Manure

A valuable resource

LIVESTOCK RESEARCH
WAGENINGEN UR

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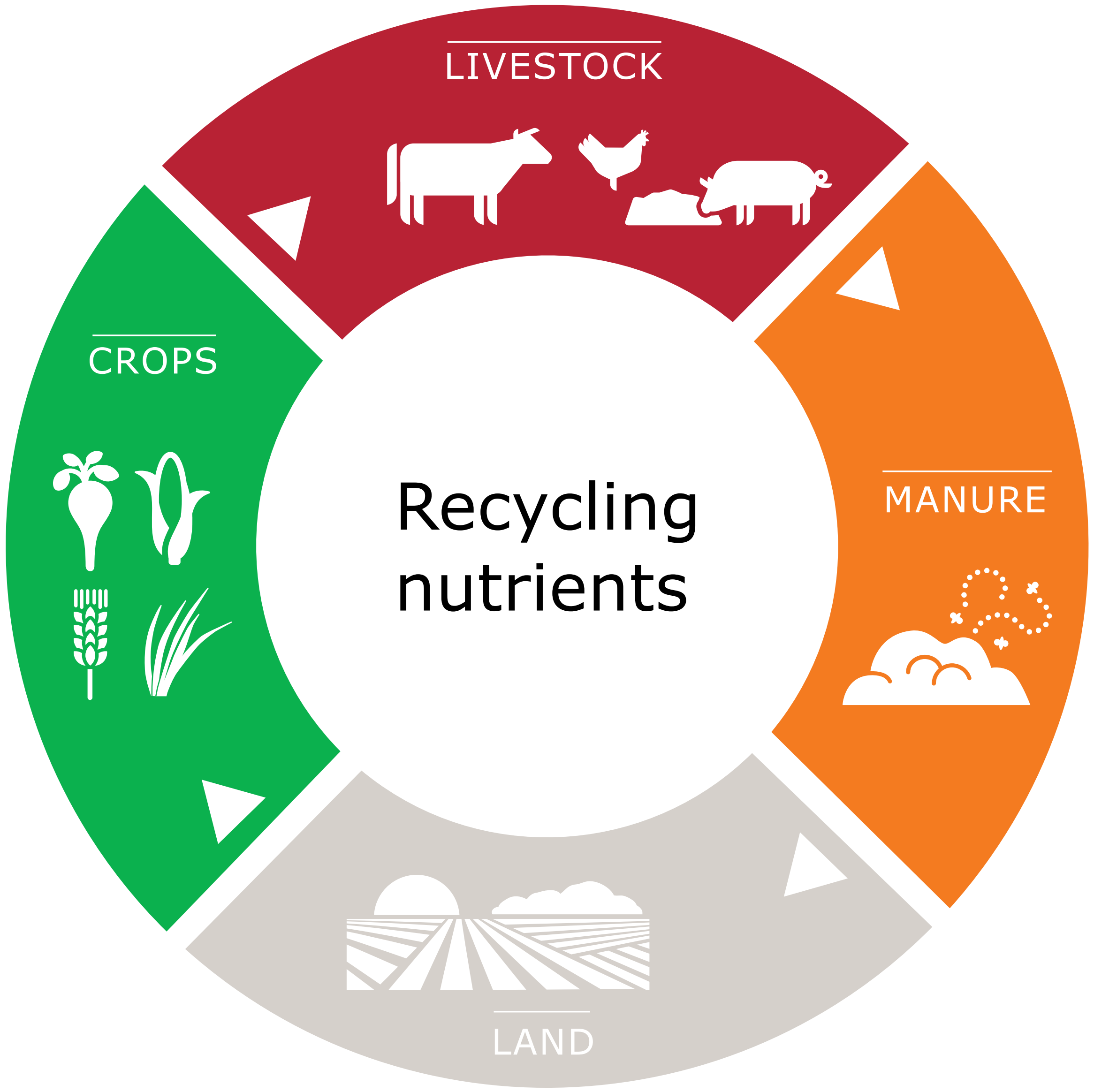
Government of the Netherlands

Foreword

The Netherlands has a long history in livestock production and Dutch livestock products are exported all over the world. Manure is a valuable by-product of the livestock industry, providing nutrients to plants, organic matter to soil and forming an essential element in the cycle of life. Improvements in the use of manure are therefore a vital factor in the drive to feed the world by producing more with less.



Based on its high livestock density, the Netherlands has developed effective mechanisms for the environmentally sound handling and distribution of manure. Environmental quality is guaranteed by strict standards for the use of animal manure and artificial fertilisers. In addition, as of 2014 all farmers are obliged to process their surplus manure. This will lead to the transportation of manure to regions with a shortage, most probably in the form of high quality fertilisers. In addition, the agricultural sector is exploring methods of refining manure to produce novel products that contribute to a bio-based economy and a resource-efficient Europe.

This brochure explores the Dutch approach to the sustainable and productive use of manure.

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Director General for Agro
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Introduction

Manure is an essential resource for our food supplyand has served as the basis for agricultural production in the Netherlands for centuries. From an environmental point of view, however, manure has acquired a negative reputation over recent decades and been subject to many regulations designed to minimise negative effects.

People involved should aim for - and be able to reach - a situation where manure is a valuable product once again. In addition to the optimal application of manure with minimal loss of nutrients, this can be achieved via manure separation and processing. Innovations that allow access to a number of specific manure components (such as bioactive substances, colouring agents and trace elements) will also contribute to improvements.

Livestock farming in regions of the Netherlands produces more manure than can be used by local agriculture, and an excess of manure is harmful to the environment and nature.
The Netherlands has therefore taken up the challenge of optimising manure management based on the principle that manure is a valuable product rather than waste.

Manure management

Optimising the use of manure through balanced fertilisation and suitable application techniques minimises losses 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. To be able to use manure where it is needed, transport of manure may be necessary. Volume reduction by reducing the water content and manure processing to increase organic matter and nutrient content make 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.

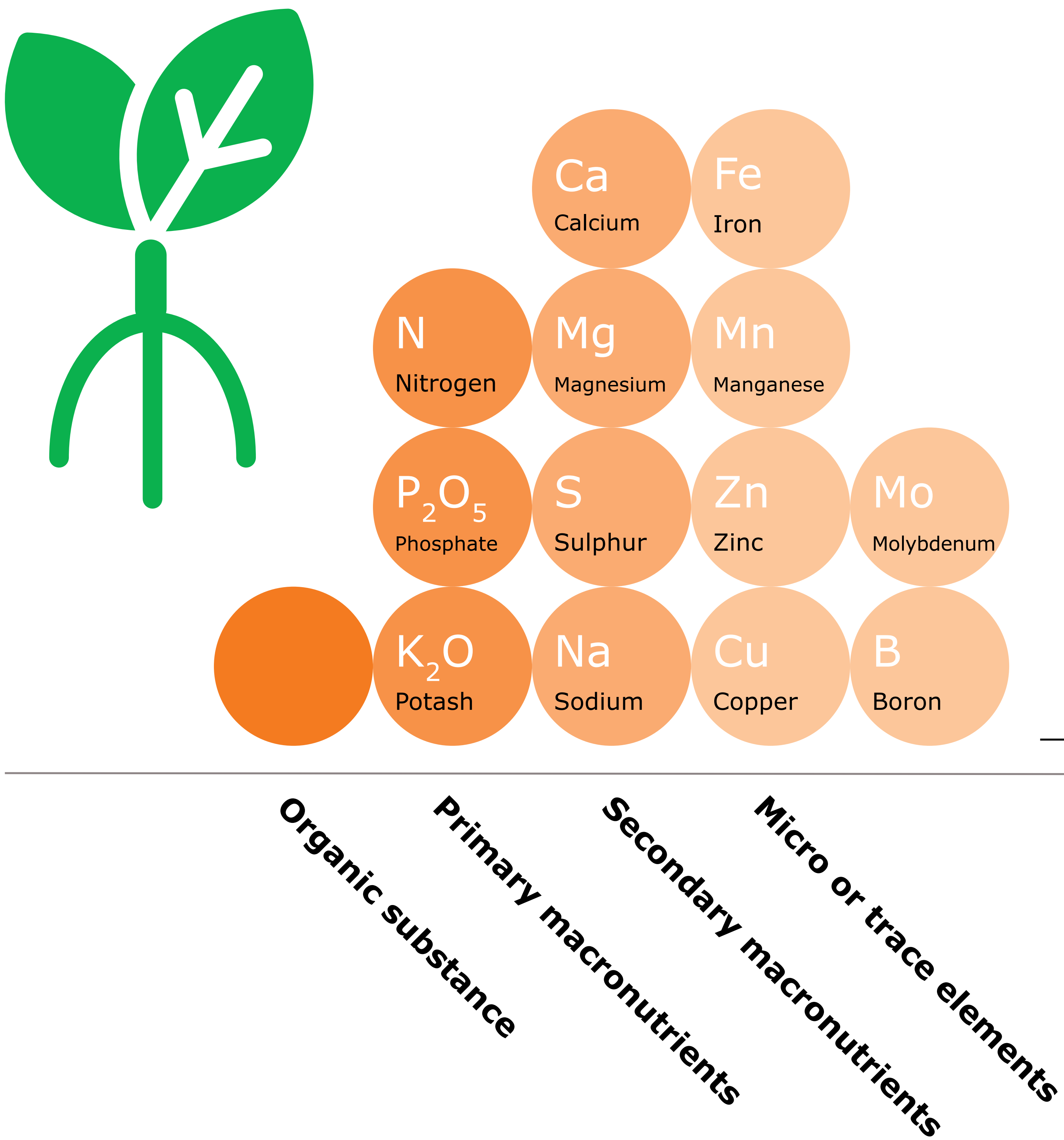
This brochure shows how the Netherlands prevents the dispersion of nutrients into the environment and optimises the value of manure. The Dutch manure policy and technology can also inspire other countries to develop their own manure management.

