



World Bank Regional Agricultural Pollution Study

Manure Management: An Overview and Assessment of Policy Instruments in the Netherlands

2017



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FOREWORD

Between July 2015 and December 2016, the World Bank conducted a regional study of agricultural pollution in East Asia with a focus on China, Vietnam, and the Philippines, in cooperation with each country's ministry of agriculture. This effort aimed to provide a broad overview of agricultural pollution associated with farming at the regional and national levels: its magnitude, impacts, and drivers, and what is being done about them. It also sought to outline potential approaches to addressing these issues going forward. In doing so, the study examined how the structural transformation of the agricultural sector and the evolving nature of agricultural production are shaping agricultural pollution issues and mitigation opportunities. It also identified knowledge gaps, pointing to directions for future research. Ministries of agriculture and environment are the study's primary audience. Its secondary audience consists of development organizations, industry associations, and other actors with an interest in sustainable agriculture and environmental protection.

The study constitutes the totality of the work and includes multiple components, including national overviews of agricultural pollution for the three focus countries, thematic working papers, and an overall synthesis report. The present working paper corresponds to a case study on manure management policy in the Netherlands. An earlier version of this report was circulated for comment to the Dutch ministry of agriculture for feedback. It was finalized by addressing comments received from the ministry and with the help of the World Bank task team.

SUMMARY

This working paper provides an overview and assessment of Dutch manure management policy instruments from 1984 to 2016. The most successful and cost-effective measures have included restrictions on manure spreading, the creation of a national Manure Bank as an offtake of last resort, the requirement to inject manure into soil, support for flagship farms, and limits on farm size managed under the Mineral Input Registration System. The various quota systems that have been implemented have proven costly for industry and the public sector alike, but have prevented livestock numbers and related pollution problems from increasing further. Ever stricter limits on the application of manure to soil, for example, have imposed costs but shown positive results. Applications of manure nitrogen decreased from 447 kg/ha in 1980 to 326 kg/ha in 2010, and applications of manure phosphate decreased from 160 kg/ha to 84 kg/ha over the same period. Dutch manure management policies have generally increased farmers' incentives to seek valuable uses of manure. At the time of writing, for the average pig farm with no land, manure disposal accounts for around 9 percent of total production costs (€0.13 per kg of pig meat), making other options such as processing manure into fertilizer more attractive. Despite this, pig production has remained stable and exports have continued to grow. The costs of manure policy to the public sector have also been relatively high, with monitoring, enforcement, and registration averaging around €900 per farm per year. Part of the effectiveness of Dutch manure policy has been owed to its incrementalism. Restrictive measures have generally been designed to increase in stringency over time and allowed industry to adapt. Dutch manure policy has, however, cost the life of many of the country's less-efficient farms. The number of pig farms in the Netherlands decreased from 34,000 in 1984 to 5,000 in 2015. Lessons learned include the effectiveness of gradually tightening standards, using combinations of sticks and carrots, and regularly evaluating policies. Promising approaches include the coupling of land and animals, and manure processing.



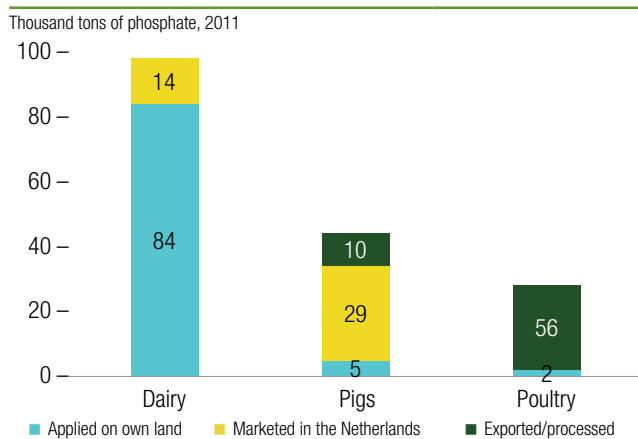
SETTING THE STAGE

While 90 percent of the population of the Netherlands lives in urban areas, as much as 70 percent of the country's land area is used for agriculture. Animal production is of prime importance in the agricultural landscape, mostly managed in relatively large and technology-intensive production units: about 99 percent of the pig and poultry population and about two-thirds of the grazing livestock population are found on holdings of 100 animals or more. Animal densities are among the highest in the world. The number of pigs per km² in Europe equals 38, compared to 55 in China and 6 in the United States. Comparing the Netherlands, Henan Province, and Iowa, being "hotspots" in Europe, China, and the United States, the number of pigs per km² in the Netherlands equals 356, compared to 267 in Henan and to 107 in Iowa.

The geographical concentration of animals for which nutrition highly depends on imported feed has led to significant nutrient management and overloading problems. Phosphorus is a key micronutrient for optimizing pig growth. But 70 to 80 percent of the phosphorus ingested in feed is excreted by the animal and ends up in manure. Phosphorus from manure applied to crops and pasture can accumulate in excess of the plants' and soil's assimilative capacity, with the potential to reach and pollute water resources through soil leaching or runoff.

Dairy farms accounted for 58 percent of total phosphorus excretion in 2011, compared to 26 percent and 16 percent for pigs and poultry farms, respectively. Manure from dairy farms is mainly applied on land belonging to the same production unit. Pigs and poultry, in contrast, are usually housed indoors on landless farms, with a limited fraction of their manure being applied to the farm's own agricultural land. Poultry manure is mainly processed or exported. Two-thirds of pig manure are marketed to Dutch crop farmers, while more than one-fifth is exported outside the country (Figure 1).

Nitrogen poses similar issues. By the early 1990s, the natural environment's capacity to assimilate nutrients had largely been exceeded in large parts of the Netherlands, with average nitrate concentrations in upper groundwater in sandy areas equal to 140 mg/l in 1992. Nitrogen application increased from 332 kg/ha in the 1970s to

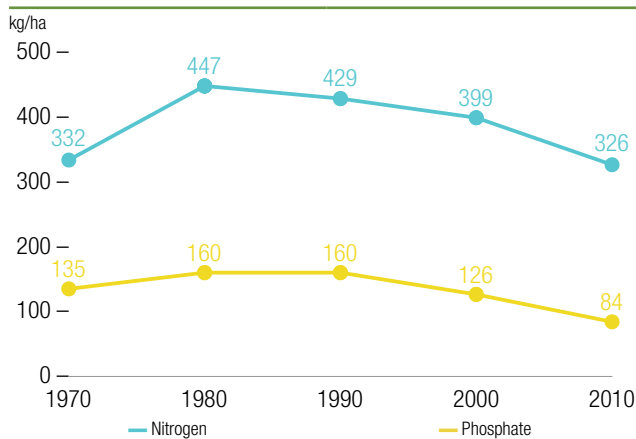
Figure 1. Application of manure in the Netherlands

Source: CBS Statline 2016.

peak at 447 kg/ha in the 1980s. By that time the sense of urgency had increased to a level that created the impetus to intervene.

