

Nitrogen emissions in the Netherlands: a policy conundrum

Tom Scheeringa

April 2020

Nitrogen emissions in the Netherlands: a policy conundrum

Tom Scheeringa

April 2020

MSc. Thesis

Wageningen University, NL

Registration number 960517733110

MSc Management, Economics and Consumer Studies

Specialisation: (Agricultural) Economics and Governance

Agricultural Economics and Rural Policy Group (AEP)

Course AEP-80436: MSc Thesis Agricultural Economics and Rural Policy

Supervisor:

Dr. ir. J.H.M. Peerlings

Second reader:

Dr.ir. C. Gardebroek



Source image cover page: Jasmijn Wijnbergen/RTV Noord

Preface

This thesis was written as part of the MSc program Management, Economics and Consumer Studies. at Wageningen University and Research and was written within the Agricultural Economics and Rural Policy chair group. The subject of this thesis fitted perfectly with my interest of agriculture and the environment and the relationship between the two. It was this interest that led me to study at the WUR in the first place. I found the writing of the thesis very interesting, challenging and in the end very rewarding. I feel that I learned a lot that will be very useful in my future career.

I would like to thank my supervisor Dr. ir. Jack Peerlings For his guidance, insights, feedback and advice. His vast knowledge of the agriculture and economics was indispensable for writing this thesis. Furthermore, I would also like to thank my fellow students family and friends for their support and encouragement. Lastly, this has been my final part of my education at the WUR bar my internship and I would like to thank everybody that helped made these last five and a half years educational and very fun.

I hope you will enjoy reading this thesis.

Tom Scheeringa

Den Haag, April 2020

Abstract

The aim of this thesis is to explore the consequences on nitrogen policy for agriculture in the Netherlands of the Dutch Council of State's ruling that the policy 'Programma Aanpak Stikstof' (PAS) is null and void. Nitrogen emissions are high in the Netherlands and have a negative effect on biodiversity. The Natura 2000 network, a EU wide conservation initiative, is the reason the nitrogen emissions have to decrease. The PAS was the policy meant to reduce nitrogen emission while creating room for new economic activity. It succeeded at the latter objective but failed at the first. The failure was due to the policy being too flexible and lacking a clear timeframe combined with the reasons the Council of State used. Namely, that the PAS used future anticipated reduction emissions to grant permits and that it also gives permits based on the deposition space that is available due to measures that are meant to prevent the deterioration of Natura 2000 areas. The fundamental problem of the PAS is that it has two objectives that cannot be reconciled. Tradable or non-tradable emission rights could be used in the new nitrogen policy. Non-tradable emission rights have the disadvantage that it is not economically efficient and incentivises rent-seeking behaviour. Tradable emission rights are economically efficient but could counteract other policy goals that can be implemented with emission rights like preferring young or organic farmers or protecting the processing industry in a region. If inter-sector tradable nitrogen emission rights were introduced in the agricultural sector the animal sectors that will buy them are the organic laying hens, organic dairy cattle and conventional dairy farming since they have the highest shadow prices of emission rights.

Keywords: Nitrogen, PAS, Natura 2000, Agriculture, Emission rights, Netherlands

Content overview

Preface	III
Abstract	IV
Content overview	V
List of figures	VI
List of tables	VI
1. Introduction	1
1.1 Main research objective and research questions	1
1.2 Theoretical framework	2
1.3 Methodology	2
1.4 Content overview	2
2. Natura 2000 and nitrogen	3
2.1 Nitrogen emissions	3
2.1.1 Definition of nitrogen emissions	3
2.1.2 Sources of nitrogen emissions	3
2.1.3 Concentration of nitrogen emissions	4
2.2 Effects of nitrogen emissions	6
2.2.1 Biodiversity	6
2.2.2 Public health	7
2.3 Natura 2000	7
2.3.1 The aim of Natura 2000	7
2.3.2 Designation of Natura 2000 areas by the EU	8
2.3.3 Assessment of Natura 2000	9
2.3.4 Natura 2000 in the Netherlands	9
3. The PAS in perspective	11
3.1 Historical development of nitrogen policy	11
3.2 The PAS	11
3.2.1 Source measures	12
3.2.2 Restoration measures	13
3.2.3 Room for economic activity	13
3.2.4 Neighbouring countries	14
3.3 Assessment of PAS	15
3.4 Legal trouble	16
4. Policy tools	17
4.1 Emission rights	17
4.1.1 Tradability and distribution of quotas	18
4.1.2 Quota for pollutants	20
5. Empirical	22

5.1 Tradable of emission rights between sectors	22
6. Conclusion and discussion.....	26
References.....	30
Annex	33
Annex I Natura 2000 areas in the Netherlands.....	33
Annex II Calculations regarding chapter 5.....	34

List of figures

Figure 2.1 Nitrogen oxides (NOx) emissions in the Netherlands divided per sector	4
Figure 2.2 Ammonia (NH3) emissions in the Netherlands divided per sector.....	4
Figure 2.3 Average nitrogen oxides concentration emissions in 2017 in the Netherlands	5
Figure 2.4 Average ammonia emissions concentration in 2012 in the Netherlands.....	5
Figure 2.5 Total ha of Natura 2000 areas per country	8
Figure 2.6 Natura 2000 areas in the Netherlands with the percentage of nitrogen deposition above the norm.....	10
Figure 4.1 Supply quota in a closed economy	18
Figure 4.2 Supply quota in a closed economy with tradable rights	19
Figure 4.3 Stylized version of a quota market for a pollutant	21

List of tables

Table 3.1 The projected reduction in ammonia emissions in tonnes from generic measures in agriculture with 2013 as base year.....	13
Table 5.1 Nitrogen emissions per agricultural sector in 2018	22
Table 5.2 Shadow prices per animal sector in 2018	24

1. Introduction

On the 29th of May 2019 the Dutch Council of State (i.e. Raad van State) ruled that the policy regulation 'Programma Aanpak Stikstof' (PAS) concerning nitrogen¹ emissions was null and void (Raad van State, 2019). The ruling followed a ruling by the European Court of Justice. PAS was deemed null and void since it gave permits under the assumption that future plans would reduce the nitrogen levels in Natura 2000 areas. However, according to European law the permits can only be given after these measures to reduce nitrogen in Natura 2000 have already been taken (EU Court of Justice, 2018). PAS was implemented in 2015 after a long debate on how to curb nitrogen emissions while at the same time continuing economic activities like construction and agriculture (Julen, 2019). The nitrogen emissions had to be cut due to negative consequences to the biodiversity of vulnerable nature habitats (Remkes et al. 2019; Bobbink et al. 2010) in Natura 2000 areas. Additionally, nitrogen emissions can also have adverse effects on public health (Remkes et al., 2019; Aneja, Schlesinger & Erisman, 2009).

The ruling from the Council of State led to great uncertainty about the validity of permits given out for big infrastructural projects and other construction projects for which still appeal possibilities exist (Niewold & Segaar, 2019). Moreover, this is the case for permits for the expansion of farms (Niewold & Segaar, 2019). The ruling combined with comments from a member of parliament who said that the total Dutch livestock should be halved led to large farmers' protests. The first farmers' protest led to the largest morning rush hour ever in the Netherlands (Kos, 2019). The protests at provincial governments succeeded at convincing politicians to stop new plans they had drawn up to reduce nitrogen emissions (The Economist, 2019). The protests in the provincial capital of Groningen even got out of hand when one tractor smashed in the door of the provincial legislature (The Economist, 2019) According to The Economist (2019) many politicians worry that the protests undermines the Dutch tradition of political compromise by showing that extreme gesturers work.

The Dutch government now has to create a new policy concerning nitrogen emissions. This new policy will be controversial no matter what the policy will be. The different actors appear to have different ideas of what policy should be implemented. The Dutch farmers' organisation LTO and the Dutch employers' organisation VNO-NCW called for more centralised and bigger Natura 2000 areas which they state are now often too small and too dispersed (VNO-NCW, 2019). On the other hand, an environmental protection organisation called for all intensive farming around Natura 2000 areas to be halted (De Gelderlander, 2019). The advisory group that was asked by the Dutch government to give an advise for short term solutions advised that farms that produced relatively large amounts of nitrogen emissions and were close to Natura 2000 areas should be bought up by the Dutch government (Remkes et al., 2019). There has been a case study done for the Natura 2000 area Nieuwkoopse Plassen which concluded that policy aimed specifically at reducing nitrogen emissions by farms that are in the near vicinity of this area is effective and cost effective (Joosten et al. 2019). An overview of the different effects of the abolishment of the PAS seems to be missing from literature.

1.1 Main research objective and research questions

The objective of this research is to explore the consequences on nitrogen policy for agriculture in the Netherlands of the Dutch Council of State's ruling that the policy 'Programma Aanpak Stikstof' is null and void. To reach this objective the following research questions have been formulated:

- What are the different technical aspects of the nitrogen emission problem in the Netherlands?
- What did the policy 'Programma Aanpak Stikstof' entail and why was rejected by the Council of State?
- What the pros and cons and effects of an introduction of nitrogen emission rights for agriculture are?

1.2 Theoretical framework

This research will review the old nitrogen policy and analyse and compare new alternative policies. The comparison will be, in part, based on the economic efficiency of the policies. The theoretical framework that will be used is the economic theory of regulation. The term refers to taxes and subsidies of all sorts as well as to explicit legislative and administrative controls over rates, entry, and other facets of economic activity (Posner, 1974). This theory has two distinct schools of thought the first is 'public interest theories of regulation'. This school entails that regulators are benevolent, have sufficient information and aim to pursue the public interest (Den Hertog, 2010). The second school is 'private interest theories of regulation', which says that regulators do not have sufficient information. They can therefore only imperfectly, if at all, promote the public interest when controlling firms or societal activities (Den Hertog, 2010). This thesis will look at policies concerning nitrogen emissions through the lenses of both schools.

1.3 Methodology

This research will be conducted by a literature review (research questions 1, 2, and 3) combined with descriptive statistics (research question 1). The descriptive statistics will give insights into the size of the nitrogen emission problem in the Netherlands. Furthermore, it will give insight into the extent that nitrogen emissions can be realistically reduced in the near future. Additionally, for the third research question I will calculate the different shadow prices in agriculture per animal sector to give an insight into what sector could buy emission rights and what sector will sell emission rights. This will indicate the effects of an introduction of tradable nitrogen emission rights.

1.4 Content overview

After the introduction in chapter 1, the different technical aspects of the nitrogen problem in the Netherlands will be discussed in chapter 2. The chapter gives an explanation of what Natura 2000 areas are and what the policy of protecting them entails. It also includes an overview of nitrogen emissions in the Netherlands and an overview of the effect of these emissions. Next in chapter 3, the old policy regarding nitrogen emissions will be described. First a broad overview of the historical development of nitrogen policy will be given. An overview of what the PAS entails will be given next and an economic assessment of this policy. The last section will explain why the PAS was declared null and void. In chapter 4 the theory of emission rights will be analysed. The subsequent chapter will use data to predict the effects of introducing tradable nitrogen emission rights. The last chapter provides a general conclusion and discussion.

2. Natura 2000 and nitrogen

This chapter discusses the technical aspects of nitrogen emissions. The aim is to provide an insight into why nitrogen emissions are a problem and how big the problem is. First, an overview of the amount and concentration of nitrogen emissions in the Netherlands will give insight into the size of the emissions problem. Thereafter, the effect of these emissions on nature, biodiversity and public health is explained. Lastly, an explanation of Natura 2000 areas and what the policy of protecting them entails. This is a key aspect of nitrogen emissions since the protection of Natura 2000 areas is the reason that PAS was declared null and void.

2.1 Nitrogen emissions

This section provides further insights on nitrogen emissions. First I discuss what I actually mean by nitrogen emissions in this thesis. Subsequently, the different sources of nitrogen emissions are briefly discussed. Lastly, the concentration of nitrogen emissions in the Netherlands is reviewed to give an indication of the size of the problem.

2.1.1 Definition of nitrogen emissions

In Dutch public discourse the terms used to describe the emissions that are a problem are 'stikstof' and 'stikstofuitstoot' meaning respectively 'nitrogen' and 'nitrogen emissions' (Julen, 2019; Niewold & Segaar, 2019; Remkes et al., 2019). However, the emissions that were referred to in the Council of State verdict were not nitrogen emissions but rather nitrogen oxide (NO_x) and ammonia (NH₃) emissions. Both do contain the nitrogen as chemical element and therefore the catch-all term nitrogen is used in public discourse to describe these emissions. Nitrogen emissions in this thesis are also nitrogen oxide (NO_x) and ammonia (NH₃) emissions. Nitrogen oxides is actually a catch-all term itself for 7 compounds, all of them are some sort of combinations between the chemical element of nitrogen (N) and oxygen (O) (EPA, 1999). However, in this thesis, for simplicity's sake, nitrogen oxides will be treated as one type of emission.

2.1.2 Sources of nitrogen emissions

In Figure 2.1 the nitrogen oxide emissions in the Netherlands are shown. Two things stand out. First, the total emissions have consistently decreased over the past 2 decades. Second, 'Road transport' as a sector emits most nitrogen oxides. However, this sector has also been most responsible for the decrease in emissions. Another sector that has reduced its emissions considerably over the last two decades is the 'Energy production and distribution' sector. An important note on Figure 2.1 is that emissions from abroad are not taken into account while they do affect the soil in the Netherlands (Remkes et al., 2019).

