Synergies and trade-offs between agricultural productivity and climate change mitigation and adaptation: Netherlands case study
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Executive summary

This paper assesses whether existing policies in the Netherlands create synergies or trade-offs between agricultural productivity growth, climate change adaptation and mitigation goals. Climate objectives in agriculture are not set in a vacuum: while the majority of current Dutch and EU agricultural policies have been designed to support food security objectives, they are gradually aiming to address a broader range of objectives, including climate-related ones. The way in which agriculture responds to climate change is complicated by the wide range of non-agricultural policies that affect farmers’ choices. Ultimately, a combination of both agricultural and non-agricultural policies will determine whether the sector can reduce its carbon footprint and adapt to changing climate and socio-economic circumstances.

To address climate change, the Dutch agri-food policies focus both on competitiveness and mitigation

With regard to climate change issues, agricultural policies in the Netherlands aim to stimulate synergies between competitiveness and mitigation, while the agri-food sector (with the exception of water resource management) is seen as primarily responsible for adaptation efforts. Emission-reduction targets have been presented to the private sector as an opportunity rather than a threat to productivity, and drive innovation in the agri-food chain. The two most GHG-intensive agri-food sectors that together account for about 90% of agricultural GHGs emissions, have already achieved their 2020 emission reduction targets: 3.3 Mton of CO2 (compared to 1990 emission levels) was reduced by the greenhouse horticulture sector and 5.6 Mton CO2-eq by livestock farmers.

The Dutch government creates favourable conditions for the agri-food sector to develop cost-effective actions in support of climate change mitigation, and to encourage uptake of climate-friendly measures. The ability of the agri-food sector to sustain its competitive position and at the same time reduce emissions has stimulated innovation. The Dutch government tries to actively reduce barriers for the uptake of sustainable technologies (including emission-reducing measures), and has designed various programmes to remove the obstacles in regulation and legislation and acts when it appears likely that the fixed emissions targets agreed with the sector will not be met.

Public-private agreements have been highly effective at tackling agricultural emissions

Dutch policy makers favour designing public-private agreements (covenants) that outline government’s emission reduction targets and allow a degree of freedom on the methods to achieve those by the private sector. The provisions laid down in the covenants are legally binding and enforceable. A number of very successful covenants were applied in the Netherlands. If the private sector fails to achieve the agreed targets, the government enforces regulations, which are often already contained in the agreements. For instance, the growth of the dairy sector following the abolition of the EU milk quota resulted in the sector’s inability to curb its emissions. Because there is a serious threat that the sector will not be able to meet the agreed targets, phosphate rights regulations are implemented, which at the end will likely result in a decrease of a number of livestock and consequently cut GHG emissions.

The main drivers for emissions reduction were the EU legislation and energy market liberalisation

European legislation has been the main driver of the Netherlands’ efforts to reduce emissions from the livestock sector while maintaining productivity growth. The most influential piece of legislation that drives national policies to reduce manure surplus and associated emissions is the 1991 EU Nitrate Directive. The pork and poultry sectors have managed to increase their productivity without additional emissions by investing in bioenergy and increasing manure exports. The same results have not been seen in all sectors; the dairy sector has been less successful in containing its emissions.
The energy market liberalisation and the, until recently, high prices of fossil fuels are behind the notable success of the greenhouse sector in reducing its emissions. In 2011 the greenhouse sector used 52% less energy per unit of production compared with 1990. This was achieved through the implementation of combined heat and power installations that both decreased the energy use per unit of production and generated income from electricity sales. The government has also played a role in the successful transition to more efficient energy use in the greenhouse sector. The ministry had provided some seed money in the past to stimulate energy development, and decreased the tax rate the sector has to pay on its gas bill, as it did for other energy-intensive sectors. Research activities on energy savings are funded up to 60% by public support.

*Societal pressure can have unintended, large impacts on competitiveness and GHG footprint of agriculture*

In the Netherlands, social pressures particularly around animal welfare create a complex interplay of factors that impact mitigation outcomes. As an example, the societal movement towards imposing anaesthesia for pig castration not only decreased production costs – as the producers stop castrating the piglets, but also led to emission reductions, because uncastrated pigs metabolise feed more efficiently. Other examples of imposing welfare measures for animals have less obvious effects; some may increase the trade-offs between competitiveness and mitigation objectives, and some may simply increase certain GHG emissions and decrease others.

**Policy recommendations**

» Increase innovation investment to further cut emissions: While the agricultural sector has cut emissions, further mitigation options may be harder to deliver as the most cost-efficient options have often already been applied. More investment in research and innovation may be required if emission reduction targets become more stringent.

» Encourage further climate friendly business practices: The Netherlands has been successful at creating an effective enabling environment for climate friendly agri-food businesses. The government is encouraged to conduct a broader review of agricultural and business policies to assess where the trade-offs between productivity and climate objectives lie.

» Continue to use public-private agreements when they are likely to be effective: The use of voluntary agreements stimulates the most cost-efficient outcomes, and as such should be encouraged for further use. However, the private sector may be less open towards voluntary measures when the cheapest climate-friendly options have already been implemented.

