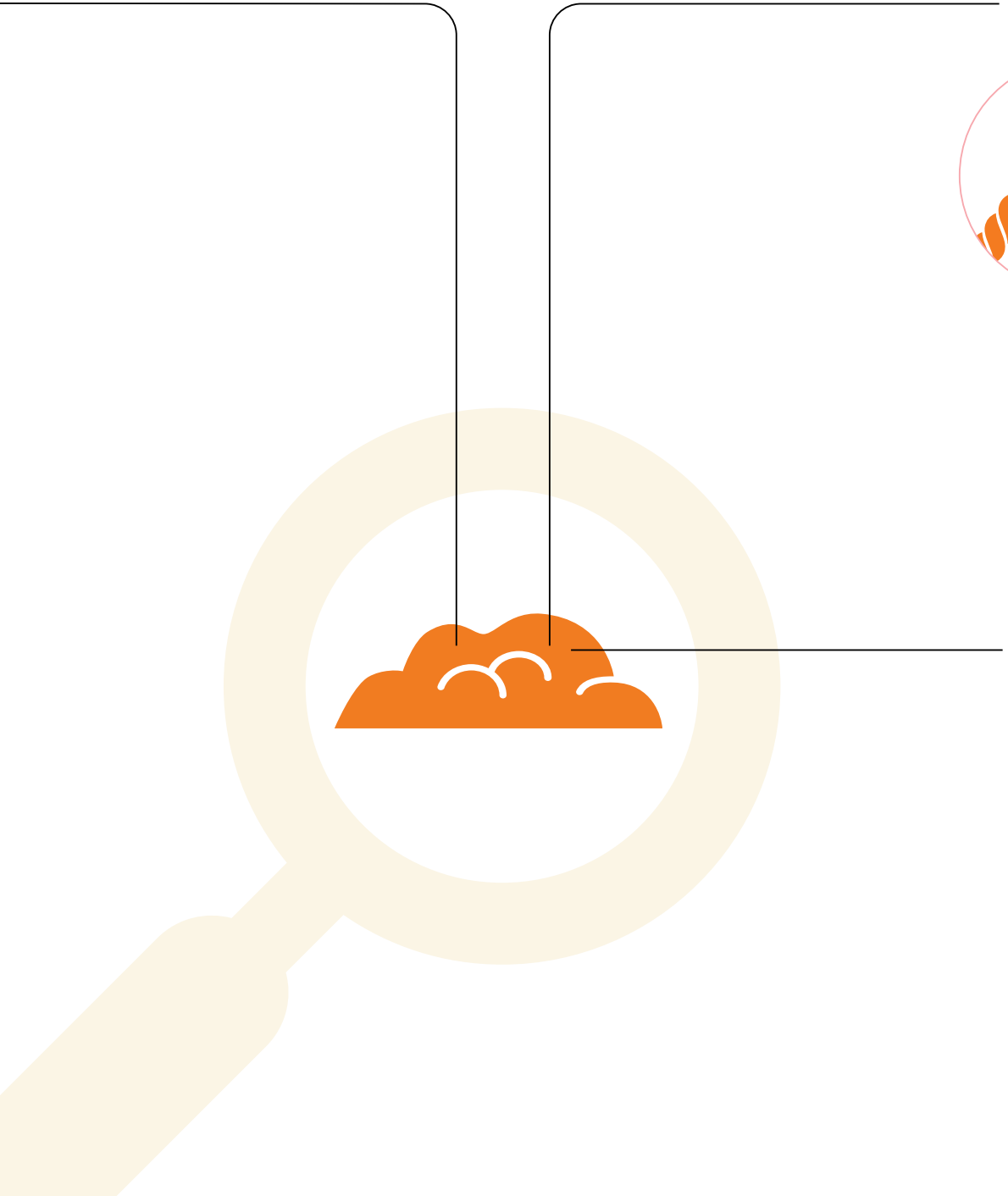
For centuries, animal manure has provided valuable nutrition for plants and has been a prerequisite for healthy soils. Manure is also a source of energy and contains many valuable raw materials. For a long time, manure – combined with urban waste – was the only source of nutrients in agriculture. Synthetic fertilizers partly substituted the use of manure. Nowadays, manure is valued again because of the benefits of organic matter and its trace elements. Manure is used as a resource to produce organic fertilizers or artificial fertilizer substitutes adapted to the needs of soil and plant, to produce energy or even to extract chemicals for industrial use.