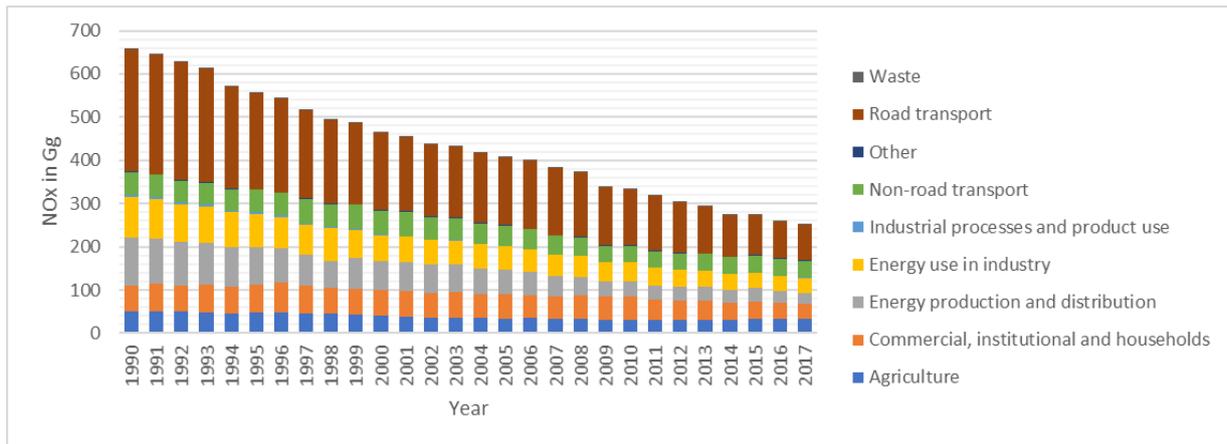


Figure 2.1 Nitrogen oxides (NOx) emissions in the Netherlands divided per sector

Source: Author based on European Environmental Agency, 2017

In Figure 2.2 the ammonia emissions in the Netherlands are shown. The sector that emits most ammonia is by far the agricultural sector. The difference between agriculture and other sectors is so stark that in an effort to make Figure 2.2 legible the other sectors had to be aggregated. The amount of ammonia emitted declined in the nineties but the decline lessened at the start of the new century. Actually, from 2013 onwards the trend seems to be upwards. Figure 2.2 also does not include emissions from abroad.

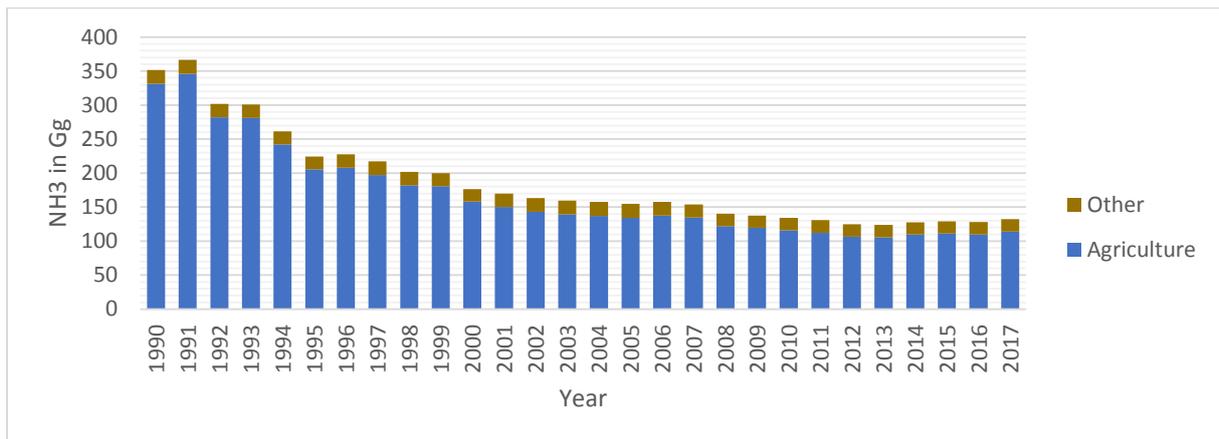


Figure 2.2 Ammonia (NH3) emissions in the Netherlands divided per sector

Source: Author based on European Environmental Agency, 2017

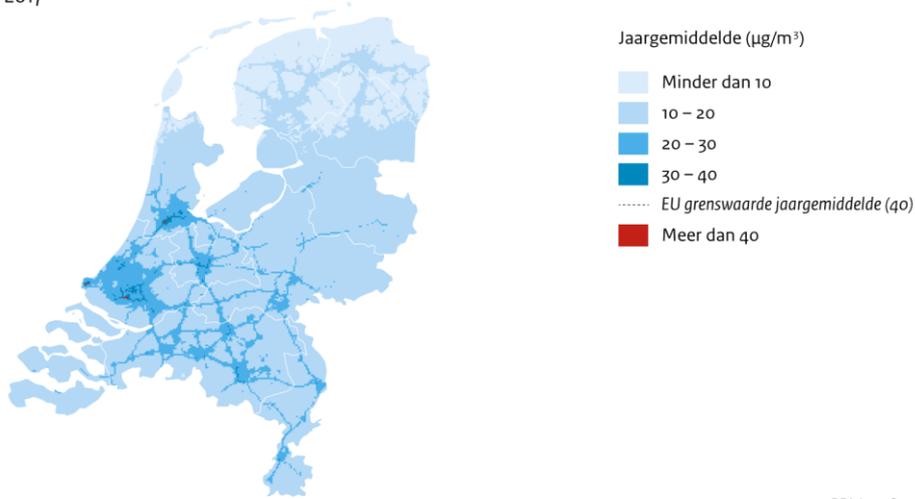
Note: 'Other' is a combination of all sectors in Figure 2.1 other than 'Agriculture'

2.1.3 Concentration of nitrogen emissions

The nitrogen emissions are different from greenhouse gas emissions in the sense that the effects of these emissions are local. In other words, if a farm emits nitrogen, it mainly affects nature areas close by. This means that not just the amount of nitrogen emissions is relevant but also the location where they are emitted. In Figure 2.3 the nitrogen oxides emissions in the Netherlands in 2017 are mapped. The emissions are most prevalent in de 'Randstad' which is the most urbanized part of the Netherlands. Furthermore, the highways in the figure are clearly visible. This is in line with Figure 2.1 since it shows that the sector with the largest nitrogen oxides emissions is 'Road transport'. The emissions are smallest in the north of the Netherlands. The emissions for the most part stayed below EU norms of $40 \mu\text{g}/\text{m}^3$, only some small areas in Amsterdam and Rotterdam exceeded the norms in 2017, shown in red on the map.

Stikstofdioxideconcentratie

2017



Bron: RIVM, 2018

PBL/apr18
www.clo.nl/nlo23115

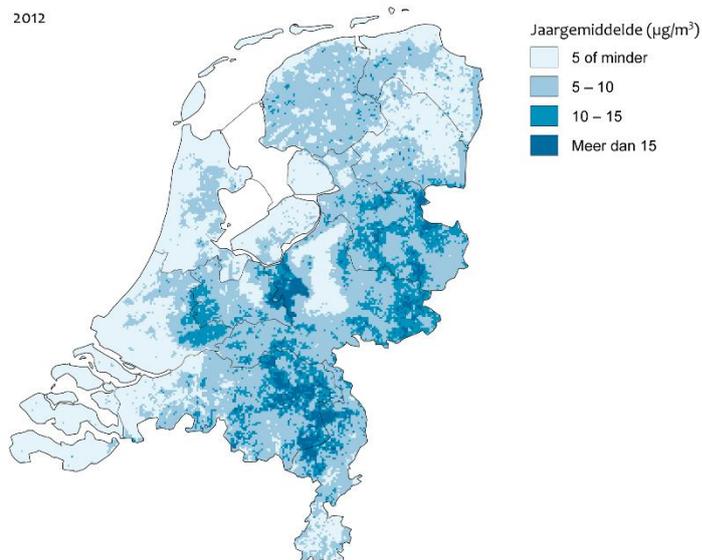
Figure 2.3 Average nitrogen oxides concentration emissions in 2017 in the Netherlands

Source: CLO, 2018

Figure 2.4 shows that ammonia emissions in contrast to nitrogen oxides are mainly emitted in the Dutch countryside instead of urbanized areas. The areas with the largest emissions are the areas with the most intensive agriculture (CLO, 2013). This is in line with Figure 2.2 which shows that agriculture is the sector with the highest emissions. The figure is for 2012 but it is not expected that large changes have occurred in recent years.

Ammoniakconcentratie

2012



Bron: RIVM, 2013.

PBL/apr13/0461
www.compendiumvoordeleefomgeving.nl

Figure 2.4 Average ammonia emissions concentration in 2012 in the Netherlands

Source: CLO, 2013

2.2 Effects of nitrogen emissions

Now that the nitrogen emissions are defined, the sources are clear and the concentration within the Netherlands is shown, the effects of nitrogen emissions can be discussed. Even though the verdict of the Council of State was about the emissions that affected the biodiversity in the Natura 2000 areas, public health effects are also discussed since it shows the additional relevance of reducing nitrogen emissions.

2.2.1 Biodiversity

It is clear from the verdict of the Council of State that nitrogen emissions affect biodiversity. In this section the way nitrogen emissions affect biodiversity are discussed. According to Brink et al. (2011), the total costs to ecosystems in the EU-27 countries was between €25 billion and €115 billion per year. The wide range indicates that it is difficult to value these costs. According to Bobbink et al. (2010) there are five ways in which nitrogen emissions affect biodiversity.

The first way is direct toxicity of nitrogen gases and aerosols. This only happens with high concentrations in the air and it affects the aboveground plant parts (Bobbink et al., 1998). To reach the level needed for such toxicity the plants need to be in the direct vicinity of sources that emit large amounts of nitrogen (Bobbink et al., 2010). Since this is a local problem, it does not affect regional biodiversity (Bobbink et al., 1998).

Secondly, the accumulation of nitrogen compounds. The amount of nitrogen available for plants increases gradually due to higher nitrogen emissions (Bobbink et al., 1998). This increase in nitrogen available to plants can lead to plants that have adapted to low nitrogen conditions to be outclassed by plants that make use of the higher nitrogen availability (Bobbink et al., 1998). As a consequence, some species of plants become dominant and other species disappear from the area. This then reduces the amount of species and therefore biodiversity. The term to describe such a process is competitive exclusion (Bobbink et al., 1998). Regarding a soil that is extremely nutrient poor, the biodiversity can actually increase due to nitrogen emissions because only a few species of plants can grow under such extreme conditions (Bobbink et al., 1998). An increase in nutrients would then lead to more species being able to grow and thus a higher biodiversity. Still, this negatively affects the native vegetation that is used to the extreme nutrient poor soil. Vitousek et al., (1997) gives an example for water, namely eutrophication. Eutrophication is when too many nutrients gets added to a body of water (Vitousek et al., 1997). It has negative consequences for biodiversity because certain algae can outcompete other organisms in water. Furthermore, it can negatively affect the amount of oxygen in water (Vitousek et al., 1997).

A third way in which nitrogen emissions affect biodiversity is the long-term toxic effects of ammonia emissions. Ammonia, or when it is deposited in soil ammonium (NH_4), can be toxic to plants (Bobbink et al., 2010). This is especially true for plants in an ecosystem that originally had nitrate as its dominant form of nitrogen (Bobbink et al., 2010). The toxicity manifests in poor root and shoot development, this is especially true for plants that are sensitive to ammonia/ammonium (Bobbink et al., 2010).

Also, soil acidification can affect biodiversity. Nitrogen deposition causes nitrogen saturation, meaning that the availability of nitrogen exceeds the aggregated nutritional demand of plants and microbes (De Vries et al., 2007). The nitrogen saturation in turn leads to nitrate leaching, meaning that nitrate leaks into soil water (De Vries et al., 2007). If this persists over a long period it leads to a lower pH of the soil or, in other words, the acidification of the soil (De Vries et al., 2007). Higher soil acidity will cause plant species that are acid resistant to become dominant and plants that are used to a more neutral pH will disappear (Bobbink et al., 1998). Furthermore, it also leads to accelerated leaching of base cations and, under specific circumstances, increased dissolution of aluminium, which can damage fine root development and mycorrhiza (Bobbink et al., 2003).

Lastly, susceptibility to secondary stress and disturbance factors increases. The increase of this susceptibility can be explained by the impacts of nitrogen emissions described above. Plants experience

stress due to these impacts of nitrogen emissions. If more stress, unrelated to nitrogen emissions, is added it can be detrimental to these plants. For example, plants can get a reduced resistance to plant pathogens and insects pests and increased herbivory (Bobbink et al., 2010). Furthermore, changes in plant physiology, biomass allocation (root/shoot ratios) and mycorrhizal infection can also influence the susceptibility of plant species to drought or frost (Bobbink et al., 2010).

2.2.2 Public health

Nitrogen emissions do not just affect biodiversity but also public health. According to Brink et al. (2011) the total costs to human health in the EU-27 countries was between €40 billion and €190 billion per year. Similar to biodiversity it is true that the wide range indicates that it is difficult to value these costs. The health effects are listed by Brink et al. (2011) as follows; asthma, respiratory disorder, inflammation of airways, reduced lung functions, bronchitis and cancers. These effects are true for both nitrogen oxides and ammonia. Ammonia has the extra disadvantage that it contributes to the odour problem. Additionally, ammonia has higher damage costs per kg emitted namely €9.5 instead of €5.6 with nitrogen oxides (Brink et al., 2011). Furthermore, increasing amounts of nitrate in drinking water, which is an effect of nitrogen deposition, can also affect public health. Cancers and effects on reproductive systems are mentioned as health effects by Brink et al. (2011). The costs of nitrate per kg is €0.7 (Brink et al., 2011). The effect on public health indicates that a reduction in nitrogen emissions is not just relevant for the environment but also for the society in general.

2.3 Natura 2000

In this section the Natura 2000 network is discussed. First the aim of the network is explained. Subsequently, the designation process of Natura 2000 areas is discussed. Thereafter, an assessment will be made of the Natura 2000 network to find out how effective it has been in reaching its aim. Lastly, the Natura 2000 network in the Netherlands and the Dutch designation process is discussed.

2.3.1 The aim of Natura 2000

The Natura 2000 network is not a policy of its own but rather a combination of the Birds Directive (79/409/EEC) introduced in 1979 and the Habitats Directive (92/43/EEC) introduced in 1992 (Beunen, Van Assche & Duineveld, 2013). These directives were introduced after growing awareness of environmental problems in the second half of the 20th Century (Evans, 2012). The directives forced member states (MS) to change their policy concerning biodiversity and conservation (Beunen, Van Assche & Duineveld, 2013). The MS had to select specific areas that together are called the Natura 2000 network or sometimes the Natura 2000 policy (Beunen, Van Assche & Duineveld, 2013). Weber and Christophersen (2002) state that it is presumably the most ambitious supranational initiative for nature conservation in the world.