» Link environmental markets across sectors: Linking the environmental markets of different livestock sectors – e.g. allowing pig farmers to sell their manure rights to dairy farmers - could encourage a shift towards more profitable, emission-efficient sectors.

» Continuously seek additional regulatory changes capable of fostering further mitigation: Emissions reductions cannot continue to be generated from past legislative changes. For example, in horticulture, the deregulation of the Dutch electricity market led to a large fall in the sector’s emissions but further reductions will need to be driven by other factors and may require new regulations or for other measures to be taken.

» Ensure that practices responding to social pressure are also climate-friendly: When producers revise their production methods in response to societal demands e.g. for certain welfare standards, it will be important to research and analyse the resulting GHG balance to ensure they do not have negative impacts on emissions.
Introduction

The agriculture and agri-food sector in the Netherlands plays a key role in the country’s economy, accounting for approximately 8.3% of gross domestic product (GDP), 19% of total export value and providing a major source of employment. The sector’s productivity and competitiveness is largely driven by market signals, which complement agricultural policies and regulations. Within the agri-food sector, the livestock and greenhouse sub-sectors are particularly important for the Dutch economy.

Climate change is likely to have both positive and negative effects on agricultural production in the Netherlands. Positive effects include higher productivity for certain crops, opportunities to cultivate new crops and lower energy bills (for greenhouse horticulture). The main climate change-related threats to agricultural production are temperature and humidity changes, precipitation variability, increased risk of extreme weather events, and rising sea level which affects water quality and quantity. Dutch agricultural and other policy initiatives that relate to climate-change adaptation in agriculture primarily focus on promoting the sustainability of water supplies.

The Dutch agri-food sector currently accounts for approximately 9.3% of total greenhouse gas (GHG) emissions (RIVM, 2015), and is expected to contribute to national mitigation targets. The Netherlands has committed to a 30% reduction of emissions compared with 1990 levels for the period of 2013 to 2020 (Coalitieakkoord, 2007). Climate-change mitigation efforts for agriculture in the Netherlands focus particularly on the livestock and the greenhouse horticulture sectors, which together comprise about 90% of Dutch GHG emissions from agriculture.

The institutional setting, private sector, and agriculture and other policies affect agricultural productivity, climate change adaptation, and mitigation. This document outlines how Dutch institutions, industry and policies impact the three objectives of agricultural productivity growth, climate-change adaptation and mitigation. This analysis implements a policy analysis framework developed by the OECD, which provides a template to assess the synergies and trade-offs in policymaking between climate change mitigation and adaptation.
1. How do existing institutions address climate change and productivity objectives?

Covenants – agreements between the public and private sectors – form the base of the Dutch policy making process, including for climate change mitigation and agricultural productivity. In the Netherlands decision-making is historically based on a multi-stakeholder process of consensus building, the so-called ‘Polder Model’. This approach is reflected in the way institutions address climate change and productivity objectives, some of which are determined at the EU level. The public sector sets its national objectives, the private sector is given the room to meet these objectives in its own way, while research and innovation is often seen as a means to help the private sector meet these objectives. Voluntary agreements between the government, the sector and sometimes other parties often underpin this approach. These covenants describe the means and the obligation to achieve certain results for each respective party to the Covenant, as well as the financial provisions, monitoring and evaluation, and provisions on observance and dispute settlement. Dutch covenants seek to incite behavioural change (Bressers et al., 2011). The provisions laid down in the covenants are legally binding and enforceable.

The Dutch champion the idea of innovation for sustainability and climate change. Innovation is seen as a means to increase the competitive position of the country, but the notion of increasing efficiency of natural resource use and decreasing agriculture’s carbon footprint (a concept referred to as green image) has become increasingly important. A sustainable, climate-friendly agri-food sector is a goal of both the government’s and the private sector’s innovation efforts. This has been especially evident in the greenhouse horticulture sector where energy costs have been lowered considerably through energy efficiency measures, and at the same time the competitive position of Dutch horticulture products in international markets increased even though their GHG footprint decreased. However, it seems that low-hanging fruits have been reaped by this sector and that it approaches the limits of this business model.

The Dutch climate, energy and sustainability policies have been presented as an opportunity for the private sector rather than a threat to productivity. The Programme ‘Clean and Energy Efficient’ (Werkprogramma Schoon en Zuinig, 2007), an umbrella program for various covenants, provides a package of measures to achieve 2020 targets for GHG-emissions reductions, energy saving and renewable energy. It outlines that: “[the government] offers ambitious plans […] as they can help the Dutch knowledge economy and energy sector to become a European, and in some areas even a global frontrunner. […] Additionally, [the government] is convinced that those companies and countries that are leading in addressing climate-related challenges in a responsible way can strengthen their economic position.” (Werkprogramma Schoon en Zuinig, 2007 p9-10). The covenant Clean and Efficient Agri-Sectors guides actions within the agri-food, forest and wood sectors.