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

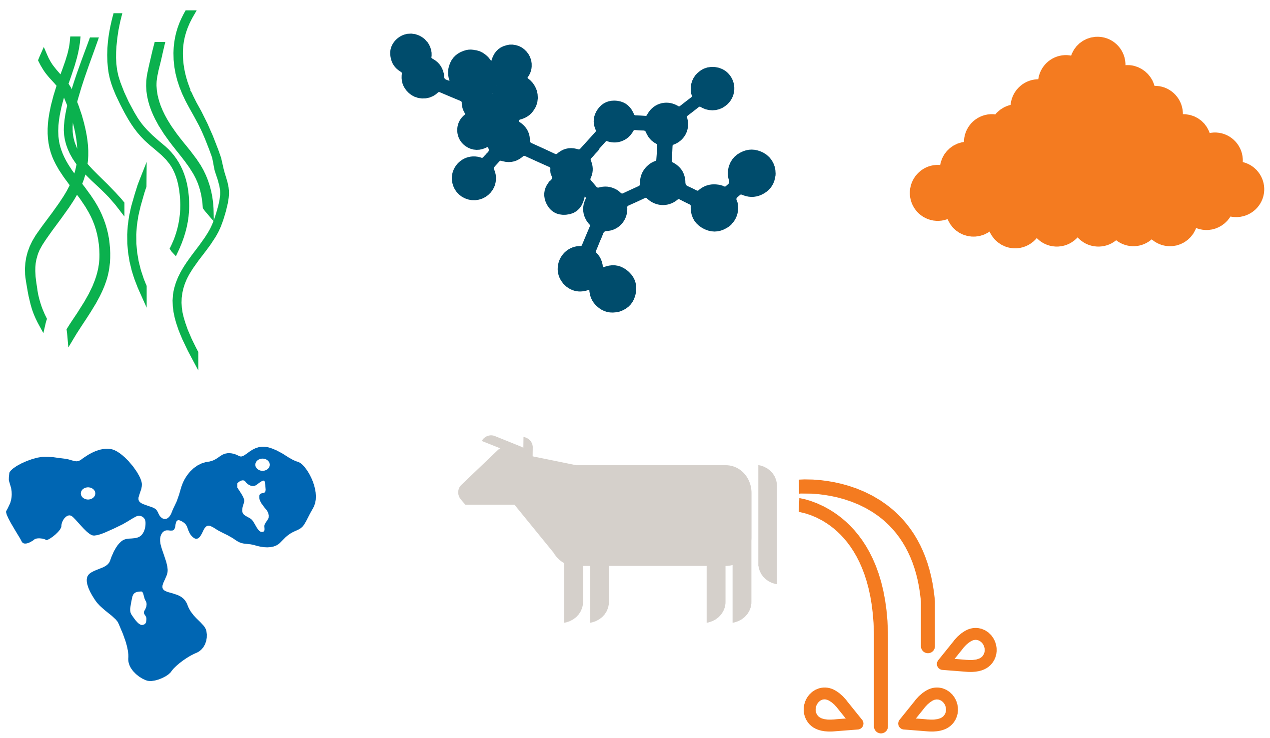
Manure is valuable in many ways

For centuries, animal manure has provided valuable nutrition for plants and been a prerequisite for healthy soil. 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. The proper use of manure was essential for food production in the period before synthetic fertilisers were developed.

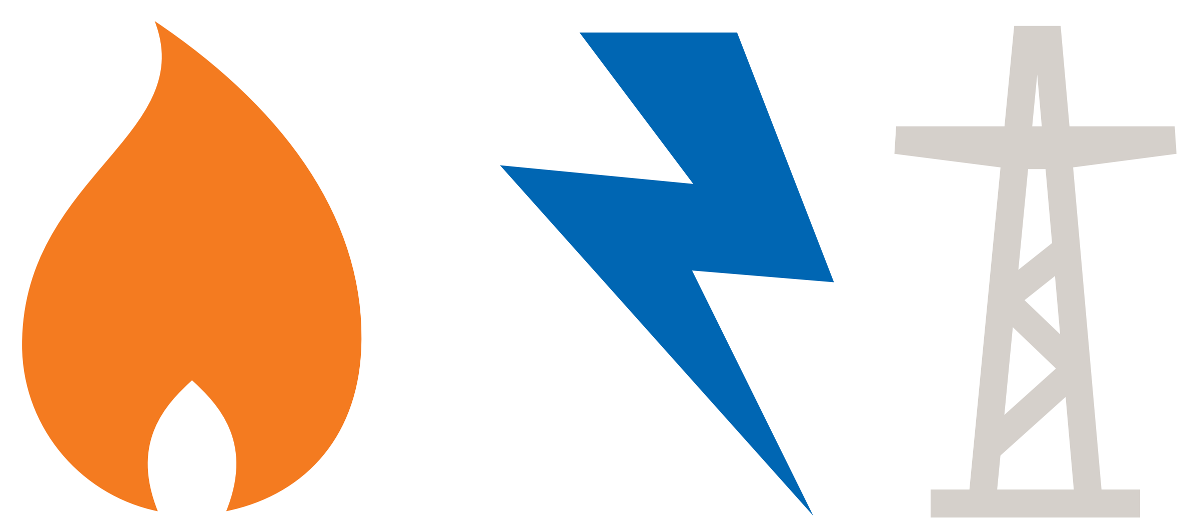
Complete fertiliser



Source of raw materials



Source of energy

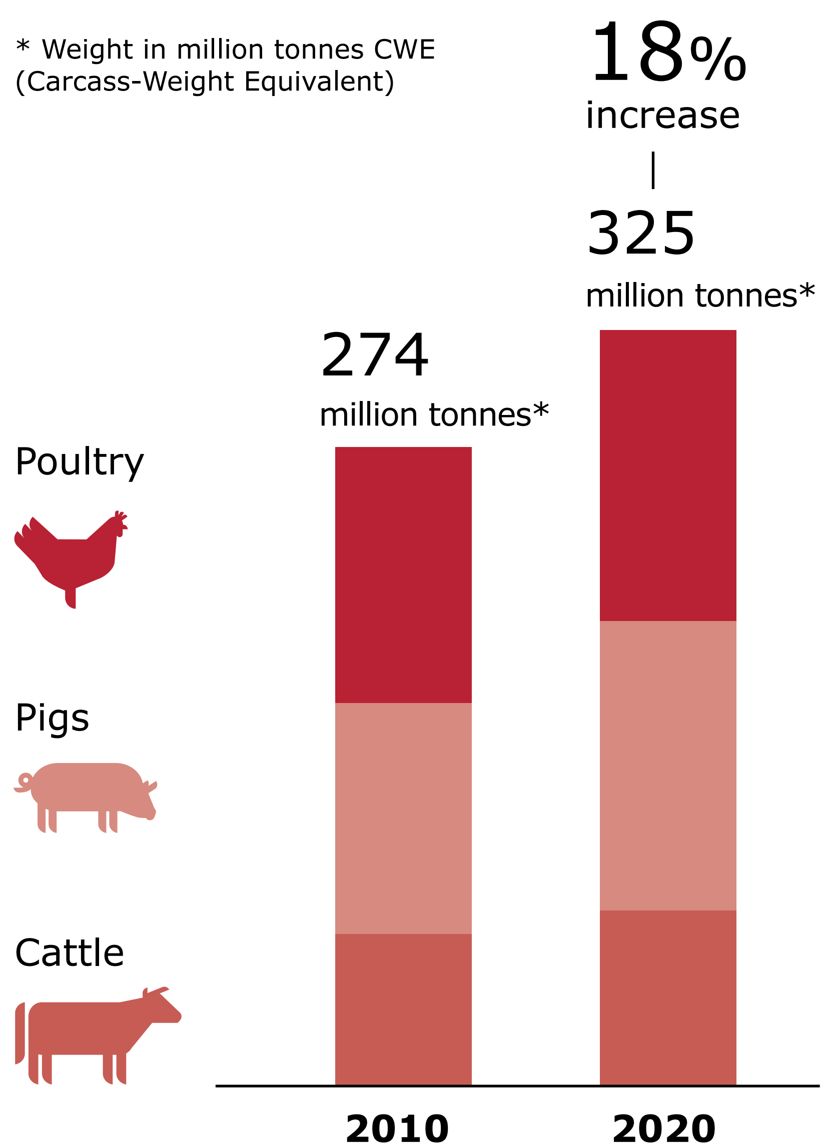


Regional manure surpluses worldwide

Livestock production is increasingly concentrated quite often close to urban areas. Although manure is a valuable product, these 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 fertilisers and alternative sources for organic matter. Synthetic fertiliser also displaces manure due to its ease of use and – in some parts of the world – government subsidies. As a consequence, the nutrient cycle is disrupted, resulting in nutrient surpluses in areas where livestock farms predominate. This also results in an unbalanced phosphate distribution as shown on the next page.

Global meat production

* Weight in million tonnes CWE (Carcass-Weight Equivalent)



Source: OECD-FAO Agricultural Outlook 2011

The challenge is to achieve a better distribution of phosphate.

Global map of agronomic phosphate imbalances for the year 2000

Increased phosphorus (P) fertiliser 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. The related P deficits in areas producing forage crops, used as livestock feed, are often compensated by synthetic phosphate fertiliser, a finite source.