Fertilizer and fertilizer products

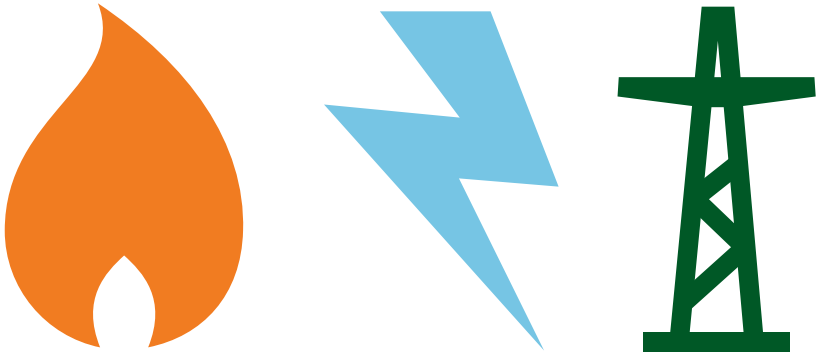


Source of raw materials





Source of energy

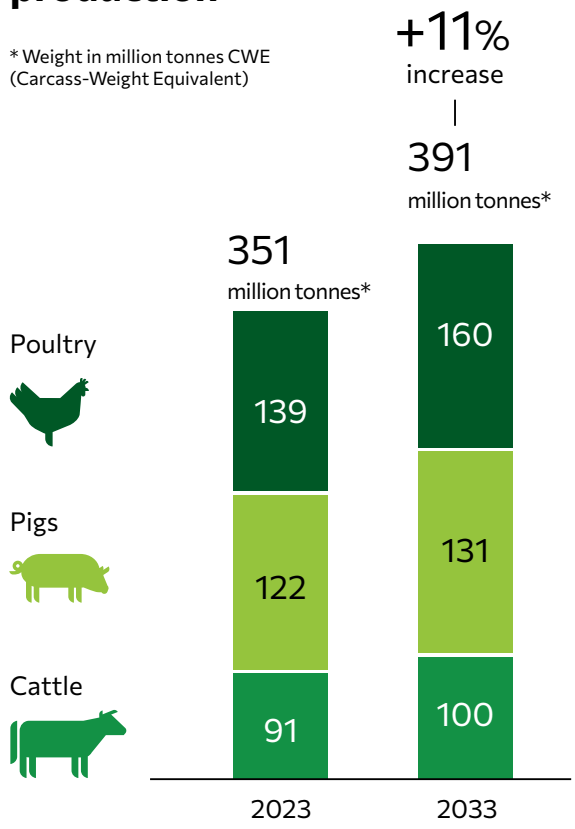


Availability of manure worldwide

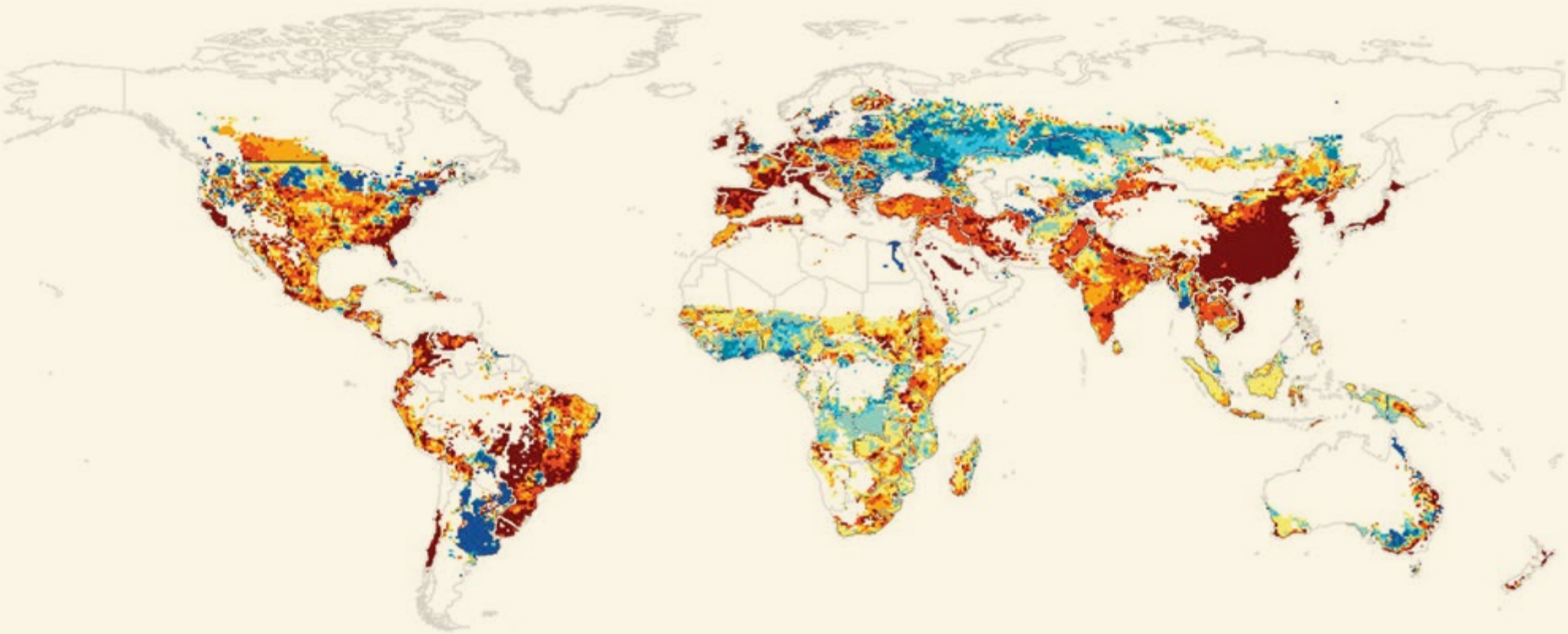
Although manure is a valuable product, certain regions produce more than is required by agriculture in the immediate vicinity. The resulting excess of nutrients threatens to pollute surface and ground water. Solutions include the spatial spreading of animal production and improving manure utilisation by transporting raw and processed manure to areas with shortages. Regional manure surpluses are a result of higher volumes of animal production and the increasing geographic separation of crop production on the one hand and animal production on the other. And as a consequence, a nutrient shortage in areas with predominantly arable farming. Reduced availability of manure increases the need for synthetic fertilizers and alternative sources for organic matter. Synthetic fertilizer also displaces manure due to its ease of use and in some parts of the world government subsidies. As a result, the nutrient cycle is disrupted, leading to nutrient surpluses in areas where livestock farms predominate. This also results in an uneven distribution of phosphate, as shown on the next page.

The challenge is to close nutrient cycles and minimize greenhouse gas emissions at the same time.

Global meat production



Source: OECD-FAO Agricultural Outlook 2024



Increased phosphorus (P) fertilizer use and livestock production has fundamentally altered the global P cycle. Manure is an important driver of P surpluses in locations with high livestock densities such as the coastal regions in Europa, Asia and the America s. As for phosphorus, high animal densities are also related to greenhouse gas emissions.

Phosphate deficits
in kg phosphate ha^{-1} yr^{-1}

- Lowest quartile (0 to -0.8)
- Lower-middle quartile (-0.8 to -1.9)
- Upper-middle quartile (-1.9 to -3.2)
- Top quartile (-3.2 to -39)

Phosphate surpluses
in kg phosphate ha^{-1} yr^{-1}

- Lowest quartile (0 to 2.5)
- Lower-middle quartile (2.5 to 6.2)
- Upper-middle quartile (6.2 to 13)
- Top quartile (13 to 840)

Source: MacDonald G K et al. PNAS 2011;108:3086-3091 (www.pnas.org)

Manure in the Netherlands

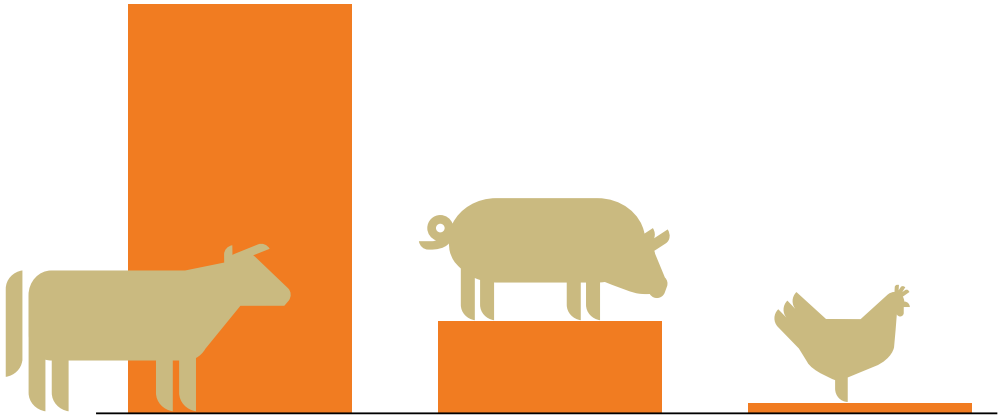
The Netherlands is a small, but densely populated member state of the European Union and has large numbers of livestock. The import of livestock feed and the use of synthetic fertilizer has led to a nutrient surplus in the Netherlands. Maintaining large numbers of animals requires the nutrient balance to be restored through a more efficient animal production and the export of nutrients (livestock manure).

