Agriculture in the Netherlands

The Netherlands is situated in western Europe along the North Sea (Figure 1). The north-western half of the country is below sea level and has marine clay soils and peat soils with many polders, drainage ditches and canals. The other half has predominantly sandy soils (fluvio, glacial and eolian deposits). Climate is temperate (mean temperature 11°C), with rainfall equally distributed over the year (total rainfall ~800 mm per year).

Figure 1. The Netherlands with distribution of soil types

Evidence of early settlements (~5000 BC) has been found on elevated areas in the southern part of the country. Expansion to other regions was slow, probably because of the risk of temporarily flooding. Early settlements in the north and west were on artificial dwelling hills (so-called 'terps'). From the 10th century onwards, large parts of the coastal provinces (Zealand, Holland) were reclaimed from the sea and lakes by making polders, including the Green Heart (between the cities Amsterdam, Utrecht and The Hague/Rotterdam). Dikes and floodgates were created and accompanied by water authorities. Increased drainage also contributed to subsidence of peat and clay soils, which made cultivation increasingly harder. This problem in turn stimulated grain trade (15th century) and subsequently the trade of other commodities, which turned out to be highly beneficial for the economy and indirectly contributed to the so-called Golden Age. The newly earned funds were invested in further reclamations. In the middle ages, wheat production was 1500 kg per hectare on the calcareous clayey soils in Zealand, twice the yield from the loess and sandy areas around Maastricht (province Limburg)

Peat soils were increasingly exploited for use as fuel from the 17th century. This resulted in many shallow lakes in the western half of the country, which in part were drained, and the resulting polders with marine clay soils were used for agricultural land. Bogs in the north-eastern half were drained via canals and the underlying glacial sandy deposits were amended and also used for agriculture. Tobacco became an important crop in the south-west and the centre of the Netherlands and remained cultivated until Tobacco Mosaic Virus became common in the mid of the 20th century. Because of their high production potential and nutritional value, potatoes became increasingly important, but the great epidemics of potato late blight that started around 1845, caused by *Phytophthora infestans*, led to very significant crop failures in large parts of Europe including the Netherlands. Around 1900, average farms size was 15 ha and there were some 140,000 farms with 600,000 workers.

Around the end of the 19th century farming cooperatives were initiated by farmers for milk processing, but also for potatoes, insurances, and for mineral fertilizers. Affordable mineral fertilizers (potash fertilizers, superphosphate, lime) made nutrient input not merely dependent on application of animal manure, sewage sludge, ashes or sods. It made fallow no longer necessary and it allowed farmers to specialize in either crop production or animal production, especially after large-scale introduction of artificial N fertilizer from the 1950s onward. Changes in fertilizers and land use are shown in Figures 2 and 3, respectively.

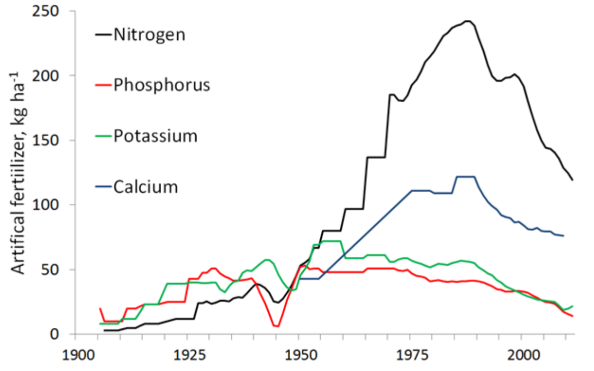

Figure 2. Changes in fertilizer use in The Netherlands between 1900-2010.

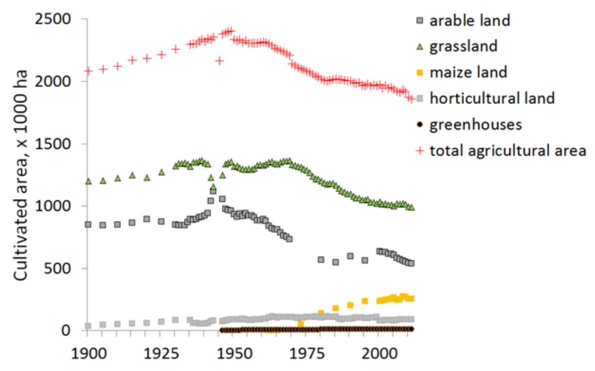

Figure 3. Changes in land use in The Netherlands.