The focus of the Dutch government is to create favourable conditions for the agri-food sector to develop cost-effective actions in support of climate change mitigation. Rather than calling for specific actions, the government provides a framework within which the private sector operates (Rotmans and Kemp, 2003). For instance, it established a “Green Deal” program, which focuses on removing obstacles for the uptake of climate-friendly measures in the legislation and regulations and provides access to networks, through to supporting access to the capital market (Green Deal, 2015). As part of the Green Deal, CO2 Network for the Greenhouse Industry in Noord-Holland, the parties concerned created a network of businesses to find less GHG-intensive ways of supplying greenhouse businesses with high-quality CO2. As affordable CO2 supply for stimulating plant production is important for the Dutch greenhouse sector, producers often chose to run natural gas-based heat and power (CHP) installations including during the summer to produce CO2, without utilising the heat (Mikunda et al., 2015). This leads to inefficiencies and unnecessary emissions. As a result of the Green Deal, the greenhouse industry can now use the CO2 emissions of the Amsterdam waste-to-energy company AEB. As such this project contributed not only to reducing the fuel use in greenhouse horticulture but also reduced
emissions from other sectors.

Recent changes to the institutional structure within the Dutch government imply a further shift of responsibilities to the agri-food sector; it shall remain competitive and at the same time it should take responsibility for its emissions. In 2010, the former Ministry of Agriculture, Nature & Food Quality and the Ministry of Economic Affairs merged. As a result, the former position of a Minister of Agriculture has been replaced with a Minister for Agriculture, subordinate to the Minister of Economic Affairs. Simultaneously, the number of agricultural specialists within the ministry was reduced. The change of the relative position of agriculture, embedded in the overarching change towards more efficient government, has brought a further shift of responsibilities to the agri-food sector. Although the industry welcomed this change as an opportunity for enhanced self-regulation, it has also expressed concern that its interests may be less well-represented in the public sector. For instance, the Energy Transition in Horticulture 2014-2020 agreement has a clause added that “Parties shall take adequate [...] manpower to run the program Greenhouse as energy source”.

There is no specific adaptation plan for the agricultural sector; water-related adaptation measures are put forth under the Delta Programme (Delta Programme, 2016). The 2007 National Adaptation Strategy (NAS) and its subsequent updates mention agriculture as one of the sectors that will be vulnerable to climate change. However, the National Adaptation Agenda that was supposed to propose concrete actions to support NAS has not yet been developed, with the exception of the Delta Programme. Despite the Netherlands being a country abundant in water resources, the government recognises two main vulnerabilities of the agricultural sector: water shortages during droughts and salinisation of water supplies. Both points are targeted in the 2008 Dutch Delta Programme. Moreover, the Dutch Federation of Agriculture and Horticulture (LTO Nederland) has developed its own ‘Delta Plan for Agricultural Water Management’. The Delta Programme is developed under the responsibility of the Ministry of Infrastructure and Environment.

Apart from these water-related measures, adaptation activities specific to the agriculture sector have focused on selected activities, such as resilience against the increased likelihood of pests and diseases due to climate change in the livestock sector. The former Ministry of Economic Affairs, Agriculture and Innovation commissioned a study on the effects of climate change on emerging animal diseases, in particular zoonoses (Algemene Rekenkamer, 2012 p40). An attempt, in 2009-10, to develop an integrated climate agenda in line with the national adaptation agenda was not finalised due to a change of cabinet in 2010 (Algemene Rekenkamer, 2012). Currently, the government is working on a new National Adaptation Strategy and Agenda, which is expected to be released in the course of 2016 and includes agriculture.

Although currently only the greenhouse horticulture sector takes part in the Emission Trading System (ETS), other agri-food sectors contribute as well to the mitigation efforts from agriculture. In 2004, to ensure that national emissions mitigations targets are met, the government triggered a policy shift from voluntary agreements with relative targets to absolute sectoral targets, under the responsibility of the relevant ministries (PBL, 2004). The first Climate Policy Evaluation Memorandum set sector emissions-level targets for CO2-eq (Evaluatienota Klimaatbeleid, 2002, p10); for the agricultural sector, the target was set at 7 Mton CO2-eq, of which 5.1 Mton CO2-eq from the greenhouse sector. The target was revised in 2005 and 2006 and set at 7.5 Mton CO2-eq and 7.6 Mton CO2-eq respectively (Evaluatienota Klimaatbeleid 2005 and 2006). The 2020 emission reduction target of 3.3Mton of CO2 (compared to 1990 emission levels) has been already achieved by the greenhouse horticultural sector in 2012. Target for other GHGs has been set at 4-6Mton CO2-eq for 2020, and already in 2012 the emission reduction from the agricultural sector reached 5.6 Mton CO2-eq.
2. Compatibility of agricultural policies to achieve higher agricultural productivity and climate change adaptation and mitigation objectives

Dealing with climate change issues, agricultural policies in the Netherlands aim to stimulate synergies between competitiveness and mitigation; adaptation is primarily seen as the responsibility of agri-food sector (with the exception of water resource management). Many agricultural policies aim to address the challenge of continuing to produce livestock in a competitive manner while reducing GHG emissions. Policies responsible for successful GHG emission reductions within the greenhouse sector are mainly energy policies, and will be discussed in Section 3. Adaptation to climate change of the livestock and greenhouse horticultural sector is not often discussed in the context of policymaking, and the government considers adaptation as the sector’s own responsibility (with the exception of water resource management).