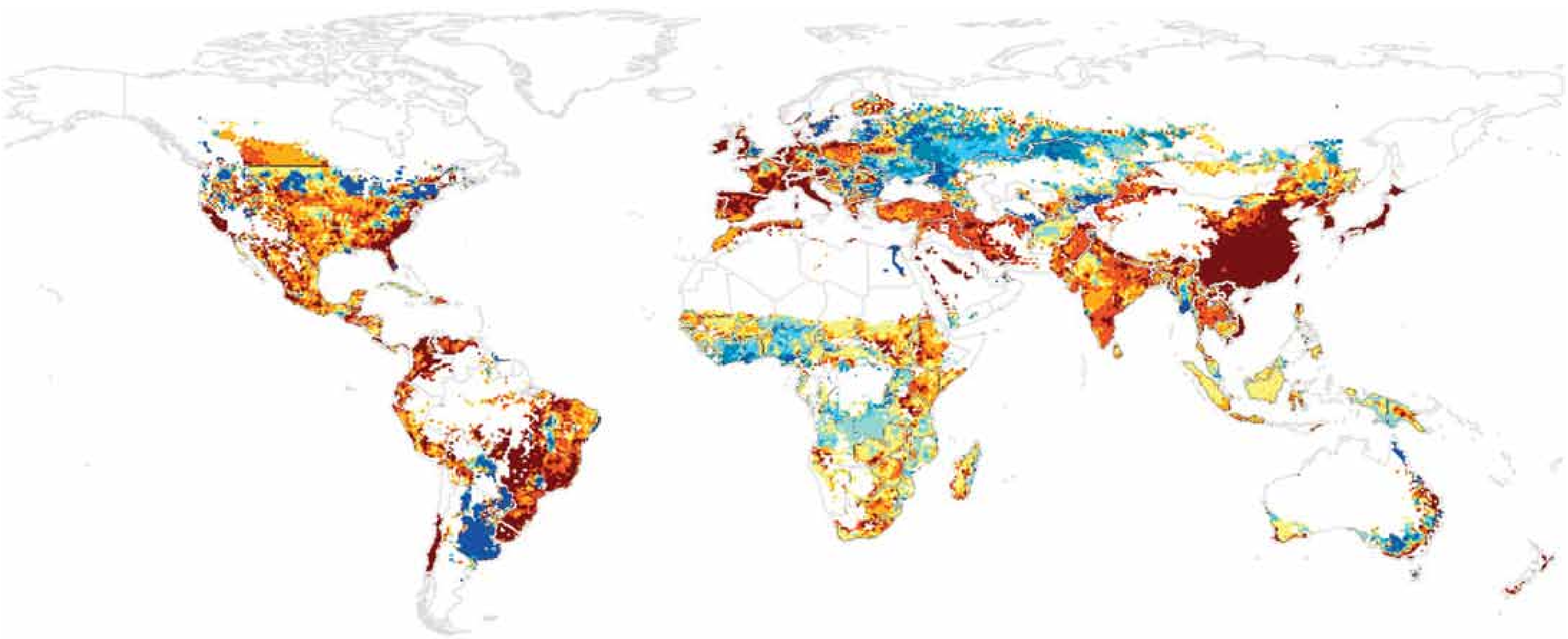
Source: MacDonald G K et al. PNAS 2011;108:3086-3091 (www.pnas.org)

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)



Manure in the Netherlands

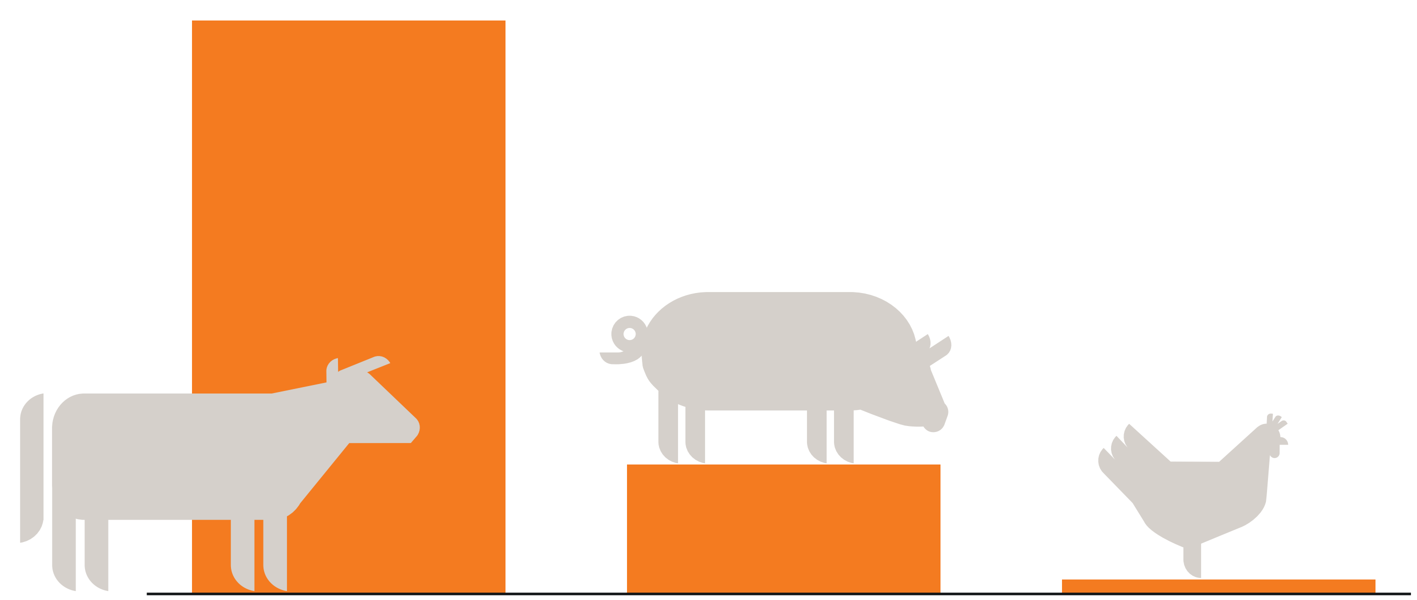
The Netherlands is a small country in the European Union with large numbers of livestock. The import of livestock feed and the extensive use of synthetic fertiliser has led to a nutrient surplus in the Netherlands. Maintaining large numbers of animals requires that the nutrient balance has to be restored via a more efficient animal production and the export of nutrients (animal manure).

The Netherlands

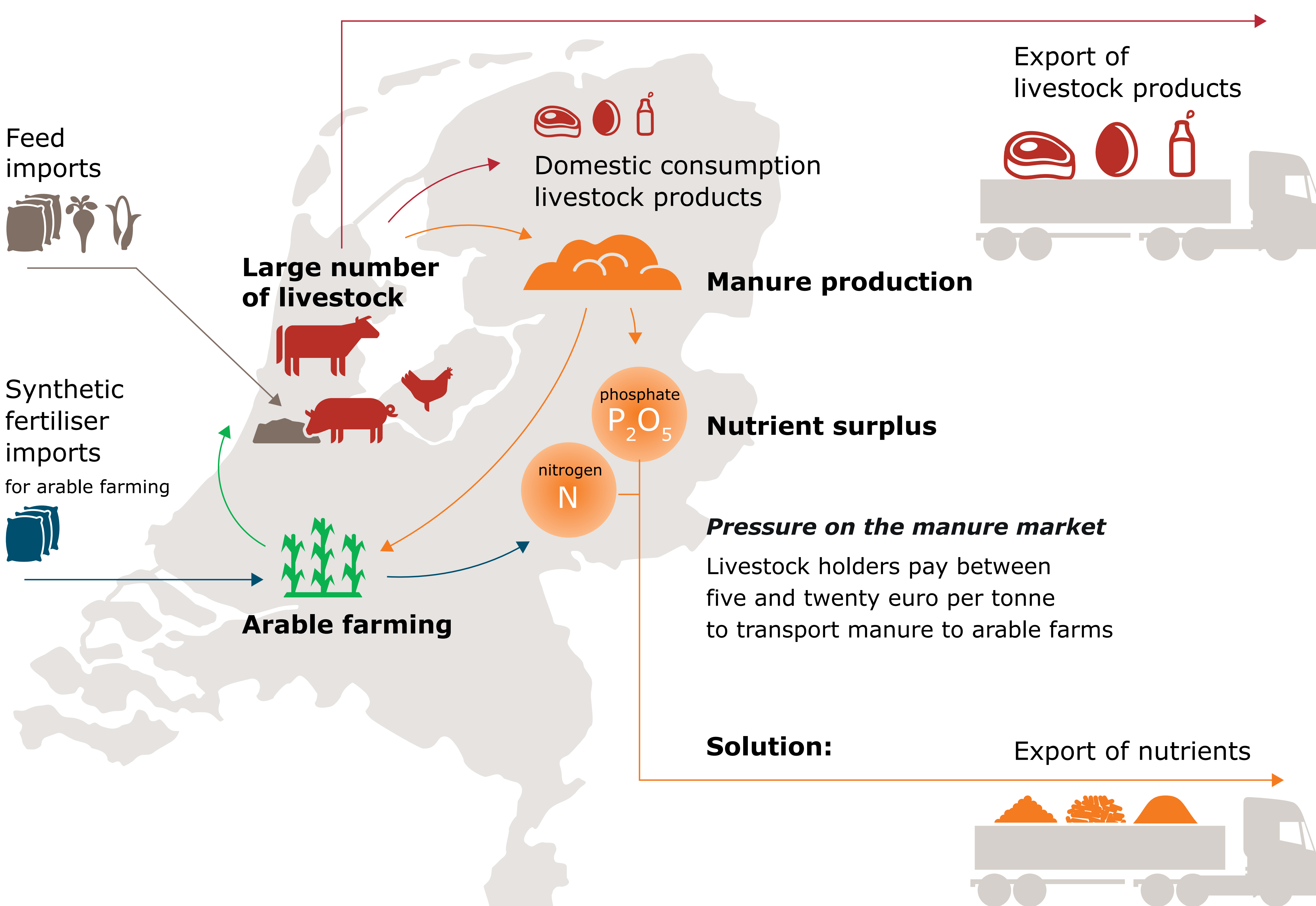
	Population	17 million
	Surface	40,000 km²
	Agricultural land	19,000 km²
	Manure production	68.6 million ton/yr
P_2O_5	**Phosphate surplus**	28 kg/ha/yr
N	**Nitrogen surplus**	119 kg/ha/yr

