



Manure

A valuable resource

This brochure is commissioned by the Dutch Ministry of Agriculture, Nature and Food Quality.



Government of the Netherlands

Foreword

Thousands of years ago, people gave up their nomadic existence to settle in one place. They started keeping livestock, working the land and growing crops. Since those times, we have manure - animal excrement which we use in the production of food. This system allows natural residual streams to be re-used in agriculture.

After World War II, so actually not so long ago, Dutch farmers started using artificial fertiliser. This was an important change which coincided with the mechanisation of agriculture and had enormous consequences, since the efforts of farmers and horticulturists were rewarded with higher yields. This allowed the Netherlands to provide good, healthy food for many people. Within no time, we were exporting large quantities of vegetables, fruit, meat and dairy. Nowadays, the Netherlands is a global leader in the export of agricultural products and knowledge. And yet, with that last transition, we also lost sight of something which we are now appreciating anew.

In current times, we find it crucial that our soil remains healthy and that we maintain the quality of our water. In order to achieve that, we have to prevent too much livestock manure being used, which is certainly possible. We have an increasingly refined insight into the agricultural and ecological usefulness of nutrients from livestock manure. And we have the knowledge and technology with which to re-use or process elements of that manure, limiting the negative consequences of using livestock manure.

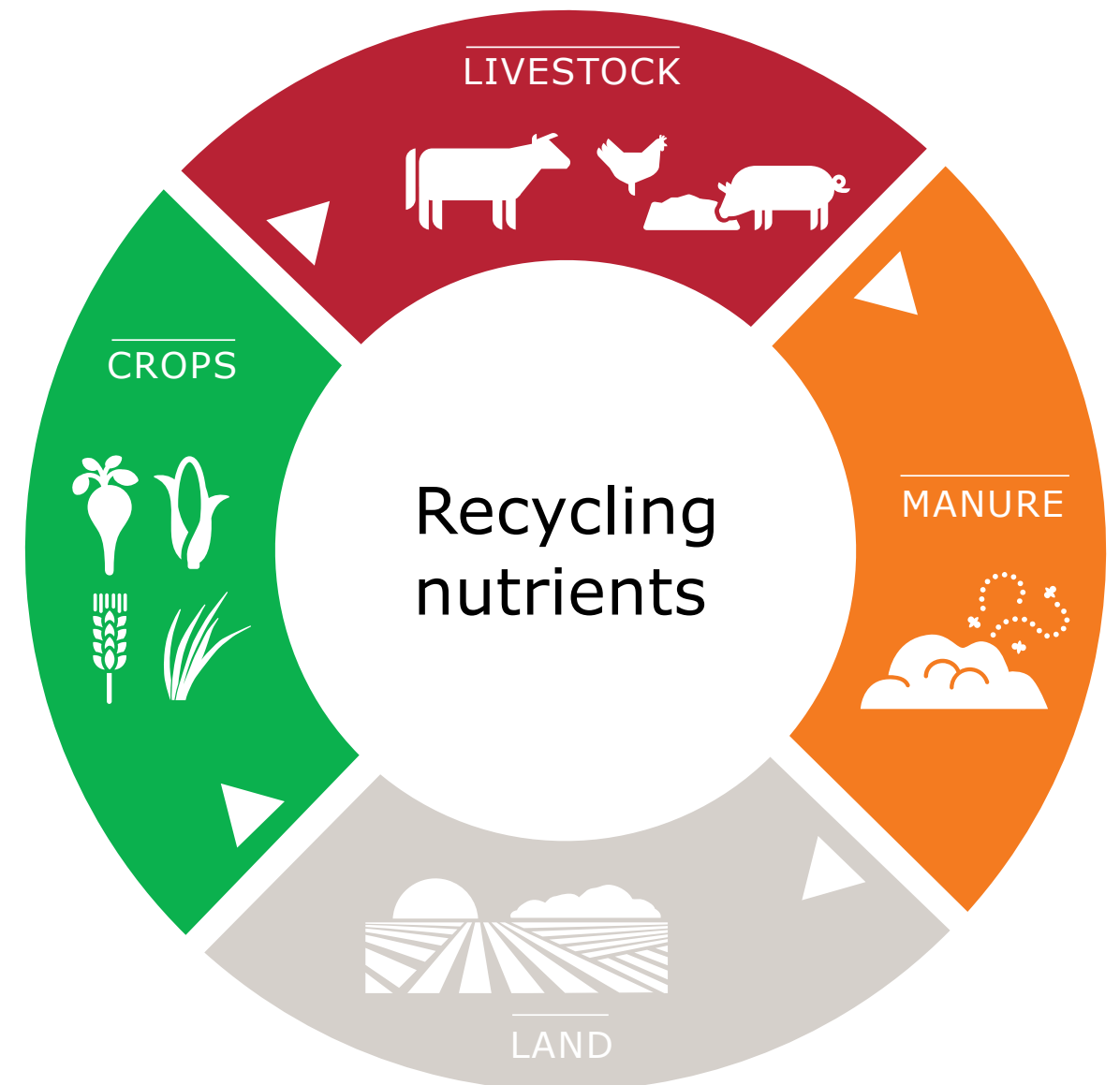
More processed livestock manure, less artificial fertiliser, that's our aim for soil management now - a result of our vision for agriculture in 2030. This is once again a time of great transition and now our goal is to create closed cycles around nature and food. One way of doing that is to use natural resources or innovative technologies and, for example, apply precision fertilising. Another method is to organize processes more smartly: any surplus at one farm can be used by others in the area or region to fertilize pastures and fields.

With a closed cycle, we can prevent more easily and quickly the dispersion of harmful substances in the water or air. Agriculture will be less dependent on phosphate, potassium, natural gas and other fossil fuels, sources of which are scarce or finite.

This brochure takes a look at policy on manure throughout the years. It describes legal frameworks, such as the manure law and the Soil Protection Act, the regulations governing such matters as transportation of manure and measures for the processing of livestock manure. It explains why it is a good idea to use products made from livestock manure, which we know are also excellent replacements for fertilizers.

I hope it will help you make choices and inspire you to use as many sustainable products as possible, since they both help crops grow and strengthen nature.

M. Sonnema
Director General Agriculture
Dutch Ministry of Agriculture, Nature and Food Quality



Contents

Introduction	6
Manure is valuable in many ways	8
Availability of manure worldwide	10
Manure in the Netherlands	12
Dutch policy on manure and fertilizer	14
Results of the Dutch policy on manure	18
Future policy on manure in the Netherlands	20



Principles for circular use of manure and nutrients	22
Minimizing the loss of nutrients	23
Connect arable farmers with livestock farmers	24
Manure and manure products	26
Outline options for manure	27
Manure processing	28
Future perspectives: bio-based society	34
Credits	35





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.

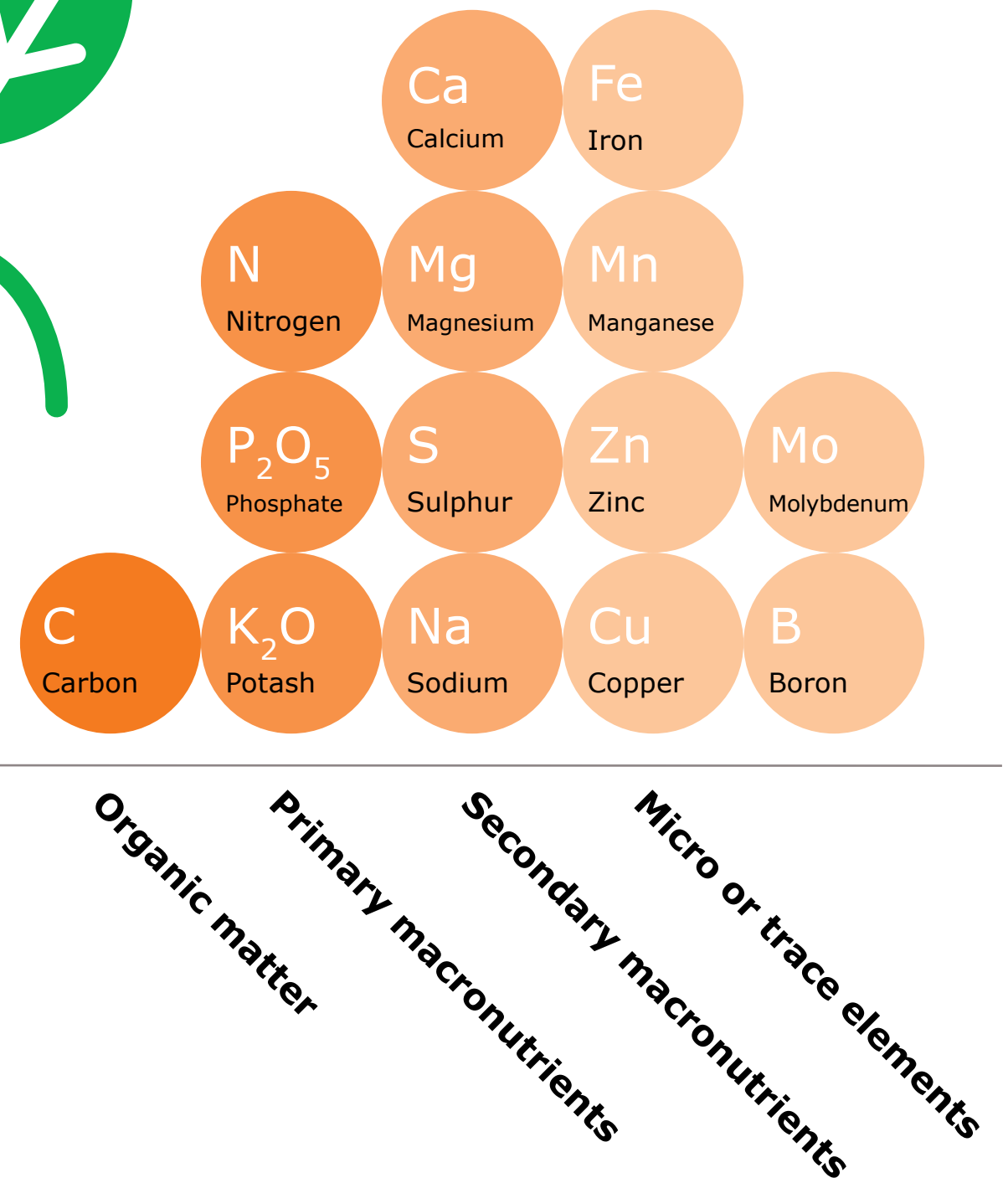
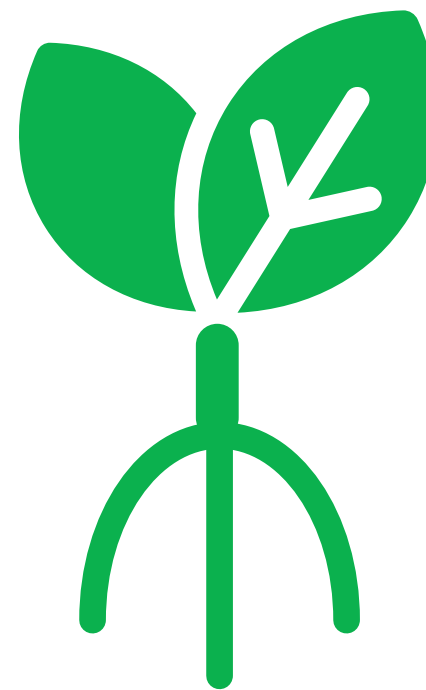
This brochure shows how the Netherlands prevents the dispersion of nutrients into the environment and optimizes the value of manure. The Dutch manure policy and technology could potentially be an inspiration for manure management in other countries.