The Netherlands

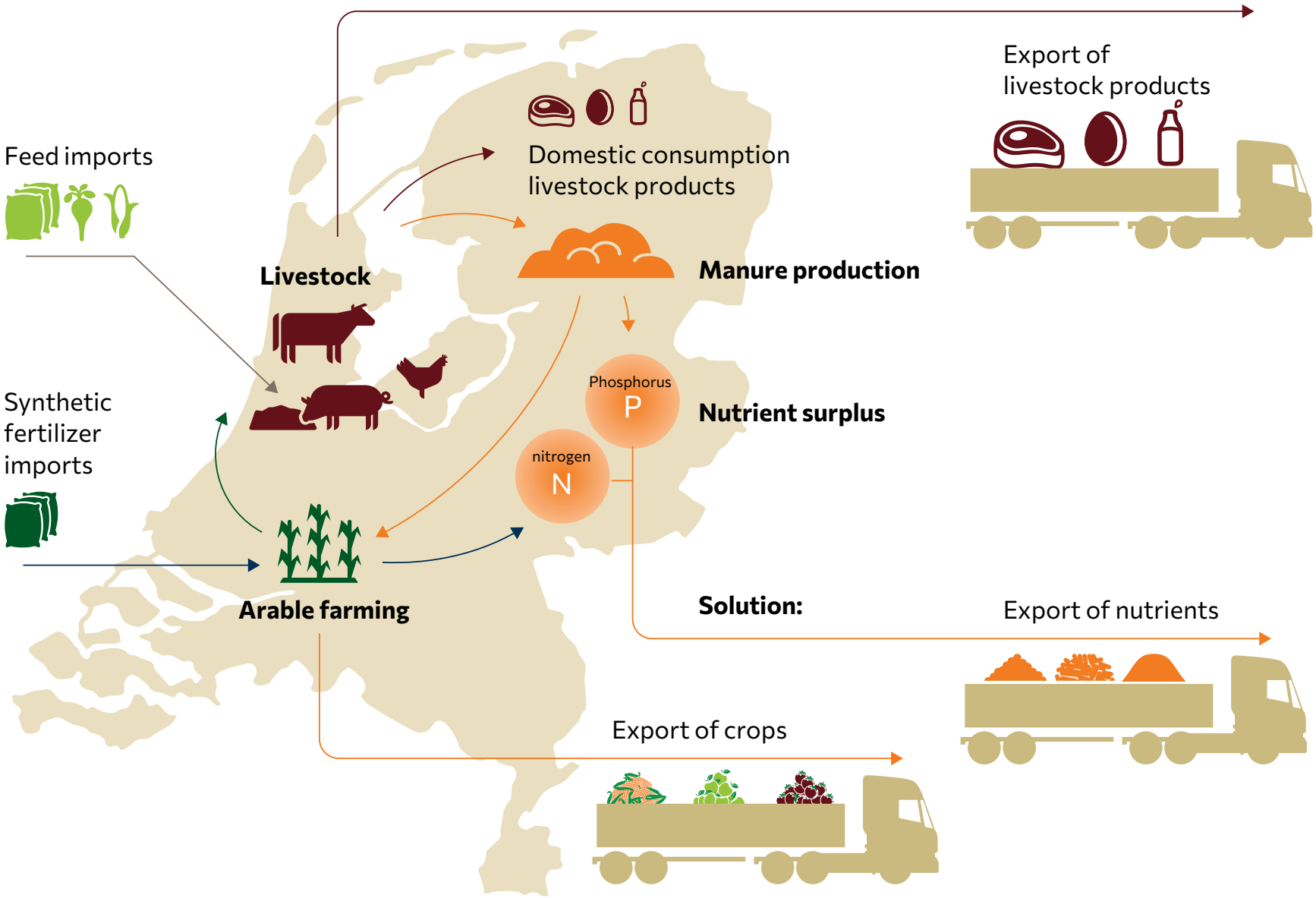
Population	18 million
Surface	41.865 km²
Agricultural land	17.990 km²
Manure production	74.4 million ton/yr
P_2O_5 Phosphate surplus	4 kg/ha/yr
N Nitrogen surplus	101 kg/ha/yr

Manure production in the Netherlands (CBS Statline 2018)

	Cattle	Pigs	Poultry
Number of animals	3.8 million	10.5 million	89.2 million
Manure production per year	61.2 million ton	9.6 million ton	1.1 million ton



Nutrients cycle in the Netherlands



Dutch policy on manure and fertilizer

Dutch manure policy focuses on both the production and the application of manure and fertilizers. The main goal is to prevent or limit nutrient contamination in the environment by regulating manure application. Manure production is regulated in order to support the system of application standards. This is done through the system of livestock production rights. A part of the surplus of manure that cannot be used on the farmer s land must be processed. Transport of livestock manure is heavily regulated. All this is backed by controls and enforcement in order to safeguard the quality of livestock manure.

EU guidelines serve as a framework for the current Dutch policy regarding manure. To comply with these, the Netherlands has developed its own regulations and incentive measures.

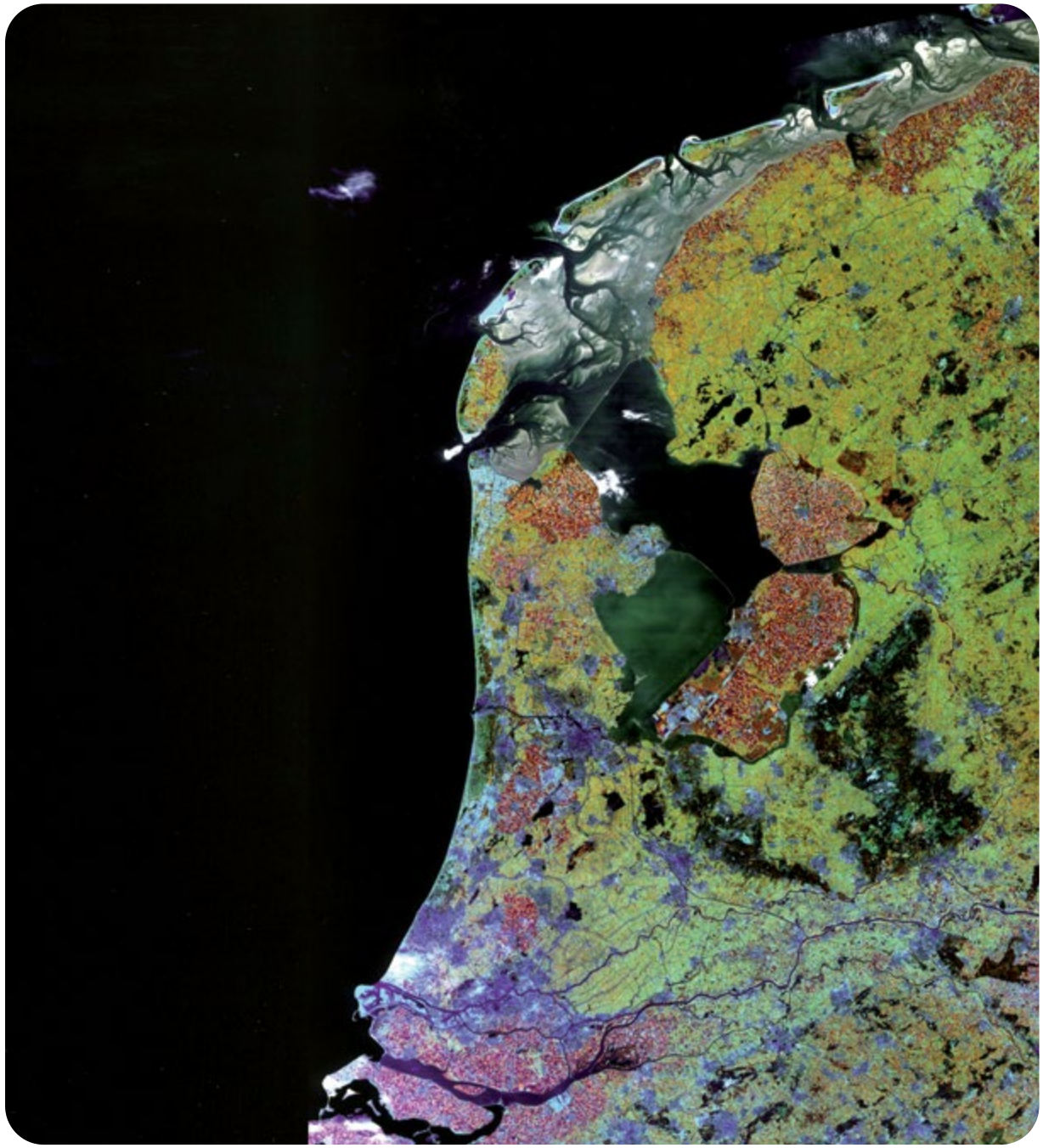
The 8th Nitrates Action Programme describes Dutch manure policy and new measures. Its goal is to achieve 50 mg/l of nitrate in percolating groundwater across all soil types and reduce surface water eutrophication. The main measures proposed are as follows:

- Develop farm-oriented management guidelines for groundwater quality.
- Further develop sustainable cropping plans, such as growing catch crops and rotating with fallow crops, that are feasible and practicable.
- Replace the designation of nutrient-contaminated areas with a designation of areas of focus for nitrogen and phosphorus in surface water.
- Implement an area-specific, tiered adjustment of nitrogen usage standards.
- Continue the strengthened manure enforcement strategy.