Manure production in the Netherlands

	Cattle	**Pigs**	**Poultry**
Number of animals	4 million	12 million	100 million
Manure production per year	54.8 million tonnes	12.4 million tonnes	1.4 million tonnes



Manure in the Netherlands



Dutch manure policy

Dutch manure policy focuses on both the production and the application of manure. The main goal is to prevent or limit nutrient dispersion in the environment through the regulation of manure application. Manure production is regulated in order to strengthen the system of application standards. Among other things, this regulation involves the transport of nutrient surpluses to areas without surpluses (either within or outside of the Netherlands).

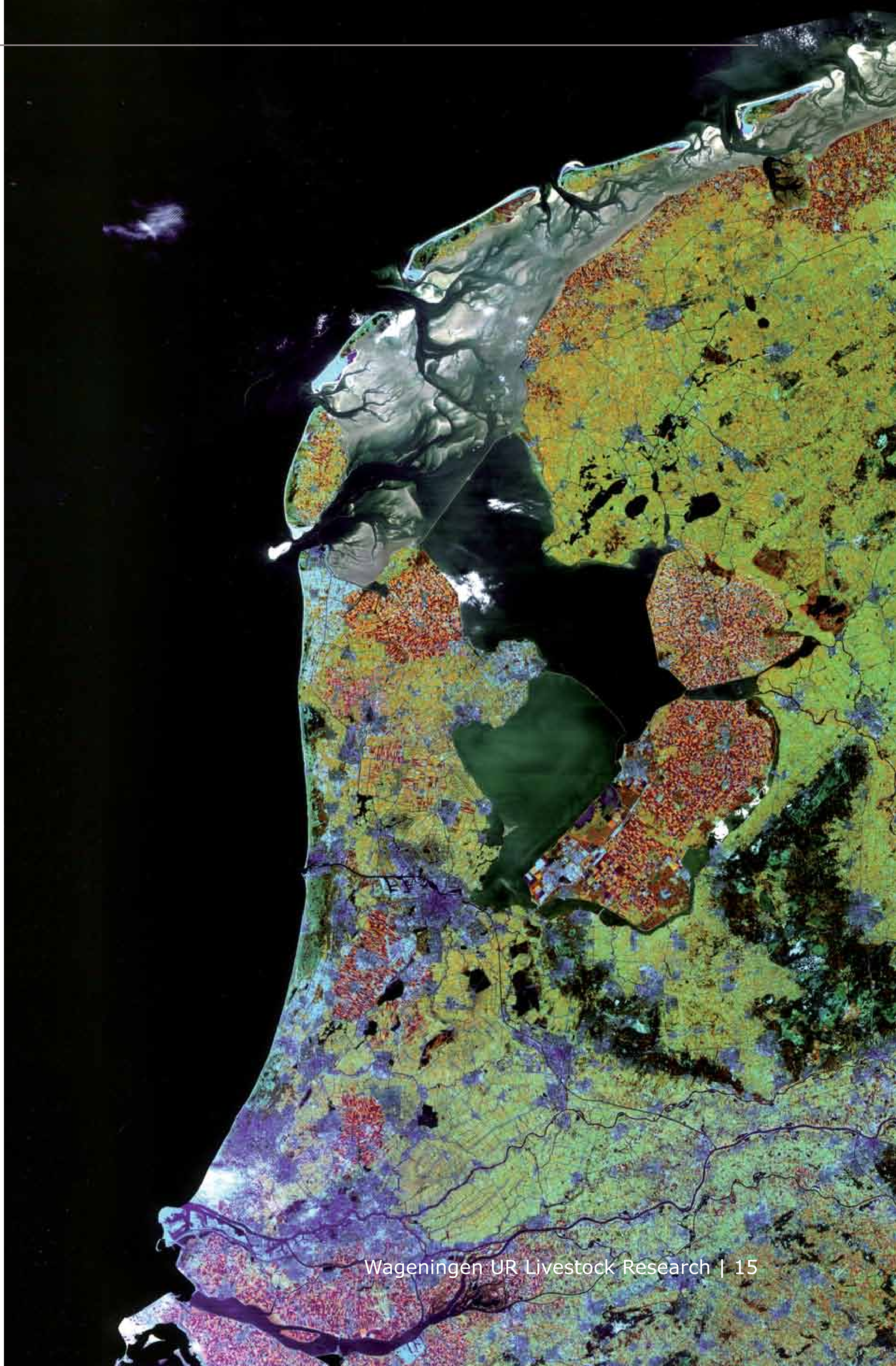
EU guidelines serve as a framework for the current Dutch policy regarding manure. To comply with these, the Netherlands has developed its own regulations and stimulation measures.

In 2009, the agricultural industry, NGOs, Dutch government and research institutes committed to the Implementation Agenda for Sustainable Livestock (*Uitvoeringsagenda Duurzame Veehouderij*). In the framework of this partnership, all parties actively contribute to the ultimate goal of making Dutch livestock production fully sustainable by 2023 with actions on six focus areas: a) system innovations, b) animal welfare and health, c) energy, environment and climate, d) market and entrepreneurship, e) sustainable and responsible consumption, and f) acceptance by society. Improved and environmental safe use of manure is part of the focus area environment and climate.

A multi-stakeholder approach is successful.

Optimising animal production and nutrient management are of critical importance to sustainable food production, not only in the Netherlands but also on a global scale.

We therefore stimulate international cooperation to improve manure management via the participation of governmental organisations, research, the private sector and NGOs in multi-stakeholder platforms, including the 'Global Agenda for Sustainable Livestock', the 'Global Research Alliance on Agricultural Greenhouse Gases' and the 'Global Partnership on Nutrient Management'.



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 animal numbers of pigs and poultry

1984
Milk quota
- Limits to milk production

1987
Fertiliser act
(manure production rights)

1987
Closed period for manure application

1990
Soil Protection Act
- Decree on Use of Fertiliser

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
- Surface water quality

2006
Application standards system for minerals

2007
Low emission housing of animals in newly-built structures

2014
Mandatory manure processing

2015
Expire European milk quota system

2015
National conditions for dairy sector growth within the EU water framework directive

Actual regulations for nitrogen and phosphate

nitrogen N · phosphate P_2O_5

Application standards

- Maximum application rates
- Account for land use and soil condition (phosphate)
- Account for soil type and crop (nitrogen)
- Application in growing season
- Low emission techniques
- Applies to manure and synthetic fertiliser

Enforcement

- Registration of production (livestock, manure and crop)
- Compulsory processing of excess manure (from 2014)

Obligations to reduce nutrient losses

- Build low emission housing
- Emission-free manure storage

Government facilitation

Innovation

- Financing and co-financing of R&D for innovative processing and manure management. Subsidies and tax reduction.