The Natura 2000 network aims to protect habitats and species in the EU (Rosa & Da Silva, 2005). The Natura 2000 areas are important for species since they are core breeding and resting sites (European Commission, 2019a). Some of these habitats themselves are rare and unique, not because of the species, and are therefore protected (European Commission, 2019a). The network tries to achieve its aim by designating areas throughout the EU as Natura 2000 areas, developing conservation objectives and establishing management measures (Fock, 2011). If an area is designated as a Natura 2000 area, policy must be made by MS ensuring that these unique features of an area are protected (Beunen, Van Assche & Duineveld, 2013).

The network now stretches over 18% of the EU's land mass and almost 9.5% of its marine territory (European Commission, 2019a). In Figure 2.5 you can see the total hectares designated as Natura 2000 per country. In this figure you can see that the total of hectares is not necessarily divided equally among

MS. For example, the Netherlands and Belgium although relatively equal in size differ in hectares designated as Natura 2000. This is likely due to the bigger coast line of the Netherlands but can also be due to the difference in designating Natura 2000 areas.

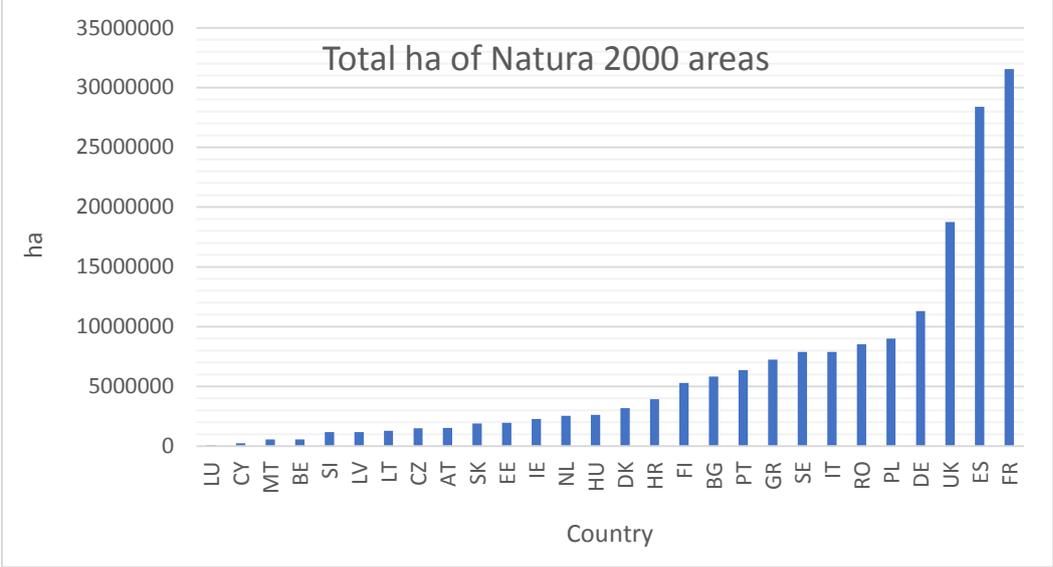


Figure 2.5 Total ha of Natura 2000 areas per country

Source: Author based on European Commission (2019a)

2.3.2 Designation of Natura 2000 areas by the EU

According to the European Commission (2019b), a Natura 2000 area is chosen according to ecological criteria which must be based on scientific methods. The selection procedure is different for areas that are designated under the Birds Directive and areas that are designated under the Habitats Directive (European Committee of the Regions, 2015). Natura 2000 areas can also be allocated based on both directives.

Under the Birds Directive MS designate areas as Special Protection Areas (SPAs) (European Commission, 2019b). The specific ecological criteria used for designating these areas are left to MS, but the MS must make sure that 'most suitable territories' are designated (European Commission, 2019b). This demand can be regarded as an 'in good faith' clause which makes sure that MS do not designate areas that are economically or politically convenient, but designate areas for their ecological value. The threatened birds species that have to be protected are listed in Annex I of the Birds Directive (European Committee of the Regions, 2015). After the MS provide their gathered information to the European Commission it decides if the SPAs form a coherent ecological network and if so they become Natura 2000 areas (European Commission, 2019b).

Under the Habitats Directive MS designate areas as proposed Sites of Community Importance (pSCIs) after they made an overview of species and habitats present (European Commission, 2019b). A 'good faith clause' similar to that of the Birds Directive is also present under the Habitats Directive (European Committee of the Regions, 2015). Natural habitat types that need protecting are listed in the directive's Annex I. The species that need protecting are listed in its Annex II (European Committee of the Regions, 2015). The European Commission gathers all information. The commission then organizes seminars for every biogeographical region where experts decide if enough 'high quality' areas have been assigned (European Commission, 2019b). If the areas are accepted they are classified as Sites of Community Importance (SCIs). MS are then obligated to re-designate these areas as Special Areas of Conservation (SACs) within six years (European Commission, 2019b). Areas designated as SACs have to abide all rules and regulations of the Habitats Directive.

2.3.3 Assessment of Natura 2000

One of the critiques on the Natura 2000 network is that the criteria used to designate areas vary between MS (Alphandéry & Fortier 2001; Apostolopoulou & Pantis, 2008; Gaston et al., 2008). Trochet and Schmeller (2012) support this critique by finding explanatory factors in their model that are not ecological criteria like the EU specifies. These include total national surface, national proportion of urban population, national population density, gross domestic product and weighted emissions of greenhouse gas emissions. Another critique is that the network is not managed in a harmonized way, every country effectively manages their part of the network independently (Trochet & Schmeller, 2012). Despite these criticisms the Natura 2000 network and programs like it bring measurable benefits to wildlife (Donald et al, 2007)

Gruber et al. (2012) performed an analysis on how well the threatened species listed in Annex II of the Habitats Directive were included by the network. They concluded that the Natura 2000 network was successful in including areas so that every listed species is represented in at least one area. However, the selection of areas led to relative underrepresentation of certain species in the network (Gruber et al., 2012). Species with a smaller spatial area where these species are found were better represented than species with a larger area. Trochet and Schmeller (2012) reach a similar conclusion when they look at 300 threatened red listed species, namely that most species are covered by the Natura 2000 network, but some are underrepresented, especially fish species. Both Trochet and Schmeller (2012) and Gruber et al. (2012) conclude that the Natura 2000 is beneficial for the protection of species.

2.3.4 Natura 2000 in the Netherlands

In the Netherlands the government has designated 163 areas as Natura 2000 areas (Rijksoverheid, 2019). Figure 2.6 and Annex I show the distribution of the Natura 2000 areas in the Netherlands. The areas on land and along the coast were designated in 2003 and the areas in the North Sea in 2008 (Ministerie LNV, 2019). The areas on land are relatively equally distributed but the areas in the west do appear to be smaller than the east. By far the biggest area on land is de Veluwe. However, the biggest areas are maritime areas. These areas also largely explain the disparity in the hectares designated in the Netherlands compared to Belgium, as you can see in Figure 2.5. Belgium is roughly equal in size but due to its smaller coastline has less hectares designated as Natura 2000. Figure 2.6 also show the percentage of nitrogen deposition above the norm in each area.

The designation procedure for Natura 2000 areas in the Netherlands is based on the Dutch 'Wet natuurbescherming', which protects nature reserves, species and plants (Ministerie LNV, 2019). The minister responsible designates an area for Natura 2000 (Ministerie LNV, 2019). A designation plan is made where the border of the area and the species and habitats that are to be protected in an area are specified (Ministerie LNV, 2019). The designation process is open to public participation (Ministerie LNV, 2019). Thereafter, a management plan is made with measures to ensure the protection of the area (Ministerie LNV, 2019). Permits then have to be granted for any activity in and around this area that can impact nature (Ministerie LNV, 2019). As a comparison, the designation procedure in the UK is similar to that of the Netherlands (Natural England, 2019). A difference is that in the UK independent governmental advisory groups give recommendations for what areas should be designated as Natura 2000, but the minister still makes the eventual decision (Natural England, 2019).

**Mate van overschrijding
stikstofdepositie**

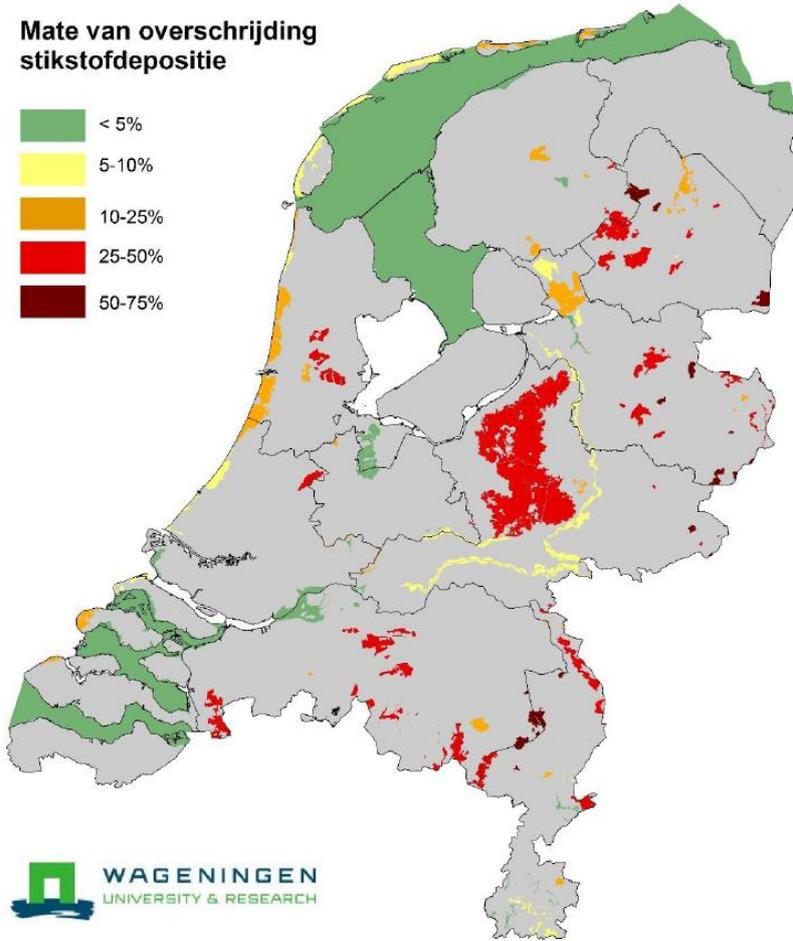
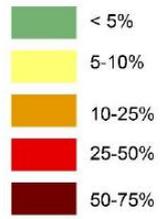


Figure 2.6 Natura 2000 areas in the Netherlands with the percentage of nitrogen deposition above the norm

Source: Gies, Kros & Voogd, 2019

3. The PAS in perspective

The Council of State's verdict on the policy regulation 'Programma Aanpak Stikstof' (PAS) concerning nitrogen emissions led to the end of that policy. To understand why the PAS ended, it needs to be seen in context. In this chapter, the PAS and the context will be explained. First, a brief overview of the history of the nitrogen policy in the Netherlands follows. This history can explain choices that were made in the formulation of PAS. Thereafter, the PAS itself is explained. Subsequently, the PAS will be assessed on how well it did to achieve its goals. Lastly, the arguments justifying the verdict of the Council of State and European Court of Justice are reviewed.

3.1 Historical development of nitrogen policy

The verdict of the Council of State in 2019 was not the first time a verdict of the Council of State affected nitrogen policy. In 2008 it ruled on the policy regarding ammonia (Julen, 2019). This policy, called 'Toetsingskader ammoniak en Natura 2000', was declared null and void since it did not offer enough guarantees that it would prevent negative consequences of extra ammonia emissions (Boerderij, 2008).

'Toetsingskader ammoniak en Natura 2000' affected the entire country and had two aims (Overheid.nl, n.d.). The first aim was to ensure that ammonia deposition in Natura 2000, in the long run, did not increase. The second aim was that economic activity could continue. The policy tried to achieve both goals by making one generic policy. Namely, if a company has a permit and wants to expand its business it can do so by producing 5% or less of the total ammonia deposition norm of the Natura 2000 areas it affects (Overheid.nl, n.d.). A company is also allowed to expand if the deposition is the same or lower compared to the deposition before the expansion (Overheid.nl, n.d.). The policy solved the problem that for every change of a permit, the impact on Natura 2000 areas had to be assessed (Provincie Drenthe, 2007). Another reason for the policy was that the management plans for the Natura 2000 areas were not finished yet (Provincie Drenthe, 2007). Therefore, it was unclear how much ammonia could be emitted (Provincie Drenthe, 2007). Important to note is that this policy is only relevant for changes in existing permits, new permits still had to be reviewed individually (Overheid.nl, n.d.).

The ruling of the Council of State critiqued the core of this policy. Namely that the 5% norm was not adequate in preventing increased ammonia deposition (Raad van State, 2008). The Council of State argued that this norm did not take into account that ammonia emissions are a local problem. Therefore, the norm can help to lessen the total ammonia emissions but not the ammonia deposition in certain Natura 2000 areas (Raad van State, 2008).

When the policy was no longer in place after the verdict, a backlog for permits and permit changes formed (Julen, 2019). For every permit that would result in nitrogen emissions an impact assessment on Natura 2000 areas had to be made. The backlog jeopardised the second goal of the original policy. Namely that economic activity is not negatively affected. An alternative policy was needed to solve this backlog.

3.2 The PAS

Huys et al. (2009), in their advice to the government, argued that a way in which nitrogen depositions can be reduced by one programmatic policy was still possible. Their argumentation was that a programmatic approach worked for permits concerning air pollution, so it can also work for nitrogen emissions. The programmatic policy for air pollution was based on recording measures (generic and specific) aimed at improving the air quality and recording activities that worsen the air quality (Huys et al., 2009). The entire policy is aimed at reaching the targets on time. The policy tries to achieve this by making relevant governing bodies responsible for implementing reduction measures (Huys et al., 2009).