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

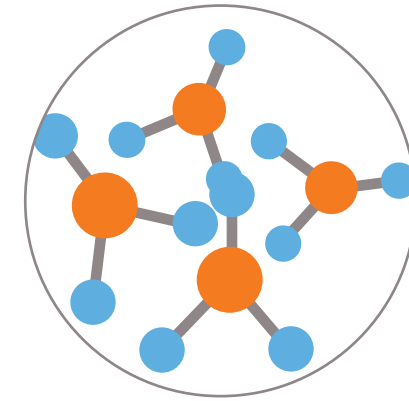
Manure is valuable in many ways

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.

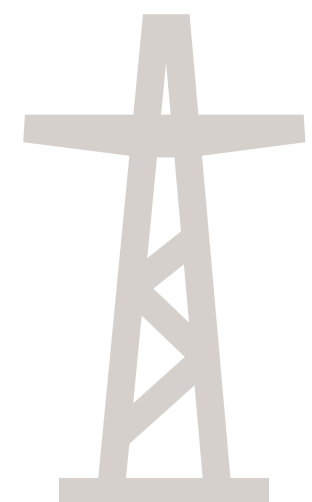
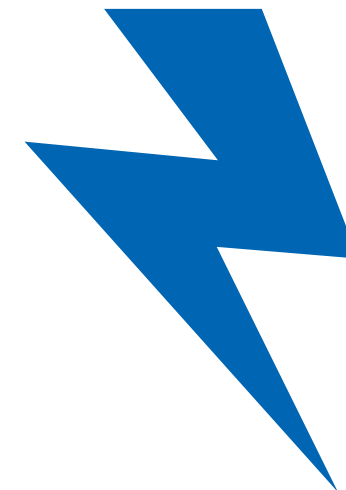
Fertilizer and fertilizer products



Source of raw materials



Source of energy



Availability of manure worldwide

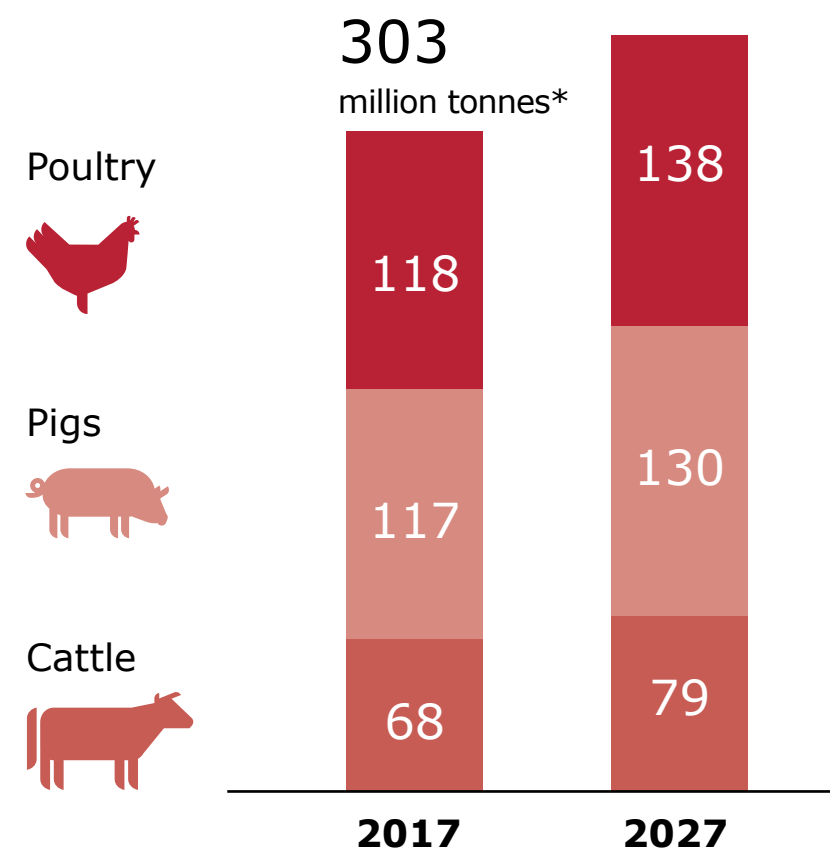
Although manure is a valuable product, certain regions produce more than is required by agriculture in the immediate vicinity. The resulting excess of nutrients threatens to pollute surface and ground water. Solutions include the spatial spreading of animal production and improving manure utilisation 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.

Global meat production

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

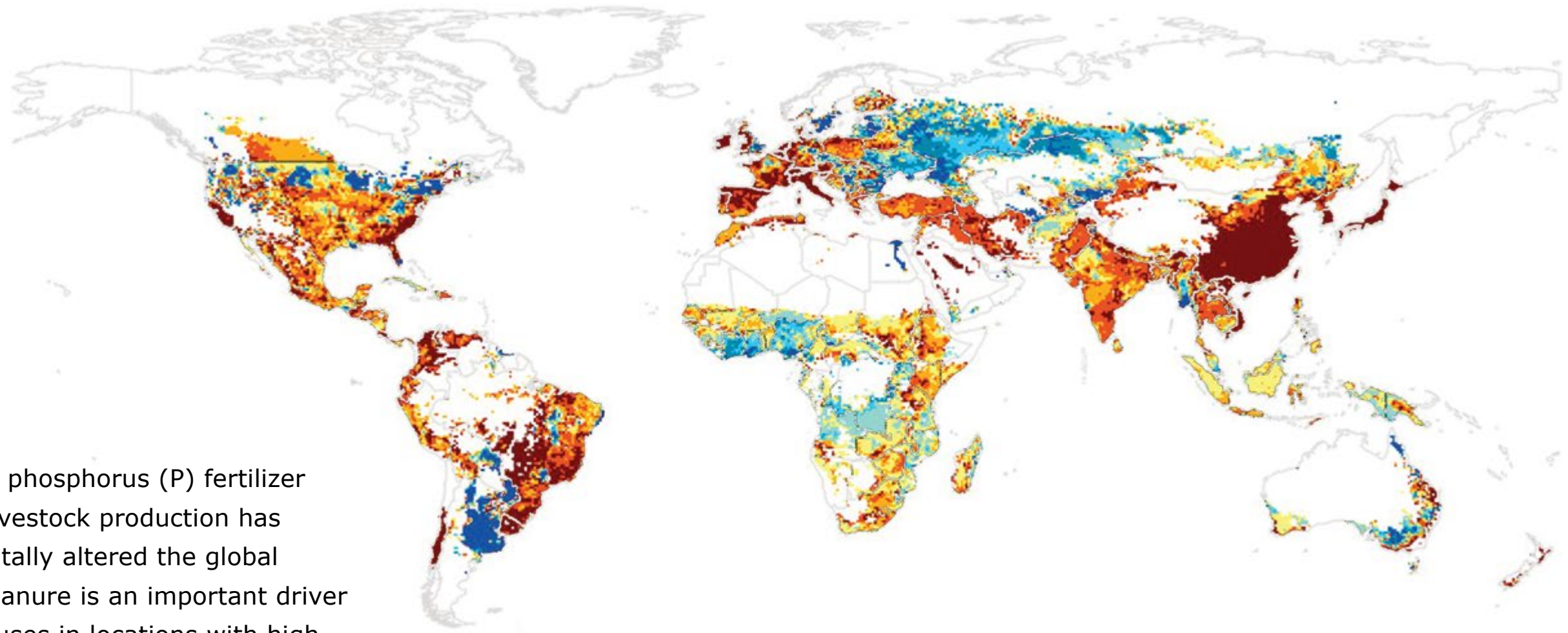
+15%
increase
|
347
million tonnes*



Source: OECD-FAO Agricultural Outlook 2016

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

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

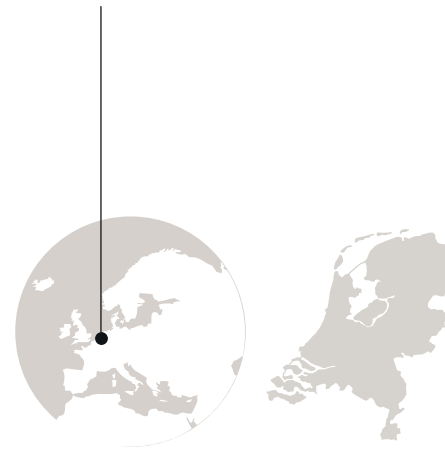
- Lowest quartile (0 to 2.5)
- Lower-middle quartile (2.5 to 6.2)
- Upper-middle quartile (6.2 to 13)
- Top quartile (13 to 840)