Subsidies and fiscal measures

- Stimulating investment in new techniques

Capacity building for farmers

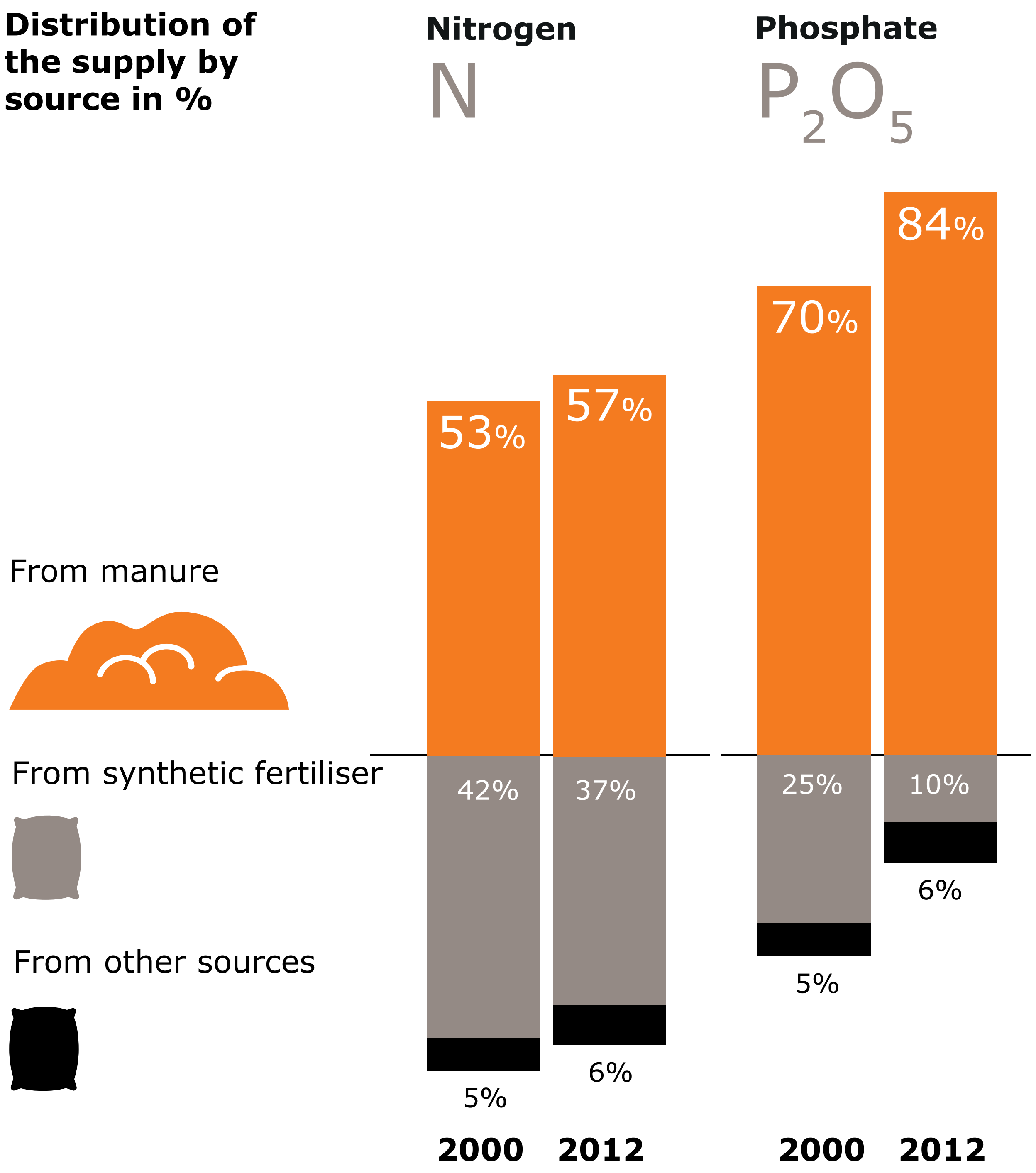
- Pilots
- Consultancy services (not subsidised)
- Farmer networks

Results of the Dutch manure policy

The fraction of phosphate and nitrogen from synthetic fertiliser has decreased, while nutrient dispersion in the environment has also been reduced. This success was made possible by:

- strict application standards for agricultural production
- more efficient production per animal
- low-emission storage and application of manure
- the processing and transport of manure (including export)

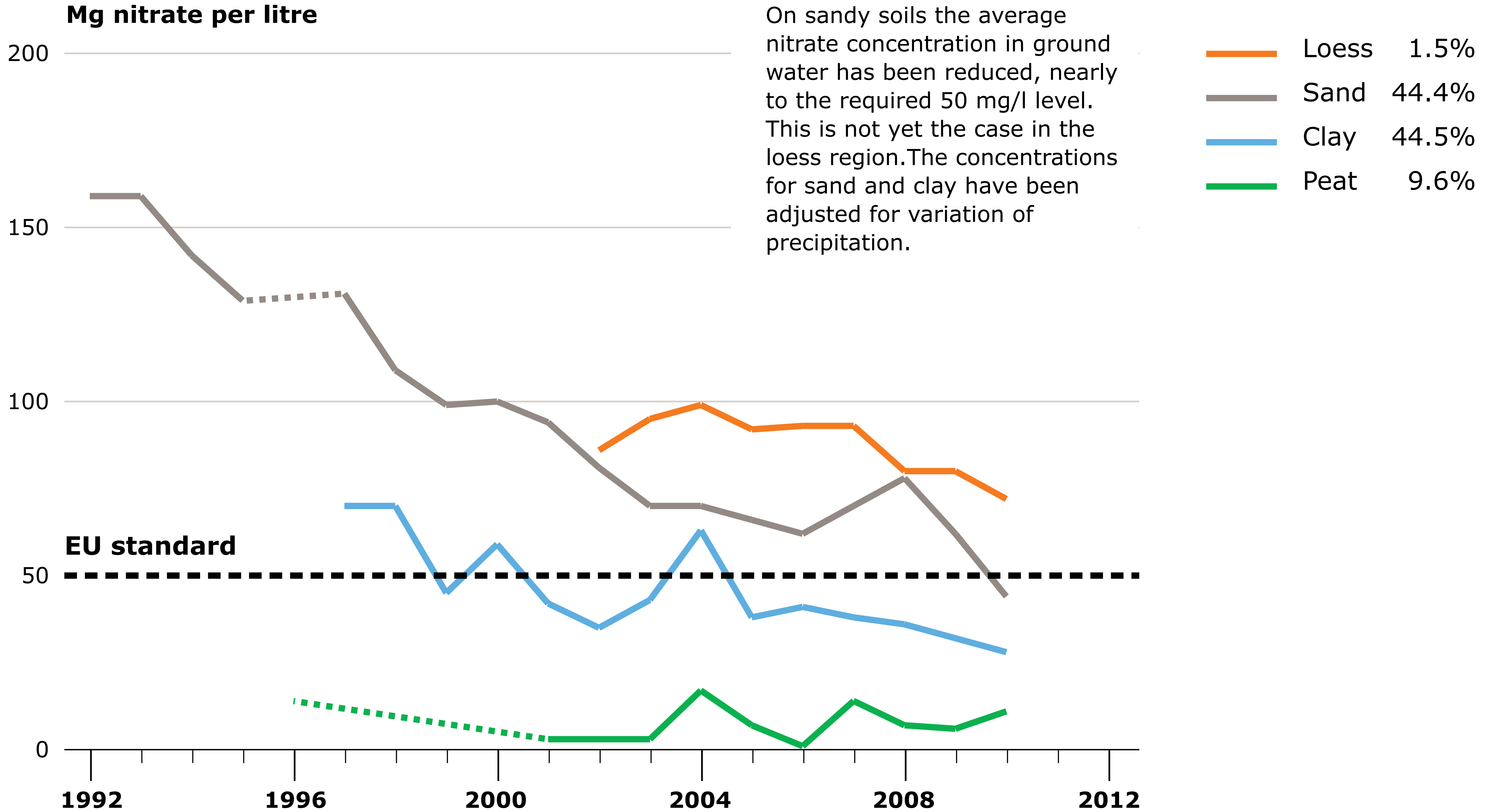
Increased rate of replacement of synthetic fertiliser by nitrogen and phosphate from animal manure



Source: CBS Statline, http://statline.cbs.nl/

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

Ground and surface water are used for drinking water



On sandy soils the average nitrate concentration in ground water has been reduced, nearly to the required 50 mg/l level. This is not yet the case in the loess region.The concentrations for sand and clay have been adjusted for variation of precipitation.

Source: RIVM (National Institute for Public Health and the Environment, The Netherlands)
http://www2.hetlnvloket.nl/mijndossier/grondsoortenkaart/GRONDSOORTEN13.HTML

Future manure policy in the Netherlands

The Netherlands currently does not meet the standards in the EU Water Framework Directive. Over the coming years the focus will be on three areas in order to meet these standards

- Manure processing
- Animal feed
- Fertiliser replacement

Manure processing

Increases export potential for animal manure (mandatory manure processing started on 1 January 2014).

Animal feed

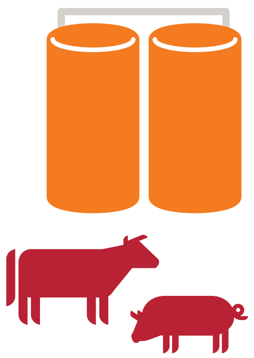
Agreement with farmers and feed industry to:

- Decrease the concentration of phosphate in the feed
- Develop innovations to create more cost-effective feed

Fertiliser replacement

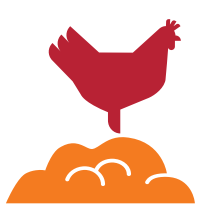
- Upgrading animal manure to products with properties comparable to synthetic fertiliser
- More use of renewable resources
- Fertilisers with high efficiency

Options for utilising pig and cattle slurry and solid poultry manure



Pig and cattle slurry *(10% dry matter)*

• Application	▶ Low emission application as fertiliser 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 fertiliser with reduced P_2O_5 content
– Reverse osmosis	▶ Mineral concentrate (NK fertiliser) and clean water
– Biological purification	▶ Nitrogen escapes as harmless N_2 gas, sludge is applied as fertiliser, liquid effluent to municipal Waste water treatment plant for further treatment
– Solid fraction (20-40% dry matter, stackable)	
– After pasteurisation (e.g. co-composting, heat treatment)	▶ Export worthy fertiliser with increased P_2O_5 level



Solid poultry manure *(> 40% dry matter)*

• Application as fertiliser 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 fertiliser 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
• Pellets from manure or composted manure (> 80% dry matter)	▶ Export worthy fertiliser with high nutrient levels

Principles for optimum use of manure

Minimising the loss of nutrients

Regulating the use of manure in the Netherlands

Balanced fertilisation

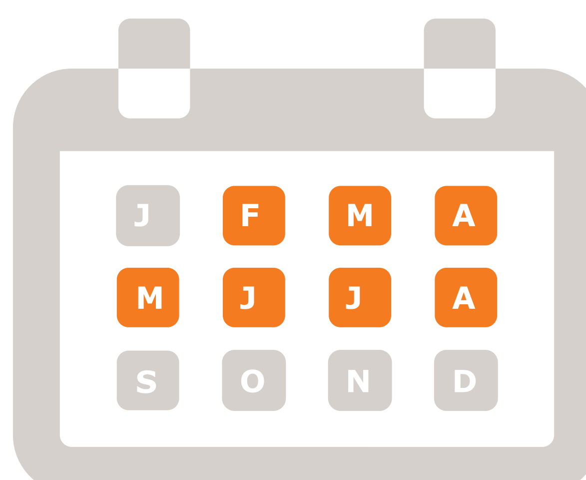
Applying exactly what the crop needs while taking into account nutrients in the soil.

