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To
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PO Box 30945
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TCB A059 (2010) The Hague, 13 August 2010

Re: Advisory report on the closing of nutrient cycles

Dear Minister,

This is the advisory report of the Soil Protection Technical Committee (TCB) on the closing of nutrient cycles. The TCB advises on the sustainable use of soil in the Netherlands. According to the TCB, closing of nutrient cycles is necessary in order to arrive at a sustainable use of soil in the Netherlands and elsewhere. The enclosure sets out the basis for and the background to this advisory report.

Nutrients, including nitrogen and phosphate, are essential for the growth of plants and animals. In nature there is a nutrient cycle: plants absorb nutrients from the soil or water, animals absorb nutrients by eating plants or other animals, nutrients return to the soil and water through urine, manure, fallen leaves and the decomposition of dead plants and animals. In natural systems this cycle is on a small scale and is more or less closed. The losses that occur into the air, soil, groundwater and surface water are small compared with the amount of nutrients in the cycle.

Our current food production systems have an adverse effect on these cycles because they are no longer closed and local accumulation, shortages and losses of nutrients occur. There are various reasons for this:

- Nutrients are produced in the form of inorganic fertiliser, animal feed and other agricultural products in large quantities and transported over long distances. As a result of this, local surpluses or shortages occur.
- In the production of crops there are considerable losses of nutrients into the environment caused by the adding of extra nutrients to the local cycle, which are absorbed only partially by the crops.
- Nutrients from human urine and faeces, which quantitatively are an important factor, are removed from the cycle, particularly in the Western world.

The TCB distinguishes four reasons for working on closing nutrient cycles.

1. Surplus and losses of nutrients in the Netherlands

On a national scale there is a surplus of nutrients (nitrogen and phosphate) in the Netherlands for the growing of crops. More nutrients are carried in through animal feed and inorganic fertiliser than are carried out via plant products, dairy products, meat, other protein-rich products and processed manure. The surplus nutrients accumulate in the soil and are emitted to (ground) water and atmosphere mainly as a result of animal manure application. This leads to a loss of quality of our terrestrial, aquatic and marine ecosystems. The decline is disadvantageous for biodiversity and the services that ecosystems offer to us, such as the supply of clean drinking water.

2. Shortages of nutrients elsewhere

The large scale import of nitrogen and phosphate through animal feed (particularly soybean) and artificial fertiliser leads to adverse effects on ecosystems elsewhere as well. The way in which soybean is cultivated at the moment depletes agricultural soils and leads to a loss of fertile soil as a result of erosion and problems caused by nutrient emissions occur during soybean production. Global livestock farming is responsible for about 30% of the loss of biodiversity on land, due to the amount of land that is needed for producing animal feed.

3. Greater need for food

World crop production has to increase in order to be able to continue to feed the world's growing population. The consumption of meat is also increasing worldwide as well, for which in relative terms even more crops have to be grown in order to provide the animal feed needed. Local shortages and losses of nutrients can only be made up for in part by inorganic fertiliser. The reserves of phosphate ore that can be mined are finite. A great deal of energy is needed to produce inorganic nitrogen fertilisers. This means that nutrients must be used as efficiently as possible, preventing excess and closing the cycles as much as possible.

4. Greater dependence on the soil

World nutrient cycles do have a wider perspective than solely that of agriculture. In view of the fact that the supply of raw materials is finite and in view of the increasing technical possibilities, new applications for biomass are being found, and in particular for crops. As well as food and animal feed, biomass can become a source of energy and many complex compounds that can serve as a raw material for, among other things, paint and adhesives, medicinal products, cosmetics and biomaterials. With this, the soil becomes a producer of raw materials. This makes our dependence on healthy soil even greater. This is a long term view. Considerable technological innovations and a social transition are still needed in order to achieve this multiple use of biomass (*biobased economy*).

The measures needed to better close nutrient cycles

Firstly, closing nutrient cycles means that the nutrients that are extracted for the production of plants and animals are ultimately returned again to the same extent to where they came from, in order to prevent local surpluses and shortages. This means that, as much as possible and to the same degree, nutrients from manure, faeces, urine, products of these, and also plant and animal residual products must go back to the agricultural land that is used for crop production. From a Dutch perspective, the efficiency of transporting manure is the limiting factor. But this can, however, be increased considerably by processing the manure, such as by converting animal manure into inorganic fertiliser substitutes. As this requires considerable technological innovations, this cannot be achieved in the short term. For control purposes it is important to choose an optimum scale level for closing nutrient cycles. For the time being the TCB is thinking indicatively of Europe as a scale level for closing nutrient cycles. The current infrastructure of the agricultural sector (logistics, transport, distribution) is aimed mainly at the European market. Also, Europe offers enough space and a favourable climate for growing the animal feed that is needed.

Secondly, losses from the cycle must be kept to a minimum, which means above all that locally no more nutrients must be put into circulation than the cycle can deal with. For the Netherlands this means that the amount of nutrients from manure put onto agricultural land should be a derivative of the amount of agricultural land that is available for the Netherlands for processing these nutrients efficiently, without significant losses into the environment.

The measures described above are interconnected. In a country such as the Netherlands, where the scale of intensive livestock farming is largely responsible for the surpluses – and losses – of nutrients, there are two options for preventing the surplus. The first is to return nutrients to the area where animal feed is produced. The second is to reduce the amount of nutrients put onto agricultural land. The first option – the exporting of manure and products of it – has scarcely been developed yet, and to develop this needs time. For this reason, in the short term the only option is to reduce the amount of nutrients added, that is, to reduce the amount of manure produced and therefore the livestock population. In the long term, as a result of innovations it may be possible to keep more animals in the Netherlands again, if the international trade in manure and its products – on the optimum scale as described above – has greatly increased.

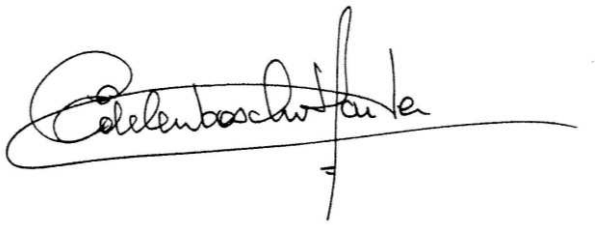
The committee recommends the following steps, in the order of implementation in the short term to implementation in the longer term:

1. To bring the scale of livestock farming in agreement with the application capacity of nutrients from manure.
2. In connection with this, to continue animal production rights and milk quota or a similar control instrument after 2015 and extend this to animal production rights for cattle, goats and sheep.
3. Developing knowledge in the area of the processing of manure into inorganic fertiliser substitutes and closing nutrient cycles.
4. Further incentives for processing manure into inorganic fertiliser substitutes, in particular in order to promote the transport and export of nutrients from manure.
5. If step 4 has been sufficiently realised, bringing the size of the area where animal feed is produced in agreement with the size of the area where animal manure can be applied, for example on the scale of Europe.
6. Use the reform of the EU's common agricultural policy to put into practice the sustainable use of soil and the closing of nutrient cycles.