From the 1950s, agriculture was increasingly influenced by the Common Agricultural Policy (CAP) of the European Union (formerly European Economic Community). The CAP focused on increasing agricultural production and encouraging agricultural intensification. Imports of cheap animal feed ingredients facilitated the intensification and specialisation of livestock production, and resulted in manure production rates exceeding crop requirements on many livestock farms, especially on sandy soils in the southern and eastern part of the country. Since then, these sandy soils have received the highest manure P loadings within Europe, resulting in a large build-up of soil P regionally.

Between 1950 and 1980 the number of dairy cattle increased by a factor of 1.5 and milk production per cow by a factor of only 1.2 (Figure 4). After the introduction of milk quota in 1984, number of dairy cattle decreased, while the milk production per cow increased strongly. The total national input in dairy farming increased from 8 to 153 million kg N year^{-1} via concentrates, and from 70 to 379 million kg N year^{-1} with mineral fertilizers, but the output in milk and meat increased only from 36 to 83 million kg N year^{-1}. Thus, the N surplus (import of concentrates, and fertilizers minus production with milk and meat) increased from 40 to 450 million kg N year^{-1}.

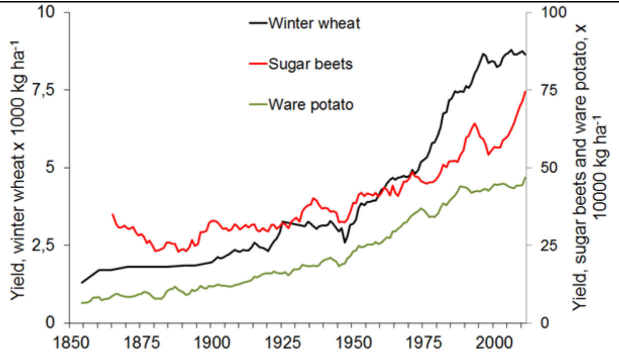

Figure 5. Changes in crop yields

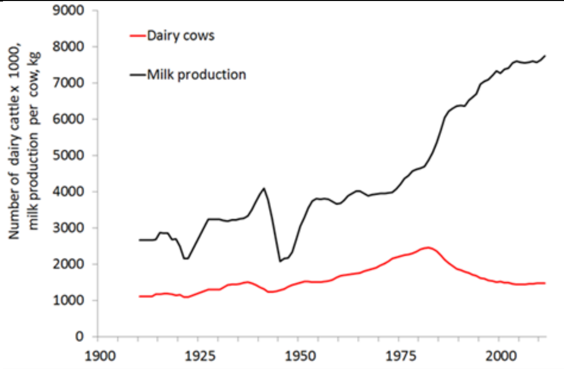

Figure 4. Changes in milk yield per cow and number of cows

The national N surplus for the whole agricultural sector increased to more than 700 million kg year^{-1} in the mid-1980s, with dairy farming as the primary source. In the period 1950 – 2000 on average 4000 kg P_2O_5 ha^{-1} was accumulated. However, surpluses decreased strongly from the mid-1980s onwards due to governmental regulations. In 1990 the surplus was >50 kg P_2O_5 ha^{-1} for both arable farms and dairy farms. Twenty years later, this surplus had decreased to < 20 kg P_2O_5 ha^{-1}.

Although the expansion of agricultural production has slowed down from the mid-1980s, The Netherlands is still a major producer and international trader of flowers, meat, meat product, fruit, vegetables, beer, dairy product, starch derivatives and seed. It ranks together with France on the second place on the list of exporters of agricultural products, behind the United States. Its production per hectare and per cow are among the highest in the world (Figure 5).