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

Manure in the Netherlands

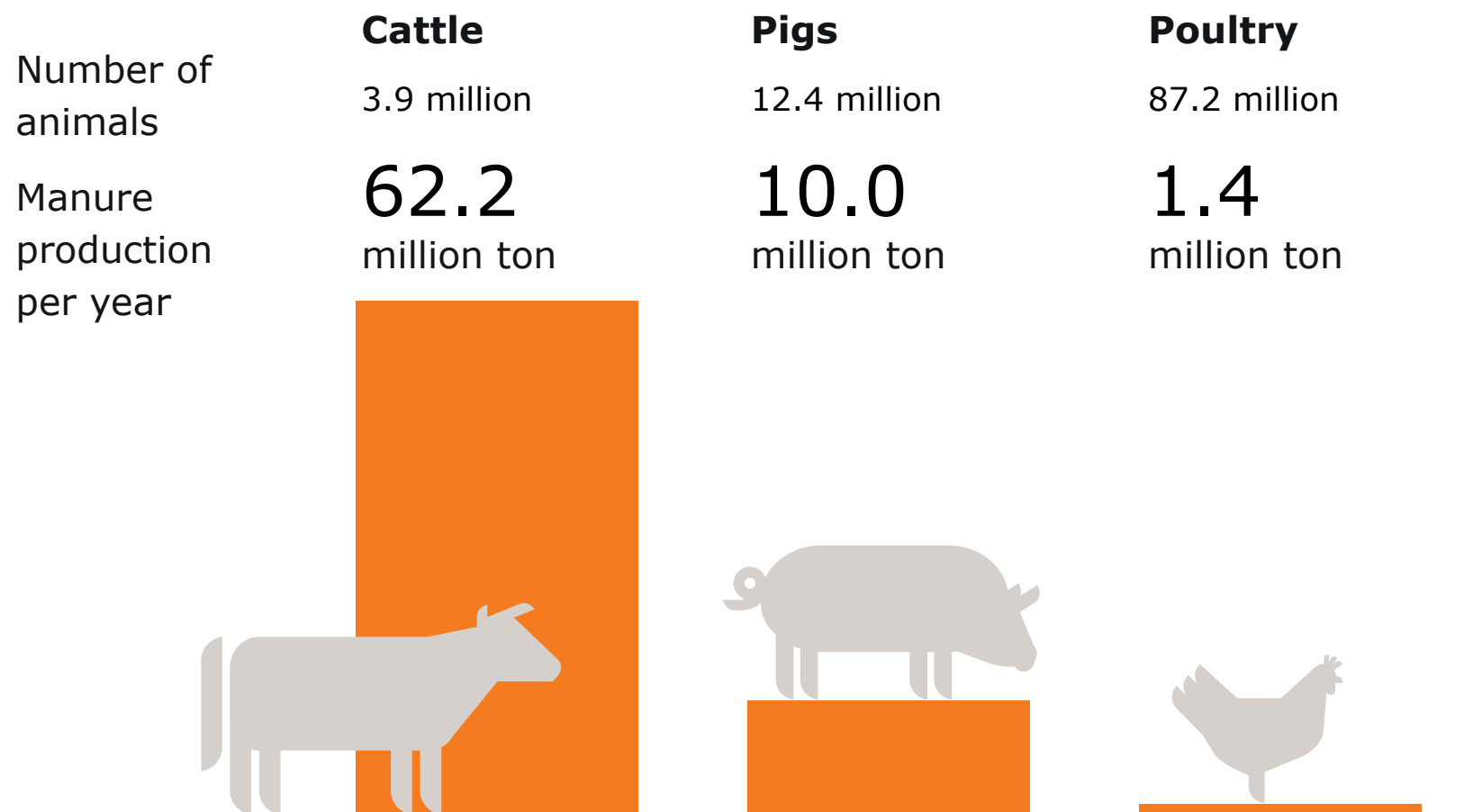
The Netherlands is a small, but densely populated member state of the European Union and has large numbers of livestock. The import of livestock feed and the use of synthetic fertilizer has led to a nutrient surplus in the Netherlands. Maintaining large numbers of animals requires the nutrient balance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

The Netherlands

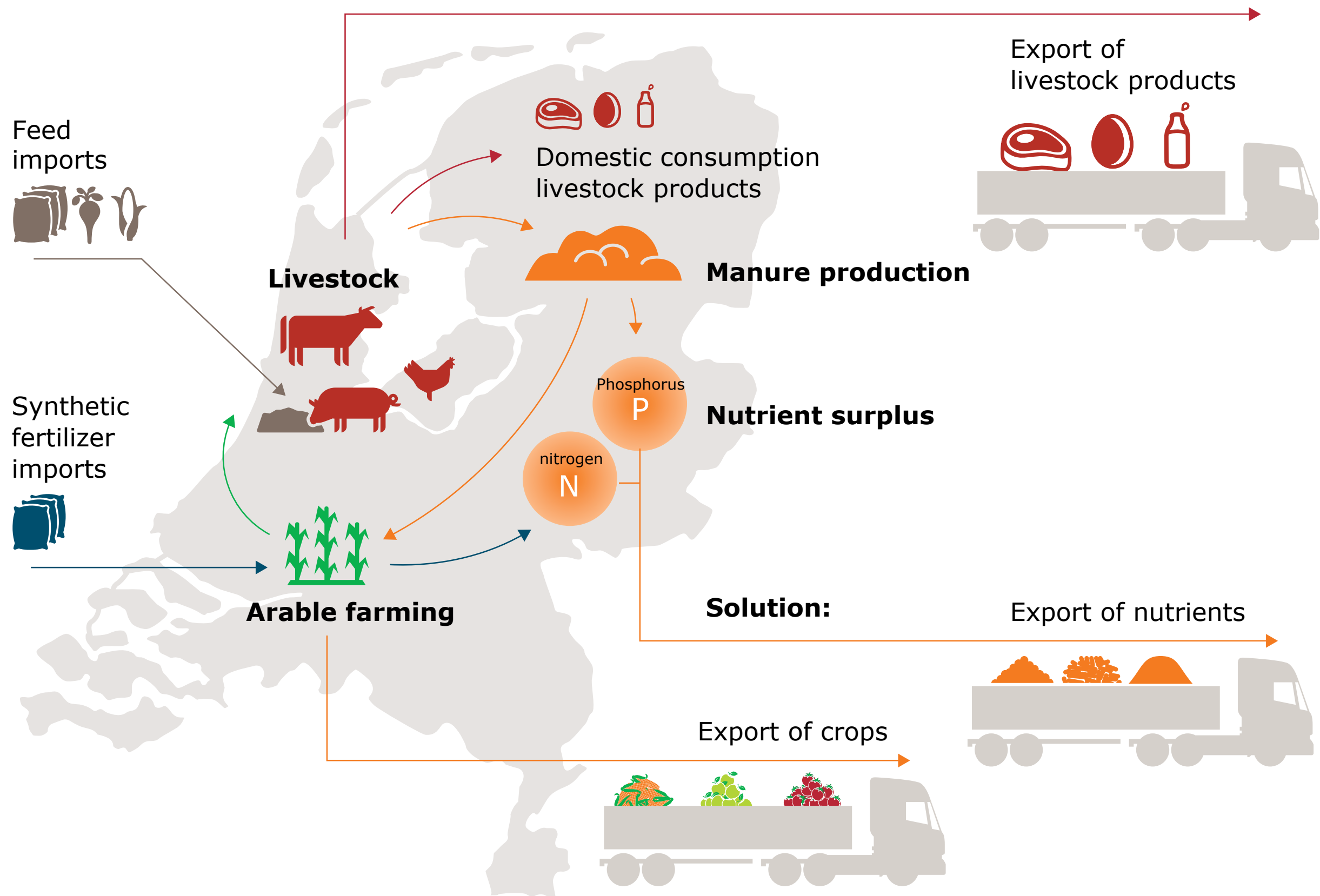


	Population	17 million
	Surface	40,000 km ²
	Agricultural land	17,500 km ²
	Manure production	76.2 million ton/yr
P_2O_5	Phosphate surplus	8 kg/ha/yr
N	Nitrogen surplus	131 kg/ha/yr

Manure production in the Netherlands (CBS Statline 2018)



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 dispersion 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 introduction 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 6th Nitrate Action Programme describes the Dutch government's manure policy and includes a package of additional regulations to reduce leaching of nutrients to ground and surface water. For example