Over the past three and a half decades, the government and private sector have progressively put in place a range of policies and technical production measures to address the issue. Some policy measures have been successful; others have had mixed results or turned out to be ineffective. It is difficult to assess to what extent each specific measure has contributed to the gradual decrease in the levels of phosphate and nitrogen applied on Dutch land that has been observed since 1980. It is however clear that the environmental burden has been reduced markedly: nitrogen application decreased from 447 kg/ha in 1980 to 326 kg/ha in 2010, and phosphate application decreased from 160 kg/ha in 1980 to 84 kg/ha in 2010 (Figure 2, see also van Boheemen 2006).

These environmental efforts were made while maintaining the economic performance of the sector: pork exports grew from 778 million kg in 2000 to 819 million kg in 2010, and to a record 944 million kg in 2015;¹ out of a relatively stable population, the number of pigs has been stable over the past 15 years: there were 13.1 million pigs in 2000, 12.3 million in 2010, and 12.6 million in 2015.²

Figure 2. Phosphate and nitrogen application on Dutch land

Source: CBS/RIVM (2004 and other years).

This working paper reviews three decades of public sector interventions in the Netherlands aiming at addressing manure-management-related pollution problems while maintaining the competitiveness of the industry. It also discusses how the private sector has contributed and adapted to the changing policy environment.

1 <https://www.cbs.nl/nl-nl/nieuws/2016/19/recordhoeveelheid-varkensvlees-uitgevoerd>.

2 <http://www.agrimate.nl/SectorResultaat.aspx?subpubID=2232§orID=2255>.



POLICY INSTRUMENTS FOR MANURE MANAGEMENT³

2

Environmental policies targeting livestock holders and crop farmers take into account environmental as well as producer and consumer costs and benefits.

Governments generally consider the environmental benefits of a policy alongside its consequences for farm incomes and household food expenditures. Part of these reflect how producers respond to a policy, that is, whether they passively comply, proactively engage in its implementation, or even go above and beyond.

Six types of manure policy instruments have been introduced aimed at regulating total number of animals, setting standards for manure application, coupling land and animals, nutrient management, inducing new technology, and supporting farm-level measures. The manure policy instruments can be grouped into three categories: (a) regulatory mandates or command-and-control instruments, (b) market-based instruments, and (c) educational instruments. While regulatory mandates can only be put in place by public authorities, market-based and educational interventions can be spearheaded by either the public or private sector. Companies can hold sway over their suppliers and customers, and can also resort to collective agreements (Table 1).

Dutch manure policy began with the Interim Law on Pigs and Poultry in 1984. In decades that followed, several other laws were introduced. Progressively, farmers were required to keep records of the number of animals on their farm as well as on their production, management, and use of animal manure and fertilizers.

3 A single English language report describing Dutch manure policy instruments is lacking. A few selected references with descriptions of one or more instruments are provided here:

- <https://www.holanda.es/media/52510/present.%20h.%20smit%20pdf.pdf>
- <https://library.wur.nl/ojs/index.php/njas/article/viewFile/416/134>
- Grinsven et al. 2005, 389–410.
- http://www.livestockdialogue.org/fileadmin/templates/res_livestock/docs/workshop/2012_24_April_Seoul/26_Mulleneer.pdf
- http://www.envtn.org/uploads/Dutch_trading_text.pdf

Table 1. Classification of Dutch manure policy instruments (1984–2016)

Policy instruments	Command-and-control	Market-based	Educational
Regulating total number of animals	<ul style="list-style-type: none"> • Interim law on pigs and poultry 	<ul style="list-style-type: none"> • Levy-based phosphate production rights • Tradable manure production rights • Pigs and poultry production rights • Buy-out-scheme 	
Application standards	<ul style="list-style-type: none"> • Maximum rates phosphate/ha • Application limits manure and fertilizer • Seasonal restriction manure spreading 		
Inducing new technology	<ul style="list-style-type: none"> • Compulsory manure injection 	<ul style="list-style-type: none"> • Mandatory manure processing • Conditional 30% Mineral Input Registration System (MiAR) reduction 	
Nutrient management		<ul style="list-style-type: none"> • Nutrient accounting and management system • Annual Nutrient Cycling Assessment (ANCA) 	
Coupling land and animals		<ul style="list-style-type: none"> • Manure transfer contracts • Land relation expansion dairy farms 	
Supporting measures		<ul style="list-style-type: none"> • National manure bank • Subsidies manure storage 	<ul style="list-style-type: none"> • Flagship farms

Source: Backus, G.B.C.

Feed companies were also required to provide data to authorities on the content of feed. What follows is a brief description of 18 manure management measures that were adopted by the government between 1984 and 2016.

Regulating the size of the livestock population

(1) Interim Law on Pigs and Poultry (1984–1986)

In November 1984, the Interim Law for the Restriction of Pig and Poultry Farms came into (sudden) effect. This law prohibited the development of new pig and poultry farms and limited the expansion of existing ones. This is not, however, what it achieved. Many building permits had already been obtained at the time the law came into effect, and many farmers made sure to use these in anticipation of a tightening of policy. As a result, the national pig herd increased by

30 percent in the three years that followed the Interim Law's implementation. Mineral surpluses continued to increase, forcing the government to further intervene a few years later.

(2) Levy-based cap on farm-level phosphate production (1987–1998)

Under the 1986 Manure Act, each farm was required to calculate its rate of manure production in phosphate terms using a so-called manure account, to serve as an annual baseline. This reference level was obtained by multiplying the number of animals held on the farm on December 31, 1986, by a phosphate excretion coefficient for each animal species. The Manure Act made it illegal for farms to produce manure that would put them above an annual manure-to-land ratio of 125 kg P₂O₅/ha based on land either owned or under long-term lease. An important exception was provided to existing farms that had a higher ratio on the reference date, but these farms were (a) not permitted to produce more manure than their reference level and (b) required to pay a levy of €0.11 per kg of phosphate

above 125 kg/ha and €0.23 per kg of phosphate above 200 kg/ha starting in May 1987.

Existing or new farms with a manure-to-land ratio of less than 125 kg of phosphate per ha (“manure deficit” farms) could increase their herd size until this level was reached. Farms with a manure-to-land ratio of over 125 kg of phosphate per ha (“manure surplus” farms) could not. They could increase the size of their herd after acquiring enough additional land to reduce their ratio below 125 kg of phosphate per ha. They could also increase their manure reference level. However, the manure reference level was not tradeable and was only transferable under certain strict conditions (marriage or heritage or the transfer of the complete farm). Pig and poultry farmers were also given the opportunity to show, through the MiAR, that the given manure coefficients were higher than what their animals actually excreted due to an improved feeding regime. While farmers were not given the opportunity to recalculate or modify their reference level, tailored coefficients could be used to bring down the amount of manure subject to levy.

(3) Tradable manure production rights (1994–1997)

In January 1994, the levy-based cap on farm-level phosphate production was replaced by a quota trading system. The system was introduced to allow farmers to expand their farm—and to incorporate new technologies—by purchasing quotas from retiring farmers. To signal the change in policy, farm manure reference levels—still expressed in phosphate terms—were renamed “manure production rights.” Program rules were designed so as to either prevent an increase or encourage a decrease in environmental pressure as a result of trading.

Farms were given two types of quotas, expressed in phosphate equivalent: a land-based quota (derived by multiplying the hectares farmed by 125 kg of

phosphate) and a non-land-based quota (the remainder of phosphate excretion).⁴ Trading was only permitted for the non-land-based quota. Manure production rights allocated for cattle and turkey production could not be purchased for pig and poultry production; however, manure production rights allocated for pig and poultry production could be purchased for cattle production.