The government took the advice of Huys et al. (2009) and drafted a new programmatic policy for nitrogen emissions. The draft policy was called 'voorlopig Programma Aanpak Stikstof' (vPAS). The policy

is based on the 'Crisis- en herstelwet' or the crisis and recovery law which was implemented in 2010 which amended the previously mentioned 'Wet natuurbescherming' from 1998 (Ministerie LNV, 2010). The 'Wet natuurbescherming' was amended to make vPAS and later PAS possible.

The goals of vPAS and PAS were the same as 'Toetsingskader ammoniak en Natura 2000'. Namely, to ensure that the habitats and species that are covered by the Birds Directive and the Habitats Directive are protected while economic activity is not negatively affected (Ministerie LNV, 2010). Schoukens (2018) calls the PAS an example of a shift towards adaptive management strategies. Schoukens (2018, p. 171) defines adaptive management as a 'flexible decision-making process that can be adjusted in the face of uncertainties as outcomes of management actions and other events become better understood'. Adaptive managing strategies have become more popular, in part, to overcome deadlock situations like the Dutch permit deadlock. To achieve both goals of the PAS specific measures are included (Ministerie LNV, 2017). These measures can be categorised in two categories: source measures and restoration measures.

3.2.1 Source measures

The first category of measures is measures aimed at the sources of nitrogen deposition (Ministerie LNV, 2017). The PAS only included generic measures since specific measures are already included in policy plans for specific Natura 2000 areas (Ministerie LNV, 2017).

The first goal for agriculture is to reduce the ammonia emissions from stables. The measure achieves this by changing the rules for stables (Ministerie LNV, 2017). The maximum emissions norms of ammonia are lowered or introduced for chickens, pigs, dairy cattle and veal calves (Ministerie LNV, 2017). The measure is only relevant for newly build stables, expanded stables and stables with a new floor (Ministerie LNV, 2017). The measure is planned to reduce the ammonia emissions with 5000 tonne of ammonia in 2030 with 2013 as base year (Ministerie LNV, 2017).

The second goal is to use manure in a way that it will reduce ammonia emissions (Ministerie LNV, 2017). The first measure to achieve this goal is to ban the 'sleepvoettechniek' on grassland, and clay and moor grounds (Ministerie LNV, 2017). The method deposits the manure in small ditches of 5 cm that are 15 to 30 cm apart (Water Over Mest, 2019). The farmers do not inject the manure, because that can be difficult on moor and clay grounds (Water Over Mest, 2019). However, injecting manure into the ground reduces the ammonia emissions (Water Over Mest, 2019). One alternative is to dilute the manure with water and otherwise use essentially the same method (Water Over Mest, 2019). This reduces ammonia emissions since ammonia dilutes in water and therefore it does not end up in the air (Water Over Mest, 2019). Another alternative is the 'pulse-trackbemester' method, which deposits the manure in small holes (Schoukens, 2018). The measure was scheduled to go into effect on the first of January 2018, but it was later postponed for one year (Schoukens, 2018). The measure is planned to reduce the ammonia emissions with 1500 tonne of ammonia in 2019 with 2013 as base year (Ministerie LNV, 2017).

The second measure comprises that on construction sites and non-cultivated land liquid manure and liquid sewage sludge must be directly injected into the ground, reducing ammonia emissions (Ministerie LNV, 2017). This measure has gone into effect on the first of January 2015 (Ministerie LNV, 2017). The measure planned to reduce the ammonia emissions with 500 tonne of ammonia in 2015 with 2013 as base year (Ministerie LNV, 2017). The total reduction until 2030 is shown in Table 1.

The final goal for agriculture is to reduce ammonia emissions with the help of feed and management measures. These measures are, in contrast with the other measures, non-binding (Ministerie LNV, 2017). Organisations that represent the agricultural sector signed a covenant with the Ministry of Economic Affairs for these measures (Ministerie LNV, 2017). The measures are aimed at providing more efficient management for minerals and thereby reducing the total amount of external minerals being brought in (Dijksma et al., 2014). The total reduction, despite the measure being non-binding, of ammonia emissions in 2030 is 3000 tonnes. The projected reduction of ammonia is also shown in Table 1.

Table 3.1 The projected reduction in ammonia emissions in tonnes from generic measures in agriculture with 2013 as base year

	2015	2018	2021	2024	2027	2030
Stables	100	500	1,400	2,600	3,800	5,000
Manure	500	2,000	2,000	2,000	2,000	2,000
Feed and management	500	2,000	3,000	3,000	3,000	3,000
Total	1,100	4,500	6,400	7,600	8,800	10,000

Source: Author based on Ministerie LNV, 2017

In addition to these measures additional funds are available to several projects (Ministerie LNV, 2017). These projects are all aimed at reducing ammonia emissions in agriculture. The projects can be divided in two categories. The first category consists of projects that stimulate innovation from farmers and agricultural firms. Furthermore, the projects also aim to improve farmers' agricultural knowledge. The second category involves projects that focus on research (Ministerie LNV, 2017). These projects include a project that looks at the effectiveness of PAS measures and it also includes two case studies on low emissions farming (Ministerie LNV, 2017).

The PAS only briefly mentions generic measures that are aimed at sources outside the agricultural sector. It refers to the national air quality partnership program where agreements have been made to reduce emissions (Ministerie LNV, 2017). Furthermore, the PAS also refers to new EU standards for cars that will lead to less emission over time (Ministerie LNV, 2017). The PAS is therefore clearly more focussed on ammonia emissions compared to nitrogen oxide emissions since generic measures aimed at reducing emissions from the source in the PAS target agriculture, which mainly produces ammonia as seen in Figure 2.2.

3.2.2 Restoration measures

The second category of measures consists of measures aimed at recovering Natura 2000 areas from high nitrogen deposition. The goal of these measures is to make these areas more resistant to the effects of high nitrogen deposition (Ministerie LNV, 2017). The measures target areas with a nitrogen deposition that is too high (Ministerie LNV, 2017). The number of these areas is planned to diminish over time after the measures aimed at the source have an effect. These measures do not affect the amount of emissions. The effects of these restoration measures are reviewed by scientists in the documents 'Herstelstrategieën Stikstofgevoelige Habitats, deel I, II en III' (Ministerie LNV, 2017). Examples of restoration measures are increasing the ground water level, stripping the top layer of high nitrogen soil, dredging and the removal of nitrogen heavy materials by mowing, grazing or periodically burning it (Ministerie LNV, 2017; Smits & Bal, 2012).

3.2.3 Room for economic activity

As mentioned before an aim of the PAS is to facilitate economic activity. The PAS assumes that the nitrogen deposition in Natura 2000 areas will decline. Partly because of the ongoing trend and partly because of the measures in the PAS that are aimed at the sources (Ministerie LNV, 2017). The trend of diminishing nitrogen emissions is calculated twice with either no economic growth or with 2.5% yearly growth. In both cases the trend of diminishing nitrogen emissions continues (Ministerie LNV, 2017). The difference between the no growth scenario and the 2.5% scenario is allocated for economic activity (Ministerie LNV, 2017). 50% of the reduction of nitrogen emissions caused by the generic measures aimed at the source can be used for economic activity (Ministerie LNV, 2017). According to the PAS, this leads to the preservation goals of the Natura 2000 areas being met in the long term while also not worsening the nitrogen deposition in the short term (Ministerie LNV, 2017). The deposition 'space' that is available for extra economic activity is included in the analysis of every Natura 2000 area. Therefore, the amount of deposition 'space' can be different for every Natura 2000 area (Ministerie LNV, 2017).

A part of this deposition 'space' is used for activities that are part of a general societal movement where no explicit permission is given (Ministerie LNV, 2017). An example of a broad general societal movement is population growth, which can mean that more houses are built and more cars are on the road. Another part is reserved for activities that have very low nitrogen emissions (Ministerie LNV, 2017). The emissions are so low that one project, in and of itself, will hardly affect Natura 2000 areas. There is some deposition 'space' reserved for this part since all these activities together can have some effect on Natura 2000 areas (Ministerie LNV, 2017).

Lastly, a part of the deposition 'space' is used for new economic activity which requires a permit (Ministerie LNV, 2017). Examples of activities are expansion of a dairy cattle farm, a new highway or new industrial activity. Some projects get preferential treatment when it comes to the deciding who gets what amount of the deposition 'space'. The projects that are included in this preferential treatment are infrastructural projects from the national government and projects from the defence ministry (Ministerie LNV, 2017). Additionally, it also can include projects for which it can be proven that they are of national or provincial importance (Ministerie LNV, 2017). These projects will be put forward by the provinces (Ministerie LNV, 2017). The list of projects that receive preferential treatment is updated every year (Ministerie LNV, 2017).

The agricultural sector is promised, on average, at least 56% of the effect of the generic measures that are aimed at the source in agriculture (Dijkema et al., 2014). Almost all the generic measures aimed at the source are aimed at agriculture as discussed previously. Only 50% of the reduction caused by all generic measures is used for economic activity, as mentioned previously. Therefore, an obvious conclusion is that most, if not all, of that 50% that is used as deposition 'space' has to be used for agriculture to reach the 56%. Another factor for the deposition 'space' for the agricultural sector is that the reduction of nitrogen emissions caused by farmers stopping can be used by the agricultural sector (Ministerie LNV, 2017).

Two other ways to facilitate economic activity are in internal and external offsetting (intern en extern salderen). Internal offsetting means that an actor scales back its nitrogen emissions in one part of their operations to allow more nitrogen emissions in another part of their operation (Bijl2, 2019). Internal offsetting has the benefit that the actor can accommodate the reduction of nitrogen emissions inside its own operation and is not dependent on another actor. External offsetting does not have this benefit. External offsetting means that one actor, or emission receiver, convinces another actor, or emission giver, to lessen its emissions. The emission receiver can 'use' the emissions from the emission giver to emit more nitrogen (Bijl2, 2019). However, external offsetting is, in principle, illegal when the PAS is introduced (Ministerie LNV, 2017). Still, external offsetting is possible despite this ban. Certain conditions have to be met to be allowed to use external offsetting (Ministerie LNV, 2017).

3.2.4 Neighbouring countries

As mentioned in chapter 2, nitrogen emissions from abroad affects Dutch Natura 2000 areas and vice versa. If a Dutch actor emits nitrogen that affects Natura 2000 areas abroad it must be taken into account for permits (Ministerie LNV, 2017). However, the deposition 'space' created by reducing deposition on these areas cannot be used for economic activity (Ministerie LNV, 2017). The deposition 'space' cannot be used since this deposition 'space' is specifically aimed at the Netherlands (Ministerie LNV, 2017). Nitrogen that gets emitted by actors abroad and which affects Dutch Natura 2000 areas fall under the jurisdiction of that country. Therefore, the PAS has no influence on these emissions (Ministerie LNV, 2017). All neighbouring countries do have to adhere to the Bird and Habitats directives since they are all part of the EU. The deposition from abroad is included in the calculations of deposition 'space' and it is expected that the declining trend in emissions will also be present in neighbouring countries (Ministerie LNV, 2017). If this would not be the case, the Dutch national government will point that out to the country in question (Ministerie LNV, 2017).

3.3 Assessment of PAS

After describing the PAS, it can now be assessed. The assessment will look into the effectiveness of the PAS. Furthermore, it will look into the efficiency of the program and the problems the program encountered.

Firstly, the assessment of the effectiveness that was done *ex ante* is discussed. The 'Commissie voor milieueffectrapportage' or MER gives advice to the Dutch government on the effect of policies on the environment. MER provided its final advice for the PAS in 2015. MER (2015) wrote in their advice to the Dutch government that it understood why the two objectives were chosen. It argued that both goals are useful for creating a broad support for the PAS (MER, 2015). A point of critique the MER (2015) has is that although the PAS strives towards the norms of nitrogen emissions within the foreseeable future, the PAS has no strict deadline for reaching this goal. MER (2015) also notes that the PAS focuses on generic measures for reduction of nitrogen emissions and less on measures specifically aimed at a Natura 2000 areas. The PAS has an analysis included for every Natura 2000 area, but the policy focuses more on general measures as opposed to specific measures. Another point made by MER (2015) is that permission granted for economic activity in the first period of the PAS could be counterproductive to measures taken in later periods of the PAS. By giving permission for economic activity in phases instead of all at once reduces this risk but does not eliminate it (MER, 2015). MER (2015) concludes that if the PAS takes all these points into consideration and the commission approves the PAS.

In the advice from MER in 2011 and 2013 the critique was harsher. In their first advise MER (2011), amongst other things, critiqued the legal basis for the PAS under European law. One reason given for the doubt about the legal basis is that projects where nitrogen emissions appears to be the same or less compared to the old situation, there could still be a need for a new permit (MER, 2011). Something that the PAS did not view as necessary (MER, 2011). The same is true for external offsetting, which was taken out of the PAS as discussed previously (MER, 2011). The advice of MER in 2013 contained the critique that was also present in the advice of 2015. Namely that no clear time limit was present.

Secondly, the assessment of the PAS *ex post* is discussed. Regarding the economic objective of the PAS, it appears that the PAS was successful (Schoukens, 2018). As mentioned before, the main problem for economic activity was the large permit backlog (Julen, 2019). According to Julen (2019), this backlog was mostly resolved between 2015 and 2019. The MER (2013) already predicted in their advice that the PAS would be successful with regard to providing necessary room for economic activity. One objective of the PAS is clearly met.

Regarding the second objective, Schoukens (2018) notes that the PAS is not primarily aimed at achieving nitrogen deposition loads below critical levels. Rather in the PAS it is assumed that resilient Natura 2000 areas can still thrive under higher levels of nitrogen deposition (Schoukens, 2018). Schoukens (2018) claims that the aim was not set at reaching the critical levels, since that would have led to societal resistance to the measures. Schoukens (2018) concludes that integrated and adaptive management should be preferred above 'business as usual' regulation. However, the PAS is not a perfect solution. In some cases it can worsen existing environmental conditions (Schoukens, 2018). The PAS seems to miss the size of the problem stemming from intensive livestock farming (Schoukens, 2018). Moreover, the PAS does not take enough uncertainty into account and lacks transparency (Schoukens, 2018). An adaptive management strategy and the flexibility that comes with this approach is exactly what makes the PAS vulnerable for legal challenges regarding the ecological protection of the Natura 2000 areas (Schoukens, 2018). The PAS having two objectives while the European directives are only focussed on conservation appears to put the two at odds. Schoukens (2018) has a similar conclusion when stating that the ultimate flaw of the PAS is that recovery of Natura 2000 areas can be reconciled with further economic expansion. He goes on to state that adaptive managing tools like the PAS can be used to hide fundamental policy choices by claiming that both objectives can be met at the same time. This conclusion is the opposite of what MER concluded (2015).