7. To prevent depletion of phosphate, phosphate from human excreta and other organic waste streams should be reused for agricultural production.
8. Performing studies at various spatial levels of scale into the effects of an increasing use of biomass as a raw material on soil quality and land use.

The TCB will be pleased to contribute to the further development of the steps recommended.

Yours sincerely,



Ali Edelenbosch
Chair of the Soil Protection Technical Committee

ENCLOSURE

CLOSING OF NUTRIENT CYCLES:

BASIS AND BACKGROUND

INTRODUCTION

Since the regulations governing the use of manure came into force at the beginning of the 1980s, the use of fertilisers in agriculture has fallen considerably. However, the supply of animal manure in areas where intensive livestock farming is concentrated is still greater than what is needed for the soil and crops. Because of this surplus of manure, the quality of the environment is not at the level that is desired. Since the beginning of this century the surplus has not decreased anymore. Most of the manure is produced and used in the eastern part of North-Brabant and western Veluwe. Because the soil in these regions generally is a very permeable sandy soil, the risk of leaching of nutrients to the groundwater is relatively great. This is one of the main reasons for not meeting the standards for nitrate in the groundwater under the Nitrates Directive, and the standards for nitrogen and phosphorus in the surface water under the Water Framework Directive. This is why the main conclusion of one of the first advisory reports of the TCB[1], nearly 25 years ago, still holds: *"The environmental consequences of the use of manure in the areas where there is a surplus means that in the short term a drastic intervention must be made in the mineral balance and the distribution of the minerals surplus in the Netherlands. The discrepancy between the amount of minerals imported as inorganic fertilisers and animal feed and exported as agricultural products and fertilisers must be reduced structurally by limiting the amount imported and/or by increasing the amount exported. If it is not possible to increase the amount exported sufficiently, a limitation on the input of minerals will be unavoidable. The committee is of the opinion that in this situation, reducing the density of livestock must definitely be considered"*.

HIERARCHY OF MEASURES

Over the years the TCB has regularly advised on manure policy. In a recent advisory report on the use of manure[2], the TCB found that the measures that can be taken to counteract the environmental effects of the use of manure have a hierarchical order, see diagram below. Hierarchy in this context means that insufficient effectiveness of measures higher in the hierarchy cannot be compensated for by a greater use of measures lower in the hierarchy.

1 V-TCB A86/01, *advies Besluit gebruik dierlijke meststoffen* (Advisory report on the decree concerning the use of animal fertilisers), March 1986.
2 TCB A044(2008), *advies Aanwenden van mest* (Advisory report on the use of manure), 16 September 2008.

Hierarchy of measures. From: TCB A044(2008) Advisory report on the use of manure.

1. Pre-condition	**Equilibrium between the demand for and the supply of manure** **Sufficient capacity for the storage of manure**	
2. Very effective:	**Application standards for nitrogen and phosphate** **Fertiliser replacement values for nitrogen and phosphate in animal manure**	
3. Additionally effective:	**Good nutrient management** - Composition of (treated and processed) animal manure is known - Matching of the demand for and the supply of nutrients during the growing season - Optimising of agronomic field management (rotation, pasture land) - Spreading manure only during the growing season - Improved techniques for spreading manure - Taking the weather into account	**Other measures for reducing losses** - Catch crops - Buffer strips - Measures on drainage and the control of water levels - Helophyte filters

If the production of animal manure and the application capacity of the nitrogen and phosphate in animal manure is not in equilibrium, there is a (regional) surplus of manure and the other measures in the hierarchy will not be sufficiently effective. Stringent application standards for nitrogen and phosphate are very effective, in combination with high fertiliser replacement values for nitrogen and phosphate in animal manure. However, if there is no equilibrium in the manure market, it will be difficult to enforce stringent application standards. With stringent application standards, good nutrient management on arable farms is additionally effective. This also applies for measures that minimise the inevitable losses from farming to groundwater and the surface water. With less stringent application standards these measures are of less interest to farmers, because although they contribute to the quality of the environment, they do not contribute (directly) to the farm's profitability.

FURTHER STUDIES INTO EFFECTIVE MEASURES

In order to investigate what other measures farmers could take, the TCB commissioned to produce an overview of information on eighty measures[3]. Many measures are already available and are being applied in practice on a small scale. Promising measures in terms of effectiveness and practical applicability are soil and grassland management, improved drainage and the use of management support systems.

In the autumn of 2009, at an international workshop[4] on the prevention of nutrient losses the TCB discussed with representatives from the Netherlands and a number of neighbouring countries packages of measures that have proved to be effective and that may perhaps be applied in the

3 Kloen, H. *et al*., 2009. *From Good Agricultural Practice towards Sustainable Nutrient Management*. CLM report number 698 – 2009.

4 Commissioned jointly by the TCB and the Scientific Committee on the Manure Act, the workshop was organised by Plant Research international (PRI). See: Ten Berge, H. and W. van Dijk, 2010. *How to reduce nutrient emissions from agriculture? International Workshop Summary Report, PRI Note 653*.

Netherlands. Virtually all the countries stress the importance of statutory measures. Of all the policy measures that have been applied so far, restrictions on the use of animal manure have contributed most to reducing emissions from farming. Participants argued for a further tightening-up of statutory restrictions. Also, farmers can choose from a range of possible measures in order to make their farm management sustainable. These arise from technological innovation for better utilisation of nutrients, a better basis for advice on the use of fertilisers and knowledge transfer. Importance is also attached to developing financial mechanisms that contribute to a greater utilisation of nutrients.

According to the hierarchy of measures, applying these measures by farmers will not, however, be sufficient if at the same time the manure market is not in equilibrium. This is not the case in the Netherlands. Statistics Netherlands (CBS) has calculated the balance of phosphorus and nitrogen in agriculture for 2007, see Appendix 1. In that year a surplus of 64 million kg of phosphate accumulated in soil in the Netherlands. That is almost one third of the amount of phosphate that was imported into agriculture. Phosphate is thus not being used efficiently. There were 398 million kg of surplus nitrogen. This is almost 60% of the amount of nitrogen that was imported into Dutch agriculture. So also nitrogen is not being used effectively. Most of the nitrogen surplus accumulated in the soil and the groundwater (299 million kg of nitrogen). The rest volatilised, mainly as ammonia (99 million kg of nitrogen).