The European legislation has been the main driver of the Netherlands’ efforts to reduce emissions from the livestock sector while maintaining productivity growth. The most influential piece of legislation that drives many national policies to reduce manure pollution and associated emissions is the 1991 EU Nitrate Directive that forms an integral part of the EU Water Framework Directive (2000) (EC, 2010). The directive underlines the maximum level of nitrogen allowed for field application. Although the limit was established at the rate of 170 kg N per hectare per year, the Netherlands received a permission (derogation) from the EU that allows farmers to apply up to 250 kg N per ha per year, if based on cow manure. In some regions, such high concentrations of nutrients may have an adverse effect on water quality; sensitive aquatic ecosystems may require additional measures to decrease excessive N and P application. The Birds and Habitats Directives and Natura 2000 have also been used to frame the Netherlands’ policy to reduce indirect GHGs emissions.

However, some aspects of the EU legislation may create a barrier to explore measures to reduce emissions. Digestate is a fertiliser derived from the co-fermentation of manure (and other organic materials for instance grass or maize). Until now the EU Regulation (EC) No 2003/2003 does not consider organic fertilisers, therefore the trade of such within the European Union is difficult. Although digestates cannot be seen as one-to-one replacement of fertilisers, their mineral content, especially of phosphate, is high and it can potentially replace a share of mineral fertilisers. If seen as mineral fertiliser replacement, it would contribute to the overall mitigation efforts by avoiding unnecessary emissions due to mineral fertiliser production. Recently the EU has recognised the benefits of utilisation of the digestate, as in line with its circular economy principles, and proposed to amend the fertiliser regulation to include recycled or organic materials for fertilising purposes (EU, 2016/0084). However further innovation is needed to produce high quality fertilisers from digestate.

Recent abolition of the EU milk quota induced trade-offs between productivity and emissions reductions objectives. The abolition of milk quotas, as of April 1, 2015, including the soft landing dairy quota system, allowed the Dutch dairy sector to grow, resulting in an increase of manure production exceeding the sector’s agreed limits; this increased direct GHG emissions. It also affected the use of manure from other sectors; mainly the pork industry. Although arable farmers are paid less for utilizing a tonne of cow manure than pig manure, they prefer to use cow manure, as they earn more money, in total, on using cow manure (pig manure contains about three times more phosphates than cow manure). Pork farmers, in turn, have to search for alternative solutions to utilise pig manure.

In the Netherlands, public-private co-operation drives actions to achieve synergies between productivity and mitigation objectives. A number of covenants were signed with the livestock
industries to achieve various sustainability targets such as to keep the production of manure within the outlined targets. Among the most influential covenants that contributed to a reduction of N2O emissions are the De Uitvoeringsagenda Duurzame Veehouderij, 2009), which is the concrete translation of the Vision for the Future of the Livestock Sector (Toekomstvisie Veehouderij, 2008), and the Sustainable Dairy Chain 2016. The covenants helped to, among other, reduce the "manure problem" within the poultry sector; the sector took its responsibility for manure which resulted in significant reduction of poultry manure utilised in the Netherlands. The problem of "pig manure" is also controlled by the pork sector; allowing the sector itself finding alternative ways to reduce manure resulted in a reduction of produced manure, while the number of animals increased since 2006. According to the Climate Policy Evaluation Memorandum, policies based on covenants had been successful as total GHG-emissions in 2013 were 5% lower than would have been without domestic policy (Evaluatienota Klimaatbeleid 2005, p.6). The covenants had been effective especially in the agri-food sector where emissions were 16% lower as would have been the case without such policies (Evaluatienota Klimaatbeleid 2005, p.7,41).

When covenants fail to achieve reduced pollution (and emissions), the government designs additional regulations to achieve its targets. For instance, the "animal allocation rights" were created to regulate the production of manure; however, currently they have limited influence on reducing the growing numbers of animals in the pork and poultry sectors. Moreover, pigs and poultry farmers can receive more allocation rights when they process the manure. A more recent example of government imposing additional regulation for the dairy sector involves phosphate rights.

Sometimes, regulations targeting other objectives can have positive effects on emission reductions. The Minister for Agriculture and the dairy sector reached an agreement on imposing the phosphate rights to let the industry manage excessive levels of phosphates in and from manure. Under this agreement, which will likely to take effect as of 1 January 2017, part of the farm phosphorus surplus (manure) must be processed or exported. The percentage of the farm phosphorus surplus that has to be processed or exported varies in each region (as they are related to the manure concentration areas). It is inevitable that due to this new regulation the number of dairy cattle will have to decrease, or additional measures will need to be applied by the private sector to reduce manure production. Lower manure production will result in lower methane and nitrous oxide emissions; however it is unclear at this point whether the sector will be able to retain its milk production level. The Dutch policy for reducing ammonia emissions is another example. In 1991, the way manure was applied changed and currently it has to be incorporated into the soil by shallow injection or ploughing-in. Although the emissions of ammonia are significantly reduced by applying such measures, they lead to an additional emission of N2O (0.5 Mton CO2-eq) (PBL, 2004, p54). Overall, however N2O emissions in the Netherlands have decreased, mainly due a reduction of N in the feedstock for livestock (CLO, 2016).