The nitrogen emissions since the introduction of the PAS appears to be stable. In Figure 2.1 it is shown that the emissions of nitrogen oxides has reduced somewhat after 2015. However, in Figure 2.2

ammonia emissions appear to have risen after 2015. Since nitrogen emissions have not reduced, one can argue that the PAS did not reach its second objective of protecting habitats and species that are covered by the Birds Directive and the Habitats Directive. To realize the second objective, nitrogen emissions should have been lowered (Schoukens, 2017). The rise of ammonia emissions means that today's situation is even worse than before the PAS.

3.4 Legal trouble

To conclude chapter 3, after 'Toetsingskader ammoniak en Natura 2000' was declared null and void the PAS was created. The PAS was a policy with two distinct objectives: to ensure that the habitats and species that are covered by the Birds Directive and the Habitats Directive are protected while economic activity is not negatively affected. The PAS tries to achieve these objectives mainly by generic measures and expecting the ongoing trend of diminishing nitrogen emissions to continue. The generic measures can be categorised in two categories: source measures and restoration measures. The assessment of the PAS ex post by MER was critical on the PAS citing multiple reasons. Assessment of the PAS ex ante was also critical regarding the environmental objective of the PAS. Schoukens (2018) states that the fundamental problem of the PAS is that it has two objectives that cannot be reconciled. Regarding the end of the PAS, the Council of State used two arguments in their ruling (Raad van State, 2019). The first argument is that the PAS used future anticipated reduction of nitrogen emissions caused by the measures in the PAS to grant permits (Raad van State, 2019). The Council of State ruled that the reduction of nitrogen needs to be achieved before granting such a permit (Raad van State, 2019). The second argument used is that the PAS also gives permits based on the deposition space that is available due to measures that are meant to prevent the deterioration of Natura 2000 areas (Raad van State, 2019). The Council of State ruled that this was also not allowed (Raad van State, 2019).

4. Policy tools

Since the PAS was declared null and void a new policy for nitrogen emissions is needed. To prevent a permit backlog that emerged before the PAS was introduced a new policy should be introduced as soon as possible. Furthermore, to prevent such a backlog the new policy has not only to be implemented as soon as possible but it has to be implemented nationwide. The policy needs to be implemented nationwide since evaluating each new permit individually has proved time consuming. An example of this is the period before the introduction 'Toetsingskader ammoniak en Natura 2000' in 2008 as discussed in chapter 3. In this chapter the theory emission rights as a policy tool that can be used for a new nitrogen policy is discussed.

4.1 Emission rights

In this section, the goals that can be achieved by emission rights or supply quota are discussed. The economic effects of introducing emission rights are explained. How emission rights compare, as a policy tool, with other policy tools like taxes is also explained. Furthermore, considerations that need to be made when implementing emission rights, like tradability of rights and the distribution of rights are discussed. Additionally, the difficulties with implementing emission rights are discussed. Lastly, a short summary and conclusion is given.

Supply quotas or emission rights is a policy tool that can be used to put an upper limit on the production of a good or a pollutant (Peerlings, 2003). In agriculture, the policy tool can be used to achieve several goals. First, it can be used to control the amount spend on agricultural subsidies (Peerlings, 2003; Alvarez et al., 2006). Furthermore, the subsidies given to the agricultural sector can lead to excess supply that can also be prevented by a quota (Alvarez et al., 2006). Additionally, a quota can support agricultural prices since it will limit the supply that drives up prices. Lastly, it can be used to limit pollutants that are directly linked to production (Peerlings, 2003).

A supply quota is an upper limit, set on the production of a good or a pollutant. Meaning that in a closed economy, the supply function is completely inelastic when the cap set by the government is reached (Peerlings, 2003). The supply is inelastic since the supply cannot increase as the price increases. Figure 4.1 shows an introduction of a supply quota in a closed economy in a market with perfect competition. The quantity supplied and demanded before the introduction was y_0 with P_0 as the market price. The quota was introduced with y_n set as the maximum supply. The market price that corresponds with this supply quantity is P_n . The price does not necessarily rise as indicated in Figure 4.1. If the supply is small compared to the demand, the price increase is small or non-existent. Another scenario where the price does not change is when the market price is equal to the price support set by the government (Peerlings, 2003). The shadow price is indicated by P_s . The shadow price is the price where producers are willing to produce the supply quantity (y_n) (Peerlings, 2003). The shadow price is equal to the marginal costs of production. The difference between P_s and P_n is known as the shadow price of the quota (Peerlings, 2003). In other words, the difference between P_s and P_n is the amount a producer is willing to pay for one unit of quota. Logically, a producer will not pay more than shadow price of the quota.

The effect of introducing a supply quota as shown in Figure 4.1 on consumer's surplus is a loss of area A and B. The loss comes from the fact that the consumers have to pay a higher price and being able to buy less since the quantity produced is lower. The effect of introducing a supply quota on the producer's surplus increases, when the market price actually goes up, by area A but at the same time decreases by area D. Assuming that area A is bigger than D, this is a gain in producer's surplus. The total welfare effect of a supply quota therefore is a loss of area B and D. Area A and C in Figure 4.1, after the introduction of the quota, represents the quota rent. Meaning, the extra earnings, compared to the initial situation, of producers that have acquired the right for production.

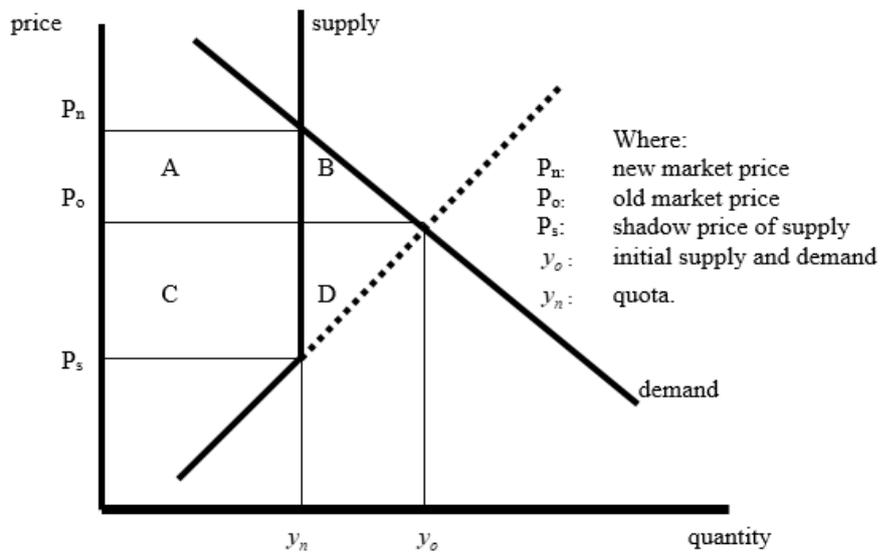


Figure 4.1 Supply quota in a closed economy

Source: Peerlings, 2003

A tax could also be used for diminishing production just like a quota. If in Figure 4.1 the policy maker wants to reduce the production from y_o to y_n , the same as the quota, the tax has to equal $(P_n - P_s)$ (Peerlings, 2003). However, a tax has different economic effects compared to a quota. Namely, with a quota area A and C are part of the producer's surplus, with a tax this changes. With a tax levied, area A and C are now government income instead of producer's surplus. The total welfare effect remains the same compared to a quota. The disadvantage of a tax is that it needs constant adjustment to keep the production on the desired amount (Peerlings, 2003). With a supply quota this amount is fixed. The constant adjustment is due to technological developments, price changes of inputs, changes in demand and other factors (Peerlings, 2003). The constant adjustment is most likely politically difficult to implement (Peerlings, 2003).

4.1.1 Tradability and distribution of quotas

An aspect that was not taken into account in Figure 4.1 is the tradability of production rights. Tradable production or emission rights have been hailed by economists as being the most efficient for production or emission/pollutant reduction (e.g. Borghesi et al., 2016). The efficiency of tradable quota rights can be logically explained. Namely, the producers that have the lowest marginal cost of production, or highest shadow price of the quota rights, will be able to pay the most for quota rights (Peerlings, 2003). This is illustrated in Figure 4.2. Figure 4.2 indicates the effect of one producer, and therefore, the demand curve is completely elastic. Meaning that one producer cannot influence the market price, the producer is a price-taker. As an example producer A has an initial endowment of quota rights of y_o , which corresponds with a shadow price of production of P_s . The quotas are tradable and the market price of a quota is $(P_m - P_{s1})$. The shadow price for quotas of producer A is $(P_m - P_s)$. Meaning that Producer A is willing to pay more for a quota than the quota market price. Therefore, producer A will try to acquire quotas for the amount of $(y_1 - y_o)$. The increase in surplus for this producer are the areas E and F. However, producer A has to pay area E so the net increase in surplus is area F. In another scenario, the market price of a quota is $(P_m - P_{s2})$. The shadow price of the producer remains the same at $(P_m - P_s)$. The producer now has an incentive to sell part of its quota, namely $(y_o - y_2)$. The producer surplus drops by the areas A+B+C. However, the gains from selling the quota rights is $(y_o - y_2)$ times $(P_m - P_{s2})$ which are the areas A+B+C+D. Therefore, the net change in profit for the producer is equal to area D. This shows that tradability of rights increase profits for producers that have a higher shadow price of a quota compared

to the market price but also for producers that have a lower shadow price of a quota. Therefore, this shows that tradability increases total economic efficiency.

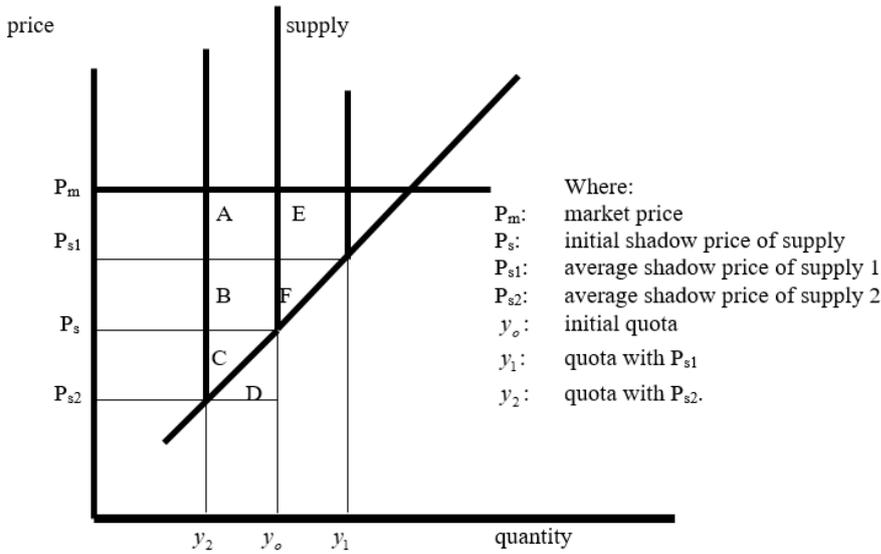


Figure 4.2 Supply quota in a closed economy with tradable rights

Source: Peerlings, 2003

Logically, with tradability of quota rights the supply of quota rights is price dependent. However, the supply, in part, is also price independent. The part of the supply of quota rights that is price independent stems from reasons such as retiring producers, think of farmers, or producers that stop for other reasons (Peerlings, 2003). The introduction of a quota would be beneficial for the structural development of a sector since it gives an extra monetary incentive for quitting to high-cost producers (Boots, Lansink and Peerlings, 1997; Peerlings, 2003). Moreover low-cost or efficient producers can expand (Peerlings, 2003). Furthermore, technological developments can lead to excess capacity, tradability can reduce this and lead to more efficient production (Peerlings, 2003).

The bid prices on quota rights are yearly prices (Peerlings, 2003). The extra profit gained from the quota rights are therefore the extra profit created in one year. The bid prices, in this case, are thus the same as the prices for leasing quota rights (Peerlings, 2003). If the quota rights are bought for in perpetuity, the bid prices will be the present value of all future income gained by the acquisition of the quota rights (Peerlings, 2003). The present value not only depends on discounting but also on the expectations on how long the quota will be in place, possible policy reforms, technological developments, fiscal treatment of quotas and other influencing factors (Peerlings, 2003).

The distribution of quota rights is an important aspect to take into account. The European Emission Trading System (EU ETS), which is probably the best-known scheme for emission rights, uses 'grandfathering' as a way of initial distribution of rights (Borghesi et al., 2016). Grandfathering means that the rights are distributed according to historical production or emission levels. For example, if 2018 is chosen as the base year and producer Y produced amount X in 2018, it will receive production rights equal to the X amount. Grandfathering could be seen as a protection of the status quo since the big producers get the largest amount of production rights. Economists often hail auctioning as the most economically efficient way of distributing since it is viewed as more simple and transparent compared to other methods (Burtraw & Evans, 2008). Auctioning protects the status quo somewhat since capital rich producers can offer the most on rights. However, as opposed to grandfathering new producers have a fair chance of getting rights at the initial distribution. Distribution of rights being fair and transparent prevents rent-seeking behaviour (Burtraw & Evans, 2008). Meaning that groups of producers will lobby

to the governmental agency responsible for distributing quota rights. Rent-seeking behaviour is also a disadvantage of non-tradable rights (Peerlings, 2003).

Government distribution of rights can also be used in order to reach certain policy goals. An example, regarding agriculture, is to maintain production in areas that are less suitable for agriculture and therefore have a higher cost of production (Peerlings, 2003). There are multiple reasons for maintaining agriculture in these regions, keeping regions economically viable, specific cultural or social reasons or indirect economical value like tourism (Peerlings, 2003). Another example of distribution of quota rights used to achieve policy goals is redistributing of income or assets (Peerlings, 2003). This can be used to favour a group of producers over another. An potential example, in agriculture, could be the preference for young farmers or organic farmers. Lastly, an example of specific distribution of quota rights in agriculture is to prevent large disinvestment in processing plants (Peerlings, 2003).