A SURPLUS OF MANURE PREVENTS THE EFFICIENT USE OF NUTRIENTS

The TCB sees the manure surplus as being the main hindrance to the efficient management of nutrient cycles in agriculture. For nutrients to be used efficiently, the application of fertiliser is governed by the needs of the crops. As long as there is not equilibrium in the manure market, the incentive remains to use animal manure without an agronomic need and in amounts that exceed the statutory application standards.

The excessive application of manure to agricultural land in large parts of the Netherlands leads to several negative effects on the environment. As a result of ammonia volatilisation and subsequently the deposition of it in natural areas, ecosystems that are low in nutrients become eutrophic and lose their character. Ammonia also causes an excessive stench when spreading the manure; an excessive stench from the stalls themselves has for the most part been removed due to the obligation to install air filters. Excessive fertiliser application leads to nitrate leaching to groundwater and runoff to surface waters. Too much nitrate in the groundwater reduces the extent to which groundwater can be used directly for drinking water and leads to the standard for nitrates in the Nitrates Directive being exceeded. Too high nitrogen (including nitrate) concentrations in surface waters are an obstacle to achieving the good ecological status of the water, which is the quality objective of the Water Framework Directive. The objective of the Marine Strategy Framework Directive, to achieve a good environmental status of the marine environment, may also be put at risk in view of the fact that saltwater aquatic ecosystems are nitrogen-limited. Emissions of greenhouse gases (in particular nitrous oxide) take place both during application of nitrogen and after leaching and deposition of nitrogen. Phosphate accumulates in the soil and therefore excessive fertiliser use leads locally to phosphate saturation of soils. This increases the risk of phosphate being leached to the topmost groundwater and to surface waters and therefore contributes to the eutrophication of surface waters. High phosphate contents in agricultural soils can also have an adverse effect on (agro) biodiversity. When agricultural land is taken out of production for the development of natural land, phosphate saturation of the soil makes it difficult to achieve specific nature aims. The spreading of nutrients into the environment to the degree in which it is now occurring leads to a loss of biodiversity and a

disruption of ecosystem services. It was already established in the *Millennium Ecosystem Assessment*[5] that changes in the global nutrient cycles lead on the one hand to over-fertilisation of natural ecosystems, which as a result become disturbed, and on the other hand to soil fertility decrease elsewhere.

SCARCITY OF PHOSPHATE

The loss of nutrients from the cycle has more disadvantages. It also leads to the wasting of nutrients necessary for biomass[6] production. Nutrients are essential for plants and animals. The production of biomass needs to increase in order to be able to feed a growing world population with a diet that is changing to one containing more animal proteins. Looked at globally, phosphate is a scarce raw material that does not form part of the world's ecological cycle. To a great extent there is one-way traffic from the reserves in the mines to the soil of (reservoir) seas, coastal waters and the ocean, and via industrial processes to combustion ashes and cement. Through use in agriculture, phosphate spreads diffusely over the earth. Depending on the scenario chosen, it has been calculated that after 50, 100 or 200 years, the amounts of phosphate ore that can be mined will have been used up[7]. As a result, in the end there may be serious food shortages. There will be a scarcity at regional level earlier due to claims of strategically operating countries on the remaining stocks of phosphate. Moreover, the stock of good quality phosphate ore will be the first to fall. After that, ores of a lower quality will be exploited. As a result, cadmium in particular will accumulate in agricultural land as a pollutant of inorganic phosphate fertiliser, more than is already the case[8], which may put food safety at risk. The EU does not have its own supplies of mineral phosphate that are enough to meet the need for phosphate for its own food production. Therefore the EU is not self-sufficient for food.

The Technology Assessment Steering Group (STA), an independent advisory committee of the Ministry of Agriculture, Nature and Food Quality, advised that in order to really tackle the scarcity of phosphate, total consumption should be reduced and that re-use in agriculture should be allowed to increase. The TCB supports this view. At the moment six times more phosphate is used in agriculture than is taken up by people through food. In mining, 30 to 50 per cent of the phosphate that is quarried is lost. Over the whole of the food chain, 30 to 50 per cent of food is wasted. The re-use in agriculture of phosphate from human excreta virtually no longer takes place in the developed world, while this is a considerable loss item. In the Netherlands, every year about 5 million kg of phosphate could be recovered from waste water[9]. The STA also sees a role for households by reducing their consumption of animal proteins. Organic residues from agriculture and industry can be utilised better, and also slaughter waste.

Natural reserves, including those of phosphate, are finite. The current economic gain consists to a considerable extent of reaping the benefits of it now. This is not sustainable and therefore cannot last.

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5 http://www.millenniumassessment.org/en/Index.aspx.

6 Biomass is a collective term for plant and animal organisms and their products.

7 *Fosfaat, van te veel naar tekort* (Phosphate, from too much to not enough). Policy paper by the Technology Assessment Steering Group, September 2009.

8 http://www.compendiumvoordeleefomgeving.nl/indicatoren/nl0265-Jaarlijkse-ophoping-van-zware-metalen-in-de-bodem.html?i=11-14.

9 *Milieubalans* 2009 (Environmental balance 2009), PBL.

There has to be a better balance between what the earth as an ecosystem can provide and bear, and the way in which people produce and consume[10].

THERE IS A LARGE SUPPLY OF NUTRIENTS

For the purposes of intensive livestock farming, large quantities of animal feed are imported into the Netherlands in the form of cereals and soybean. In 2002, worldwide, about 35 per cent of the cereal harvest was used as animal feed. Soybean is the main source of protein for animal feed. In the Netherlands about a third of animal feed consists of by-products from the food industry, such as steam peelings (a residual product from the production of chips and crisps) and brewers' grains (a residual product of beer) from the Netherlands, and corn gluten feed and citrus pulp from abroad. Most of the raw materials for animal feed come from abroad. The protein raw materials come in fact mainly from outside the EU. Since 2003, when animal feed in the EU was no longer allowed to contain animal proteins because they are seen as a source of infection for BSE (mad cow disease), imports of high-protein soybean meal by the EU have greatly increased. Growing soybean elsewhere and transporting it to the Netherlands leads to large movements of nitrogen and phosphate[11]. Growing soybean depletes agricultural soils and leads to erosion which is also a loss of fertile soil. Intensifying cultivation results in accompanying problems with pesticide and nutrient emissions. Tropical rain forest is cut down because soy bean cultivation pushes away agricultural production systems for the local market. Livestock farming worldwide is responsible for about 30 per cent of the loss of biodiversity on the land.