To account for the existence of “inactive” rights, farms’ phosphate production levels (from manure) were reassessed for the years 1988–1990 using the same methodology (number of animals × given coefficients). This did not change farms’ manure production rights. But if the initial reference level was greater than the highest level reached in 1988–1990, the difference between the initial reference level and the highest level reached in 1988–1990 was not tradeable.

(4) Pigs and poultry production rights (1998–)

As restrictions on the application of manure to land became more stringent, there was a growing need to reduce the overall volume of manure being generated. In September 1998, the Pig Farming Restructuring Act came into force, replacing production rights for pig manure with production rights or quotas, based on the actual number of pigs and poultry on each farm in 1995 or 1996. These were based on the capacity of each farm. The government also wanted to lower the volume of manure produced to reduce the incentive for fraudulent behavior, especially in the pig sector where manure surpluses were the largest. In an attempt to eliminate the total amount of surplus manure—that is, manure above the rate deemed sustainable—the government passed a number of measures. For example, it passed an across-the-board, 25 percent reduction in pig production rights; withdrew additionally a percentage of retiring farmers’ production rights; and bought pig production rights from farmers. However, pig farmers expressed their hostility to these and took the government to court.

⁴ To illustrate how this quota system functioned, assume a pig farmer had 2,000 fattening pigs. Having one fattening pig was equal to a quota of 7.4 kg of P_2O_5 per year. So a farmer with 2,000 fattening pigs had a total quota of 14,800 kg of P_2O_5 . For a farmer with 10 ha of land, the part of this quota that was considered land-based would be equal to $10 \text{ ha} \times 125 \text{ kg of } P_2O_5/\text{ha} = 1,250 \text{ kg of } P_2O_5$, the rationale being that applying up to 125 kg of P_2O_5 per ha does not represent an environmental pollution problem.

A lengthy legal battle ensued during which time the measures were not applied. In January 2000, the court ruled that the government could introduce animal-based production rights for pigs and implement a generic 10 percent reduction in those rights (instead of the scheduled 25 percent reduction). Manure production rights were also converted to animal-based rights for the poultry sector in 2001. Manure production rights (in phosphate terms) continued to apply to cattle and sheep farms.

(5) Buy-out scheme (2000–2002)

The purpose of the buy-out scheme was to reduce the manure surplus by giving pig, poultry, and fattening calf farmers an opportunity to close their operations in a socially acceptable way. The adoption of manure management policies placed an increasing administrative burden on farmers, and this proved challenging for many elder farmers. Many were located near villages, and villagers were vocal about the odor. As a result, many farmers started considering an exit from pig and poultry farming. Under the program, the government (with financial support from the regional government) offered farmers a lump-sum payment equal to the replacement value of their livestock and part of the cost of breaking down the stables in an environmentally responsible manner. In total, €250 million was spent by the national government during the two years during which the scheme was in place. The total purchase of animal production rights by the government was equivalent to 55 percent of the estimated national manure surplus in 2003 (van Vliet and Ogink 2004). Animal production rights on pig farms were thus reduced by 18 percent in 2004 (Statistics Netherlands CBS). In addition, provinces designed the so-called “space for space” rule. Under this rule, farmers who joined the national buy-out scheme received additional subsidies for the demolition of farm buildings. The buy-out scheme and the “space for space” rule together led to a clear decrease in the Netherlands’ manure production.

Regulating manure applications

(6) Maximum applicable rates for manure phosphate (1986–2005)

The Soil Protection Act of 1986 authorized restrictions on the quantity, timing, and method of manure application. The application of manure was limited to amounts equivalent to 250 kg of phosphate per ha for grassland, 350 kg per ha for green maize, and 125 kg per ha for all other arable crops. These standards were then to be reduced in four steps to meet the requirements of the European Union (EU) Nitrates Directive. Average phosphate applications on grassland in sandy areas had decreased from 160 kg in 1993 to 80 kg in 2014, and in clay areas from 132 kg in 1993 to 85 kg in 2014.⁵

(7) Application limits for manure and fertilizer (2006–)

The tightening of caps on manure application rates resulted in the price of manure becoming negative. Livestock farmers had to pay crop farmers to take their manure. The total annual costs of manure disposal increased from €42 million in 1990 to €192 million in 2000 and to €274 million in 2007 (CBS). To prevent animal manure being replaced by fertilizer, application limits for phosphate (1986–2005) were extended to both manure and fertilizer sources in 2006.⁶

(8) Seasonal restriction on the spreading of manure (1991–)

In an effort to reduce water pollution, the government put in place restrictions on the time of year when manure can be spread onto grassland and arable land. Rules vary for different types of manure and soil. The season for spreading manure is winter (initially the period was October 1 to February 1; at the time of writing, it was September 1 to February 16

5 <http://www.agrimatie.nl/ThemaResultaat.aspx?subpubID=2232&themaID=2282&indicatorID=2773>.

6 In 2006, the European Commission allowed the Netherlands to adopt a higher application standard of 170 kg of phosphate per ha from grazing animals on farms with at least 70 percent grassland. The derogation was coupled with a phosphate production ceiling for the Dutch livestock sector equal to the 2002 level of 173 million kg (<http://www.clo.nl/indicatoren/nl010614-stikstof-en-fosfaat-in-mest>).

for grassland and August 1 to February 1 for arable land). This rule induced livestock farmers to invest in manure storage facilities. Currently, every livestock farm must have manure storage capacity for at least six months. Yearly investment in manure storage facilities increased from €20 million in 1991 to €45 million

Figure 3. Manure injector



Source: RPW de Jong. Photo copyright https://www.shutterstock.com/nl/image-photo/injection-liquid-manure-spreader-netherlands-201403241?src=b7ysR3bEZZ_twztAqeBIMg-1-2.

in 1992 and to €90 million in 1996. From 1996 onwards, after having built up a sufficient total volume of manure storage, annual manure storage investments were equal to €35 million.

Supporting the adoption of new technology

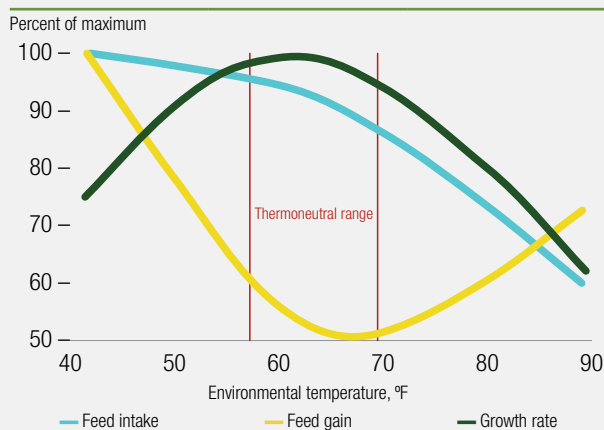
(9) Compulsory manure injection (1992–)

Injecting manure into the soil is a means of reducing ammonia emissions. Since 1992, it has been compulsory to inject all manure that spread on all grasslands and sandy soils or plough fields within 24 hours of application. Manure injection requires an important investment in equipment. As a result, annual cost of manure injection increased from €4 million per year in 1990 to €22 million in 1992 to reach a stable level of €30 million in 1997 and

Box 1. Farmers' reactions to environmental measures: ammonia emissions and odor control

Sensor technology and information and communication technology (ICT) are among the technologies that enable farmers to optimize indoor climate, and thus also reduce the need for end-of-pipe technologies such as air washers.