However, tradability of quota rights would negate the effect of distributing the quota rights to these specific groups, a disadvantage of tradable rights (Peerlings, 2003). There are other disadvantages to having quota rights be tradable. Namely, that the quota rights have to be financed which can lead to quota rights becoming a sizable part of the total costs (Peerlings, 2003). Moreover, tradability will make quotas harder to abolish since it would entail large capital losses (Peerlings, 2003).

4.1.2 Quota for pollutants

After having discussed the economic theory of a supply quota and quota rights I now discuss the specific situation for pollutants. Pollutants are a by-product of production. In the case of this thesis, the nitrogen pollutants are a by-product of the production of, amongst other things, milk, eggs and meat. Since pollutants are a by-product of production a simple supply quota is not relevant, simply because the pollutant is not what a producer wants to produce. If the example of milk production is followed, a supply quota will be simply implemented for milk, an X amount is set as a max and the logic of the market as described in 4.1 is followed. The only difficulties regarding policy would be distribution and tradability as discussed in 4.1.1. With a pollutant several other difficulties regarding policy come up. One difficulty is that, unlike the scenario with milk, there is not one market that is affected. A new market of quota rights will be created. To solve this issue, taking agriculture is as an example, the amount milk produced and the amount of the nitrogen emitted, caused by the milk production, can be used to calculate the amount of nitrogen per litre milk produced. The price of a litre of milk can then be used to calculate the price of nitrogen emissions for this sector. This can be done for all the sectors and with that showing the different price for nitrogen per sector.

The previous makes that a policy maker has to consider whether or not to allow for tradability. More specifically, if different sectors are allowed to trade the pollutant permits amongst each other or not. The advantage of this would be economic efficiency. Meaning that with inter sector tradability one or a few sectors are able to buy up all of the emissions rights. The dominance of one or a few sectors can be against other policy goals than efficiency. For example, it can be politically disadvantageous to help only a couple of industries with the introduction of a quota for a pollutant. Additionally, the problem of clustering of the emission rights is also possible region wise. Meaning that one or a few regions are able to buy up all emission rights. The problem this can create with certain pollutants is that if the producers of a pollutant are geographically close, the emissions will be concentrated which can be detrimental to the environment. A similar situation is true for inter country tradability of emission rights. In short, the trade-off between economic efficiency and concentration of emission rights that comes with tradability or preventing a concentration but without the economic benefits of tradable permits seems to be important for quotas regarding pollutants.

Another difficulty regarding a tradable quota for a pollutant is what kind of system a policy maker uses to minimize the amount of pollutant emitted. A common method used is the cap-and-trade system, like is used with the EU ETS (Borghesi et al., 2016). Cap-and-trade systems distribute permits with one of the methods mentioned in 4.1.1 and the permits add up to the total amount that may be emitted, the cap

(Borghesi et al., 2016). To reach the policy goals for emissions, the governing body lowers the cap over time (Borghesi et al., 2016).

There are other ways to reduce emissions. The syphoning system (afromen in Dutch), which holds back a part of permits when trading is also used. Syphoning is illustrated in Figure 4.3. Without a syphoning system the demand equals the supply of quotas. The corresponding price is P1 and the corresponding quantity is Y2. In this initial situation there is no reduction in the emission of pollutants since all the quotas offered at price P1 are bought up. With the introduction of a syphoning system this changes. With syphoning, a permit is supplied but only Z percent goes to the demander while the rest is taken out of the market e.g. it is given to a deposition bank. This means that for the same amount of quotas a demander now has to pay more. This is indicated in the shift in prices from P1 to P2. At this new price level the quantity demanded is Y1 while the quantity supplied is Y3. The difference is indicated with an X in Figure 4.3. Since the amount diminished from Y2 to Y1 this shows that a syphoning system reduces quotas and thus the emission of pollutants.

For example, take phosphate (PO_4) rights in the Netherlands. After the milk quota was abolished in the EU in 2015 the total Dutch dairy livestock increased substantially (Samson et al., 2016). Cows produce phosphorus. Logically, the total phosphate emissions rose. The Dutch government wanted to prevent a further rise in phosphate emissions. Therefore, the government introduced phosphate emission rights in 2018 (Rijksoverheid, 2020). The scheme includes syphoning. If farmers want to trade their permits 10% of the traded quantity is withheld and kept in a so-called phosphate bank (European Commission, 2017). The phosphate bank will provide these permits to so-called land-based farms, which are farms that can fully apply their emitted phosphate on their own land (European Commission, 2017). The land-based permits are non-tradable (European Commission, 2017). The approach for phosphate appears to work. The total phosphate emissions from manure in the Netherlands in 2018 declined compared to the emissions in 2017 (CBS, 2019).

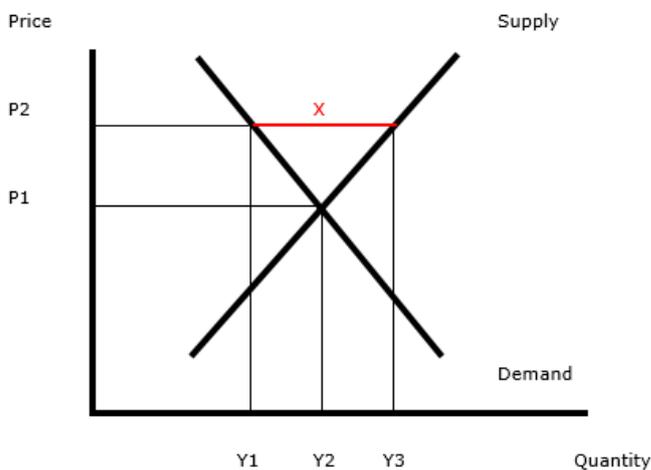


Figure 4.3 Stylized version of a quota market for a pollutant

Source: Author based on Guyomard et al., 1994

5. Empirical results

In this chapter the nitrogen emission rights as a policy tool is discussed and assessed using data. Using this data the effect of the introduction of emission rights can be estimated. It will focus on emission rights that are tradable between sectors. The assessment will indicate to policy makers if nitrogen emission rights as a policy tools have the desired effect or other policy tools should be considered.

5.1 Tradable of emission rights between sectors

In chapter 4 the considerations regarding the tradability of emission rights are discussed. In that chapter it is discussed that emission rights that are tradable between sectors will lead to a welfare gain for everybody trading. However, it will also imply a shift of emission rights from one sector to the other. So, some sectors will shrink and other will expand. This can be politically difficult to accept for the stakeholders in the shrinking sector. Moreover, it can contradict other policy goals such as the ones discussed in chapter 4. In this section the different shadow prices for emission rights per sector within agriculture will be derived and discussed. This will identify the sectors that will be shrink or expand after free tradability between sectors is made possible.

Table 5.1 shows all nitrogen emissions per animal sectors. Some minor sectors are excluded for simplicity's sake. The sectors that are excluded are veal, breeding chickens for broilers, ducks, turkeys, horses, goats, sheep, rabbits and fur animals. What is obvious is that dairy cattle emit the most nitrogen. The amount of nitrogen this sector emits is considerably higher than any other sector especially if the young cattle are included. Some other sectors that are big emitters are fattening pigs, breeding pigs and laying hens.

Table 5.1 Nitrogen emissions per agricultural sector in 2018

Sector	Nitrogen emitted (1000kg)
Total dairy cattle	289,900
Dairy cattle	234,000
Young dairy cattle	55,900
Female beef cattle	10,900
Beef bulls	3 900
Breeding pigs	31,400
Fattening pigs	65 400
Laying hens	31,700
Broilers	17,100

Source: Calculations from the author based on data from CBS (2020)

Table 5.2 shows the shadow prices per animal sector for 1 kg of nitrogen. The calculation of the shadow prices consists of a few steps. First, the total nitrogen emissions per agricultural sector are taken from the literature. Second, the gross margin per sector is also taken from literature. The gross margin is available per animal or sometimes unit of produce. For example, the gross margin for the dairy cattle is available per 100 kg of milk while the gross margin of breeding pigs is available per sow. Third, the amount of animals or the amount of produce in the relevant unit is taken from literature. Lastly, using this data the shadow price per 1 kg of nitrogen is calculated. Since describing the calculations in detail are too extensive to show in this section, they are available in Annex II. Annex II also shows the gross margins for every animal sector. Adding up all the shadow prices and diving that number by the total amount of sectors gives the average shadow price.

The animal sector with the highest shadow price is the organic laying hens. Followed up by the organic dairy cattle sector and thereafter the conventional dairy cattle sector. The sector with the lowest shadow price is the female beef cattle industry. The second lowest sector is another beef cattle industry, namely the beef bull sector. The dairy cattle sector and the meat cattle sector clearly have a different value regarding the emission of nitrogen despite them both using cattle. To explain the difference between the meat and dairy cattle sector is difficult since the gross margin of dairy cattle is available per 100 kg milk and the gross margins of the female beef cattle and the beef bull sector are available per cow. However,

the amount of nitrogen per cow can be compared. For one cow in the female beef cattle sector 381.12 kg of nitrogen is emitted, as explained in Annex II. The amount of nitrogen per cow in the dairy sector is 178.74 kg of nitrogen. Young dairy cattle and young beef cattle are both not included in the total number of dairy cattle and female beef cattle. So the difference in shadow prices can partly be explained by the nitrogen emission per cow. The other explanation is the likely the higher gross margin.

Another difference between shadow prices that is noteworthy are the differences between conventional production and organic production. The organic dairy cattle sector has a higher shadow price compared to the conventional production. It is assumed that the amount of nitrogen per kg of milk is the same for both sectors as described in Annex II. Tuomisto et al. (2012) did a meta-analysis of published studies that compare environmental impacts of organic and conventional farming in Europe. According to Tuomisto et al. (2012), organic farming generally has positive impacts on the environment per unit of area, but not necessarily per product unit. Tuomisto et al. (2012) states that nitrogen leaching, ammonia emissions and nitrous oxide emissions per unit of field area is lower with organic farming. In this thesis it is assumed that the nitrogen emission per product unit is the same for organic and conventional farming. Tuomisto et al. (2012) did not find a significant difference in nitrogen emissions per product unit. Therefore the assumption can be true.

The difference in shadow prices is explained by the higher gross margin of the organic sector compared to the conventional sector. For the laying hens sectors it is also assumed that the nitrogen per hen is equal across all laying hen sectors, as described in Annex II. Therefore, the differences between the laying hens sectors are also explained by the differences in the gross margin. Similar to the dairy cattle sectors the organic laying hens sector has the highest shadow price and the cage laying hens sector the lowest. It appears that organic sectors are willing to pay more to emit nitrogen since their gross margins are higher.

The difference between the breeding pigs sector and the fattening pigs is substantial, breeding pig farmers are willing to pay almost double for 1 kg of nitrogen emissions compared to the fattening pigs farmers. Fattening pigs and sows are not perfectly comparable since the animals have different purposes. However, to give some indication where the difference in shadow prices comes from the amount of nitrogen per animal can be useful. The amount of nitrogen emitted per fattening pig is 11.61 kg and the amount of nitrogen emitted per sow is 34.03 kg, as is described in Annex II. So the difference comes from the difference in gross margins, which is relatively high for breeding pigs.

The difference between the shadow prices of the broiler sector and the laying hens sectors are not as big compared to the differences of between the pig sectors. Actually, the shadow price of broilers and free-range laying hens are nearly the same. The amount of nitrogen emitted per chicken in the broiler sector is 0.35 kg while the amount of nitrogen emitted in the laying hens sector is 0,67 kg, as described in Annex II. Laying hens emit almost double the amount of nitrogen per chicken compared to the broiler sector. This implies that the gross margin of laying hens compared to the gross margin of broilers is relatively high.

Table 5.2 Shadow prices per animal sector in 2018

Sector	Shadow price for 1 kg nitrogen in euros
<i>Average shadow price</i>	8.26
Dairy cattle (conventional)	13.13
Dairy cattle (organic)	18.88
Female beef cattle	0.08
Beef bulls	0.65
Breeding pigs	10.25
Fattening pigs	5.68
Laying hens (cage)	3.34
Laying hens (free-range)	5.05
Laying hens (free-range plus)	9.28
Laying hens (organic)	19.53
Broilers	5.03

Source: Calculations from author based on data from CBS (2020) and KWIN (2019)

In the case of inter sector trade of nitrogen emission rights, it is expected that dairy cattle farms and the organic lay hens farms will buy these rights. As explained in section 4.1 this will lead to more efficient production compared to a situation where no inter sector trade is allowed. However, there are also clear drawbacks in allowing inter sector trade, as described in section 4.1. Furthermore, the introduction is politically difficult to implement, as farmers are opposed to it for fear that they may be forced to sell their farm (Peelen, 2020).

Some remarks regarding the validity of the figures in Table 5.2 should be made. First, the assumption that a few sectors with the highest shadow prices are able to buy the emissions rights relies on the assumption that the shadow prices remain constant regardless of the production of a sector. Economic theory assumes that a change in production also means a change in marginal costs. If the marginal costs change, the gross margin of a sector also changes. Consequently, if the gross margin of a sector changes, the shadow price of nitrogen emissions also changes. To use the dairy cattle sector as an example again, according to the figures in Table 5.2 this sector will buy up nitrogen emission rights. As this sector acquires more emissions rights the production of this sector will increase. If the assumption of constant shadow prices is followed, the dairy cattle sector will keep trying to acquire emission rights since this sector still is willing to pay more for these rights than most sectors. If economic theory is followed, as production increases marginal costs will eventually rise. As marginal costs rise the gross margin will decrease. As the gross margin decreases the shadow price of the sector also decreases. Therefore, following economic theory, the shadow price of the dairy cattle sector will decrease after the production has increased. The shadow price will decrease till it equals the shadow prices of the other sectors. Meaning that the dairy cattle sector stops buying emission rights. The change in gross margins as the production increases could be due a farm reaching their stable capacity. If they then want to keep increasing their production they would need to make an investment into a bigger stable driving up costs and thus reducing the gross margin. The assumption of constant marginal costs is made because of the limited scope of this thesis.