In the Netherlands intensive livestock farming is an important economic activity, aimed at the production of and trade in meat, milk(products) and eggs, with (liquid) manure as the main by-product. The added value of intensive livestock farming as a sector (including processing, delivery and distribution) to the Dutch economy was over 5 billion euro in 2003, and nearly 80,000 people were employed in the industry[12]. Part of the meat that is produced is consumed in the Netherlands and part is exported, mainly to the surrounding countries. Most of the animal manure that is produced is used as organic fertiliser in the Dutch farming industry. Surplus manure is mainly used locally, because of the high cost of transporting liquid manure. With the manure, arable farmers get money from the livestock farmers who want to empty their manure cellars. This encourages the over-use of manure.

Intensive livestock farming is characterised by large-scale soybean imports and this causes a disruption in the global nutrient balance. This does not, however, affect the scale of livestock farming, because the cost of the damage this causes to nature, the environment and health is not included in the price of meat. Also there are various subsidies that keep the price of meat low. The scale of livestock farming is now being maximised by animal production rights and milk quotas. These are to be abolished in 2015, which means that there will no longer be any restrictions in law on the further growth of the livestock farming sector. This may lead to the manure surpluses increasing further.

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10 Van Egmond, K., 2010. *Een vorm van beschaving* (A form of civilisation). Published by Uitgeverij Christofoor. ISBN 9060386485.

11 Kamp *et al*., 2008. *Perspectieven van sojavervanging in voer, op zoek naar Europese alternatieven voor soja* (Prospects for replacing soy in feed, on the search for European alternatives to soy). PPO report number 3250119600.

12 Bruchem van, C., 2007. *Verkenning economische aspecten van een kleinere en meer extensieve veehouderij* (An exploration of the economic aspects of smaller and more extensive livestock farming). LEI report, project code 20826.

The debate about the closing of nutrient cycles is closely connected to the debate about the size of the intensive livestock farming industry in the Netherlands. At the moment there is a social debate on-going about intensive livestock farming on account of, among other things, public health (resistance to antibiotics, Q fever, bird flu), animal welfare, ammonia emissions, nutrient cycles, soybean imports and the disruption of cycles and biodiversity and the quality of the countryside due to large scale farms. A few years ago there were major problems with animal diseases, partly as a result of the high concentration of animals and the many animal transports over a small area. There is also a social debate on-going arising from the global climate change and food security. The world's population is expected to increase towards nine billion people in 2050 and a shift in the diet is expected to more animal proteins. As a result, as well as due to the use of biomass for the production of biofuels and other applications, the need for nutrients will increase further.

In April 2010 over a hundred Dutch professors published a plea for sustainable livestock farming. They believe that still little has been done with the recommendations of the Wijffels committee in 2001, which advised that intensive livestock farming had to be radically changed. Now over 250 professors have signed the petition and another 16,000 people have declared their support.

Further to this petition, the TCB finds that the current scale of intensive livestock farming produces such a large amount of animal manure that at the moment efficient management and efficient use of nutrients in farming in the Netherlands cannot be combined with this. The large flows of nutrients to the Netherlands are also not conducive to the sustainable use of soil elsewhere in the world. If people were to consume the cereals and the soybean that are now used as animal feed, then only 15 per cent of the current area of agricultural land would be needed to produce the same amount of protein[13]. Therefore, with the production of meat the area of fertile agricultural land that is available is being used inefficiently. A high consumption of meat also leads to world and local biodiversity being damaged, because in order to produce animal feed a great deal of land has to be used or has to be made available for crop production. By returning manure back to the land where the animal feed is produced[14], the nutrient balance could be restored and the quality of the soil in the production areas for animal feed could be maintained. The transport movements that go with this do, however, bring with them the associated disadvantages for the environment, such as emissions of CO_2 and air pollution. If the (forecast of the future) consumption of animal proteins does not change, the area of agricultural land needed for the production of animal feed will increase further.
The TCB therefore sees a number of arguments related to the sustainable use of soil for the need to reduce the size of the livestock population in the Netherlands. Moderating the consumption of animal proteins can contribute further to the sustainable use of soil.

PROSPECTS FOR THE FUTURE

Close the nutrient cycles in Europe

In the opinion of the TCB, the size of the livestock population should be a derivative of the amount of agricultural land in an area that is available for recycling the animal manure that is produced by the

[13] http://www.volkskrant.nl/archief_gratis/article992590.ece/Het_vlees_is_sterker_dan_de_geest

[14] Laan, L., 2009. De voer-mestkringloop, het sluiten van fosfaatkringlopen voor een duurzamere veehouderij (The feed/manure cycle, closing phosphate cycles for more sustainable livestock farming). Background document to support the implementation agenda "feed/manure cycle". Report further to work placement WUR. Ministry of Agriculture, Nature and Food Quality – Agriculture Directorate.

livestock. The size of the area is limited by the distance over which animal manure can be transported responsibly, both economically and ecologically. This creates a ceiling for the scale of livestock farming in the Netherlands and contributes to minimising nutrient losses. Technological developments may enable future scaling-up.

Sustainable livestock farming limits the number of worldwide transport movements of nutrients by using as much as possible animal feed produced in the region and by using, as much as possible, animal manure in the same area. The importing of raw materials for feed (produced sustainably elsewhere) in a production system based on closed cycles requires a world trade in animal feed and also animal manure or products of it. To make the trade in manure profitable, technological innovations are needed for the production of inorganic fertiliser substitutes from manure. At the present time these products cannot compete with inorganic fertilisers.

Data from Statistics Netherlands (Appendix 2) show that animal manure is not transported across borders of agricultural areas[15], or at least not sufficiently. The application capacity for nitrogen and phosphate in animal manure is exceeded in precisely those agricultural areas where a great deal of the animal manure is produced. Above all the costs of transporting animal manure limit the radius of action of the cycle. With a further development of manure treatment economically attractive products can be produced from manure that are more in agreement with the requirement that arises if precision fertilising is used more widely. A great deal of research has already been carried out into manure treatment. The opportunities for manure treatment increase if energy prices increase because the products can then better compete with inorganic fertiliser. Also a policy aimed at closing nutrient cycles and stimulating precision farming is favourable for the further development of manure treatment. At the moment the fertiliser replacement value of these products is not yet comparable with that of inorganic fertiliser. As a result, the environmental losses with the current products are too high, as a result of which they are not seen as inorganic fertiliser substitutes.

The radius of action for the transporting of manure could become wider, perhaps to the scale level of Europe, if products of manure processing become competitive with inorganic fertiliser. It is currently not clear what the optimum scale level is for closing the cycle. The TCB believes that the scale level of Europe is both economically and ecologically attractive. In economic terms the current infrastructure of the sector is already aimed mainly at the European market. In ecological terms, Central Europe has the space and a favourable climate for growing protein-containing crops.