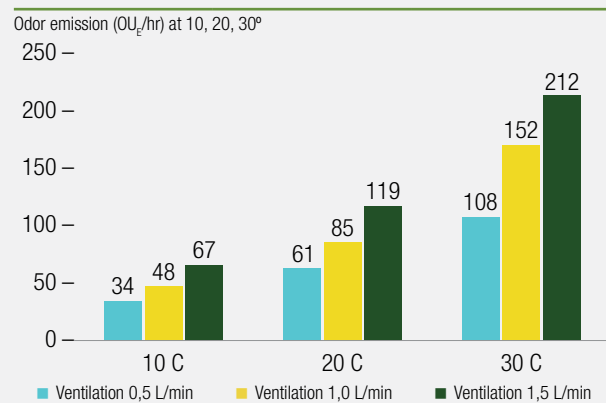
Figure 4. Effects of ambient temperature on growing-finishing pig "performance"



Source: Coffey, Parker, and Laurent 1995.

Note: Within the thermoneutral zone the feed gain ratio (kg feed / kg weight gain) is lowest, and thus feed utilization optimal.

Figure 5. Effects of ambient temperature on odor



Source: Calculated on the basis of Le et al. 2005 (table 3, p.761).

continued on next page

Box 1, continued

The climate within pig and poultry barns influences both farm-level productivity and emissions to the environment. Climate control aims to keep the temperature in the barn within the thermoneutral zone to optimize animals' feed intake and daily weight gain. When the barn is too hot, animals reduce their feed intake and may be stressed. When it is too cold, animals require more feed to maintain their body temperature (see Figure 4).

Air washers have traditionally been used to reduce the ammonia and other odor emissions of pig and poultry barns. These do this effectively, but are a costly technology and exert no control over the climate conditions that favor ammonia emissions and odors in the first place. Ventilation and temperature are major control variables to optimize the climate in the barn (see Figure 5). In pig barns, for example, lowering the indoor temperature from 21°C to 19°C results in a 14 percent lower ammonia emission rate (Aarnink, Smits, and Vermey 2010).

Livestock farmers are searching for technologies that reduce ammonia emissions and odors using climate control. Many see this as a way to invest in local community relations. Two alternatives have been developed for use on farms: cooling pads and heat cold storage. Evaporative cooling pads are used to reduce incoming air temperatures. Heat cold storage makes use of a heat recovery ventilator (heat exchanger) together with a ground source heat pump. During winter months the incoming air can be heated, and during summer months the incoming air can be cooled. Sensor technology and ICT enable real-time climate monitoring and control. Under Dutch climatic conditions and prices, the payback period for these two technologies ranges from 3.9 years (pad cooling on new/existing buildings) to 4.3 years (heat cold storage on new buildings). A faster adoption of these technologies could be stimulated by investment subsidies for existing buildings.

onwards (CBS Statistics Netherlands). The necessary equipment is highly visible, making monitoring and enforcement of manure injection relatively easy (see Figure 3). Benefits are more efficient nitrogen use and less use of fertilizer.

(10) Conditional, 30 percent reduction in non-land-based manure production rights (1996–1997)

In 1995, the government announced a 30 percent reduction in the non-land-based manure production rights for pig and poultry farmers. This measure was taken up because a new kind of compound feed became available. This feed had lower phosphorus content and could reduce animal phosphorus excretion. The new feed cost 1.6 percent more than regular feed (van Wagenberg and Backus 1997). The 30 percent reduction was waived for farmers able to demonstrate that they were using lower-phosphate feed (with at

least 30 percent lower phosphate content), through the MiAR.

(11) Mandatory manure processing percentages (2013–)

In 2013, a law was adopted to induce manure processing and to help manure processing facilities reach profitability. It prohibits farmers from producing more manure than they can apply to their land. If farmers produce more manure, they are required to either process or export it. The percentage of manure that farmers are required to process is set to increase over time, to incentivize livestock farmers to build farm-level processing facilities or to sell their manure to large-scale processing facilities. The latter are often owned by cooperatives. In the southern part of the country, that percentage increased from 10 percent in 2013 to 30 percent in 2014, to 50 percent in 2015,

Box 2. Farmers' reaction to environmental measures: MiAR 30 percent and pig feed nutrient control

Maximum phosphate production rights were introduced in 1986. Each farm received a number of “reference” rights based on their actual production of manure. This level was estimated on the basis of an inventory of animals, and standard phosphate production coefficients per animal per year. These coefficients corresponded to the difference between phosphate supply (in feed and animals) and phosphate removal (in meat, milk, eggs, and animals). The difference was assumed to represent the phosphate content of manure for a given animal category.

In 1995, the government announced a 30 percent reduction in the non-land-based quota for pig and poultry farmers in response to the commercialization of low-phosphate feed. Only farmers who could prove that they had reduced the total phosphate content in pig manure by at least 30 percent were allowed to maintain their original number of pigs. In the years preceding this rule change, the state had invested heavily in research and development (R&D) to make low-phosphorus feeds available. Farmers and feed companies, however, had not switched to using these feeds due to their higher price tag.

With the 30 percent reduction in production quotas in place, pig farmers faced the following choice. Their first option was to purchase and absorb the higher cost of lower-phosphorus feed (a difference of €0.84 per pig per year) and maintain the same number of pigs on the farm. This would amount, on average, to a 1.4 percent decrease in farms' margin on feed.¹ Farmers' second option was to continue using conventional feed but reduce their animal headcount by 30 percent. This equated on average to a 30 percent decrease in farms' margin on feed. The first option being much more attractive, the policy incentivized farmers to purchase feed that substantially lowered phosphate production in pig manure. The measure's success is partly owed to the fact that by the time it was adopted, multiple years of empirical research had generated evidence on the costs and benefits of different types of feed.

¹ Farm margin on feed is defined as farm revenue minus cost of feed.

and to 59 percent in 2017.⁷ Farmers are allowed to transfer their manure processing obligation to other farmers via a “replacing processing agreement” (in Dutch: *vervangende verwerkings overeenkomst*). These agreements stipulate that one farmer will take responsibility for another farmer's processing obligation.

Nutrient accounting

(12) MINAS nutrient accounting and levy system (1998–2005)

The *Mineralen Aangiftesysteem* (MINAS) was the accounting system that was put in place for the

manure account to track the nitrogen and phosphate content of manure, and to compute levies on surplus nutrients being generated by farms. Levies were imposed on nitrogen and phosphate surpluses above a certain level per hectare. The objective of MINAS was to bring nutrient inputs and outputs into balance at farm level, with a certain acceptance for unavoidable losses. Inputs that were accounted for included all the nutrients in concentrated feed, livestock, by-products, roughage, livestock manure, organic manure, and nitrogen fertilizers, and those generated through nitrogen fixation. Outputs included livestock, all products of animal origin, arable crops, roughage, and livestock manure (Oenema and Berentsen 2005).