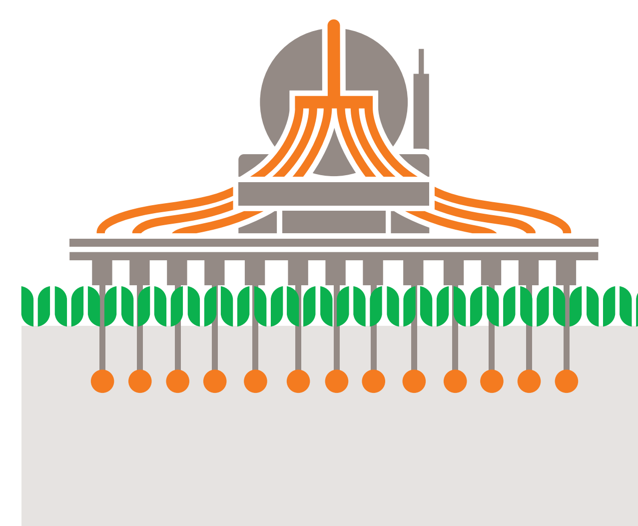
Only using manure in the growth season

- 1 February – 1 September
- Interim period: manure storage
- Throughout the year: application prohibited when soil is frozen or covered in snow

Low-emission application techniques

This results in minimum losses of nitrogen in the form of ammonia, which in turn increases the fertilisation value of the manure and reduces farmers’ need to use synthetic nitrogen fertiliser.





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

Supplying manure to arable farms

Excess manure at farm level can be transported to other, mainly arable, farms. In the Netherlands, mainly pig and poultry farms have large manure surpluses, as they usually cover little land. Transport is expensive because manure consists largely of water. Reducing the water content, increases the potential transport distance. This distance is also determined by whether arable farms have to pay for the manure (for instance in northern France) or are paid to receive the manure (in the Netherlands). For longer distances and export, it is most cost-effective to reduce the water content as much as possible from the manure. In addition, to reduce veterinary health risks, the exported manure must comply with the requirements for animal by-products (Regulation (EC) No 1069/2009 Animal by-products).