The Common Agricultural Policy (CAP) has limited impact on the livestock and greenhouse horticulture sectors (except on extensive dairy sector) in the Netherlands. The shift away from production support to income support has stimulated the sector to adjust its production in reaction to the market. The Dutch livestock sector is competitive and will receive relatively limited support under the current CAP; mostly in the form of Pillar I direct income support per hectare. Due to the non-area based character of pig, poultry, and cow production systems, the share of direct income support in total income will be limited. With the further decoupling of CAP, the shift to a hectare based direct income support and the national convergence of the per-hectare premiums means that the veal, beef, and the intensive dairy sectors will face reductions of the previous direct payments during the transition to 2019. The government will financially support the transition towards measures aimed at strengthening the sustainability and the future viability of the sectors as part of the Pillar II measures. For extensive livestock farmers, i.e. most of the dairy farmers, direct income support is higher, as it is linked to support per hectare. The greenhouse horticulture sector does not receive any direct income payments. As for the second pillar the government has chosen not to explicitly include specific measures.
on promoting resource efficiency and the transition to a low-carbon economy. In line with the Dutch position that innovation is key to strengthen the competitiveness of a sustainable sector, a portion of Pillar II funds is designated to this objective, including livestock farmers and greenhouse horticulture\textsuperscript{16}.

In response in part to the EU regulations on nitrogen and voluntary agreements, and in part as a means to improving its public image, the livestock industry created standards for internal business conduct, which take into account climate and sustainability criteria. For example, a farmers’ cooperative and leading dairy company - Royal Friesland Campina, highlighted in its 2014 report that “[it] wants to achieve climate-neutral growth and accepts its responsibility for it”. It has implemented its own system of accounting for all nutrients and associated emissions. Another system that has been designed for practically all agri-food sectors, an Environmental Quality Label (Milieukeur) includes in its basic criteria a ‘climate-friendliness’ in terms of emission-, energy- and mineral- intensity of a given product. It is difficult, however, to assess to what extent such standards or labels contributed to achieving climate objectives.

2.1 How does the ministry deal with synergies and trade-offs?

The ministry’s approach is to support innovations that encourage sustainability in the sector, but it is the agri-food sector that develops and implements the cost-effective strategies that reflect the government’s objectives. Markets determine, to a large extent, which measures are applied. Although the choice of measures is left to the industry, the government highlights the benefits of applying the measures that are both economically and environmentally beneficial (e.g. production of biogas through fermentation of manure), and create co-benefits like improving air quality, increasing the national energy security and stimulating national innovation and technology development (PBL, 2008).

Policy-makers favour setting up agreements on achievable goals, although when the private sector is not able to fulfil its commitments the government sets regulatory measures. The private sector is at liberty to secure the targets as they best see fit from their own particular business perspective (NL Agency, 2012). Covenants are among the key instruments of the Dutch government when discussing how to approach trade-offs and stimulate synergies. Such agreements involve a large degree of trust, and if respected have benefits for both parties: the government will reach its objectives and the private sector will have flexibility in how to reach the objectives.

The question remains, however, of whether covenants will continue to be the main instrument where more stringent actions are needed. The agri-food industry may be less inclined to search for more costly solutions for emission reductions when the “easy” technological solutions are applied. More stringent climate legislation may then be necessary.

The Netherlands has focused action on effective compliance with nitrogen and phosphate balance through actions targeting necessary structural changes within its borders, in line with the IPCC GHG emissions accounting methodology. The government and the industry focus on achieving win-win solutions, accounting for actions within the country. The emissions included in the GHG balance are those that are created and remain within the Netherlands. Emissions originating from feed production abroad, for instance, are not accounted for.

How are synergies and trade-offs identified?

There is no specific mechanism to identify trade-offs, but rather, the Dutch approach is to seek to promote synergies between productivity and climate change mitigation. Trade-offs between productivity and emissions are not explicitly dealt with, but there is an expectation that the emissions are going to decline as a result of innovation. Adaptation is seen as primarily a responsibility of the agri-food sector, with the exception of water. Through agreements with the private sector the government expects that the agreed upon mitigation goals are achieved in a cost-effective way; the private sector deals with potential trade-offs.
How are synergies and trade-offs monitored?

Both the costs of implementation of climate measures and the trends in productivity and emissions are monitored. Until 2005, agricultural emissions decreased due to a reduction in the number of animals and to priority actions targeting “low hanging fruits”. The greenhouse and livestock sectors used the most cost-effective measures for GHGs and non-GHG where possible (Tweede Kamer, 2012). The government initially supported the introduction of climate measures with EUR 43 million per year, which were then undertaken by the rest of the sector. As a result the overall costs for the sector was negative (between EUR -66 and -51 mln per year) (Tweede Kamer, 2012). According to the Climate Policy Evaluation Memorandum, the net receipt in the sector for end users amounted on average to a savings of EUR 70 to 90 per ton of equivalent CO2 reduced (Evaluatienota Klimaatbeleid 2005, p44-45). This can be attributed to lower expenses for energy as a result of energy efficiency measures (PBL 2004, para 2.4.1). Fewer quantitative sector evaluations and ex-post evaluations of the main instruments are available for the years following 2005 (Tweede Kamer, 2012, p8).