A circular agriculture requires optimization across the sectors.

Circular agriculture

The Netherlands is striving for sustainable agriculture that goes hand in hand with a healthy environment on land and in water. The main areas of focus are efficient and circular use of nutrients and resources on the lowest scale as possible, and beneficial use of residual streams. Most importantly, circular agriculture should also benefit the environment, climate (reduction in greenhouse gas emissions), biodiversity, animal welfare and be competitive. Overall, the food production system will become more sustainable because of lower emissions into soil, water and atmosphere and a decrease in waste. In the case of manure, the opportunities can be found in the fact that manure is the connecting factor between livestock and crop farming and is abundantly available. The challenge is to use manure as efficiently as possible and to develop the best technical, social and economic solutions with which to do so.



Composite satellite photo of the Netherlands. The different colours show the land use. For instance: reddish is agricultural crops, light green is grass, light blue is bare soil and black is water.

Policy

1984
Production rights
- Limited livestock numbers of pigs and poultry

1984
Milk quota
- Limits on milk production

1987
Fertiliser act
(manure production rights)

1987
Closed period for manure application

1991
EU Nitrates Directive
(Ground water monitoring network)
- Maximum application rate 170 kg N/ha/year

1993–2006
Mineral Accounting System at farm level
- Penalty for plant nutrient losses

2000
EU Water Framework Directive
- Quality of surface water

2006
Application of standards system
for minerals

2007
Low emission housing of animals in
newly-built structures

2014
Mandatory manure processing

2015
Expiry of European milk quota system

2018
Phosphate rights for dairy farmers
to restrict increase in dairy cattle numbers

2020 - 2024
Various national exit schemes for
livestock farms to reduce the number
of farm animals in the Netherlands.

2023 - 2026
Phase-out of the derogation in the Netherlands.

2025
Approval of RENURE products
(fertilizer substitutes)

Current regulations for nitrogen and phosphate

Manure and fertilizer application

- Maximum application standards (N and P)
- Account for soil type and crop (nitrogen)
- Account for land use and soil condition (phosphate)
- Application in growing season
- Low emission techniques application livestock manure
- Regulation for both manure and artificial fertilizer

Other obligations to reduce

- nutrient losses
- Build low emission housing and manure storage
- Compulsory processing of manure
- Production rights for livestock farmers

Enforcement

- Analysis and real-time registration of manure transport
- Registration of production (livestock, manure and crop) and application (manure and artificial fertilizer)
- Analysis and registration of manure transport
- Data exchange between agencies
- ICT-architecture

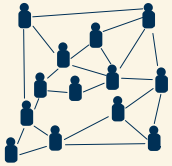
Government facilitation

Innovation

- Financing and co-financing of Research and Development (R&D) for innovative processing and manure management
- Stimulating cooperation research and companies

Subsidies and fiscal measures

- Stimulating investment in new techniques
- Stimulating investment in climate and environmental-friendly measures



Capacity building for farmers

- Pilots
- Consultancy services
- Networks of farmers

Vision

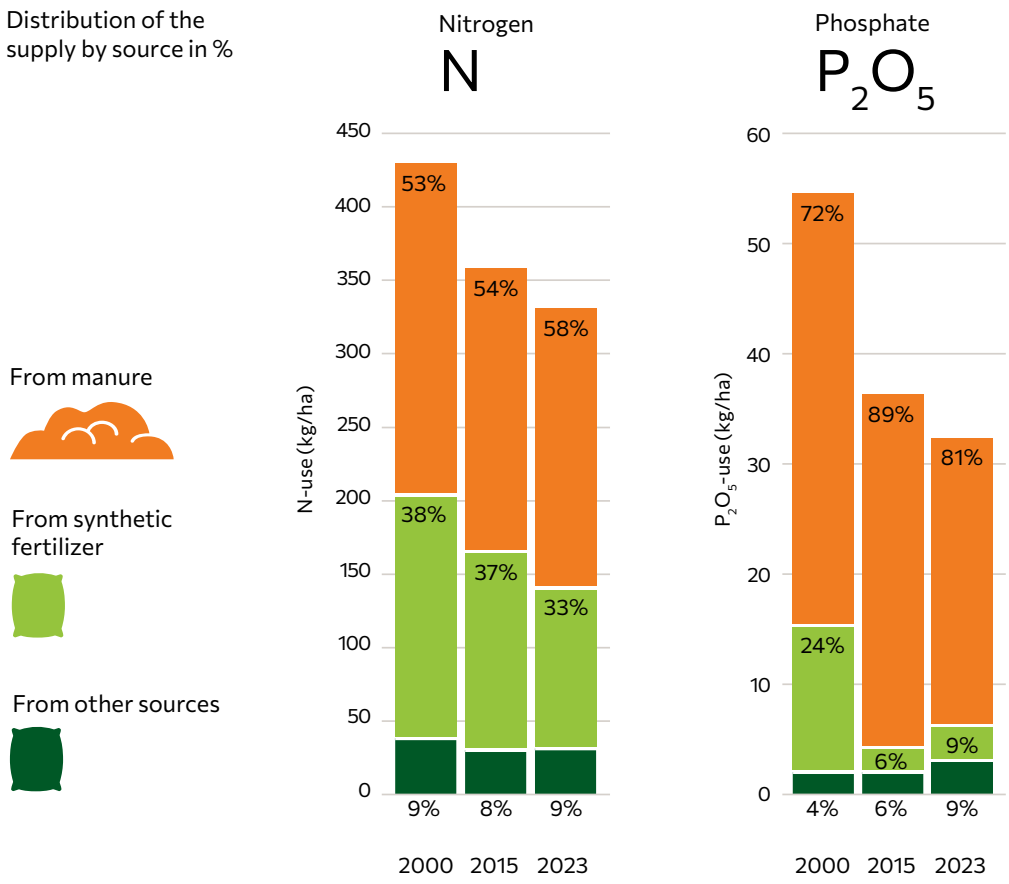
- Strong vision on circular agriculture
- Facilitate with Laws and Regulations
- Stimulate innovators

Results of the Dutch policy on manure

Measures such as strict application standards, low-emission manure storage and application regulations and regulations for the processing and export of manure have led to:

- A decrease in total nutrient use in agriculture in the Netherlands
- A decrease in the use of phosphate and nitrogen from synthetic fertilizer compared to livestock manure
- A reduction in nutrient dispersion in the environment
- An increase in manure-processing capacity and redistribution and export of manure and nutrients
- Awareness that quality of manure depends on input (for instance nutrients in feed)