Second, is that the figures in Table 5.2 do not include a syphoning system that could be implemented simultaneously with the introduction of nitrogen emission rights. Syphoning means that a part of the traded emission rights is taken out of the market, as described in section 4.1.2. Meaning that the prices of emission rights will rise and the demand will decrease. This has an effect on trade of emission rights since a syphoning system will drive up prices. Meaning that less emission rights are traded. Notice that after trade, the shadow price between the different sectors will be equal.

Third, the shadow price of the emission rights depends on the gross margins. In agriculture these can change over time due to the output price volatility. Therefore, the shadow prices will also vary over time. It is to be expected that farmers will base their decision whether or not to trade on the expected shadow prices. These could be different from the calculated prices. The predictions of average gross margin per animal sector of the KWIN are only relevant for the period 2019-2020.

Fourth, the shadow prices are based upon gross margins that are average. The size and specifics of farms within the same animal sector can vary widely. Therefore, the gross margins and consequently the shadow prices can differ between farms within the same animal sector. Large farms might have higher gross margins because of economies of scale and therefore are willing to offer more for emission rights than small farms.

Lastly, as described in chapter 4, there are downsides to introducing tradable emission rights other than the concentration of emission rights by a few animal sectors. One downside of tradable emission rights is that if there is a concentration of emission rights in a few animal sectors, the processing industry of the animal sectors that sell their emission rights will have nothing to process anymore. If the processing industry fails, a large amount of capital and employment is lost. This is true for the downstream part of the value chain but also the upstream part. Tradable emissions would also make it impossible for the government to favour any group of farmers or a specific region by handing more emission rights to them. Emission rights will also become a big part of the total costs of a farm. This will also mean that emission rights will complicate taking-over of farms. Another disadvantage of emission rights is that an abolishment of such a system would be hard since it will involve large capital loss.

6. Conclusion and discussion

The decision of the Dutch Council of State (Raad van State in Dutch) to declare the nitrogen policy 'Progamma Aanpak Stikstof' (PAS) null and void had an impact on Dutch agriculture and agricultural policy making. The PAS was deemed null and void since it gave permits under the assumption that future plans would reduce the nitrogen levels in Natura 2000 areas. However, according to European law the permits can only be given after these measures to reduce nitrogen in Natura 2000 have already been taken (EU Court of Justice, 2018). The ruling from the Council of State led to great uncertainty about the validity of permits given out for big infrastructural projects and other construction projects for which still appeal possibilities exist (Niewold & Segaar, 2019). Moreover, this is the case for permits for the expansion of farms (Niewold & Segaar, 2019). The ruling combined with comments from a member of parliament who said that the total Dutch livestock should be halved led to large farmers' protests. The first farmers' protest led to the largest morning rush hour ever in the Netherlands (Kos, 2019).

A new national policy regarding nitrogen has to be created. The ideas from the different stakeholder on what this new policy should look like are different. The Dutch farmers' organisation LTO and the Dutch employers' organisation VNO-NCW called for more centralised and bigger Natura 2000 areas which they state are now often too small and too dispersed (VNO-NCW, 2019). While an environmental protection organisation called for all intensive farming around Natura 2000 areas to be halted (De Gelderlander, 2019). The advisory group asked by the Dutch government to give an advise for short term solutions advised that farms that produced relatively large amounts of nitrogen emissions and were close to Natura 2000 areas should be bought up by the Dutch government (Remkes et al., 2019). The literature lacks the effects of different policy tools that can be used in a new policy. This thesis has tried to analyse the effects the introduction of a national system for tradable nitrogen emission rights. It has done this by first giving an overview of the effects of nitrogen emissions. Furthermore, this thesis explained what the PAS entailed and why it was declared null and void. Thereafter the economic theory regarding emission rights was analysed. Lastly, the different shadow prices per animal sector were calculated. Shadow prices show which animal sectors are able to buy emission rights if these rights are introduced.

The first research question of this thesis aims to find out what the different technical aspects of the nitrogen emission problem in the Netherlands are. The aim is to provide an insight into why nitrogen emissions are a problem and how big the problem is. In this paper nitrogen refers to nitrogen oxide (NO_x) and ammonia (NH₃). Where nitrogen oxide is actually a catch-all term itself for 7 compounds, all of them are some sort of combinations between the chemical element of nitrogen (N) and oxygen (O) (EPA, 1999). The total emission of nitrogen oxide has been steadily declining since 1990 (European Environmental Agency, 2017). The sector that emits the most nitrogen oxide is 'road transport' (European Environmental Agency, 2017). The concentration of nitrogen oxide is mainly in the urban west of the Netherlands (CLO, 2018). The ammonia emission was declining between 1990 and 2013 but since 2013 the decline levelled off. The agricultural sector is a bigger ammonia producer than all other sectors combined (European Environmental Agency, 2017). The ammonia emission is concentrated in the more rural parts of the Netherlands (CLO, 2013). The costs of these emissions for biodiversity are estimated between €25 billion and €115 billion per year in the Netherlands (Brink et al., 2011). Nitrogen emissions affect the biodiversity in five ways (Bobbink et al., 2010). The first way is direct toxicity of nitrogen gases and aerosols. The second is the accumulation of nitrogen compounds, which can lead to competitive exclusion (Bobbink et al., 1998). The third way is long-term toxic effects of ammonia. The fourth is soil acidification can affect biodiversity. Lastly, susceptibility to secondary stress and disturbance factors increases. The costs for public health are estimated between €40 billion and €190 billion per year in the EU-27 countries (Bobbink et al., 2011). The effects on public health are an increased chance on getting a wide range of diseases.

The protection of the Natura 2000 areas is the reason the PAS was declared null and void. The Natura 2000 project is an initiative from the EU to protect habitats, species and biodiversity. The network includes over 18% of the EU's land mass and almost 9.5% of its marine territory (European Commission, 2019a). A Natura 2000 area is proposed by a member state (MS) and has to be chosen according to ecological criteria that must be based on scientific methods (European Commission, 2019b). These

criteria can differ vastly depending on the MS and these criteria are not always based on the protection of biodiversity, habitats and species (Alphandéry & Fortier 2001; Apostolopoulou & Pantis, 2008; Gaston et al., 2008; Trochet & Schmeller, 2012). Despite these criticisms the Natura 2000 network bring measurable benefits to wildlife and cover most of the endangered species it tries to cover (Donald et al, 2007; Trochet & Schmeller, 2012; Gruber et al., 2012).

The second research question was what did the policy 'Programma Aanpak Stikstof' (PAS) entail and why the Council of State rejected it. The PAS was implemented to deal with the backlog for permits and permit changes formed after the previous policy was declared null and void (Julen, 2019). The PAS had two objectives, to ensure that the habitats and species that are covered by Natura 2000 program are protected while economic activity is not negatively affected (Ministerie LNV, 2010). To reduce the nitrogen emissions the PAS used two types of measures, source measures and restoration measures. The source measures had three goals; reduce the nitrogen emissions from stables and from manure and to use feed and management to reduce emissions. Additionally it also includes projects aimed at facilitating innovation and research. The restoration measures were aimed at recovering Natura 2000 areas from high nitrogen deposition. The goal of these measures was to make these areas more resistant to the effects of high nitrogen deposition (Ministerie LNV, 2017). To ensure that economic activity is not harmed, the PAS dedicated a part of the reduction in nitrogen emission to economic activity.

The ex ante assessment by the 'Commissie voor milieueffectrapportage' or MER at the first inception of the PAS was critical, with doubts about legal basis for the PAS under European law and a lack of time limit for the reduction targets. The eventual advice by the MER, after the revisions of the initial PAS, also included critique on the lack a time limit. However, the MER, in their final advice, did understand the choice by the government of the two objectives of the PAS and did approve of the PAS. The ex post assessment of the PAS was positive regarding the economic activity objective (Schoukens, 2018). The PAS solved the permit backlog problem that existed before the introduction of the PAS (Julen, 2019). The assessment regarding the second objective of the PAS was not positive. Schoukens (2018) critiques the PAS on the notion that it assumed that resilient Natura 2000 areas were capable of thriving under high nitrogen emissions. Schoukens (2018) claims that the PAS did not reduce the nitrogen emission by enough, since that would have led to societal resistance to the measures. Furthermore, Schoukens (2018) critiques the PAS for not taking enough uncertainty into account, the lack of transparency and underestimating the size of the problem stemming from intensive livestock farming. The PAS is an example of an adaptive management strategy (Schoukens, 2018). The flexibility that comes with an adaptive management strategy is exactly what made it vulnerable for legal challenges (Schoukens, 2018). Additionally, the PAS having two objectives while the European directives are only focussed on conservation appears to put the two at odds. Schoukens (2018) notes that adaptive managing tools like the PAS can be used to hide fundamental policy choices by claiming that both objectives can be met at the same time. This is reflected in the nitrogen emission since the introduction of the PAS, nitrogen oxides emissions are stable while ammonia emissions have slightly risen (European Environmental Agency, 2017).

Lastly, the third research question of this thesis is about the emission rights and its pros and cons for agriculture, which could be implemented to curb nitrogen emissions. Supply quotas or emission rights is a policy tool that can be used to put an upper limit on the production of a good or a pollutant (Peerlings, 2003). A tax could also be used for diminishing production just like a quota but a tax will need constant adjustments for the desired upper limit to be present (Peerlings, 2003). Emission rights can be non-tradable or tradable. If the emission rights are non-tradable the introduction will mean a welfare loss for the society. Only for the producers that have managed to obtain emission rights the introduction of emission rights will mean a welfare gain. Additionally, non-tradable emission rights incentivise rent-seeking behaviour. If the emission rights are tradable it will increase welfare for producers that buy emission rights but also for producers that sell their emission rights. Additionally, the tradability of emission rights can be beneficial for the structural development of a sector since it gives an extra monetary incentive for quitting to high-cost producers and efficient producers can expand (Boots, Lansink and Peerlings, 1997; Peerlings, 2003). The initial distribution of quota rights is an important

aspect to take into account. The two most popular systems for distribution of rights are 'grandfathering' and auctioning. Grandfathering means that the distribution of rights is based upon the historical production. Auctioning means that the rights are sold to the highest bidder. Auctioning is often hailed as the most economically efficient way of distributing (Burtraw & Evans, 2008). Government distribution of rights can also be used in order to reach certain policy goals. However, if rights are tradable, it can negate these effects (Peerlings, 2003). Other disadvantages of tradability of rights are the costs of rights and it is difficult to abolish due to these high costs (Peerlings, 2003). Since pollutants like nitrogen are emitted by several sectors the question is not only of rights should be tradable but also if the rights should be tradable between sectors. The advantage of this would be economic efficiency. However, the trading of emission rights between sectors will mean that the sectors that are willing to pay the most for emission rights will do so. The dominance of one or a few sectors can be against certain policy goals. There are several systems that are used to minimize the amount of pollutants. The two common methods are cap-and-trade method, which is used by the EU ETS, and the syphoning method used for Dutch phosphate rights.

To predict the effects of an introduction of nitrogen emission rights that are tradable between all agricultural animal sectors I calculated the shadow prices of nitrogen for each sector. The animal sector with the highest shadow price is the organic laying hens. Followed up by the organic dairy cattle sector and thereafter the conventional dairy cattle sector. The sector with the lowest shadow price is the female beef cattle industry. The second lowest sector is another beef cattle industry, namely the beef bull sector. Meaning that if these rights were introduced the sectors with the highest shadow prices, like the organic hen sectors, will buy nitrogen emission rights and sectors with low shadow prices, like female beef cattle, will sell its rights.

To come back to my overall research objective of this research, which was to explore the consequences on nitrogen policy for agriculture in the Netherlands of the Dutch Council of State's ruling that the policy 'Programma Aanpak Stikstof' is null and void. The nitrogen emissions in the Netherlands were too high before the implementation of the PAS and are still too high. This clashes with the European Natura 2000 program that requires the Dutch Natura 2000 areas to be protected from excessive nitrogen deposition due to the negative effects on biodiversity. Still, there are many new economic activities that require a permit that will emit nitrogen. Before the PAS this demand for permits with limited room for more nitrogen emissions led to a permit backlog. The PAS was a national policy aimed at reducing nitrogen emissions while creating room for new economic activity. It succeeded in the second objective but failed with the first objective since it designated room for economic activity based on future emission reduction. The PAS being declared null and void led to a situation similar to that before the PAS and thus a permit backlog. To remedy this new backlog emission rights as a policy tool can be used. Emission rights are often hailed as the economically most efficient way to reduce emissions. If emission rights are introduced choices have to be made regarding the distribution of rights, methods of reducing emissions, tradability within sectors and tradability between sectors. All with different effects some opposed to other policy goals. If emission rights with inter sector tradability was introduced for the Dutch agricultural sector the shadow prices calculated in this thesis show the animal sectors that will buy these rights and the sectors that will sell them.

Research on PAS has also been critical on the policy. Schoukens (2018) states that adaptive managing tools like the PAS can be used to hide fundamental policy choices by claiming that both objectives can be met at the same time. Beunen and Turnhout (2019) also stated, after the abolishment of the PAS, that the PAS had been used to postpone decisions that eventually have to be made. The new Dutch policy regarding nitrogen has not yet been finalised. Therefore no research has been done on the new policy or policy tools that will be used. Tradable emission rights as a tool to reduce have been widely propagated by economists as the most efficient way to reduce emissions (e.g. Borghesi et al., 2016; Peerlings, 2003). To my knowledge there has been no research done on the shadow prices of nitrogen for the different animal sectors in Dutch agriculture.

Regarding the validity of empirical research in this thesis, it is assumed that shadow prices will remain constant regardless of the production of a sector. Economic theory assumes that a change in production

also means a change in marginal costs. If the marginal costs change, the gross margin of a sector also changes. Consequently, if the gross margin of a sector changes, the shadow price of nitrogen emissions also changes. The assumption of constant marginal costs is made because of the limited scope of this thesis. Another assumption is that the shadow prices do not include a syphoning system that could be implemented simultaneously with the introduction of nitrogen emission rights. Syphoning means that a part of the traded emission rights is taken out of the market. Meaning that the prices of emission rights will rise and the demand will decrease. Additionally, the gross margins on which the shadow prices are based are an average and can significantly change over time.