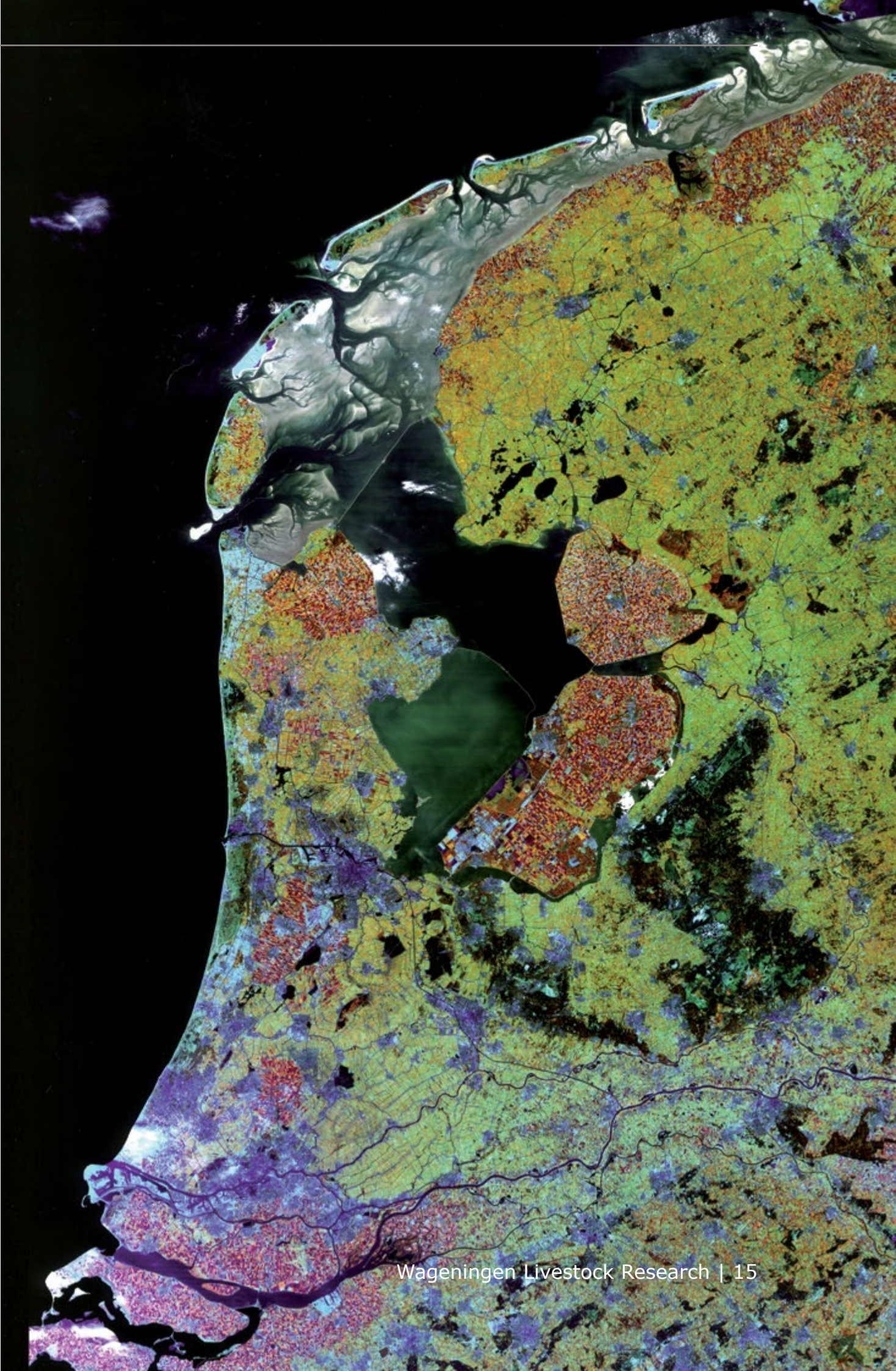
- The period of application of stackable livestock manure
- The requirement for row fertilization in maize cultivation on sand and loess soil
- Effective use of catch crops to avoid leaching of nitrate
- The prevention of erosion by creating ridges

A circular agriculture requires optimization across the sectors.

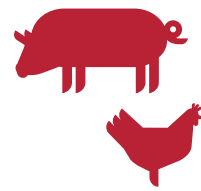
Circular agriculture


The vision of The Netherlands is to transition to a circular agriculture. 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




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
• Quality of surface water



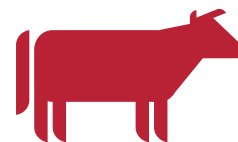
2006 
Application of standards system for minerals



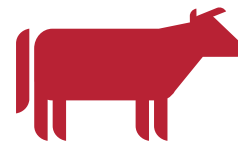
2007 
Low emission housing of animals in newly-built structures




2014 
Mandatory manure processing




2015 
Expiry of European milk quota system

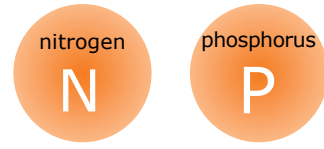


2015 
National conditions for dairy sector growth within the EU water framework directive



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

Current regulations for nitrogen and phosphate



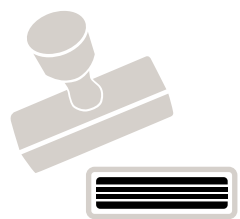
Manure and fertilizer application

- 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

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

Government facilitation



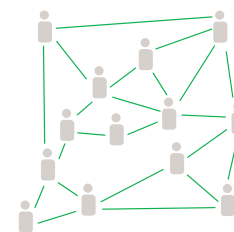
Innovation

- Financing and co-financing of 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

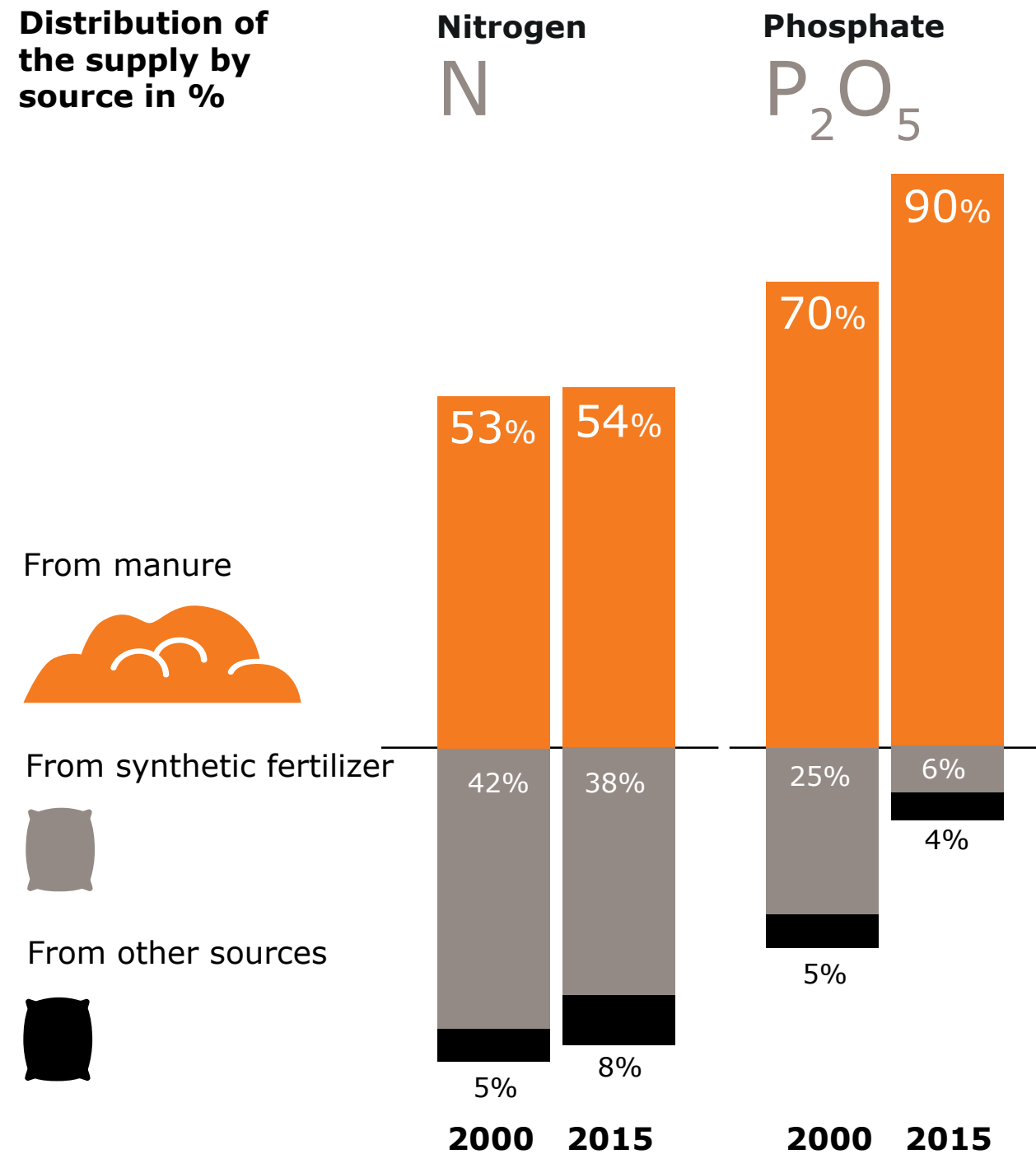
- Strong vision on circular agriculture
- Facilitate with Laws and Regulations
- Stimulate innovators

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 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)