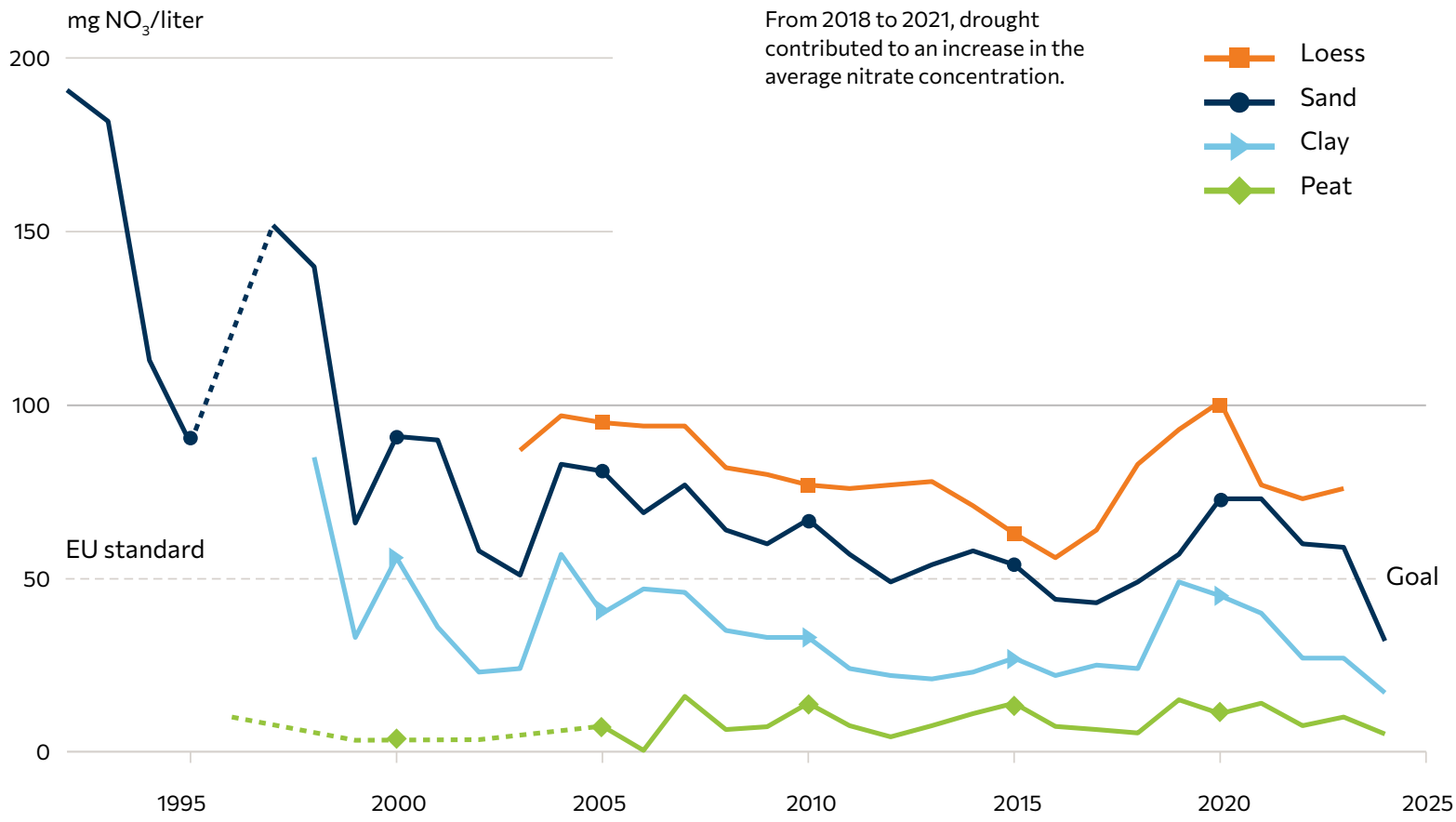
Decrease in use of nutrients and Increase rate of replacement of synthetic fertilizer by nitrogen and phosphate from livestock manure



Source: CBS Statline (2023)

General decrease in nitrate levels in shallow groundwater in agricultural land in the Netherlands

Ground and surface water are used for drinking water



Source: RIVM (National Institute for Public Health and the Environment, The Netherlands, 2025)

Future policy on manure in the Netherlands

Future policy will support the transition to a circular agriculture. In a circular agriculture, resources and residuals are efficiently used in the food chain. So cross connections have to be made between crop and livestock farming. It is important to closed cycles to focus on:

- A sustainable sector (economic, climate and environment)
- Connecting producers and consumers
- Innovation

Cross connections are found in:

Manure

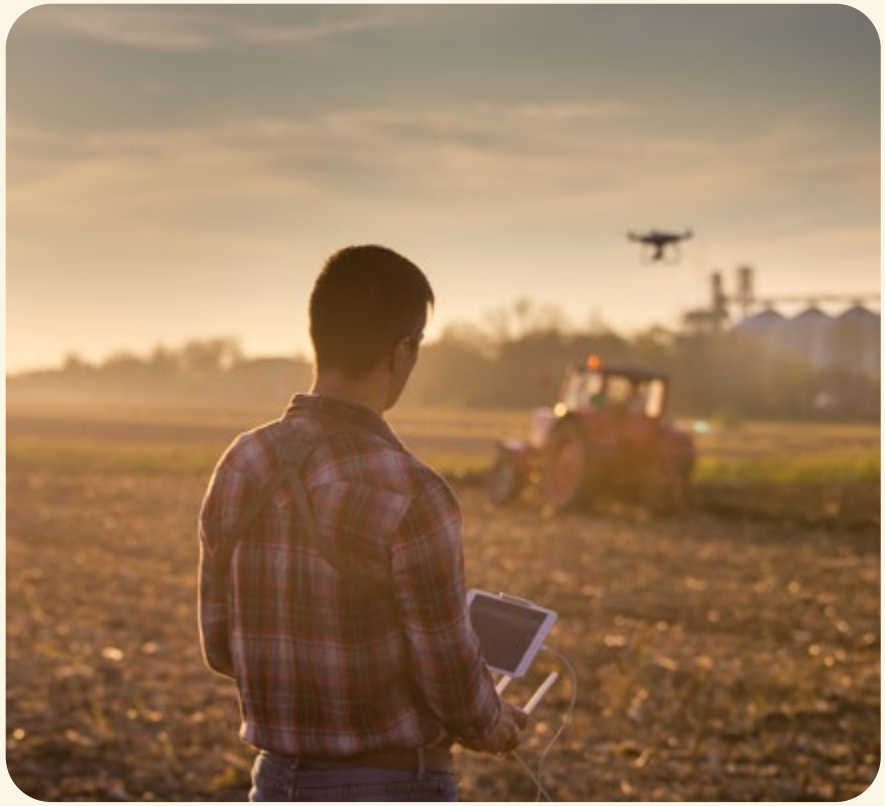
- Minimize loss of nutrients
- Manure processing: adapt manure products to demands
- Fertilizer product with high mineral content
- Soil conditioner with high organic carbon content

Animal feed

- Increase the use of by-products for animal feed such as food waste
- Decrease phosphate content in feed
- Develop new sources of proteins

State of the art farming practices

- Precision farming: right product, right time, right place
- Develop innovative techniques, real time NIRS analyses of manure and crops harvested, plant and soil measurements by drones and slurry dilution for application
- Collaborations between crop and livestock farmers



Principles of circular use of manure and nutrients

How to increase the circular use of manure and nutrients?