Sustainable livestock farming uses as much vegetable and animal residual products as possible as animal feed. This contributes to a better utilisation of nutrients. But at present these products end up too much with the waste and as a result disappear from the agricultural cycle. Intensive livestock farming that is situated close to urban areas provides logistical advantages in this respect. Finally, the TCB also argues that nutrients should be extracted from human excreta to enable re-entering the nutrient cycles. Compared with the current situation in which hardly any nutrients are recovered, large benefits can be gained.

Also to keep nutrients in the cycle large innovations are needed, on several fronts. For example, there is limited availability of **phosphate** in the soil. To a great extent it is fixed in the soil and then 'disappears' from the agricultural cycle. It is well known that plant-associated bacteria in the soil can

[15] About 10,000 km², according the classification of Statistics Netherlands.

potentially dissolve and mineralise phosphate that is immobilised[16]. The use of bacteria like this can increase farming productivity and in part make inorganic phosphate fertiliser superfluous, but there are still many practical questions to solve. **Nitrate** will to some extent always discharge into the groundwater and the surface water, so-called unavoidable leakage losses. Limiting these leakage losses is still a great challenge. Important for being able to close cycles is separation at the source, where the manure is produced. This applies in the case of animal manure as well as human excreta. An *end-of-pipe* solution, whereby phosphate is recovered from waste water before it ultimately discharges into the seas and oceans, can also contribute. Once it is there, at present it can barely be recovered due to the low concentrations and the relatively fast precipitation. The great challenges and the considerable number of questions that have not yet been solved make the TCB call for a targeted knowledge development programme in the area of the closing of nutrient cycles.

At the beginning of 2008 the Minister for Agriculture, Nature and Food Quality presented her vision for the future of livestock farming[17]. In respect of *planet*, the minister sees a closed production cycle through the wide application of technologies. Feed/manure cycles are for the most part closed at the level of the farm, nationally or at the level of North-West Europe. Animal feed from outside the region is produced sustainably. The TCB supports this vision, which as this stage is formulated in abstract terms and has not been developed yet into a concrete policy. In order to arrive at a balanced assessment of the pros and cons of different scenarios for closing feed/manure cycles, the TCB needs quantitative data. On behalf of the Planbureau voor de Leefomgeving (Netherlands Environmental Assessment Agency), in 2010 Wageningen UR will carry out a study into options for closing feed/manure cycles in agriculture[18]. Based on facts and figures the study will examine what prospects for policy action there are for closing these cycles at various scale levels (the farm, regionally, the Netherlands, North-West Europe, the EU), also against the background of the worldwide scarcity of phosphate and energy. The TCB is looking forward with interest to the results of this study.

Economic and social costs and benefits

Various studies show that closing nutrient cycles will have considerable economic consequences. The LEI has calculated that[19], based on equilibrium in the manure market on the basis of the indicative application standards for 2015 from the 4th Dutch action plan under the Nitrates Directive, the number of livestock needs to fall by almost 20%. The balance from arable farming and livestock farming then falls by 15%, equivalent to 725 million euro (including concomitant costs). The income of dairy farms falls then by on average 12,800 euro per year. In the chain, among other things a fall of 39,000 jobs is to be expected. In this scenario the added value to the Dutch economy falls by 2.3 billion euro. Also, on behalf of *Vereniging Milieudefensie* (the Dutch branch of Friends of the Earth International) the LEI has investigated the economic consequences of shifting to more sustainable, more animal-friendly, smaller-scale and more extensive livestock farming[12]. Based on ammonia

16 Weyens *et al*., 2009. Exploiting plant-microbe partnerships to improve biomass production and remediation. Trends in biotechnology, 591-598.

17 *Toekomstvisie op de veehouderij* (Vision for the future of livestock farming). Letter of the Minister for Agriculture, Nature and Food Quality to the Lower House of 16 January 2008, reference DL 2007/3569.

18 *Project plan: Opties voor het sluiten van voer-mestkringlopen op verschillende schaalniveaus* (Options for closing feed/manure cycles at various scale levels). WOT project Nature and the Environment, commissioned by PBL, carried out by: Alterra, WUR.

19 Vrolijk, H., *et al*., 2010. *Economische gevolgen van een beperking van de veestapel, quick scan naar winnaars en verliezers* (Economic consequences of restrictions on the number of cattle; Quick scan regarding the winners and losers). LEI report 2010-020, project code 3190.

reduction as a limiting factor, the intensive livestock farming sector needs to decrease by 70%. The added value of the 'new livestock farming complex' then emerges as being some 3 billion euro less than now, while the number of jobs falls by 40,000. This is equivalent to about 0.5% of national income and national employment.

Against this substantial decrease in added value there is a considerable reduction in the social costs of livestock farming. In the new livestock farming, the problem of manure is solved. The operating costs of livestock farming as envisaged by Milieudefensie are about one billion euro a year higher than with the current system. A billion euro is a considerable amount, but is equivalent to about 0.8% of total tax revenues.

Biobased economy

The TCB wants to put world nutrient cycles in a wider perspective than simply that of agriculture. In view of the increasing world population, the disadvantages of the way in which food presently is produced, the finite nature of raw materials and the technical possibilities, a new perspective on plant production is needed. The concept of the *biobased economy* offers opportunities for a more efficient use of biomass. In a biobased economy the present use of fossil fuels is to some extend replaced by the use of biomass. In this concept biomass is a source of food, animal feed and energy, and also of many complex compounds that can serve as a raw material for, among other things, paint and adhesives, medicinal products, cosmetics and biomaterials. For example, sugar cane, which now above all is converted into ethanol, also contains raw materials for the bulk and fine chemicals industry. The multiple use of biomass means that first the components are used in high-value applications such as pharmaceuticals, flavourings and aromatic substances and food, and then the high-volume residual products are used for animal feed, fibres and energy. This multiple use of biomass, also called cascading, increases the efficiency of the use of biomass. Technical and economic innovations are needed before biomass will be used on a commercial scale in accordance with the cascading principle. The time horizon of this transition lies considerably further in the future than the scope of the current policy frameworks and instruments.

With the increasing use of biomass and the growth in the production of biomass, sustainable soil use and management and the closing of nutrient cycles are becoming even more important. If the nutrient cycle is closed, the soil can continue to provide biomass as a raw material to replace fossil raw materials. The TCB strongly recommends that knowledge be developed about the consequences of increasing biomass production for, among other things:

- the quality of the soil in the wider sense;
- the intensity of water and land use;
- the effects on land degradation and erosion;
- the further spilling of nutrients;
- the use of plant protection agents (which with *non-food* uses of biomass is no longer limited by food safety requirements);
- deforestation and threats to biodiversity;
- finite phosphate resources and the possibilities for closing nutrient cycles.