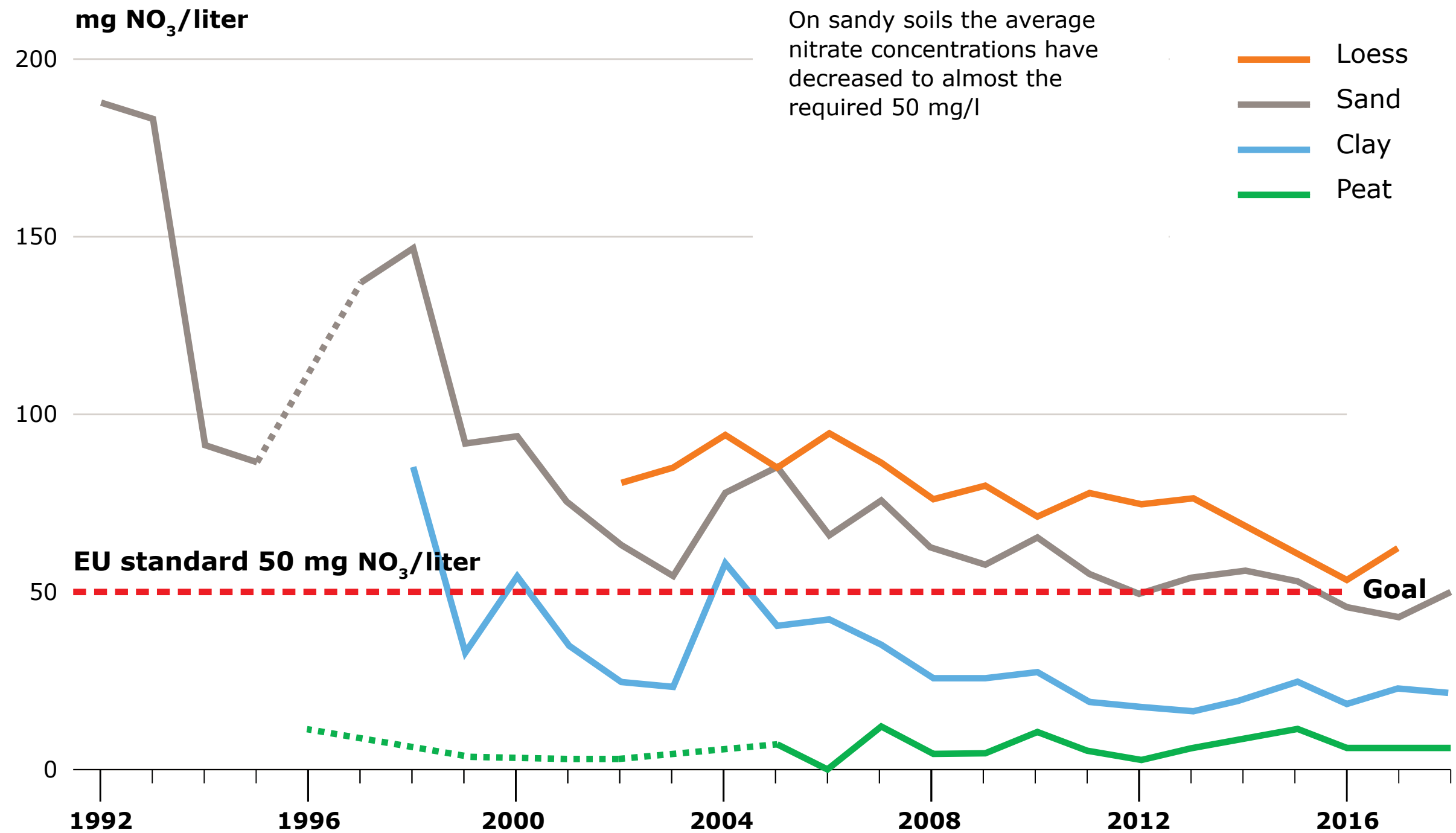
Increased rate of replacement of synthetic fertilizer by nitrogen and phosphate from animal manure



Source: CBS Statline (2017)

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, 2018)

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

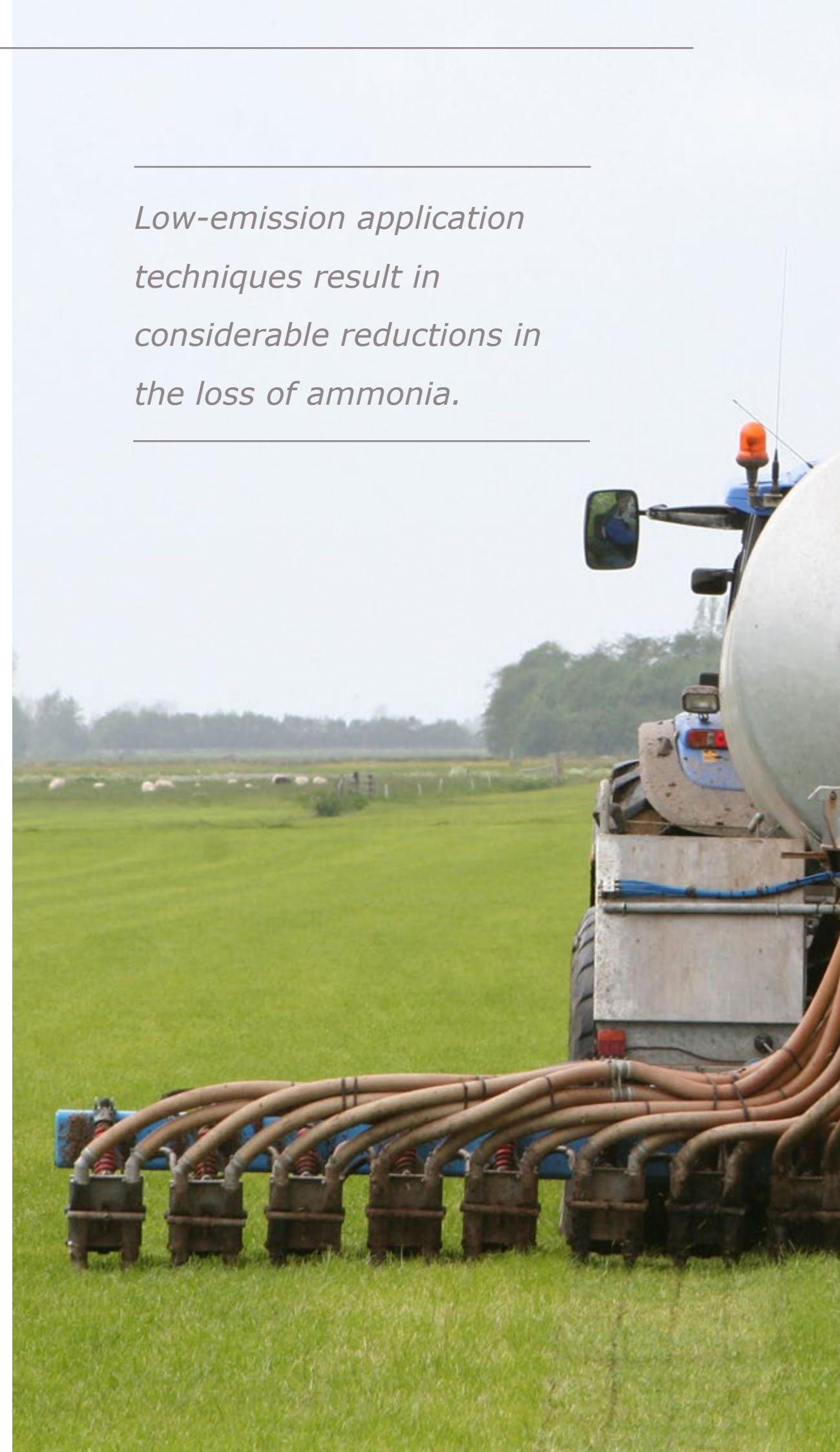


Principles of circular use of manure and nutrients

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

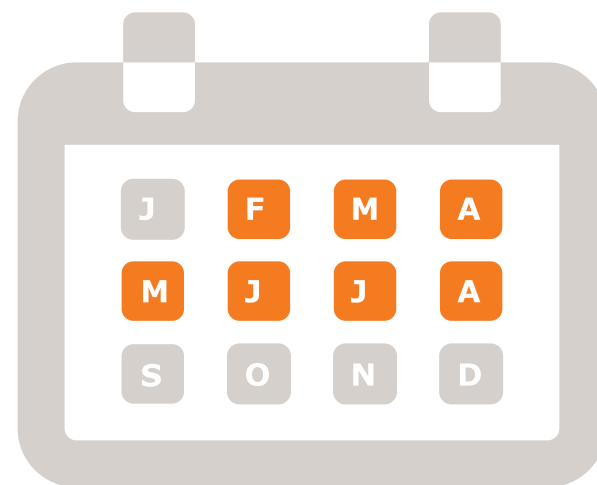
Applying exactly what the crop needs while taking into account nutrients in the soil.

Choosing fertilizers that are locally available



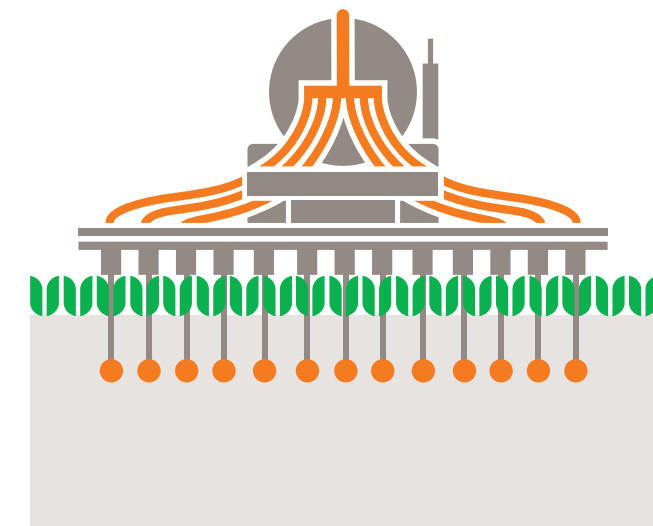
Using manure in the growing season

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.



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).