⁷ <https://www.rijksoverheid.nl/documenten/kamerstukken/2016/12/20/kamerbrief-over-het-percentages-verplichte-mestverwerking-2017>.

Under MINAS, farmers had to keep accurate records of their farm's nutrient inputs and outputs. Nutrient return forms calculating farms' actual nitrogen and phosphate surpluses had to be submitted to the (Agricultural) Levies Office annually. For the purposes of MINAS, the nutrient content of manure is determined by laboratory analysis. The Levies Office audited the nutrient recording forms and imposed a levy on farms for which the nutrient surplus exceeded acceptable loss standards set by the program. Loss standards, that is, levels of nutrient losses deemed acceptable by MINAS, varied by soil type and crop. Loss standards for grass on sandy soils were stricter than those for grass on peat or clay, for instance. Loss standards were gradually tightened and stricter standards were introduced for dry soils prone to nitrate leaching.

Meanwhile, levies increased over time to the point of becoming prohibitive. In 2003, the tolerated loss for phosphate was set at 20 kg P₂O₅/ha/year. For nitrogen, it was set at 100 kg N/ha/year on arable land (60 on peat soils) and 180 kg N/ha/year on grassland (140 on peat soils). Nutrients exceeding these levels were taxed at a rate of €9 per kg of phosphate and €9 per kg of nitrogen. MINAS' farm coverage also increased over time. During 1998–1999, it covered all livestock farms with more than 2.5 livestock units per ha, that is, about three-quarters of dairy farms and nearly all pig and poultry farms. Starting in 2000, it covered all livestock farms, and starting in 2001, all farms (including crop farms) had to participate.

MINAS was effective in reducing the environmental burden. However, the European Court considered it to be in conflict with the EU Nitrates Directive. The Directive required that there should be a statutory application of animal manure and no loss standards. At the end of 2005, MINAS was replaced by a system of application limits for animal manure and fertilizers, in compliance with the EU Nitrates Directive.

(13) Annual Nutrient Cycling Assessment (2015–)

As of 2015, approximately 70 percent of all dairy farms have a farm-level manure surplus. For these farms it is mandatory to report on manure management using the ANCA model. The model outcomes help dairy farmers demonstrate to authorities and the dairy industry that they have produced their milk in accordance with sustainability standards. It offers farmers the ability to calculate farm-specific coefficients used to determine their obligations under the law, rather than use standard coefficients derived from average farm data. For example, ANCA allows farmers to calculate farm-specific nitrogen and phosphorus excretion rates. If farm-specific rates are beneath the standard coefficient, farmers can lower the amount of manure they are required to process or export. Similarly, standard fertilization rates are based on average soil conditions and crop yields. The ANCA model can be used to compute farm-specific fertilization rates. In the future ANCA may also be used as basis for differentiating products on the market.

Coupling of land and animals

(14) Manure transfer contracts (2002–2005)

The government introduced manure transfer contracts as a means of complying with the requirements of the EU Nitrates Directive. Under this system, farmers had to ensure that they had sufficient land on which they could potentially dispose of their manure at the application rates imposed by the Nitrates Directive, that is, 170 kg of nitrogen on grassland and 210 kg of nitrogen on arable land. If farmers had more manure than could be applied according to the maximum applicable rates, they were required to enter into manure transfer contracts for their manure surpluses a year in advance. Farmers could apply manure on their own land provided they did not exceed the Nitrates Directive rates and the MINAS loss standards. Surplus manure could be transferred to crop or livestock farmers with sufficient land for extra manure application, or to manure processors. Farmers unable to contract sufficient buyers for their surplus

manure had to reduce the number of livestock they kept on their farm. The calculation of the farm-level manure surplus was based on the number of animals and a statutorily fixed rate of nitrogen production per animal species.

The objective of the manure transfer contracts system was to limit the total amount of nutrients produced by Dutch agriculture. However, the manure transfer contracts system proved not to be fraud-proof. It ultimately failed to control manure production or regulate disposal, though its farm-level costs were considerable.

(15) Land-related expansion of dairy farms (2016–)

The recent introduction of maximum livestock units per unit of land on dairy farms aimed to counter the decoupling of animal farming from farmland. Dairy farmers who increase the number of cows on their farm and consequently produce more phosphate must demonstrate, on an annual basis, that they have enough land for its application. Farms that increase the number of cows on the farm and have a farm-level phosphate surplus are required to prove that they have sufficient land area to apply a part of the associated increase in phosphate production—that is, on land acquired for this purpose. Farms that have enough land or extensive holdings with a farm-level phosphate surplus of less than 20 kg per ha do not have to take action. Farms with a farm-level phosphate surplus of 20–50 kg per ha need to buy land so they can apply a quarter of the additional phosphate production on that land. The other three-quarters of the additional phosphate production have to be processed. Intensive dairy farms with a farm-level phosphate surplus over 50 kg per ha need to acquire additional land for half of the additional phosphate production. The other half of the additional phosphate production has to be processed. Coming up is a system of tradable phosphate rights for dairy cattle (similar to pig and poultry rights) starting from January 1, 2018.

Supporting measures

(16) Manure Bank (1987–1998)

The Manure Act called for the establishment of a national Manure Bank to promote efficient spatial distribution of animal manure. It used a variety of incentives and instruments to achieve this. The Manure Bank is credited with having helped develop the Dutch market for manure that exists today. It recorded the delivery notes associated with the transportation of livestock manure.⁸ The other statutory tasks of the Manure Bank were to promote the efficient disposal of manure surpluses and act as a safety net for farmers who could not get rid of their manure. The Manure Bank held manure storage silos across the country for this purpose. All surplus farms paid a destination charge, so that the functioning of the manure market was financed collectively. This method of finance was rejected by the European Commission in 1992; the European Commission was of the opinion that only the fixed costs of administrative infrastructure and the construction and maintenance of storage facilities could be financed by the levy. This decision of the European Commission brought the Manure Bank to an end.

(17) Subsidies for manure storage (1987–2012)

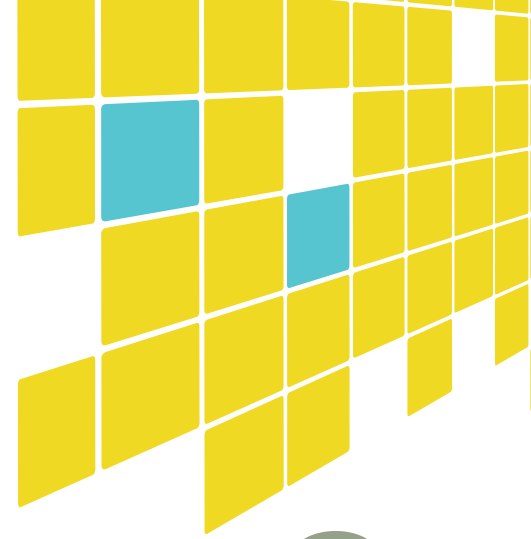
The government started subsidizing investments in storage capacity on individual farms as well as shared storage facilities. Financial support was also provided to farmers wishing to apply innovative techniques to reduce the production of manure or improve the reprocessing or disposal of livestock wastes.