In an earlier advisory report on the effects of the production of biomass for energy[20], the TCB has already investigated this for soil quality in the Netherlands. The testing framework for sustainable

[20] Advisory report, Effecten productie biomassa voor energie op bodemkwaliteit in Nederland (The effects of the production of biomass for energy on soil quality in the Netherlands). TCB S07(2007), 19 March 2007.

biomass[21], which was drawn up in 2007 by the 'Cramer Commission' in the context of the policy developments concerning biofuels, applies to all biomass, regardless of its application. The testing framework can also be used for sustainable production of animal feed.

The wider perspective is about the global challenge about how and with what diet to feed a growing world population and the development towards a wider use of crops than only for food. In this perspective the TCB stresses that nutrients are precious commodities that we should not spill. We need to make maximum use of them. This requires considerable technological innovations.

CONCLUSION

The TCB notes that losing nutrients has been going on for many years. The regional surplus of animal manure is put onto and into the soil and as a result is lost for re-use in agriculture. In the Netherlands, excessive fertiliser application causes the quality of the environment and natural land to fall. Elsewhere, these losses lead to a reduction in biodiversity and the degradation of agricultural land. The size of the livestock population in an area should be brought in agreement with the application capacity for animal manure. For this reason the size of the livestock population in the Netherlands needs to be reduced.

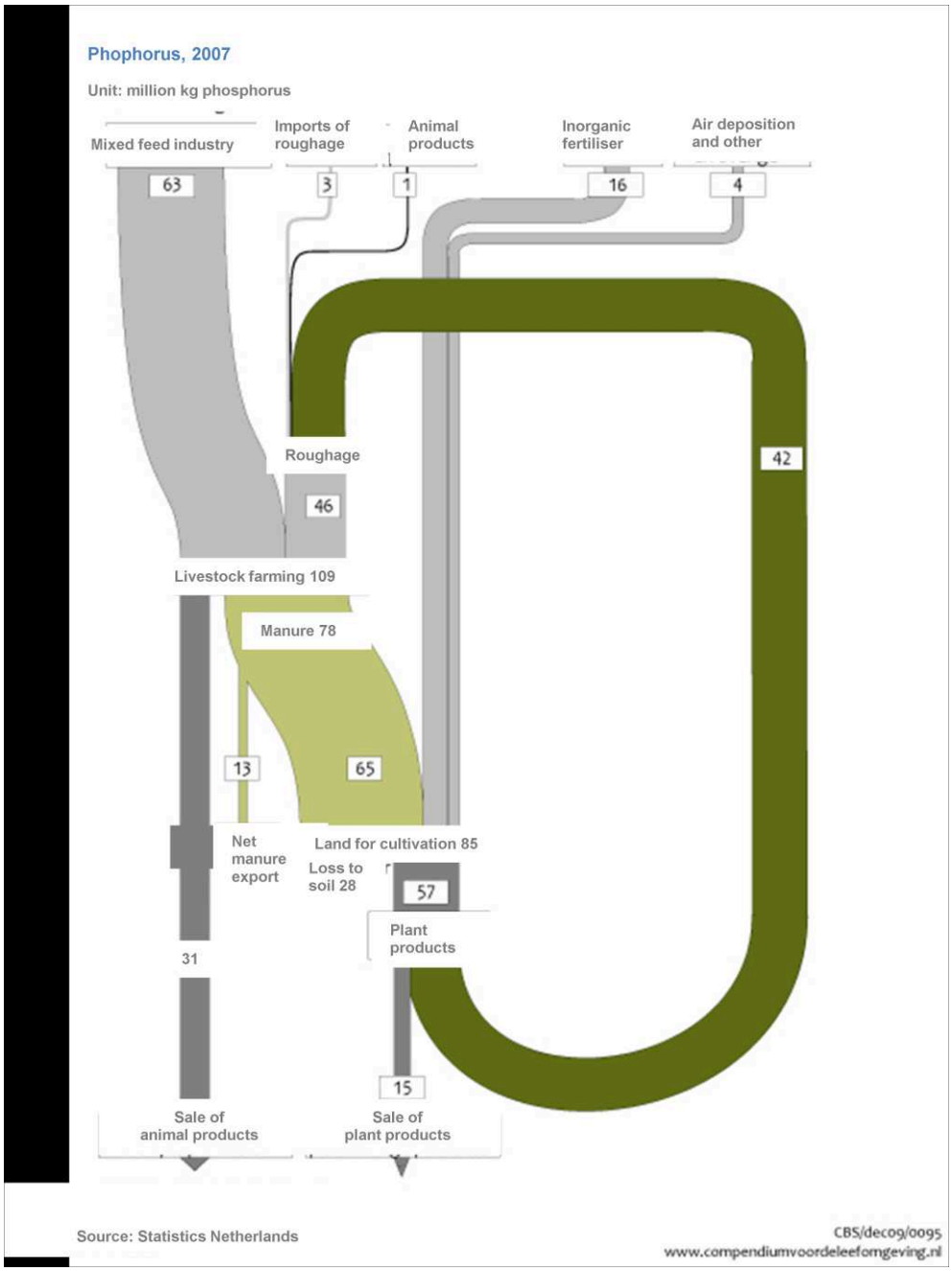
The transition to a biobased economy also means that nutrients have to be used sparingly. With the increasing use and production of biomass as a raw material, the importance of the soil and water system as an essential production factor for biomass is increasing. In order to be able to continue the production of biomass in the long term as well, it is essential to continue to make the use of soil more sustainable and through technological and economic innovations to close nutrient cycles as much as possible.

21 *Toetsingskader voor duurzame biomassa* (Testing framework for sustainable biomass). Final report of the project group "Sustainable production of biomass", on behalf of the Energy Transition Interdepartmental Programme Management Team, 2007.

APPENDIX 1

Balance of phosphorus in agriculture, 2007. *www.compendiumvoordeleefomgeving.nl*.

Large amounts of phosphorus enter agriculture mainly through mixed feed for livestock and inorganic fertiliser. It is removed via animal and plant products. Every year there is a surplus that loads the soil. After: Statistics Netherlands.



Explanatory notes to the flow chart

The flow chart shows a simplified presentation of the phosphorus flows that occur in agriculture. It describes the inputs, outputs and returns of phosphorus in agriculture. Based on this chart the amount of phosphorus can be calculated that accumulates in soil or is emitted to water(the surplus of phosphorus).

Input items

The input items are shown at the top of the flow chart. Phosphorus enters agriculture mainly via mixed feed and inorganic fertiliser. There are also some smaller input items: the import of roughage, animal products and an item "air depositions + other". In 2007, through all the inputs together, 87 million kg of phosphorus was imported into agriculture.