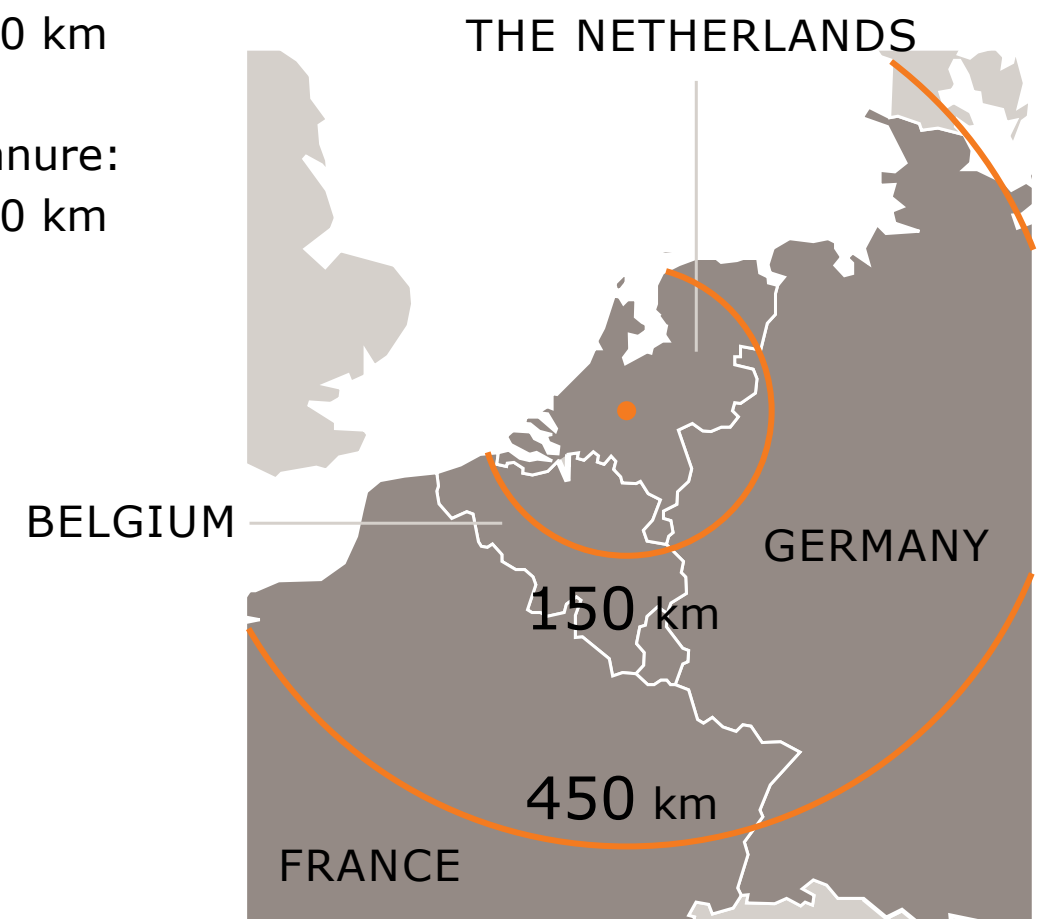
Costs of manure, disposal within the Netherlands to be paid by the livestock farmer



Affordability of manure transport

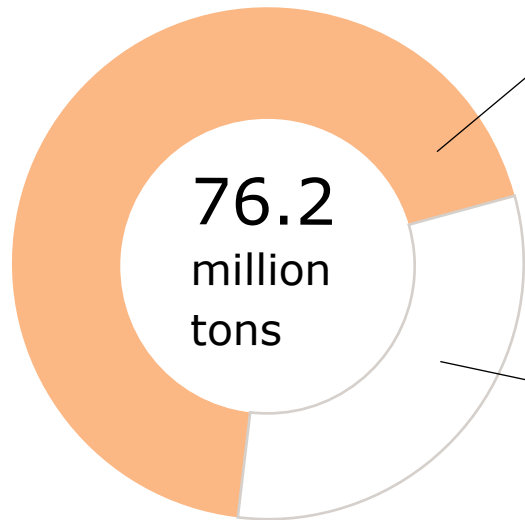
Liquid manure:
up to 150 km

Solid manure:
up to 450 km



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

Total manure production



Limited or no transport application within the own livestock farm

52.3 million tons

68%

Mainly dairy farms



Excess manure transport within the Netherlands and export

23.9 million tons

32%

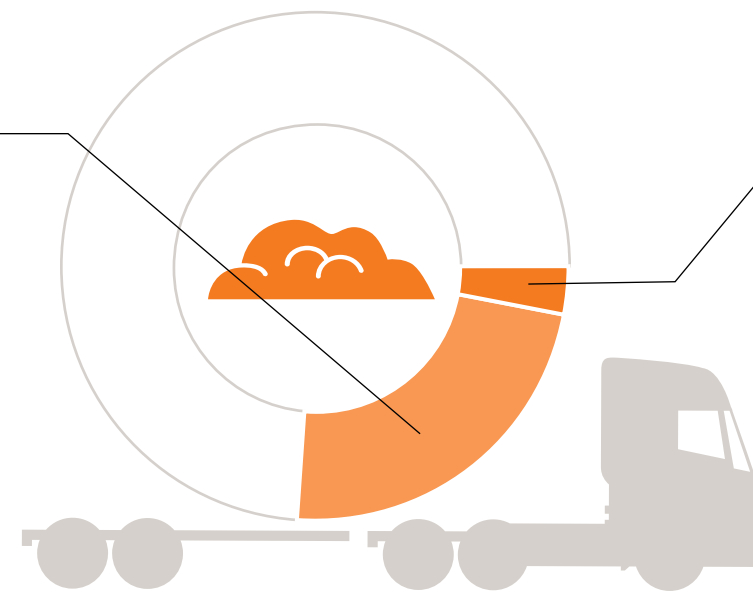
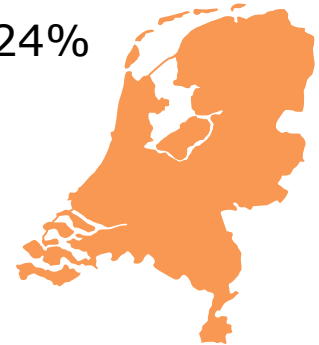
Mainly pig and poultry farms



Transport within the Netherlands

18.0 million tons

24%



Export

5.9 million tons

8%



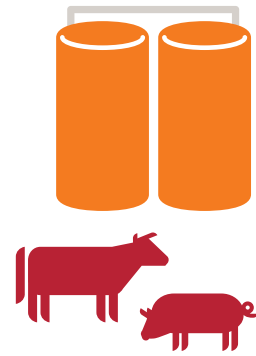


Manure and manure products




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.

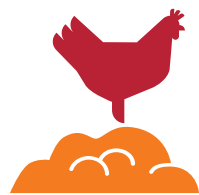
For the Dutch market ratios of N and P are important and also the content of organic carbon. When considering export of manure, a low water content and increased nutrient levels are desired, and sanitization is often required to eliminate pathogens.

Outline options for manure



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 P₂O₅ content
 - Reverse osmosis ▶ Mineral concentrate (NK fertilizer) and clean water
 - Biological purification ▶ Nitrogen escapes as harmless N₂ gas, 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 P₂O₅ 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)

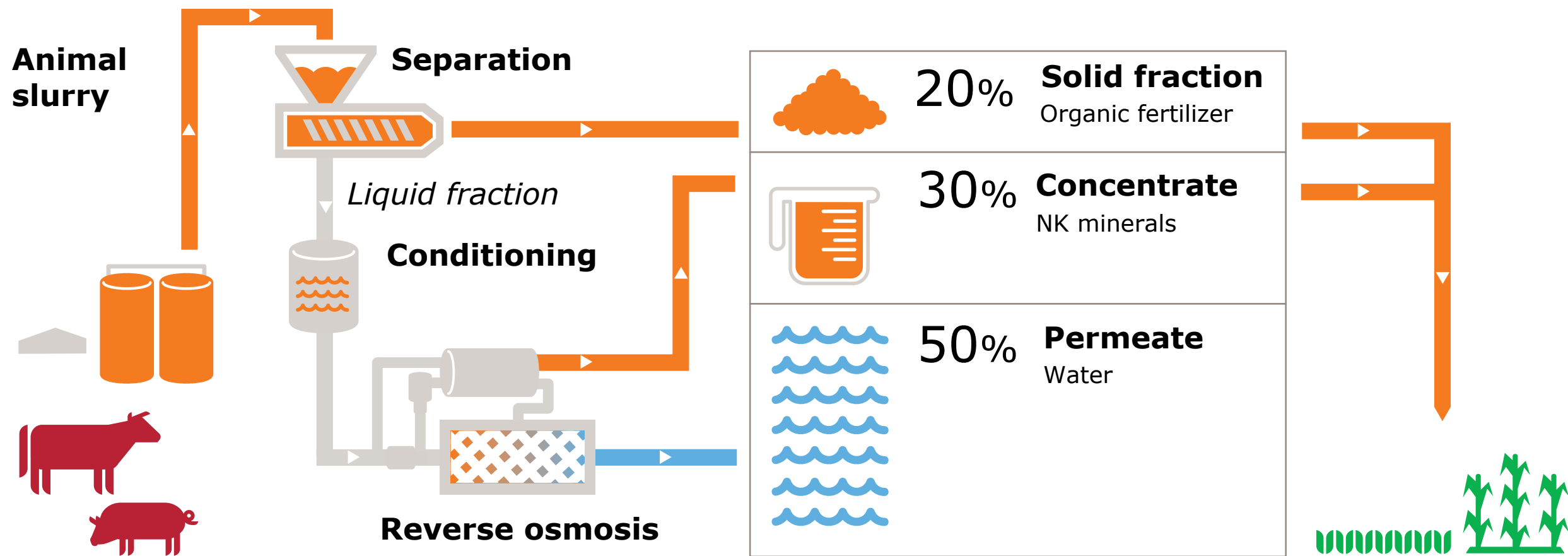
Manure processing

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.