(18) Flagship farms (1987–)

To bridge the remarkable gap in environmental performance between average commercial dairy farms and experimental dairy farms, a program was initiated to make role models out of the latter as well as other high-performance farms. In one project

⁸ The delivery notes applied to the persons concerned to prove that the manure was exchanged from one owner to another.

known as Cows & Opportunities, several farms were selected to represent the full range of dairy farming conditions. These farms underwent an agronomic and environmental performance assessment, which was used to develop a farm development plan that, among other things, would enable the farms to meet nitrogen and phosphorus surplus targets. Farm performance was monitored and evaluated over several years. Projects like Cows & Opportunities demonstrated that it is possible to meet nitrogen and phosphorus surplus targets by taking simple measures.



3

EFFECTIVENESS OF MANURE POLICIES

Farmers’ response to the manure policy instruments—command-and-control, market-based, and educational instruments—depends on the motivation, opportunity, and ability of farmers to change practices. It also depends on agribusiness companies’ will and ability to support farmers in making these choices. Rothschild (1999) offers a framework for assessing policy instruments. Farmers may be prone, resistant, or unable to respond to manure policies (Table 2). Importantly, since the motives of the parties involved are not aligned, their goals can conflict with improved manure management. Education makes sense when farmers are able, motivated, and have the opportunity to change. A farmer is resistant to policy when motivation does not exist, regardless of existing opportunities or abilities.

Table 2. Conceptual framework for the analysis of farmer behavior and selection of policy instruments

Motivated Opportunity		Yes		No	
	Yes	Yes	No	Yes	No
Ability	Yes	Prone to act Education	Unable to act Marketing	Resistant to act Legislation	Resistant to act Legislation and marketing
	No	Unable to act Education and marketing	Unable to act Education and marketing	Resistant to act Education, legislation, and marketing	Resistant to act Education, legislation, and marketing

Source: Rothschild 1999.

This section rates the effectiveness of the 18 policies introduced between 1984 and 2016 and described in Section 3.

- Policies considered to be a “success” were not only “effective” as defined below, but also cost-effective (defined as either beneficial or not compromising the long-term viability of livestock farmers who want to maintain their farm operation for the foreseeable future).

Table 3. Criteria used to evaluate manure policies

Evaluation framework	Measure adopted by a vast majority of farmers (>80 percent)	Technology available to implement the measure	Cost-effective	Vulnerable to fraud	Vulnerable to anticipatory behavior
Success	+	+	+		
Effective	+	+			
Mixed	+			+	+
Failure				+	+

Source: Backus, G. B. C.

- Those considered to be “effective” are those that resulted in the broad adoption of effective environmental measures by producers, were fraud resistant, and triggered limited anticipatory behavior.
- Policy instruments that were more or less cost-effective but vulnerable to fraud and anticipatory behavior are considered to have had “mixed results.”
- Those measures considered to be “failures” were ineffective and vulnerable to fraud and anticipatory behavior (Table 3).

Table 3 summarizes the criteria used to assess the Netherlands’ manure policy instruments.

Of the 18 policy instruments described in Section 3, six are considered to be successful: supporting flagship farms, the national Manure Bank, the conditional 30 percent reduction of manure production rights, the tightening of the prohibition on spreading manure, making the injection of manure into the soil mandatory, and ANCA. Table 4 provides a snapshot of the 18 major policy instruments discussed above and their level of effectiveness.

The systems aimed at regulating industry size were all more or less effective: they limited further growth of the livestock but were costly. Though not fully effective, they were necessary to prevent the livestock population and associated pollution from increasing. The tightening of maximum applicable rates and the introduction of the buying-up scheme were effective but very costly.

The Manure Bank made sure that the animal manure was disposed of as cheaply as possible. The method of collective funding was rejected by the European Commission in 1992. Only the fixed costs of administrative infrastructure and the construction and maintenance of the storage of the Manure Bank could be financed by the levy. This decision of the European Commission brought the Manure Bank to an end. As of January 1998, the Manure Bank was discontinued, without an (better) alternative being put in place. In 1993 pig farmers paid up to €9 for the disposal of 1 m³ of manure, compared to up to €24 in 2016.

The introduction of mandatory manure processing percentages appears to be an effective instrument, but it is too early to draw conclusions about its cost-effectiveness. The instrument provides strong incentives for pig farmers to join farmer cooperatives with large-scale manure processing units. But the development of such units will also depend on their acceptability to rural communities and local authorities. Furthermore, their cost-effectiveness will depend on the market for manure-based fertilizer. If successful, the marketing of processed manure could change the dominant business logic in which manure is treated as waste into a model where manure is traded as a valuable resource.

MINAS achieved mixed results. Its greatest success was in the dairy subsector, where it stimulated efficient nutrient management. MINAS, however, was of limited effectiveness in the pig and poultry subsectors, which generate the largest manure surpluses. For landless farms, MINAS acted more like a manure disposal requirement than like an incentive to switch to low-phosphorus feed. It even counterproductively strengthened a business logic in which pig and poultry manure came to be seen as a waste stream that needed to be disposed of at the lowest cost possible.

Table 4. Overview of manure policy instruments (command-and-control, market-based, and educational)

Dutch policy instruments (*, **)		1984	1986	1988	1990	1992	1994	1996	1998	2000	2002	2004	2006	2008	2010	2012	2014	2016
Regulating total number of animals	1. Interim Law on Pigs and Poultry (C)	Orange	Orange															
	2. Levy-based cap P ₂ O ₅ production rights (C)			Orange	Orange	Orange	Orange											
	3. Tradable manure production rights (M)						Orange	Orange	Orange									
	4. Pigs and poultry production rights (C)									Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange	Orange
	5. Buy-out scheme (M)										Yellow	Yellow						
Application standards	6. Maximum applicable rates in kg P ₂ O ₅ /ha (C)		Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow						
	7. Application limits manure and fertilizer (C)												Yellow	Yellow	Yellow	Yellow	Yellow	Yellow
	8. Seasonal restriction on spreading manure (C)				Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
Inducing new technology	9. Compulsory manure injection (C)				Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green
	10. Conditional 30% MiAR reduction (M)					Green	Green											
Nutrient management	11. Mandatory manure processing percent (C)																Yellow	Yellow
	12. Nutrient accounting and levy system (M)							Orange	Orange	Orange	Orange	Orange	Orange					
	13. ANCA (M)																	Green
Coupling land-animals	14. Manure transfer contracts (M)									Red	Red	Red						
	15. Land-related expansion of dairy farms (C)																	
Supporting measures	16. National Manure Bank (M, E)			Green	Green	Green	Green	Green										
	17. Subsidies on manure storage (M)			Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	Yellow	
	18. Flagship farms (E)			Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green	Green

Source: Backus, G. B. C.

Note: * C = Command-and-control, M = Market-based, E = Educational. ** Green = success; Yellow = effective; Orange = mixed; Red = failure.

Like MINAS, the system of tradable rights achieved mixed results. It was effective in establishing a ceiling on the total number of animals in the country. However, it resulted in a transfer of money from the new generation of young farmers to the generation of retiring farmers. This limited younger farmers' financial capacity to invest in more environmentally friendly technologies.

The most recent introduction of “maximum livestock units” per unit of land on dairy farms is not evaluated due to its recent introduction.