To stimulate the continuous monitoring of policies, the Dutch research institute Alterra is developing a monitoring system of the CAP, focusing on its greening component in general and on the effects it can have on climate. This will enable an evaluation of the effects of changes following the introduction of the most recent CAP in 2015 within the Netherlands.

Some initiatives in the private sector help to monitor changes in productivity and emissions. The dairy sector created monitoring systems that track the nutrients entering and leaving farms, so-called ‘kringloopwijzer’, which can help monitor the actual farm level N2O emissions. The system is now working on a few farms; it is expected than within a couple of years all farms will be obliged to implement this monitoring system. Similar systems are developed for the pork sector.

2.2 How does the ministry make decisions about synergies and trade-offs?

The ministry’s approach to making decisions on synergies and trade-offs is to first discuss the problem at stake with the private sector in order to search for cost-effective solutions. If working with the private sector is not successful, the next step is to establish appropriate regulations, or eventually to remove regulatory barriers. Sometimes the government takes unpopular decisions to deal with trade-offs. For instance, the tax concession for diesel use was permanently removed during a period of austerity in 2014 with an argument that a subsidy on an environmental harmful product was not justified. While it is too early for a full evaluation of how the abolition of fossil-fuel support resulted in changes in productivity and emissions, it is likely to be positive.

3. Compatibility of other policies with achieving higher agricultural productivity and climate change adaptation and mitigation objectives

Policies that are not specifically focused on agricultural productivity or climate change can have a profound effect on policy makers’ ability to encourage a more efficient use of resources and reduce emissions. In the Netherlands, social pressures, particularly around animal welfare, create a complex interplay of factors that affect mitigation outcomes. Similarly, effective competition policy may deter producers from making climate change mitigation investments that could raise consumer prices. By contrast, energy market liberalisation has led to a fall in GHG emissions in the greenhouse sector. And the agricultural sector has been helped in its efforts to adapt to possible drier weather conditions in the future by government investments in water infrastructure.
Societal pressures are of an increasing importance in the Netherlands; they have consequences on the mitigation and productivity objectives of the agri-food sector. For instance, due to society cultural appreciation for the landscape of cows grazing in the fields; dairy cows are subject to a minimum quota of "pasture time", as regulated by the private sector itself. More grazing reduces ammonia emissions but increases nitrous oxide emissions (CBS, 2015; Haan et al., 2015). Inversely, emissions of methane from manure meadow are low compared to manure produced in the stable, which is relatively high. The final GHGs balance is likely to be slightly less favourable for the climate objective; though it depends on many locally determined aspects. Another regulation for the dairy sector currently being discussed, as result of societal pressures, but facing strong pushback from producers, requires calves be kept with their mothers for the first weeks of their life. If this regulation passes, it will require extensive adjustment of the system and most likely will affect the competitiveness of Dutch farmers. The GHG emissions are likely to be lower if young calves are milk rather than milk-replacements fed (FAO, 2010). However at this point it is difficult to make an assessment of whether these changes will positively or negatively affect climate objectives, since the positive aspect of young cows diet may be over-compensated by increased production.

Animal welfare policies affect the regulatory environment within the agricultural sector and can have an impact on the GHG balance. For example, the recent obligations to use anaesthesia while castrating pigs resulted in a significant reduction of GHG emissions. Because it increased potential production costs, the pig industry decided not to castrate pigs for the domestic market. Non-castrated pigs can more easily absorb minerals, and the industry could thus reduce mineral-rich feed in piglets' diets. This, in turn, resulted in much lower levels of phosphorus and nitrogen in their manure, and explains to a large extent why the emissions from pig manure did not increase, despite a significant increase in pig population. The emerging requirements for animal housing to meet new animal welfare standards, on the other hand, are expected in many cases to contribute to increased emissions of NH3, which when converted to N2O during bio-physical processes can contribute to increased GHGs emissions (Oenema et al., 2011; EC, 2012).

Although consumers could encourage the uptake of climate measures by the livestock sector, their priority remains the availability of a wide range of low cost food products. Despite consumers' impulse for greater animal welfare, the implementation costs of sustainability and climate friendly measures do not transfer easily to consumers, as high prices and reduced choice are not favoured by consumers. The Ministry of Economic Affairs presented the Agenda for the Sustainability of Food, with the objective to make the food chain sustainable by 2020. The Agenda addresses issues of production, distribution, and food waste. One of the priorities was that in 2020, poultry, meat and pork consumed in the Netherlands would meet more strict and integrated sustainability standards. These standards were partially applied to the Chicken of Tomorrow proposal. However, the sustainability arrangements designed were stalled as they did not comply with the condition for exemption from the prohibition of cartels within the competition law i.e. the benefits for consumers did not exceed the cost associated with fewer options for consumers and a higher retail price. Consumers have been found to be willing to pay more for measures to improve sustainable production, but not for those proposed under the Chicken of Tomorrow programme (ACM, 2015).