The intensification of agricultural production sketched above resulted in increasing environmental costs recognised by some scientists from the early 1970s onwards. The policy response came only in 1984, when the government introduced a policy with increasing restrictions and gradual tightening of manure and fertilizer application limits.

Manure policy and manure processing in NL; ‘learning by doing’

The first governmental policy measures regulating the use of animal manure and fertilizers date from 1984. The so-called *manure policy* was set-up with the idea of a step-wise tightening of restrictions on manure production and the use of manure and fertilizers. Initially, three phases were planned, namely (i) stop the growth of the animal production sector (1984 to ~1990), (ii) step-wise decrease of the manure burden (1990 to ~1995), and (iii) balancing inputs to outputs as regards N and P (~1995 to ~2000). The step-wise implementation of measures in the subsequent phases allowed farmers to adapt gradually to increasingly tighter environmental requirements and to adopt environmentally friendly production methods. Initially, there was a strong belief that the manure burden could be solved by technological innovations. This belief was partly based on the conviction that manure processing could produce marketable products (for export to other countries), partly also on the conviction that structural measures, i.e. a decrease in the number of livestock were politically not realistic.

The general aim of the manure policy in the Netherlands is to decrease the losses of N and P from agriculture to the environment (atmosphere, groundwater and surface waters) to environmentally acceptable levels. An important constraint is the socio-economic impact; the manure policy should not deteriorate the socio-economic strength of the agricultural sectors (too much). Further, the manure policy must be effective and efficient. In practice, the instruments of the manure policy have to realize three common aims at the same time:

1. On intensive livestock farming systems, the surplus amount of animal manure has to be transferred to farms that can accommodate this manure or it has to be (processed and) exported;
2. On farms that accept animal manure from other farms, N and P losses may not increase above environmentally acceptable losses, even when it is financially attractive to buy animal manure from other farms; and
3. On all farms, the N and P losses have to be decreased to environmentally acceptable levels, through a drastic improvement of N and P use efficiency.

The first phase of the manure policy (1984-1990) banned further growth of pig and poultry sectors. These sectors grew almost exponentially in the sixties, seventies and first half of the eighties, and initially the manure surplus was strongly associated with pig and poultry production. The ban on further growth of pig and poultry sectors coincided with the introduction of milk quotas in member states of the EU, to limit the growth of the surpluses of dairy products (notably butter) and thereby to limit the intervention costs for the EU. The implementation of the milk quota banned the growth of the dairy sector. As the milk quota decreased in subsequent years while the milk production per cow continued to increase, the number of dairy cows started to decrease for the first time. During the first phase limits were also implemented for the application of animal manure to agricultural land, based on the amount of P in the manure. Initially, these limits were much higher for maize land (350 kg P_2O_5 per ha per year) than for grassland (250 kg P_2O_5 per ha per year) and arable land (125 kg P_2O_5 per ha per year). These initial limits reflected where the pressure of the manure burden was highest. The first phase of the manure policy is further characterized by the belief that the manure surplus can be solved by technological innovations. Various pilot plants were set-up to explore the possibilities for manure processing and initiatives were made for marketing processed manure abroad. Most of these initiatives failed, except for those concerning drying and pelletizing poultry manure for export to surrounding countries.

The second phase (1990-1998) can be characterized by (i) lowering of the application limits for P in animal manure, (ii) restrictions on the timing of manure application and the resulting requirement to take care of sufficient storage capacity for animal manure, (iii) implementation of various measures to decrease NH_3 emissions, and (iv) further facilitation of manure distribution and manure processing. The application limits for animal manure were lowered step-wise, e.g. for maize land from ~350 kg P per ha per year in 1987 to 200 kg P per ha in 1991 and to ~100 kg P per ha in 1998. Because of the rather fixed ratios between

N and P in animal manure, the amounts of N in animal manure decreased also step-wise. Restrictions on the application of animal manure in autumn and winter forced farmers to build facilities for storing animal manure for up to 6 months. Further, agreements were made between farmers organizations and the suppliers of animal feed to lower the phosphorus and protein contents of the animal feed and thereby the P and N excretion of the animals. Finally, the transport of animal manure from areas with a large surplus to areas with a potential demand for manure was subsidized and facilitated, to decrease the environmental burden in the areas with intensive livestock production.