Output items

The two main output items are shown at the bottom of the flow chart: phosphorus leaves agriculture mainly through the sale of animal and plant products. There is also a third, smaller output item: "net export of manure". In 2007, through these three items together, 59 million kg of phosphorus disappeared from agriculture.

Return streams outside agriculture

Some of the animal and plant products re-entered agriculture through two return streams, which in part are outside agriculture (see next paragraph; these streams are not indicated in the chart). Some of the agricultural products (such as cereals) are supplied directly to the mixed feed industry, and some reach the mixed feed industry and the livestock industry through the food industry (waste that is produced during the processing of animal and plant products). A large proportion of each of these streams is re-used in agriculture as concentrates (the rest is exported or sold as animal feed outside agriculture).

Return stream in agriculture

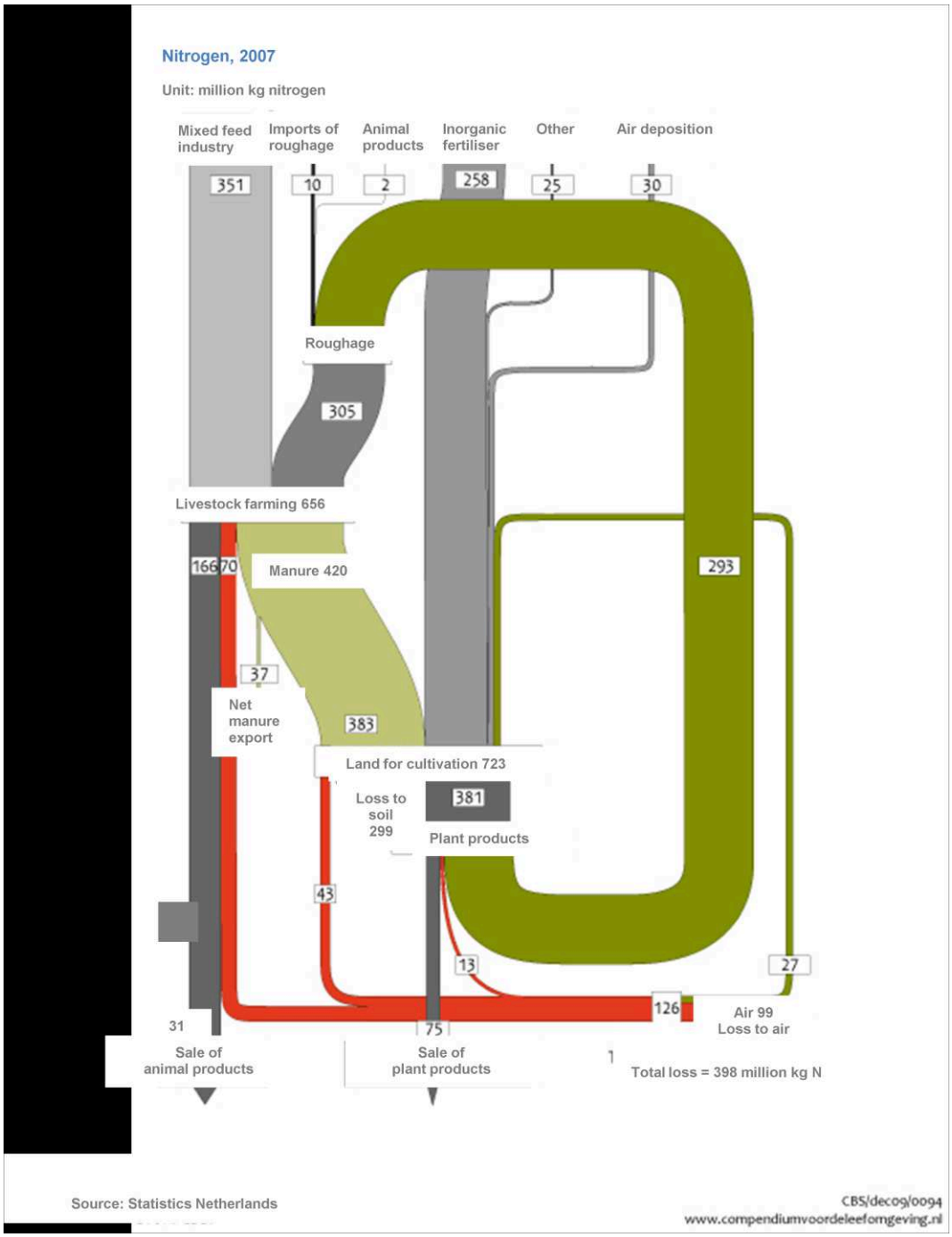
For phosphorus there is one return stream in agriculture: through crops such as silage maize and grass, phosphorus exported from agricultural land is imported into livestock farming as roughage (42 million kg of phosphorus).

Phosphorus surplus

The phosphorus surplus in 2007 was 28 million kg (inputs-outputs). This is equivalent to 64 million kg of phosphate. This surplus accumulates in the soil.

Balance sheet of nitrogen in agriculture, 2007. *www.compendiumvoordeleefomgeving.nl*.

Large amounts of nitrogen enter agriculture mainly through mixed feed for livestock and inorganic fertiliser. It is removed via animal and plant products. Every year there is a surplus that loads the soil and the air. After: Statistics Netherlands.



Explanatory notes to the flow chart

This flow chart shows a simplified presentation of the nitrogen flows that occur in agriculture. It describes the inputs, outputs and returns of nitrogen in agriculture. Based on this chart the amount of nitrogen can be calculated that accumulates in soil or is emitted to water and atmosphere (the surplus of nitrogen).

Input items

The input items are shown at the top of the flow chart. Nitrogen enters agriculture mainly via mixed feed and inorganic fertiliser. There are also some smaller input items: the import of roughage, animal products, air depositions and an item "other". In 2007, through all the inputs together, 676 million kg of nitrogen came into agriculture.

Output items

The two main output items are shown at the bottom of the flow chart. Nitrogen leaves agriculture mainly through the sale of animal and plant products. There is also a third, much smaller output item: "net export of manure". In 2007, through these three items, 278 million kg of nitrogen disappeared from agriculture.

Return streams outside agriculture

Some of the animal and plant products re-enter agriculture through two return streams outside agriculture (see next paragraph; these streams are not indicated in the chart). Some of the agricultural products (such as cereals) are supplied directly to the mixed feed industry, and some reach the mixed feed industry and the livestock industry through the food industry (waste that is produced during the processing of animal and plant products). A large proportion of each of these streams is used again in agriculture as concentrates (the rest is exported or sold as animal feed outside agriculture).