- Minimizing the loss of nutrients
- Connect arable farmers with livestock farmers
- Manure processing focused on soil/crop and market demand
- Manure as input for the bio-based economy

Low-emission application techniques result in considerable reductions in the loss of ammonia.

Minimizing the loss of nutrients

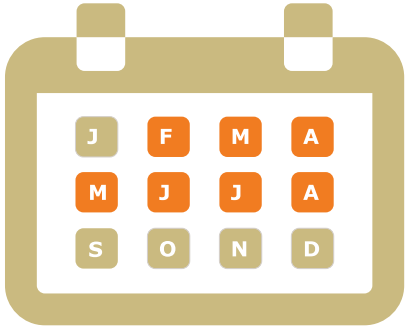
Regulating the use of manure in the Netherlands

Balanced fertilization

Applying exactly what the crop needs while taking into account nutrients in the soil. Choosing fertilizers that are locally available

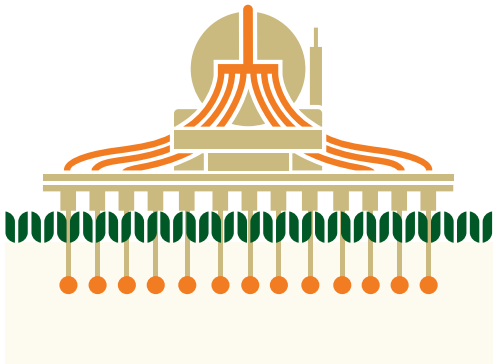
Using manure in the growing season

Application of manure from 1 February - 1 September, (depending on type of manure) interim period: manure storage (minimum of 7 months). Throughout the year: application prohibited when soil is frozen or covered in snow.



Low-emission application housing and storage techniques

This results in minimum loss of nitrogen in the form of ammonia, which in turn increases the fertilization value of the manure and reduces farmers need to use synthetic nitrogen fertilizer. Daily manure removal from the barn combined with anaerobic digestion can also reduce greenhouse gas emissions.

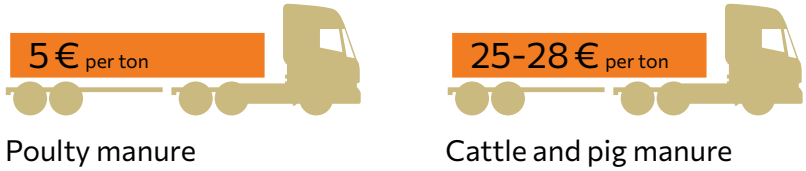


Connect arable farmers with livestock farmers

Excess manure at farm level can be transported to other, mainly arable, farms. In the Netherlands, pig and poultry farms in particular have manure surpluses, as they usually cover less land.

Transport is expensive. Reducing the water content increases the potential transport distance. This distance is also determined by whether arable farms are willing to pay for the product (whether it provides them with added value). For longer distances and export, it is most cost-effective to reduce the water content as much as possible. In addition, to reduce veterinary health risks, the exported manure must comply with the sanitary requirements for animal by-products (Regulation (EC) No 1069/2009 Animal by-products). Recently, these requirements were incorporated into EU Regulation (2019/1009), which regulates the export of fertilising products.

Costs of manure, disposal within the Netherlands to be paid by the livestock farmer



Poulty manure

Cattle and pig manure

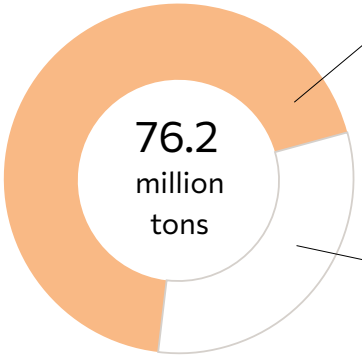
Affordability of manure transport

Liquid manure:
up to 150 km

Solid manure:
up to 450 km

Annual manure transport in the Netherlands (CBS, figures 2018)

Total manure production



No or limited transport application within the own livestock farm

48.5 million tons

65%

Mainly dairy farms

Excess manure transport within the Netherlands and export

25.9 million tons

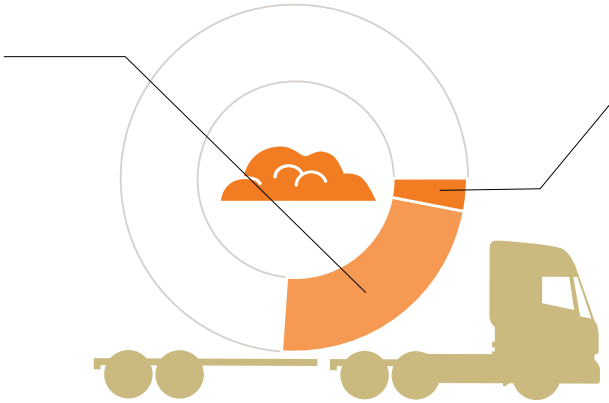
35%

Mainly pig and poultry farms

Transport within the Netherlands

20.9 million tons

28%



Export

5.0 million tons

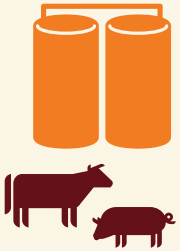
7%

Manure and manure products

Adequate use of manure is a spearhead for circular agriculture. This means that in addition to milk, eggs and meat, manure must be seen as a product of animal husbandry and quality standards must be achieved. The food production system (feed, animal, manure collecting and storage system and manure processing) should be aligned to produce the manure product demanded.

For the Dutch market ratios of N and P are important and also the content of organic carbon. When considering export of manure, a low water content and increased nutrient levels are desired, and sanitization is often required to eliminate pathogens.

Outline options for manure valorisation



Pig and cattle slurry (10% dry matter)

• Application as fertilizer on arable land (mostly cattle slurry)	▶ Low emission application as fertilizer on arable land or grassland
• Anaerobic digestion or codigestion (minimum 50% manure)	
– Digestate	▶ Higher in ammonium nitrogen, low emission application
• Separation of slurry or digestate	
– Liquid fraction	▶ Low emission application as fertilizer with reduced P_2O_5 content
– Nitrogen stripper	▶ Ammonium salt (N-product) en effluent (K-product)
– Reverse osmosis	▶ Mineral concentrate (NK fertilizer) and clean water
– Biological purification	▶ Nitrogen escapes as harmless N_2 gass, sludge is applied as fertilizer, liquid effluent to municipal wastewater treatment plant for further treatment
– Solid fraction (20-40% dry matter, stackable)	
– After pasteurization (e.g. co-composting, heat treatment)	▶ Export-quality fertilizer with increased P_2O_5 level

Solid poultry manure (> 40% dry matter)