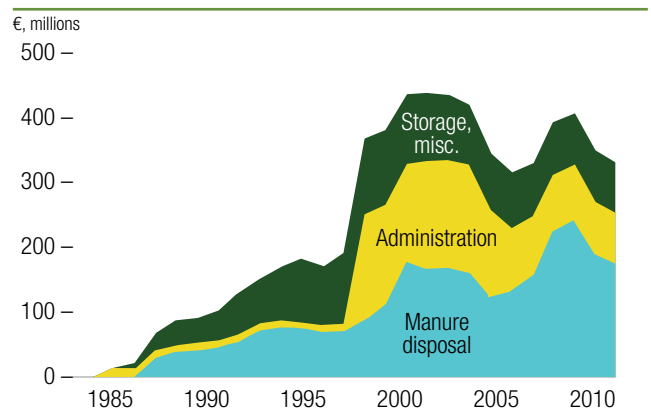
PUBLIC AND PRIVATE COSTS OF MANURE POLICY INSTRUMENTS

4

The costs of Dutch manure policy faced by producers increased steadily from almost zero in 1984 to almost €200 million in 1996 (see Figure 6). Manure disposal is the costliest part of compliance. Total manure disposal costs rose to an all-time high of €386 million in 2015. In contrast, manure injection cost a total of €27 million, equal to €1 per m³ of animal manure in 2002. In the period 1998–2003, producers' administrative costs increased sharply due to the introduction of measures that call for complex management instruments (for example, MINAS).

Landless pig farmers paid up to €9 to dispose 1 m³ of manure in 1993, a cost that rose to €24 in 2015. For a closed sow/fattener farm, €24 per m³ of disposed manure is equivalent to 9 percent of total production costs. A pig slaughtered at a weight of 93 kg in the Netherlands produces an average of 0.5 m³ of manure during its life.⁹ This implies that Dutch pig farmers—and ultimately the consumers of pork meat—were paying €0.13 per kg of pig meat for manure disposal. These costs are a strong burden for the competitiveness of the export-oriented Dutch pig industry. The industry did overcome this by means of an accelerated shift of production capacity to the most efficient farms.

Figure 6. Total producer-level costs of Dutch manure policy



Source: PBL 2012, 22, Figure 9.

Dutch manure policies have not been without cost, especially to the pig industry. Two-thirds of the pig manure has to be marketed, compared to one-sixth of the

⁹ Including associated manure from sows and piglets, equal to one-third of the total manure volume.

dairy manure, and so the pig farms are most affected by the manure policy measures. Nevertheless, pig production succeeded in remaining internationally competitive. The total number of pigs in the Netherlands has been stable over the last 15 years: it was equal to 13.1 million in 2000, 12.3 million in 2010, and 12.6 million in 2015. The Dutch pig industry exported a record volume of 944 million kg of pork meat in 2015, compared to 819 million kg in 2010 and 778 million kg in 2000. The pig industry was capable of adopting these manure policy measures, because they were not immediately introduced, and became only gradually stricter. However, this came at a price: the need to improve productivity through specialization and using economies of scale was strong, and only the most efficient farmers succeeded in adopting the costly policy measures. The number of pig farms in the Netherlands decreased from 34,000 in 1984 to 5,000 in 2015, whereas the number of dairy farms only decreased from 80,000 in 1984 to 29,000 in 2015.¹⁰ However, as of 2015 the cost of manure disposal has risen to a level that economies of scale do not exist anymore for most of the pig farms. The only remaining directions for solutions for the remaining farms are decreasing manure disposal cost by manure processing and/or creating added value by producing and marketing in high-value pork supply chains.

In contrast to the pig sector, the poultry sector succeeded in implementing a collective solution by building a biomass central unit, BMC Moerdijk. This is the sole power plant on the European mainland that converts poultry manure into sustainable energy.¹¹ The incineration of the manure releases energy in the form of heat, which is then converted into steam and fed into a turbine that drives a generator to produce electricity. Benefits are that manure is processed in a responsible manner, green energy is supplied to the grid, and ash packed with valuable minerals is available for the agricultural and horticultural sector.

The governmental costs of policy development and implementation are related to subsidies, monitoring, and enforcement. The Dutch government spent

€27 million in 2014, that is, an average €900 per livestock farm, or around €0.27 per pig. Note that producers are eligible for a 25–40 percent subsidy on the cost of manure storage facilities, but no statistics exist on the total costs of subsidies related to animal manure.

10 <http://statline.cbs.nl/Statweb/publication/?DM=SLNL&PA=71904ned&D1=6,12-32&D2=133,1&HDR=G1&STB=T&VW=T>.

11 <http://www.bmcmoerdijk.nl/en/home.htm>.



LESSONS LEARNED

5

On-farm management versus central processing of animal manure

Reflecting on 32 years of developing manure policies for landless production systems, we can observe that concentration and economies of scale have created opportunities for technology firms to develop and market pollution-reducing systems. Two broad manure management strategies emerge:

- Larger individual pig farms are able to invest in manure management technologies and resolve their nutrient issues at the farm level.
- For smaller farms, manure processing requires the establishment of central facilities that process at least 100,000 m³ of manure annually. They process manure into a fertilizer, the quality and stability of which in terms of nutrient content can compete with synthetic fertilizers.

While generally superior in overall resource management, the second option raises issues of organization and acceptance by local communities and is prone to the free-rider problem.¹² Preference for either option will depend, among other aspects, on the enforcement capacity of public authorities, farm size and structure, road infrastructure, and the prices of land and fertilizers.

Path dependencies

Ex ante evaluations of manure policies should aim to identify possible path dependencies that limit options for improving the manure policy framework in the future. Current options should not be limited by the impact of manure policy instruments implemented in the past. A prime example of such a path dependency

¹² In this context, the free-rider problem arises when some individual farmers do not deliver slurry to the central manure processing facility. They benefit from the fact that other farmers do contribute to the common goal. In the market, the manure disposal costs of slurry decrease as a consequence of part of the total volume being processed and marketed elsewhere. The farmers, who did not deliver to the processing plant, still receive the benefits by paying lower manure disposal costs for slurry.

comes from the rules that were put in place to increase manure storage capacity in the 1980s. These induced Dutch pig farmers to develop housing systems with slatted floors and the storage of liquids beneath the pen. This system is currently making it nearly impossible for farmers to daily collect slurry and feed it to a digester to retrieve energy. To prevent this kind of situation, it is crucial to monitor the effectiveness of manure policies regularly and to build in the option to adjust the policy when necessary.

Progressive enforcement and sound policy evaluations

Adopting a step-by-step approach is a key success factor. An approach based on policies becoming gradually more stringent enables the livestock sector to develop technologies and market infrastructure that allow them to adapt to changing policy. When standards gradually increase in stringency, this also seems to bring about social norm change within farming communities, helping to bring along those who are initially resistant to change.

Monitoring and information systems using farm-level data are crucial to developing policy measures based on ex ante and ex post evaluations of new and existing instruments. They also provide useful content to develop capacity among policy officers.

Monitoring progress also enables timely adjustments to measures when necessary and helps mitigate the risk of path dependency. Finally, sound ex post evaluations of manure policies reduce the risk of errors in judging manure instruments, and this is especially critical when one instrument is replaced by another. In the Netherlands, manure policy is evaluated every fourth year, within the framework of updating the four yearlong Action Programs of the Nitrates Directive.