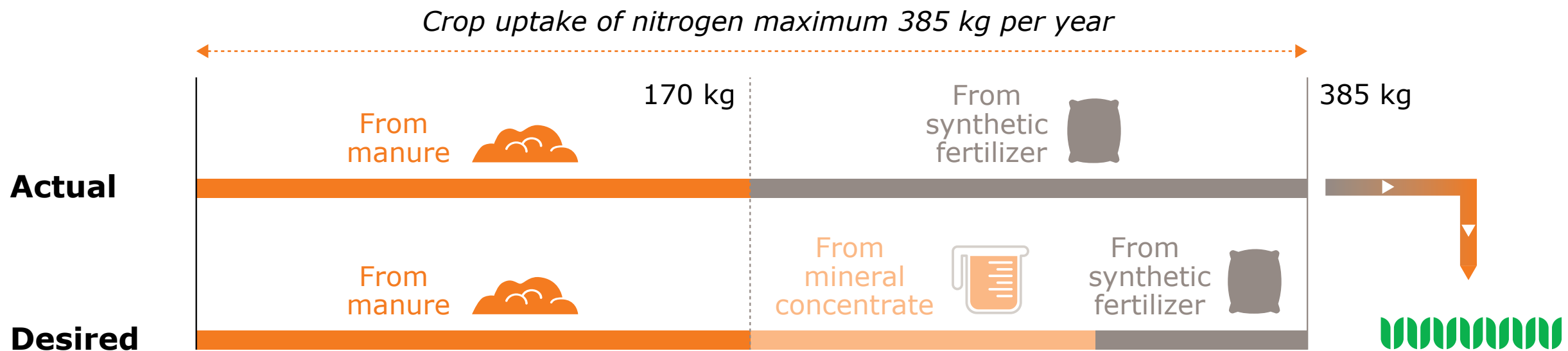


An important benefit of mechanical manure separation is that N and P can be used separately.

Production of liquid nitrogen concentrate by reverse osmosis



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

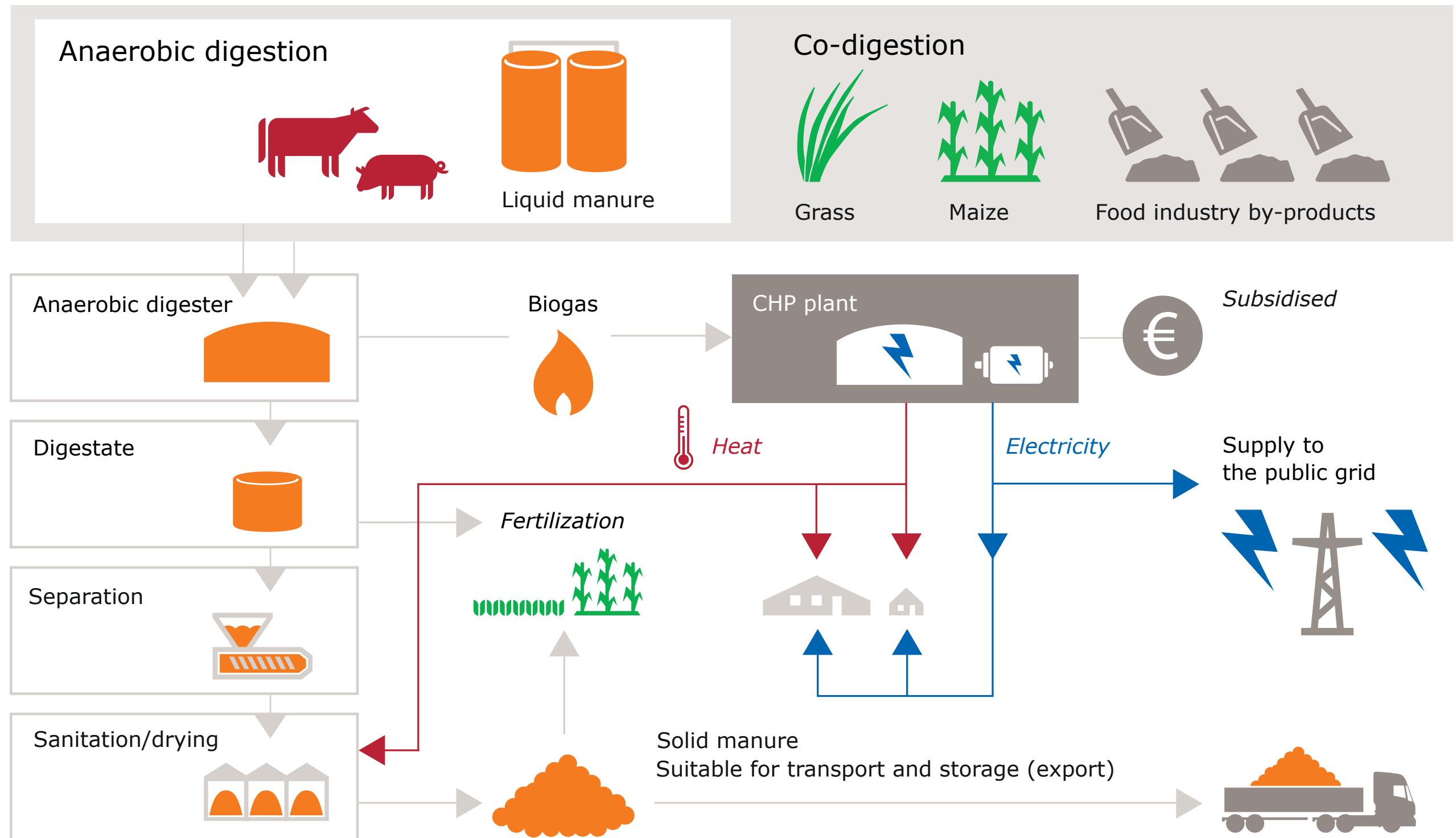




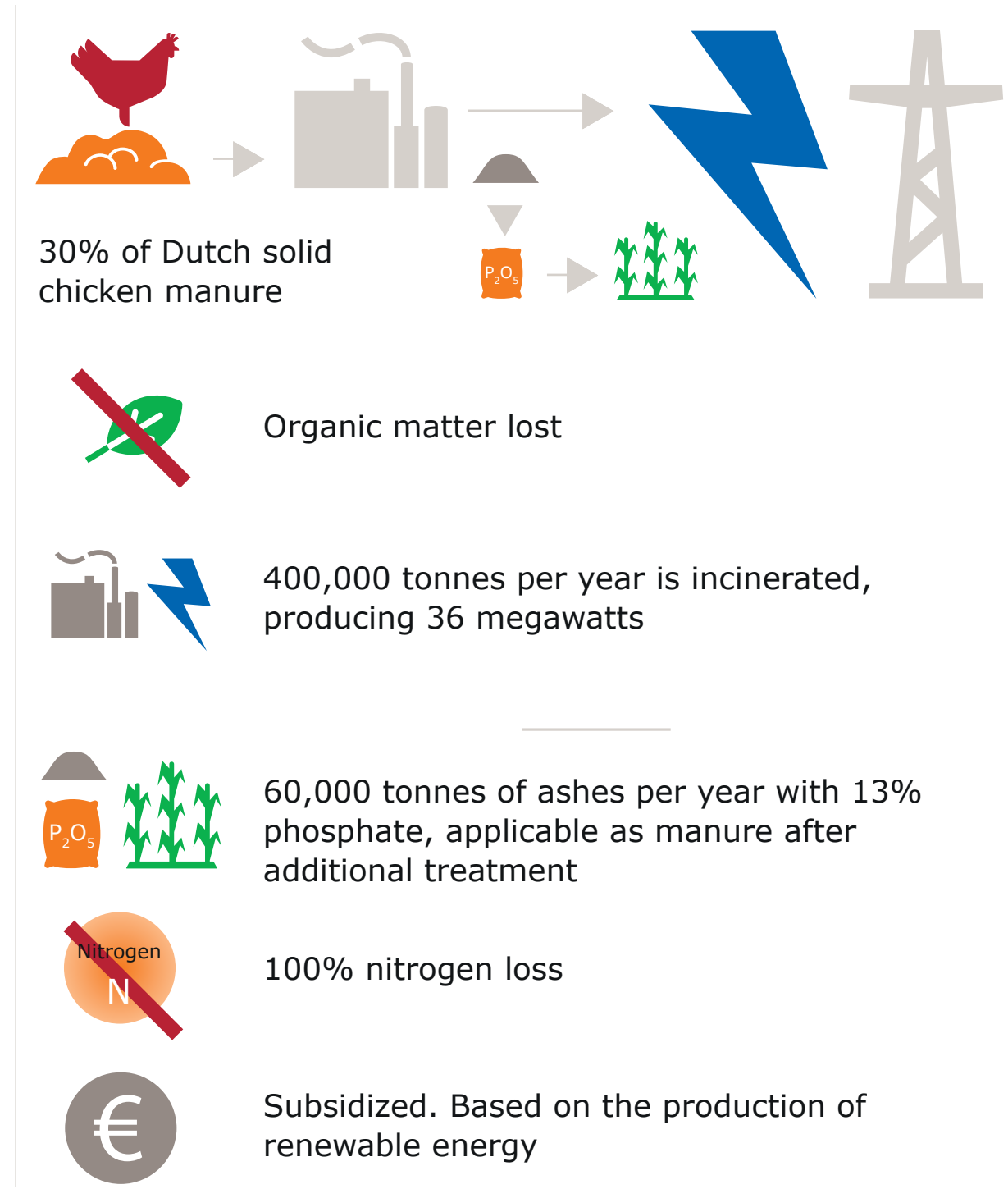
Digestion

Anaerobic digestion is a method to produce energy, primarily combustible biogas, from manure. However, with 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 certain co-products directly stands in the way of use as animal feed and is not sustainable. The residual product of anaerobic digestion remains livestock manure and has to be applied as such.