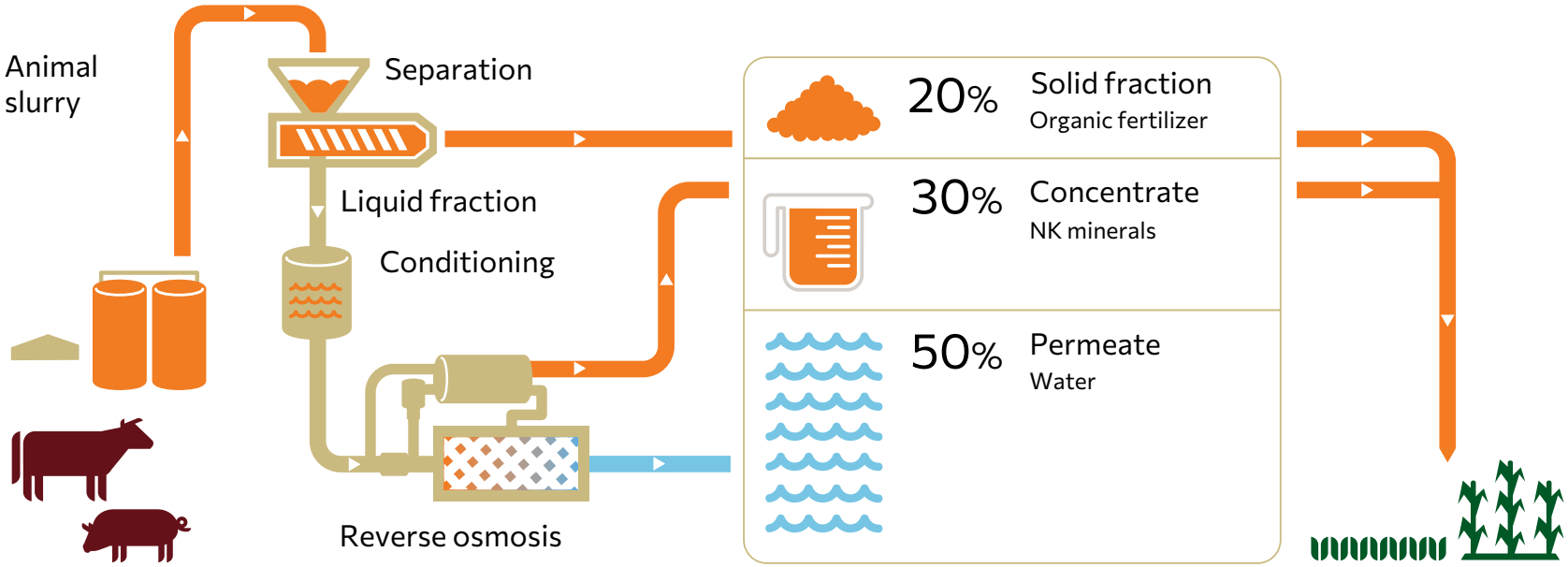
• Application as fertilizer on arable land	▶ Mostly exported to Germany and France
• Incineration (minimum 60% dry matter)	▶ Green electricity and ashes that can be used as raw material for PK fertilizer production. Nitrogen and organic matter are lost.
• Composting (biothermal drying) from 40% dry matter up to 80% dry matter	▶ For volume reduction and increased nutrient levels, export worthy
• Pellets from manure or composted	▶ Export-quality fertilizer, high nutrient content manure (> 80% dry matter)

Manure processing

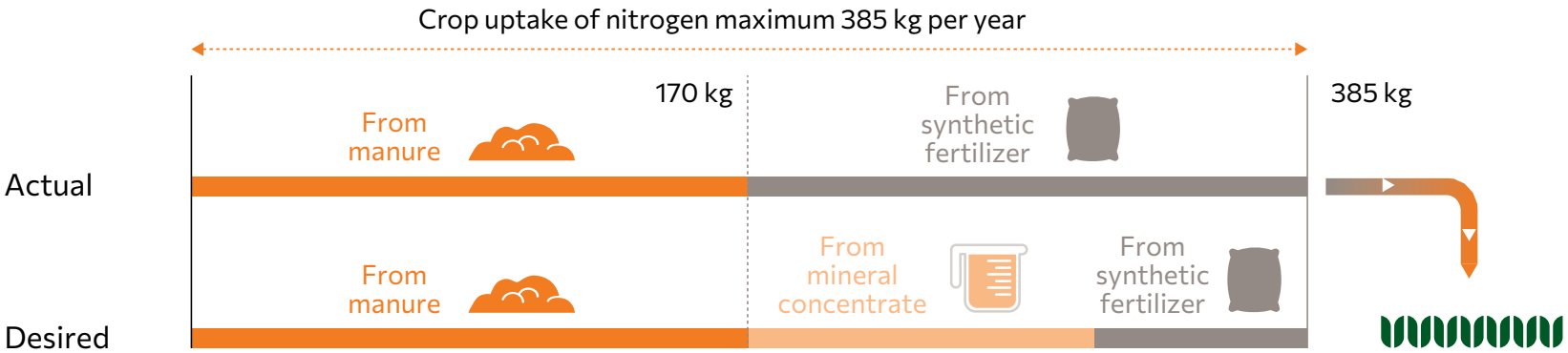
Depending on the desired end product (by crop and soil) various manure-processing techniques can be combined. The following page shows a production scheme for mineral concentrates (combination of separation, filtration and reversed osmosis). The goal is to produce a concentrate which can replace artificial fertilizer. On pages 30 and 31, the digestion process is described. Incineration, composting, granulating and biological treatment are summarized by process and strength and weaknesses in the following pages. When manure is destined for export, the manure should also be sanitized.

An important benefit of mechanical manure separation is that N and P can be used separately.

Production of liquid nitrogen concentrate by reverse osmosis



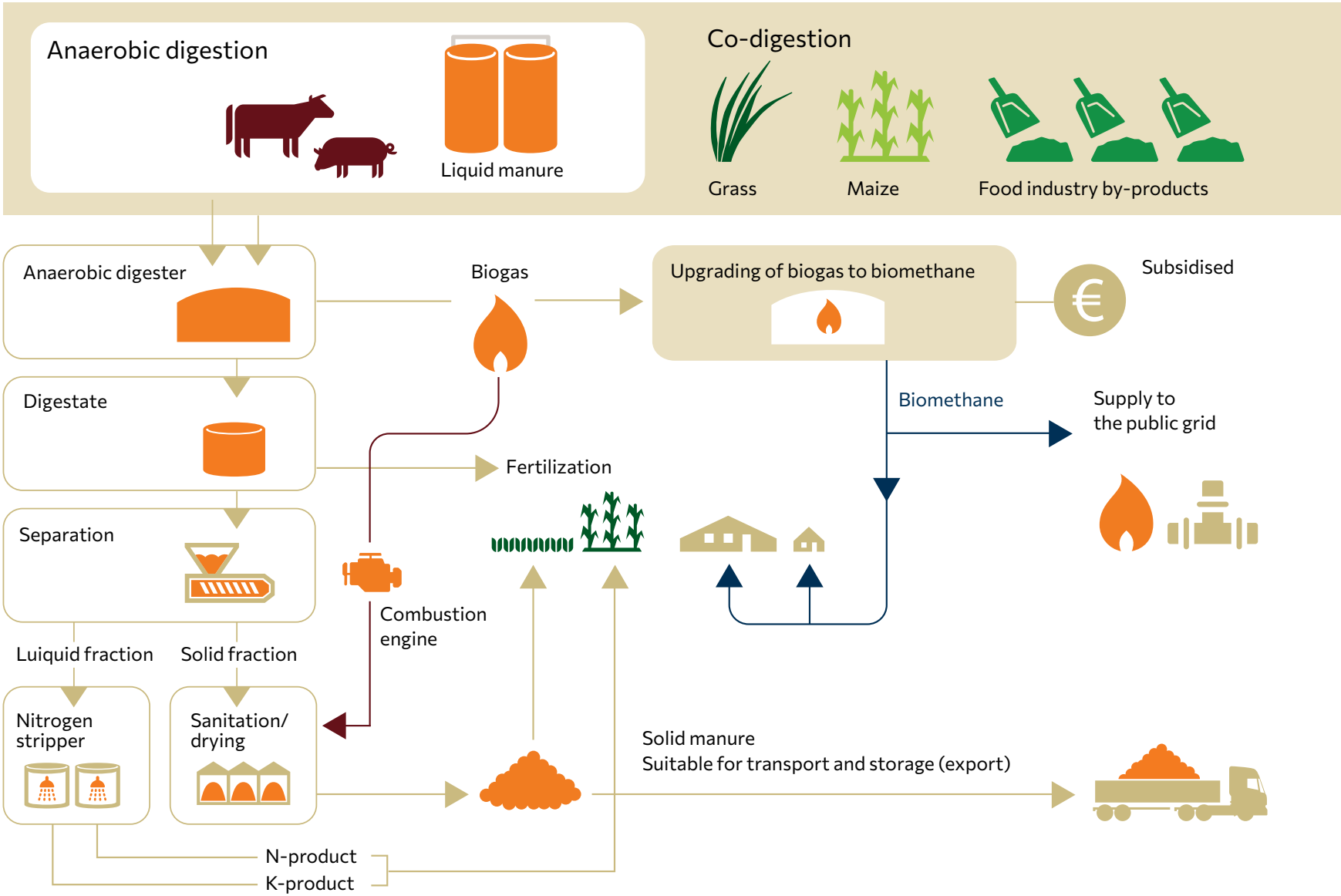
Desired utilization of nitrogen by source in kg N/ha, per year