The second phase of the manure policy coincided with the start of the so-called ammonia policy. During the second half of the 1980s, there was increasing awareness that NH_3 emissions from animal manure contributed to acidification of lakes and soils and to 'forest dieback'. The policy decision by the end of the 1980s to decrease the total NH_3 emissions from agriculture in 2000 by 65-70% relative to 1980 led to various regulations, including the requirement to cover all manure storage facilities, to apply animal manure to land via injection into the soil or via immediate incorporation into the soil following surface spreading, to build low-emission animal housing systems when old ones had to be replaced, and to lower the protein content of the animal feed.

The third phase started with the implementation of the nutrient accounting system MINAS at farm level in 1998 (3 years later than initially planned, and starting with a much lower ambition level than initially planned), following consultation between the agricultural sectors and the Government. This phase was meant to solve the remaining nutrient surpluses at once. This phase also marks a change in understanding and policy. Technological innovations were no longer seen as the main solution for the manure burden. The insight grew that a drastic improvement of nutrient management would be needed to decrease N and P losses at farm level to environmentally acceptable levels. The third phase also marks a change from a policy that was largely based on regulations to a policy that is partly based on economic stimulations. The nutrient accounting system MINAS basically is a farm-gate input-output balance for N and P, with financial charges on the N and P surpluses when the N and P surpluses exceeding some target levels (so called levee-free surpluses). MINAS was seen as a flexible instrument that would be able to address the large differences between farms in environmental performance. MINAS was also seen as a key instrument to implement the EU Nitrates Directive, which was approved in 1991. However, the European Commission has criticized the NL government from the 1990s onwards for insufficient (delayed) implementation of the Nitrates Directive. Notably, they criticized the lack of application limits for N from animal manure and the lack of specific prescriptions and regulations for the use of animal manure and fertilizers. Following the decisions of the European Court and the European Commission in 2003, the NL government implemented crop and soil specific N fertilization standards by 2006, which are tightened step-wise until the environmental targets have been achieved by 2015. At the same time, MINAS was abandoned.

The 'current' manure policy is based on five pillars, namely (i) application limits for animal manure (170 kg N per ha per year; 250 kg per ha grassland in case of derogation), (ii) crop and soil specific N and P application limits, which are lowered step-wise until the targets of the Nitrates Directive and the Water Framework Directive have been achieved, (iii) manure-specific N fertilizer replacement values, which indicate the fraction of total N in animal manure that is as available as mineral N fertilizer, (iv) obligations to process (export) animal manures for livestock farms with insufficient land to accommodate all manure within the set limits, and (v) various restrictions and regulations on the timing and method of manure and fertilizer applications and storage, and on the use of cover crops and land use change.

From 2014, all intensive livestock farms with insufficient land to accommodate all animal manure produced on the farm are obliged to process a fraction of that manure. The fraction ranges from 10 to 50% depending on the region of the farm. These obligations are tradable between farms. Hereby, manure processing is defined as 'the export of manure phosphorus out of agriculture in the Netherlands'. Manure is only processed if the phosphorus in the manure is exported to other countries and/or if the manure phosphorus is transferred into fertilizer phosphorus (special defined fertilizers). Hence, separation, ultrafiltration and reverse osmosis is counted as manure processing when phosphorus in the end products is exported.

Monitoring results indicate that the manure policy has been effective in decreasing nutrient losses from agriculture to the environment. Mean nitrate concentrations in the upper groundwater of nitrate leaching sensitive areas have decreased from an average of ~150 mg per litre in the early 1990s to a mean of ~60 mg per litre in 2010. Similarly, total ammonia emissions to the atmosphere have decreased by ~50% between 1990 and 2005. The mean phosphorus application via animal manure and fertilizer has decreased from ~85 kg P per ha in 1990 to 45 kg P per ha in 2005. The variations between farms in N and P applications per unit area of agriculture land have also decreased greatly; dumping of excess manure on small areas of agricultural land has been abandoned.