The key role of geographical distribution

When intensive animal production is both competitive and geographically concentrated, regulating the total number of animals in the region or country is necessary to enable enforcement of stricter environmental performance standards. Quota systems, zoning, and

maximum numbers of animals per unit of land or in a region act as a safety net by imposing restrictions on farm size and/or preventing too many farms from becoming separated from farmland.

Inducing manure measures by both the carrot and the stick

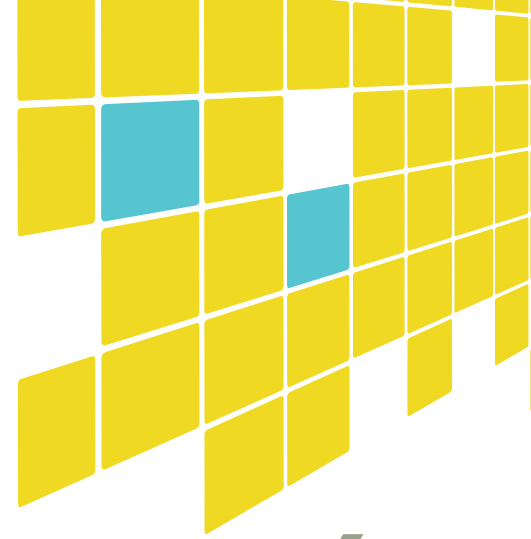
Prohibitions and penalties prevent undesired behavior only to a certain extent. For full compliance, both very frequent monitoring and high penalties are necessary. These, however, are usually unwelcome by producers and costly for the public sector to sustain.

It is generally more cost-effective to combine prohibitions and penalties with positive incentives for farmers, such as investment subsidies and quality premiums. In this case, targeted subsidies and fiscal incentives are positive incentives that increase producers' ability to comply.

Finally, some farm manure management measures (manure storage, modified feed) require more costly farm inputs and their adoption may occur only when economic incentives are provided to induce farmers to purchase these.

Education

Though feasible and legitimate, it is difficult to determine the effectiveness of many educational instruments (for example, mass media, labeling). However, flagship farms in the Netherlands demonstrate to farmers how environmental measures can be implemented in real operating conditions. These farms help the entire producer community to start thinking in terms of solutions instead of thinking in terms of obstacles. These farms also serve as incubators for cost-effective market-based instruments such as the ANCA.



EMERGING ISSUES

6

High manure disposal costs are a bottleneck for the competitiveness of the Dutch pig farming industry. In this respect, manure processing is promising as it adds value to manure and allows it to be marketed as organic fertilizer. This may be crucial to the long-term viability of the Dutch pig farming industry, and require a shift in the dominant business logic in which manure is treated as a waste into manure being treated as a valuable resource again. The experiences and developments in the Dutch poultry industry are a beckoning perspective.

The end of the EU Milk Quota System in 2015 has led many dairy farmers to want to expand their farms. As a result, the number of cows has increased sharply over the last two years, forcing the Dutch government to announce in March 2016 regulations to limit the production of phosphate in cow manure, with July 2, 2015, as the reference date. The government aims to reduce this reference number by 4–8 percent, to bring phosphate production levels back to what they were when the EU Milk Quota System was in place. Besides this, newly introduced measures like the maximum number of livestock units on land aim at limiting farm expansion.

REFERENCES

- Aarnink, A. J. A., M. C. J. Smits, and I. Vermeij. 2010. "Reduction of Ammonia Emissions from Houses for Growing-Finishing Pigs by Combined Measures." Wageningen UR Livestock Research Report 366 (in Dutch). <http://edepot.wur.nl/155192>.
- Boheemen, van P. 2006. *The Dutch Approach to Water Quality Problems Related to Fertilisation and Crop Protection*. <https://www.oecd.org/tad/agricultural-policies/36885889.pdf>.
- Statistics Netherlands CBS / National Institute for Public Health and the Environment RIVM. Milieucompendium. 1994, 2001 and 2004.
- CBS Statline. 2016. <http://statline.cbs.nl/StatWeb/publication/?VW=T&DM=S LNL&PA=71461NED&D1=a&D2=a&D3=0-2&D4=1&HD=110516-1032&HDR=G3,T&STB=G2,G1>.
- Coffey, R. D., G. R. Parker, and K. M. Laurent. 1995. *Feeding Growing-finishing Pigs to Maximize Lean Growth Rate*. University of Kentucky, Lexington, and Kentucky State University, Frankfort. Cooperative Extension Service. ASC-147.
- Atiyeh, D. J. 2015. Manure Injection Study. Cornell University. <https://blogs.cornell.edu/agsci-interns/2015/08/07/manure-injection-study/>.
- Grinsven, H. van, M. van Eerdt, W. Jaap, F. Hubeek, and E. Mulleneers. 2005. "Evaluation of the Dutch Manure and Fertilizer Policy 1998-2002." In *Evaluating Agri-environmental Policies: Design, Practise and Results*. Paris: Organisation for Economic Co-operation and Development. https://www.researchgate.net/publication/40111857_Evaluation_of_the_Dutch_manure_and_fertilizer_policy_1998-2002.
- Le, P. D., A. J. A. Aarnink, N. W. M. Ogink, and M. W. A. Versteegen. 2005. "Effects of Environmental Factors on Odor Emission From Pig Manure." *American Society of Agricultural Engineers* 48 (2): 757-765. <http://www.prairieswine.com/pdf/3065.pdf>.
- Oenema, O., and P. B. M. Berentsen. 2005. *Manure Policy and MINAS: Regulating Nitrogen and Phosphorus Surpluses in Agriculture of the Netherlands*. OECD (Organisation for Economic Co-operation and Development). [http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=COM/ENV/EPOC/CTPA/CFA\(2004\)67/FINAL&docLanguage=En](http://www.oecd.org/officialdocuments/publicdisplaydocumentpdf/?cote=COM/ENV/EPOC/CTPA/CFA(2004)67/FINAL&docLanguage=En).
- PBL (Planbureau voor de Leefomgeving). 2012. Evaluatie Meststoffenwet 2012. <http://www.pbl.nl/sites/default/files/cms/publicaties/pbl-2012-evaluatie-meststoffenwet-2012-hoofdrapport-624.pdf>.
- Rothschild, M. L. 1999. "Carrots, Sticks, and Promises: A Conceptual Framework for the Management of Public Health and Social Issue Behaviors." *Journal of Marketing* 63: 24-37.
- Smits, M. C. J., A. J. A. Aarnink, H. H. Ellen, and C. M. Groenestein. 2010. "Overzicht van maatregelen om de ammoniakemissie uit de veehouderij te beperken." Wageningen UR Livestock Research 645. <http://edepot.wur.nl/247488>.
- van Vliet, J. A. M., and G. J. A. Ogink. 2004. Regeling Beëindiging Veehouderijtakken (RBV) Eindevaluatie. EC-LNV 2004/287, Ede, the Netherlands.
- van Wagenberg, C. P. A., and G. B. C. Backus. 1997. *Effects of Measures to Reduce the Mineral Excretion by Pigs in the NUBL Area*. <http://library.wur.nl/WebQuery/wurpubs/fulltext/33725>.



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