A combination of energy policies and the extended animal rights have resulted in increasing productivity of the livestock sector while reducing GHG emissions. The advice to "turn manure into energy", supported by initial seed money for first investments for digestors and support for renewable energy producers (e.g. feed-in tariff for bioenergy), had a positive effect on GHGs balance. Incinerating or fermenting manure, together with other by-products (co-fermentation) became an appealing option for farmers around 2006. As a result of signed covenants and high oil prices, many small-scale bio-digester units were created (Landbouw-economisch Bericht 2006, p.90). Bioenergy production was further stimulated by the fact that livestock farmers who used co-fermentation installations had to purchase only 50% of the normally required pork or poultry allocation rights in case of expansion of their farm, on the condition that all manure would be processed or incinerated and the by-products would be marketed outside the Dutch agriculture sector (Landbouw-economisch Bericht 2006, p.94). Higher revenues from by-
products and lower costs for the removal of waste and manure (since Dutch farmers pay for its manure disposal) serve as incentives for farmers to produce bioenergy (Landbouw-economisch Bericht 2008, p.129).

The energy market liberalisation and the high prices of fossil fuels are behind the notable success of the greenhouse sector in reducing its emissions. In 2011 the greenhouse sector used 52% less energy per unit of production compared with 1990. The sector made efficiency improvements mainly by modifications in cultivation, energy conservation, and the use of gas motors with a combined heat and power plant. Approximately 70% of 9 200 ha of greenhouses produce 10% of national electricity consumption. The impetus to rethink greenhouse horticulture production, specifically its energy use, evolved from energy market liberalisation, fuel prices, and other market considerations. With high fuel prices, investments in combined heat and power plants for energy production and investments in geothermal energy as a source of energy were viable. The low energy prices of 2014-15 have however considerably reduced the profitability of heat and power plants.

The government has also played a role in the successful transition to more efficient energy use in greenhouse sector. The greenhouse sector has signed a number of covenants with the government where it committed itself to become a ‘clean and efficient’ sector. The ministry had provided some seed money in the past to stimulate energy development, and decreased a tax rate the sector has to pay on its gas bill, as it did for other energy-intensive sectors. Research activities on energy savings are funded up to 60% by public support. Energy policies targeting clean and efficient energy use provided an additional stimulus for the greenhouse sector to reduce emissions; for instance the sector could benefit from participating in the emission trading scheme (ETS). The government led initiative for a low-carbon economy as the marker of a successful economy was an additional impetus behind firm climate and energy objectives (Werkprogramma Schoon en Zuinig, 2007 p10). The total CO2 emissions of the greenhouse sector, including energy generated for sale, are expected to further decrease to about 6 Mtonne in 2020 (Ministry of Infrastructure and the Environment, 2013). It means that all new greenhouses have to be energy neutral and economically viable.

Water policies play an important role for the agricultural sectors’ ability to adapt to climate change. The Delta Programme includes water infrastructure measures and measures to store additional water resources in case of drought. These additional water resources can also be used for flushing the canals and ditches to reduce salinity that stems from seepage of saline groundwater. Such measures require large investments that are in principle carried out by the public sector in the Netherlands. Part of the cost of investment that affects the agricultural sector is expected to be paid via the CAP Pillar II at a rate of EUR 2 million per year, and about EUR 20 million is likely to be resourced from CAP Pillar I. The Netherlands’ provinces and water boards will contribute the same amount to the development of infrastructure projects. Some water-storing measures involve energy use as well, which may ultimately create additional emissions. The desalinisation is targeting intensive arable and horticulture field crop farmers in West Netherlands and involves a large amount of fresh water to flush canals and ditches. With a limited availability of fresh water it is questionable whether this scarce resource should be used for desalinisation purposes.
4. Does the policy framework effectively promote synergies and address trade-offs between productivity, climate change mitigation and adaptation?

4.1 Successes of the policy framework

Overall, the Dutch government can be congratulated for the results it achieved in reducing agricultural emission while stimulating agricultural productivity. The way the Netherlands achieves its competitiveness and climate objectives, while at the same time complying with EU and national regulations, is via simulating innovations and collaborating with the agri-food industry. Since the private sector’s responsibility is to define solutions to achieve commonly agreed objectives, the result is likely cost-effective. So far, the gradual transfer of responsibilities for being more sustainable and climate friendly, towards the agri-food sector resulted in better climate performance while keeping up the competitive position of the Dutch agriculture.

A key success has been that despite an increase in the number of pigs and poultry, the volume of manure within the country decreased in recent years; it resulted in an overall decrease of emissions, which keep the manure application in line with the EU regulations. The positive trend in emissions reduction was achieved thanks to a combination of factors. Many changes are driven by the sector itself, and are often induced by changing markets of consumer preferences; there is however a number of policies that had a positive impact on the way the agricultural sector dealt with the externalities.