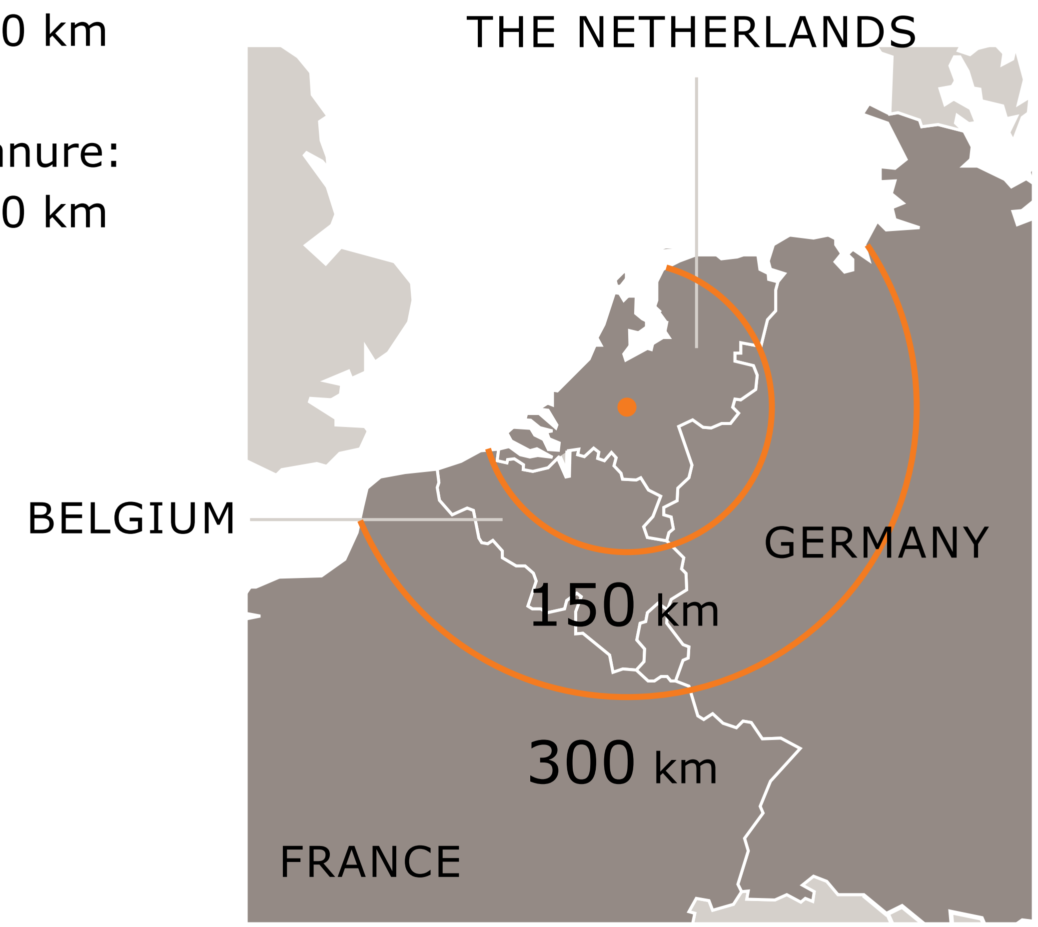
Costs of manure transport

Costs of manure transport within the Netherlands

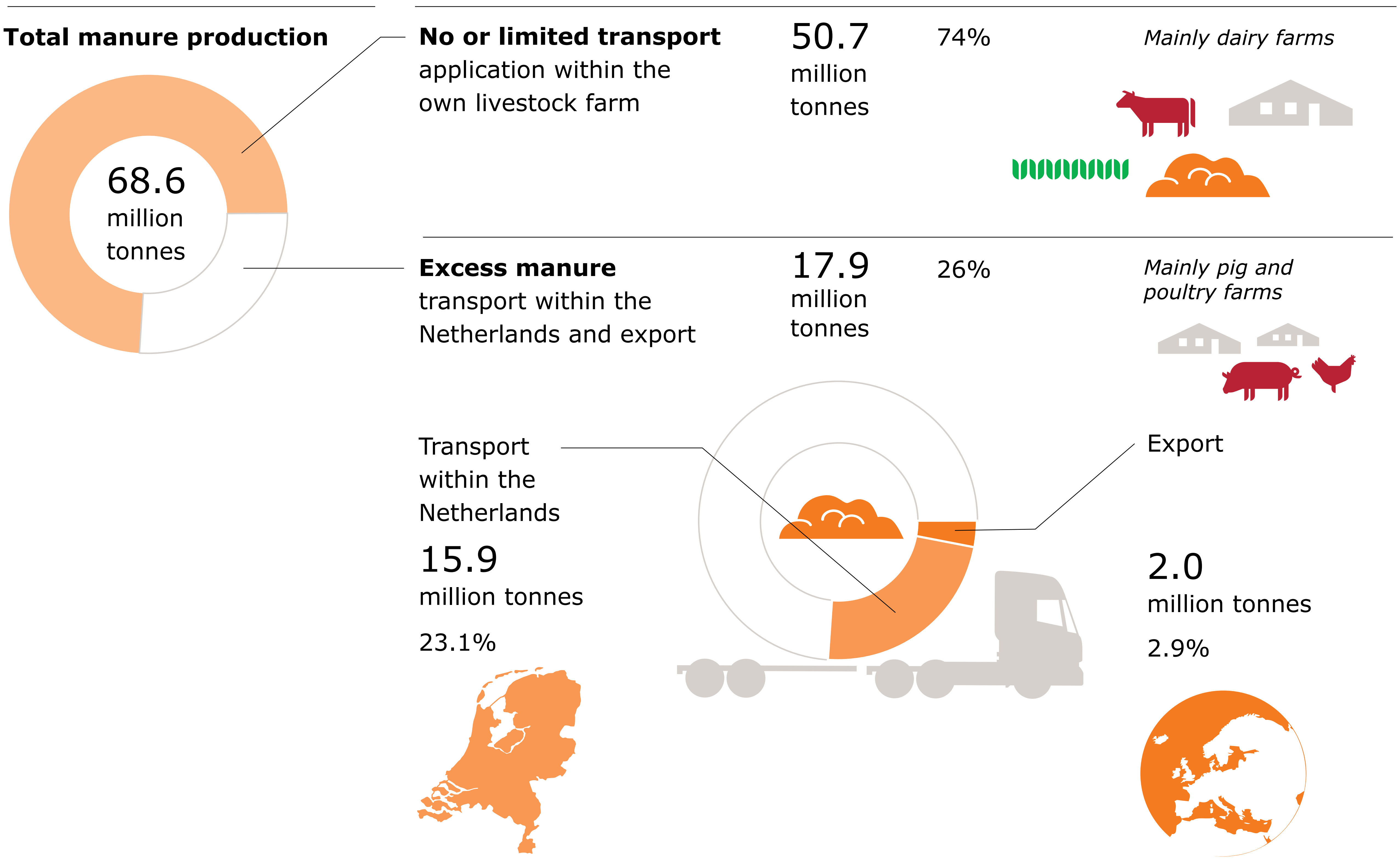
Affordability of manure transport

Liquid manure: up to 150 km

Solid manure: up to 300 km



Annual manure transport *in the Netherlands (2011)*

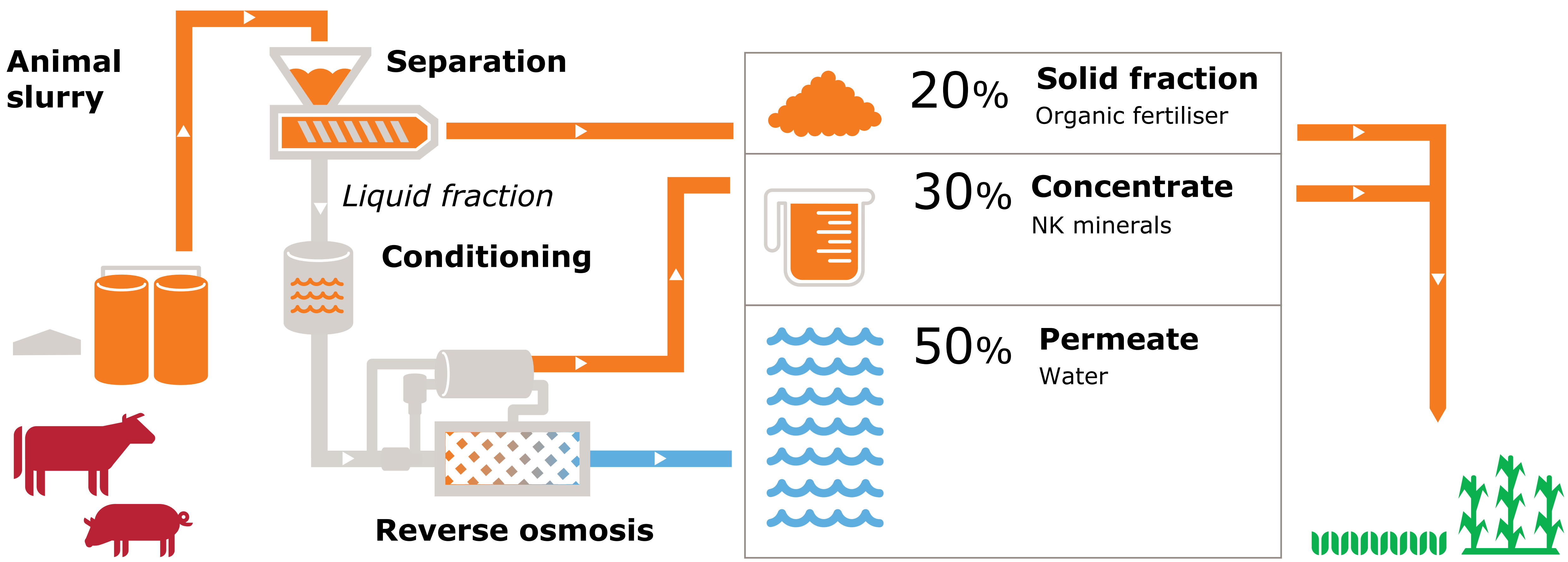


Mechanical separation of manure

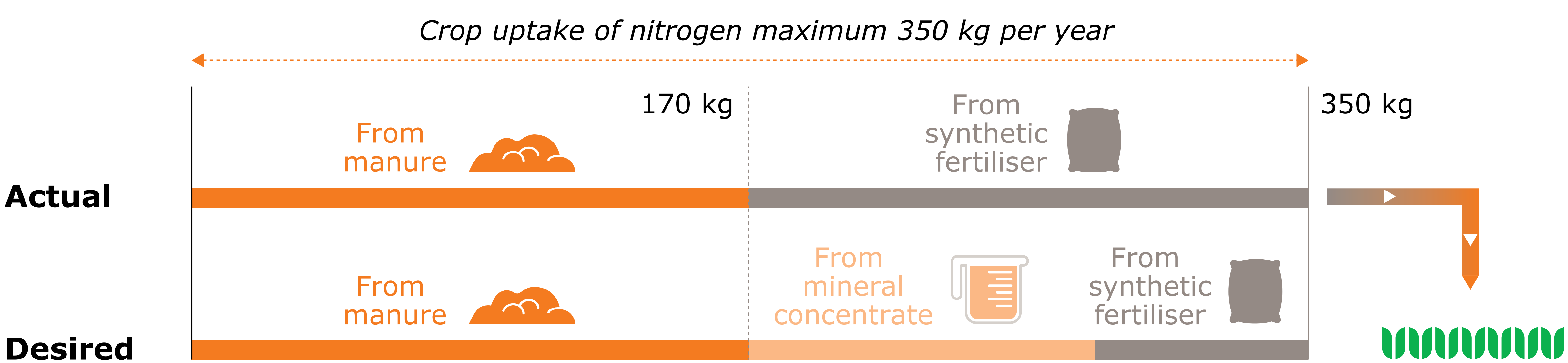
An important benefit of mechanical manure separation is that N and P can be used separately.

Mechanical separation is the initial stage of the processing of liquid manure and increases the possibilities for utilising nutrients from manure. Another important benefit is the improved utilisation of N and P. Organic matter and phosphate accumulate in the solid fraction, to be applied as solid manure, compost or dried in pellets. The liquid fraction has a high level of nitrogen and a low phosphate content. It can be used as liquid fertiliser in the crop growth phase with high nitrogen uptake rates.

Production of liquid nitrogen concentrate by reverse osmosis



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



Manure processing and anaerobic digestion

Processing of manure improves export opportunities. Sanitation, heating the manure, eliminates pathogens and is often required for export. Each processing method results in a different end product. This section describes the processing methods which are currently most applicable.

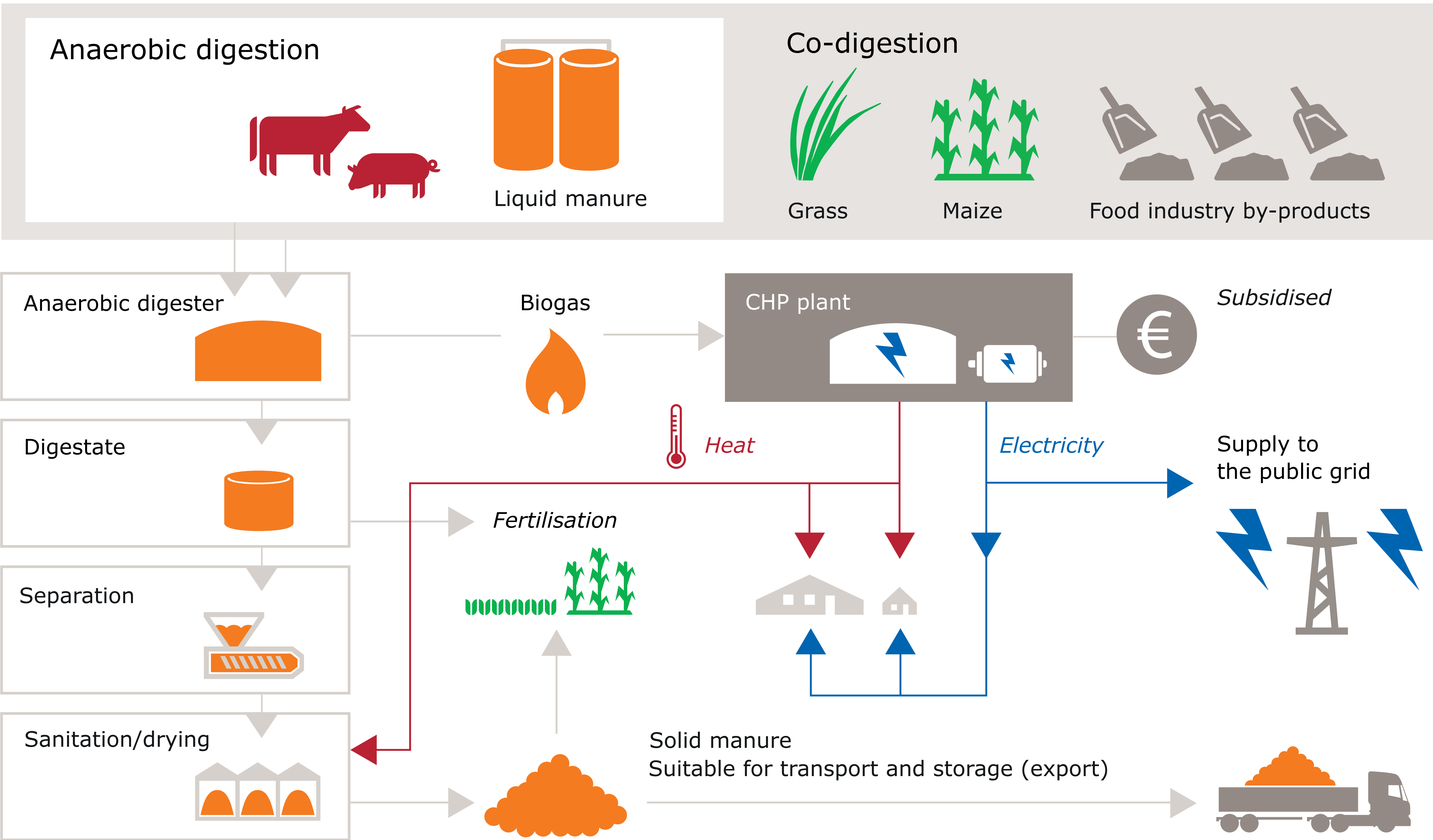
Anaerobic digestion is a method to produce energy, primarily combustible biogas, from manure. However, with the current energy prices this is not cost effective. Anaerobic digestion can be made more efficient by adding co-products, such as corn silage and grain products, and industrial by-products such as fats and glycerine. The use of co-products often directly competes with use as animal feed and is not sustainable.