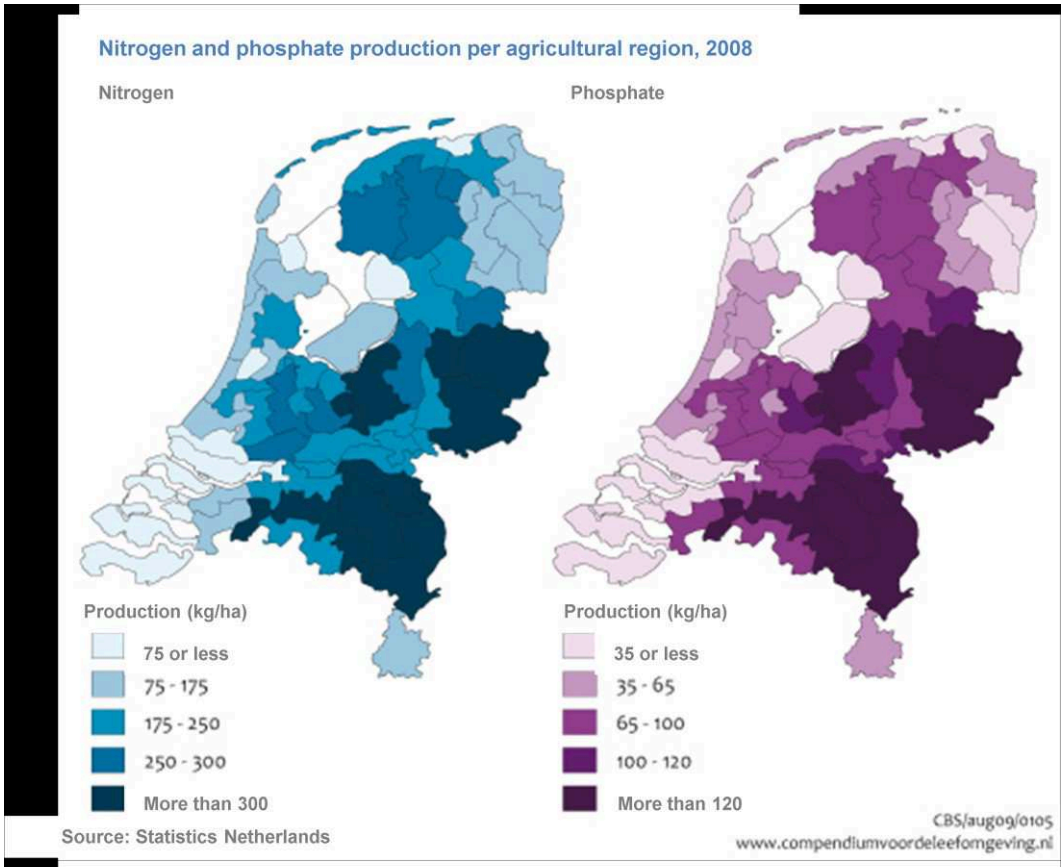
Return streams in agriculture

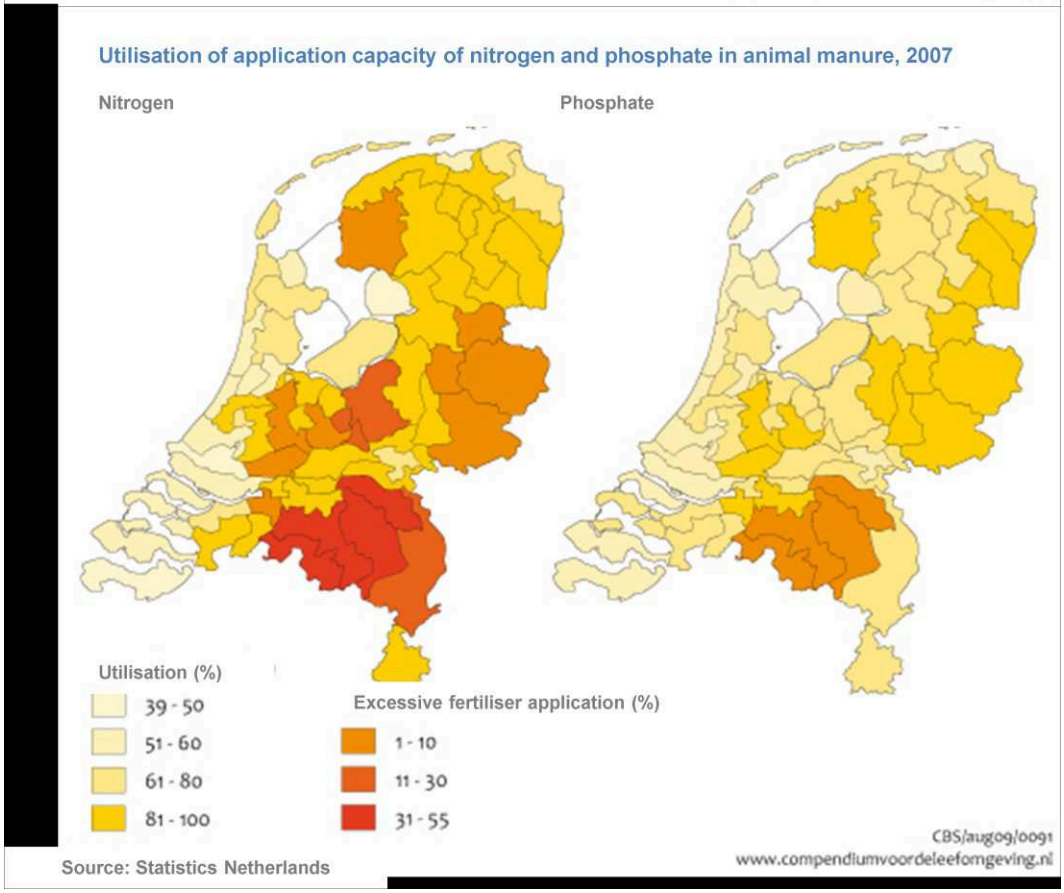
There are two return streams in agriculture. Through crops such as silage maize and grass, nitrogen exported from agricultural land is imported into livestock farming (293 million kg of nitrogen). A second stream is the deposition of evaporated ammonia (NH_3) onto agricultural land (27 million kg of nitrogen). This ammonia is produced during excretion and storage of manure, spreading of manure and inorganic fertiliser on agricultural land, and the preserving of crops (mainly silage maize)

Nitrogen surplus

The nitrogen surplus in 2007 was 398 million kg (inputs-outputs). Most of this accumulates in the soil (299 million kg of nitrogen). The rest evaporates, mainly as ammonia (99 million kg of nitrogen).

APPENDIX 2





After: Statistics Netherlands