4.2 Recommendations to improve the policy framework

The Dutch approach of using the voluntary agreements as a tool to stimulate synergies between agricultural productivity growth and climate change mitigation forms a well-working policy framework. The Dutch agricultural policy toolkit should continue to collaborate with the agri-food sector and encourage it to stimulate innovative and climate-friendly practices.

The government has made efforts to remove existing regulatory barriers, by e.g. the Green Deals programmes, and shall be encouraged to follow this path. Further efforts should be placed on analysing and revising, when necessary, policies that potentially discourage synergies between productivity and climate objectives such as e.g. the EU regulation on using digestate (being proposed recently to the EU council).

To improve the efficiency of its mitigation policy, the government may consider linking the environmental markets of various livestock sectors. This would support an expansion of the more profitable livestock system and a phasing out of some of the less profitable ones. Currently, the “environmental” markets are separated according to livestock types; a growth of one type of livestock is pre-determined by the policies that target this specific livestock.

The government may also revise particular targets related to the maximum use of nitrogen per hectare. Targets that are more specific and reflect local particularities could help reducing manure pollution and associated emissions. In order to set the locally-specific targets and also to control it, a better collaboration between water bodies and farmers should be encouraged.

The Dutch Delta Programme aims at helping the Netherlands to be more resilient against climate-change impacts. For the agri-food sector the two most evident set of adaptation investments are investment that aim to increase water storage capacity to reduce the negative effects of droughts and investments that prevent salinisation of (surface) water by drainage. These two objectives may create trade-offs and require careful analysis of long term priorities. Since most of these measures will create private benefits, it would require sustainable financing mechanisms that should be borne partially by farmers, for instance, by charges for water use or fees to access drainage infrastructure.
1. This translates to a target ceiling of 150 mega ton CO2 equivalent ceiling (Coalitieakkoord, 2007). All sectors under the EU Emissions Trading Scheme (ETS), including greenhouse horticulture, must realise this target proportionally. These target reductions in the Netherlands fall under EU-wide emissions limits. EU standards for emissions levels also apply to non-ETS–sectors, namely agriculture (Milieubalans, 2008).

2. The level of phosphates is dealt within the EU Water Framework Directive (2000).

3. The exception to this ceiling is sandy soils in Noord Brabant, Overijssel, Gelderland, Utrecht and Limburg where up to 230 kg N per ha per year can be applied.

4. The Birds and Habitats Directives aim to safeguard biodiversity, and lowering NH3 and NOx emissions are part of this aim by virtue of the precautionary approach (COST, 2009). Natura 2000 requires that nature areas do not deteriorate and outlines where the nitrogen deposition is critical. Between 1990 and 2011, the NH3 emissions from manure and synthetic fertiliser (in the stable and during storage, grazing and application to the field) decreased from approximately 25% to 12% (RIVM, 2015).

5. More than 90% of the phosphate fertilisers used in the EU is imported.

6. Over the period 2009–2014 the milk quotas have been annually increased by 1% by the EU.

7. While the Dutch dairy farm sector achieved continuous productivity growth, the change in milk quota regime changed its dynamics. The total factor productivity growth, before the phasing out of the milk quota, was almost entirely driven by a decline in input use. However, currently the main driving force of TFP growth in the Dutch dairy farm sector became the expansion of milk output (Kimura and Sauer, 2015).

8. Cow manure contains less nitrogen and phosphorous, therefore a larger amount of cow manure can be utilised per hectare.

9. Annually, about 55 million ton of cattle, 12.5 million ton of pig, and 1.4 million ton of poultry manure is produced in the Netherlands.

10. The manure from the poultry sector has been dealt by the sector itself. About 65% of the manure is exported and the remaining part is used for energy production. The remaining product of the energy conversion is exported as fertiliser.

11. These rights, established in 1984 under the manure policy, have been given based on the historical allocations of animals. These animal allocation rights along with disease outbreaks, led to a decline of the number of pigs by 20% between 1995 and 2003 (from 14.4 to 11.2 million animals). Between 2002 and 2010, some of the animal allocation rights were not implemented, leaving a room for a production increase. Starting around 2011, the number of pigs has increased but remains within the limits set by the “animal allocation rights”. A similar situation happened in the poultry industry.

12. According to Berentsen en Oenema (2005): “An agreement was made with 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 and the emission of NH3 from manure.”

13. In 2015, the livestock sector produced a total of 176.3 million kilograms of phosphate in the Netherlands, or 3.4 million kilos over the phosphate ceiling set by the EU. Although phosphorus is not mentioned in the Nitrates Directive, several Member States have included phosphorus regulations.

14. This resulted in a reduction of 66% in the amount of nitrogen deposited atmospherically over the 1990–2013 period (RIVM, 2015), however it is uncertain how this directly and indirectly contributed to the overall GHG balance.

15. The veal sector will receive EUR 10 million per year and the beef sector half a million euros per year under the RDP.

16. About EUR 800 million is dedicated to productive and non-productive investments under RDP that enable farms to respect regulations via further innovation, but it is unclear how much is dedicated to improve innovation within the livestock sector.
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