The residual products of anaerobic digestion remain animal manure and have to be applied as such.

Digestion

The anaerobic digestion of manure results primarily in combustible biogas which can be used to generate energy. Although it is possible for manure to undergo anaerobic digestion only, even with subsidies this is not cost-effective. Consequently, co-products are added to produce more biogas. This is called co-digestion.

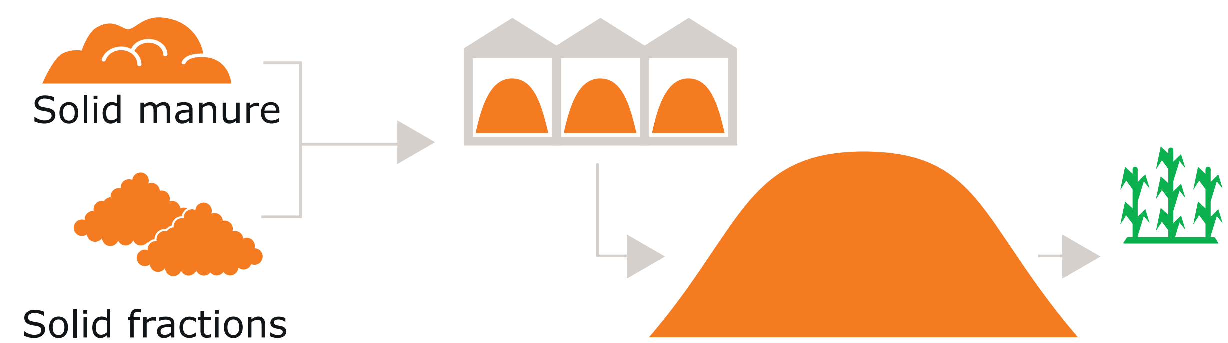
The co-products produce more biogas than manure. But when the co-products consist of agricultural crops or products that can also be used as animal feed, codigestion is considered as not being sustainable. And also: co-digestion increases the manure quantity.



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
- Subsidised. Based on the production of renewable energy

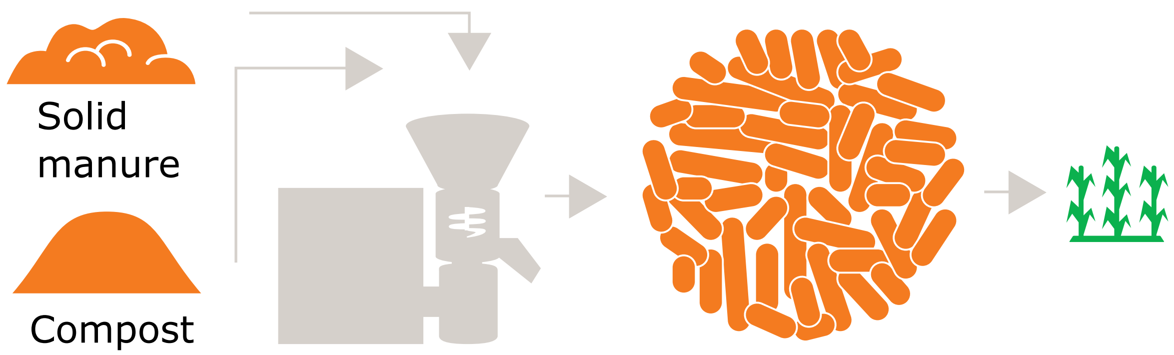
Composting ('biothermal drying')



- 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
- Not subsidised

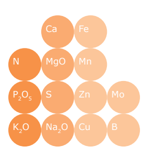
Producing manure granules

Solid manure



80% organic matter

Suitable for transport and storage (export)

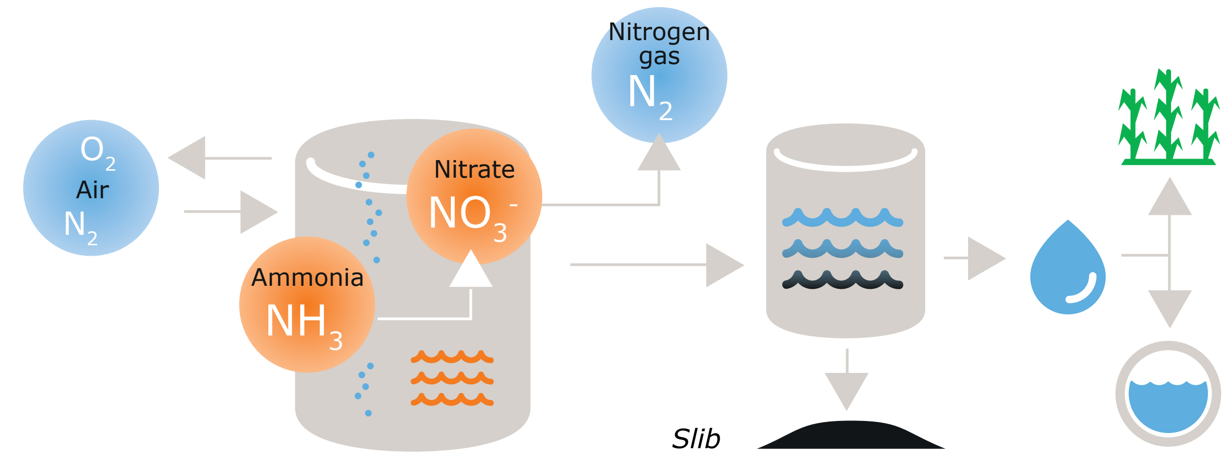


High in nutrients and other (trace) elements

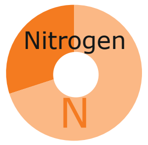
Not subsidised

Biological treatment

Liquid fraction



Nitrogen (N) is converted into nitrogen gas (N2) into the atmosphere



Up to 70% nitrogen loss

Risk of releasing N2O (nitrous oxide, a potent greenhouse gas)

Residual product in sewer system. Possible application on land

Not subsidised

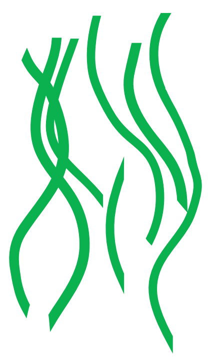
Perspectives for the future: extraction of valuable components from manure

Manure does not only contain nutrients that can be reused as fertiliser in agriculture such as N, P and K. It also contains valuable organic compounds like proteins, amino acids, fatty acids, carbon chains and other chemical properties. As an organic substance of animal origin, manure contains far more bio-vital components than fossil fuel, offering significant potential to the chemical industry.

Making the most of all manure components.

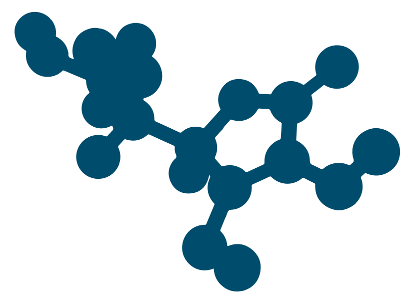
Valuable components in manure which can be utilised

Undigested feed components



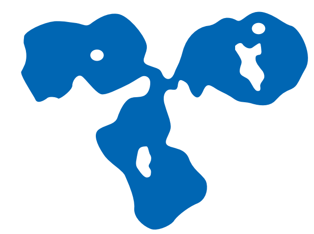
- Fibres for glucose and ethanol production, or for thermochemical decomposition during oil production (pyrolysis)
- Nutrients: P, N, K, Ca
- Trace elements: Mg, S, Fe, Al, Na, Cu, Zn, Mn, B, Cr
- Fats, calcium soaps
- Undigested starch
- Undigested protein

Microflora



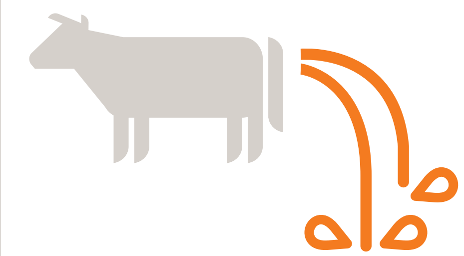
- Vitamins (K, B12)
- Amino acids
- Bioactive proteins
- (Volatile) fatty acids

Endogenous substances



- Bile acids, glycoproteins, enzymes (such as lipase)
- Colouring agents (biliverdine, bilirubine)
- Other bioactive substances (lysozyme, immunoglobulin, antioxidants?)

Urine components



- Urea, NH_3 (N-source)
- Hormones, enzymes?
- Colouring agents (urobilin, porphyrin)
- Creatinine
- Purine derivatives, including allantoin, uric acid, (hypo)xanthine

Substrate for biomass production

To be used for

- Cultivating duckweed
- Cultivating algae
- Farming insects
- N source for ruminants
- Solid state anaerobic digestion (microbial protein)

Colophon

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Wageningen UR Livestock Research

Together with our clients, we integrate scientific know-how and practical experience to develop livestock concepts for the 21st century. With our expertise on innovative livestock systems, nutrition, welfare, genetics and environmental impact of livestock farming and our state-of-the art research facilities, such as Dairy Campus and Swine Innovation Centre Sterksel, we support our customers to find solutions for current and future challenges.

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