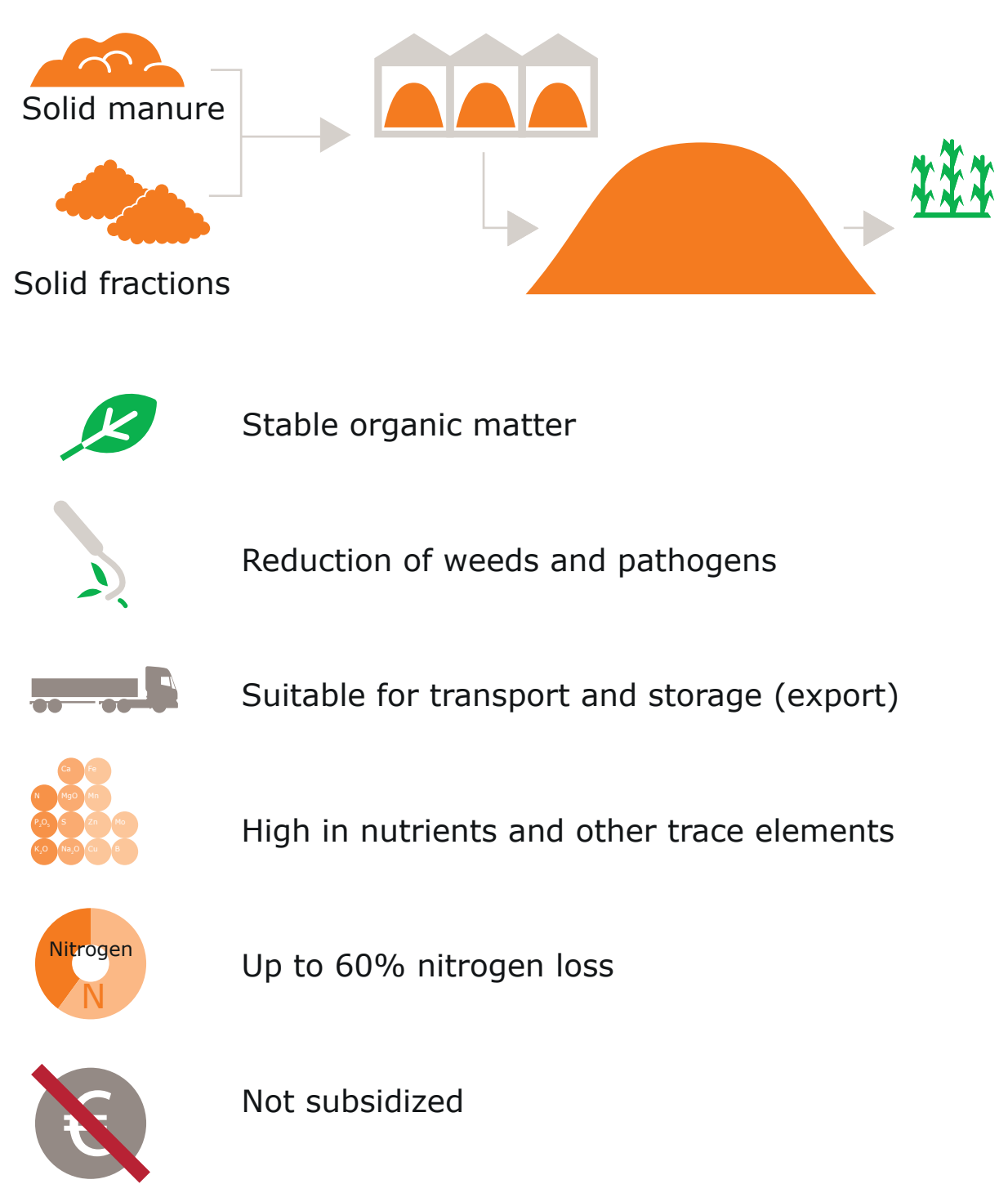
Digestion



Incineration

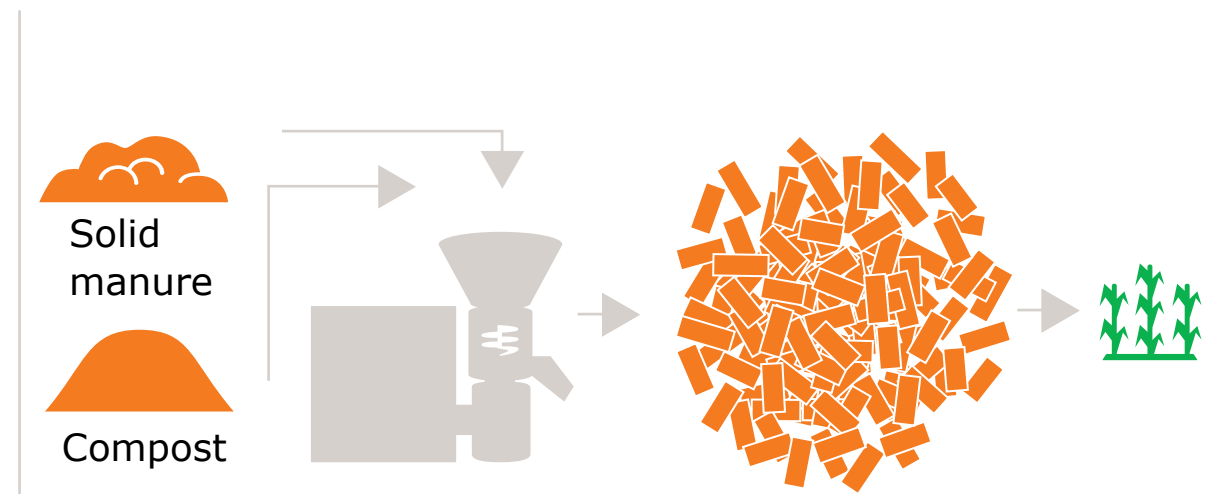




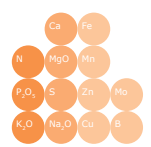

Composting ('biothermal drying')



Producing manure granules

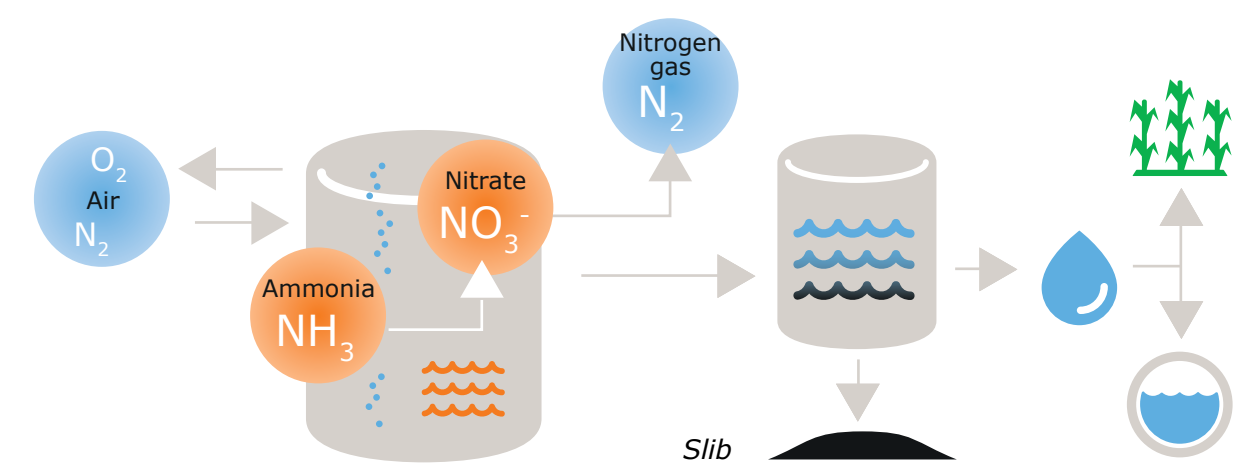
Solid manure








-  80% organic matter
-  Suitable for transport and storage (export)
-  High in nutrients and other trace elements
-  Not subsidized

Biological treatment

Liquid fraction



-  Nitrogen (N) is converted into nitrogen gas (N₂) in 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 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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Editors

Ferry Leenstra PhD, Theun Vellinga PhD,
Francesca Neijenhuis PhD, Fridtjof de Buissonjé BSc and
Luuk Gollenbeek MSc

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For more information please contact:

Wageningen Livestock Research
www.wur.nl/manuremanagement

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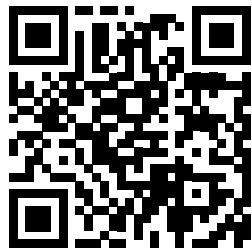


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Wageningen Livestock Research
P.O. Box 338
6700 AH Wageningen
The Netherlands
T +31 (0)317 48 39 53
E info.livestockresearch@wur.nl

www.wur.nl/livestock-research



Wageningen Livestock Research

Wageningen Livestock Research creates science-based solutions for a sustainable and profitable livestock sector. Together with our clients, we integrate scientific knowledge and practical experience to develop livestock concepts for future generations.

Wageningen Livestock Research is part of Wageningen University & Research. Together we work on the mission: 'To explore the potential of nature to improve the quality of life'. A staff of 6,500 and 10,000 students from over 100 countries is working worldwide in the domains of healthy food and living environment for governments and the business community at large. The strength of Wageningen University & Research lies in its ability to join the forces of specialised research institutes and the university and in the combined efforts of the various fields of natural and social sciences. This union of expertise leads to scientific breakthroughs that can quickly be put into practice and be incorporated into education. This is the Wageningen Approach.