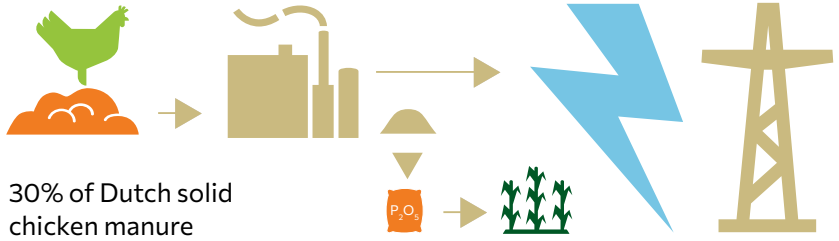
Digestion

Anaerobic digestion is a method of generating energy from manure through biogas production. Once it has been upgraded to biomethane, this product can be added to the natural gas network. The Dutch government is supporting biomethane production by providing subsidies and from 2027 onwards by requiring energy companies to deliver a set percentage of biomethane. This will create demand for biomethane and will raise its price. Manure digestion alone produces a limited amount of biogas. Anaerobic digestion can be made more efficient by adding co-products such as corn silage and grain products, as well as industrial by-products such as fats and glycerine. However, using certain co-products for this purpose makes them unavailable as animal feed and is unsustainable. The residual product of anaerobic digestion is known as digestate. This manure product is regarded as livestock manure under the law and must also be used as such.

Digestion


Anaerobic digestion
Liquid manure
Co-digestion
Grass
Maize
Food industry by-products
Anaerobic digester
Biogas
Upgrading of biogas to biomethane
Subsidised
Digestate
Biomethane
Supply to
the public grid
Fertilization
Separation
Combustion
engine
Luiquid fraction
Solid fraction
Nitrogen
stripper
Sanitation/
drying
Solid manure
Suitable for transport and storage (export)
N-product
K-product

Incineration



Organic matter lost

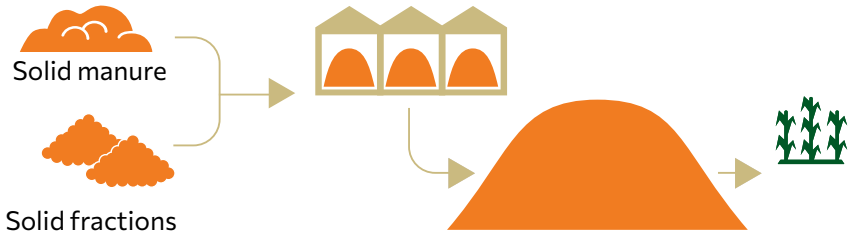
400,000 tonnes per year is incinerated, producing 36 megawatt

60,000 tonnes of ashes per year with 13% phosphate, applicable as manure after additional treatment

100% nitrogen loss

Subsidized. Based on the production of renewable energy

Composting ('biothermal drying')



Stable organic matter

Reduction of weeds and pathogens

Suitable for transport and storage (export)

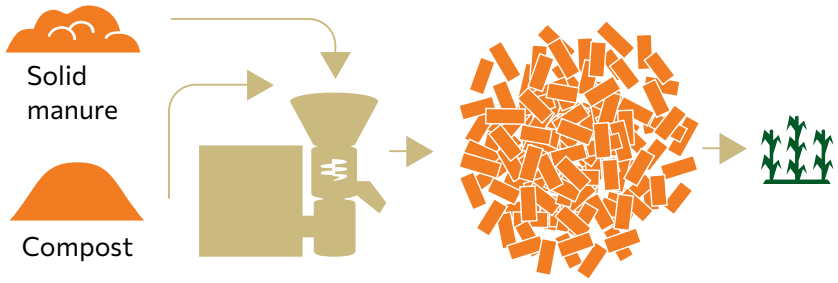
High in nutrients and other (trace) elelements

Up to 60% nitrogen loss

Investment partly subsidized

Producing manure granules

Solid manure



80% organic matter

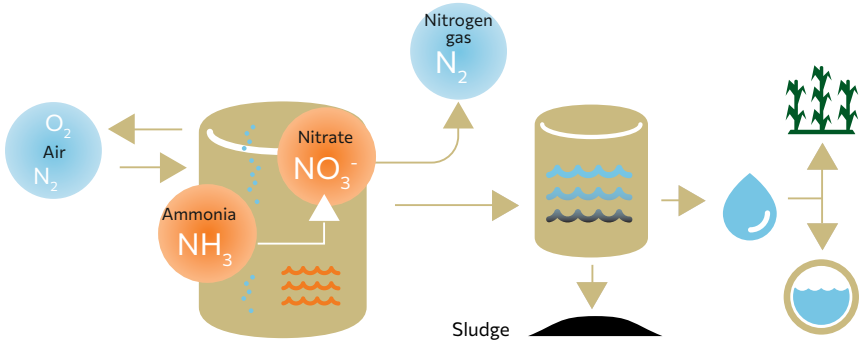
Suitable for transport and storage (export)

High in nutrients and other (trace) elelements

Investments partly subsidized

Biological treatment

Liquid fraction



Nitrogen (N) is converted into nitrogen gas (N_2) into the atmosphere

Up to 70% nitrogen loss

Risk of releasing N_2O (nitrous oxide, a potent greenhouse gas)

Residual product in sewer system. Possible application on land

Not subsidized

Future perspectives: bio-based society

Manure not only contains nutrients such as N, P and K which can be re-used as fertilizer in agriculture, it also contains valuable organic compounds such as proteins, amino acids, fatty acids and carbon chains, which have potential for use in the bio-based industry. Manure can also be used as a growing substrate of alternative cultivations like duckweed, algae, fungus, black soldier fly. The quest to restore value to manure is ongoing.

Making the most of all manure components.

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To explore the potential of nature to improve the quality of life

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