Further research on this topic could look at estimated shadow prices of other non-agricultural sectors that emit nitrogen. Additionally, the view of different stakeholders on emission rights and the different choices that have to be made when implementing emission rights could be researched. Furthermore, additional research could look at other policy tools that can be used for the new nitrogen policy. Regarding the PAS, more research could be done on why the policy was implemented while it turned out that it did not reduce nitrogen emissions by enough and therefore did not comply with European law. Lastly, when the new nitrogen policy will be published by the Dutch government research could be done on the expected results of this new policy.

References

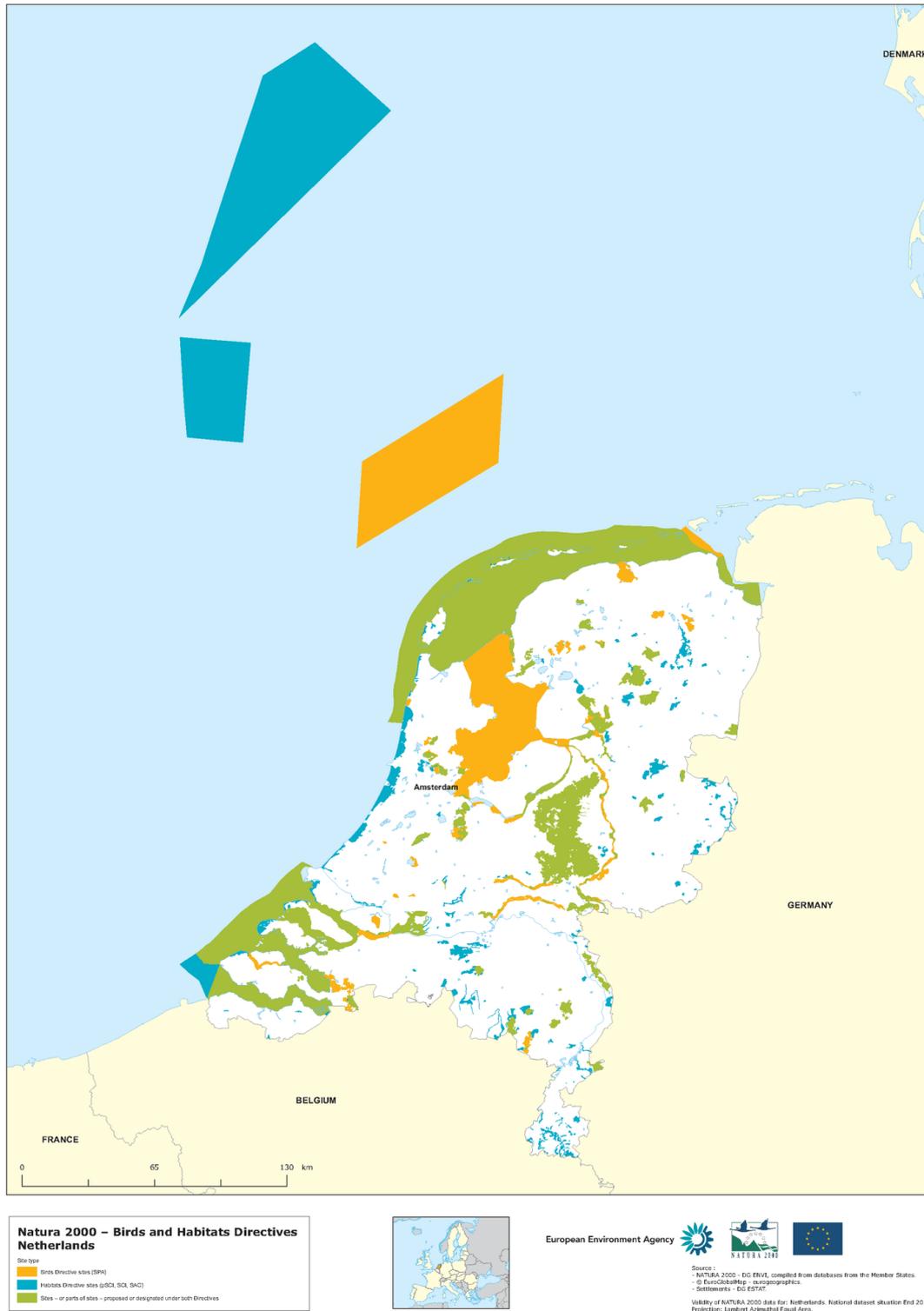
- Agrimatie. (2020). "Varkenshouderij." accessed 21-03-2020. <https://www.agrimatie.nl/SectorResultaat.aspx?subpubID=2232§orID=2255&themaID=3577>.
- Alphandéry, P., & Fortier, A. (2001). Can a territorial policy be based on science alone? The system for creating the Natura 2000 network in France. *Sociologia ruralis*, 41(3), 311-328.
- Alvarez, A., Arias, C., & Orea, L. (2006). Explaining differences in milk quota values: the role of economic efficiency. *American journal of agricultural economics*, 88(1), 182-193.
- Aneja, V. P., Schlesinger, W. H., & Erisman, J. W. (2009). Effects of agriculture upon the air quality and climate: Research, policy, and regulations: ACS Publications.
- Apostolopoulou, E., & Pantis, J. D. (2009). Conceptual gaps in the national strategy for the implementation of the European Natura 2000 conservation policy in Greece. *Biological conservation*, 142(1), 221-237.
- Beunen, R., & Turnhout, E. (2019). "'Stikstof' als symbool voor een falende overheid." accessed 20-04-2020. https://www.montesquieu-instituut.nl/id/vl4ad8kszgu8/nieuws/stikstof_als_symbool_voor_een_falende.
- Beunen, R., Van Assche, K., & Duineveld, M. (2013). Performing failure in conservation policy: The implementation of European Union directives in the Netherlands. *Land use policy*, 31, 280-288.
- Bij12. (2019). "Intern salderen." accessed 06-01-2020. <https://www.bij12.nl/onderwerpen/stikstof-en-natura2000/vergunningen-en-toestemmingsbesluiten/intern-salderen/>.
- Bobbink, R., Ashmore, M., Braun, S., Flückiger, W., & Van den Wyngaert, I. J. (2003). Empirical nitrogen critical loads for natural and semi-natural ecosystems: 2002 update. *Empirical critical loads for nitrogen*, 43-170.
- Bobbink, R., Hicks, K., Galloway, J., Spranger, T., Alkemade, R., Ashmore, M., . . . Dentener, F. (2010). Global assessment of nitrogen deposition effects on terrestrial plant diversity: a synthesis. *Ecological applications*, 20(1), 30-59.
- Bobbink, R., Hornung, M., & Roelofs, J. G. (1998). The effects of air-borne nitrogen pollutants on species diversity in natural and semi-natural European vegetation. *Journal of ecology*, 86(5), 717-738.
- Boerderij. (2008). "Toetsingskader Ammoniak en Natura 2000 betwijfeld." accessed 02-12-2019. <https://www.boerderij.nl/Home/Achtergrond/2008/3/Toetsingskader-Ammoniak-en-Natura-2000-betwijfeld-AGD000279W/>.
- Boots, M., Lansink, A. O., & Peerlings, J. (1997). Efficiency loss due to distortions in Dutch milk quota trade. *European Review of Agricultural Economics*, 24(1), 31-46.
- Borghesi, S., Montini, M., & Barreca, A. (2016). *The European emission trading system and its followers: comparative analysis and linking perspectives*: Springer.
- Brink, C., van Grinsven, H., Jacobsen, B. H., & Velthof, G. L. (2011). "Costs and benefits of nitrogen in the environment-Chapter 22". *The European Nitrogen Assessment. Sources, effects and policy perspectives* 513-540.
- Burtraw, D., & Evans, D. A. (2009). Tradable rights to emit air pollution. *Australian journal of agricultural and resource economics*, 53(1), 59-84.
- CBS. (2019). "Fosfaatproductie dierlijke mest opnieuw lager." accessed 04-03-2020. <https://www.cbs.nl/nl-nl/nieuws/2019/07/fosfaatproductie-dierlijke-mest-opnieuw-lager>.
- CBS. (2020). "Statline." accessed 15-03-2020. <https://opendata.cbs.nl/statline/#/CBS/nl/>.
- CLO. 2013. "Ammoniak in lucht, 1993-2012." accessed 13-11-2019. <https://www.clo.nl/indicatoren/nl0461-ammoniak?ond=20888>.
- CLO. (2018). "Stikstofdioxide in lucht, 1990-2017." accessed 13-11-2019. <https://www.clo.nl/indicatoren/nl0231-stikstofdioxide>.
- De Gelderlander. (2019). "Brabantse Milieufederatie: 'Maak extensieve zone rondom natuur'." *De Gelderlander*. <https://www.gelderlander.nl/brabant/brabantse-milieufederatie-maak-extensieve-zone-rondom-natuur~acd04ca4/>.
- De Vries, W., Kros, H., Reinds, G. J., Wamelink, W., Mol, J., van Dobben, H., . . . Evans, C. (2007). *Developments in deriving critical limits and modelling critical loads of nitrogen for terrestrial ecosystems in Europe*: Alterra.
- Den Hertog, J.A., (2010). "Review of economic theories of regulation." *Discussion Paper Series/Tjalling C. Koopmans Research Institute* 10 (18).
- Dijksma, S.A.M., S.J. Schenk, H.W.C.M. Flipsen, P. Boer, J.H. Zweverink-Bosch, D.J. Schoonman, T. Duteweerd, and J. Brok. 2014. Overeenkomst generieke maatregelen in verband met het Programma Aanpak Stikstof.
- Donald, P. F., Sanderson, F. J., Burfield, I. J., Bierman, S. M., Gregory, R. D., & Waliczky, Z. (2007). International conservation policy delivers benefits for birds in Europe. *Science*, 317(5839), 810-813.
- EU Court of Justice. (2018). "Judgment of the Court of Justice - 7 November 2018 Case C-293/17." accessed 15-10-2019. <http://www.landmarkchambers.co.uk/wp-content/uploads/2018/11/C-293.17-and-294.17->

- Judgment.pdf.
- European Commission. (2017). State aid: Commission approves introduction of tradable phosphate rights for dairy cattle in the Netherlands.
- European Commission. (2019a). "Natura 2000." accessed 30-10-2019. https://ec.europa.eu/environment/nature/natura2000/index_en.htm.
- European Commission. (2019b). "Natura 2000 sites designation ", accessed 30-10-2019. https://ec.europa.eu/environment/nature/natura2000/sites/index_en.htm.
- European Committee of the Regions. (2015). The implementation of the Natura 2000, Habitats Directive 92/43/ECC and Birds Directive 79/409/ECC (Preparation for an ex-post territorial impact assessment).
- European Environmental Agency. (2019). "Natura 2000 - Birds and Habitats Directives Netherlands." accessed 05-11-2019. https://www.eea.europa.eu/data-and-maps/figures/natura-2000-birds-and-habitat-directives-10/netherlands/Natura2000_End2018_Netherlands.eps.75dpi.gif/download.
- Evans, D. (2012). Building the European union's Natura 2000 network. *Nature conservation*, 1, 11.
- Fock, H. O. (2011). Natura 2000 and the European common fisheries policy. *Marine Policy*, 35(2), 181-188.
- Gaston, K. J., Jackson, S. F., Nagy, A., Cantú-Salazar, L., & Johnson, M. (2008). Protected areas in Europe: principle and practice. *Annals of the New York Academy of Sciences*, 1134(1), 97-119.
- Gies, E., Kros, H., & Voogd, J. C. (2019). *Inzichten stikstofdepositie op natuur: Memo*. Retrieved from https://www.wur.nl/upload_mm/9/7/b/0e3bba36-5a6f-46c7-b442-ef7d64ebd93c_inzichten-stikstofdepositie-op-natuur-wenr.pdf.
- Gruber, B., D. Evans, K. Henle, B. Bauch, D. Schmeller, F. Dziock, P.Y. Henry, S. Lengyel, C. Margules, and C. Dormann. (2012). "'Mind the gap!'—How well does Natura 2000 cover species of European interest?" *Nature Conservation* 3:45.
- Guyomard, H., N. Herrard, and L.P. Mahé. (1995). "Modelling a siphon on quota transfers: an application to milk in France." *Oxford Agrarian Studies* 23 (1):15-26.
- Hiedanpää, J., and D.W. Bromley. (2011). "The harmonization game: reasons and rules in European biodiversity policy." *Environmental Policy and Governance* 21 (2):99-111.
- Joosten, L., T. Verhoeff, M. Wilmot, G. Migchels, and C. Dijk. (2019). Naar een depositiegerichte aanpak van ammoniakemissies rond de Nieuwkoopse Plassen: Scenariostudie voor Proeftuin Veenweiden. Wageningen Livestock Research.
- Julen, J.. (2019). "Hoe het stikstofgedrocht groeide en ter wereld kwam." *Trouw*. <https://www.trouw.nl/verdieping/hoe-het-stikstofgedrocht-groeide-en-ter-wereld-kwam~be56db7b/>.
- Kos, J.. (2019). "ANWB: Drukste ochtendspits ooit door tractoroptocht naar Den Haag." *NRC*. <https://www.nrc.nl/nieuws/2019/10/01/veel-verkeershinder-door-tractoroptocht-naar-den-haag-a3975166>
- KWIN. (2019). Kwantitatieve Informatie Veehouderij 2019-2020. Wageningen UR Livestock Research.
- MER. (2011). Programmatische Aanpak Stikstof (PAS) Advies van de Commissie voor de milieueffectrapportage.
- MER. (2013). Programmatische Aanpak Stikstof (PAS) Advies over reikwijdte en detailniveau van het milieueffectrapport.
- MER. (2015). Programmatische Aanpak Stikstof (PAS) Toetsingsadvies over het milieueffectrapport en de aanvulling daarop.
- Ministerie LNV. (2010). "Het Voorlopige Programma Stikstof." accessed 08-01-2020. <https://www.synbiosys.alterra.nl/natura2000/documenten/pas/algemeen/Voorlopig%20Programma%20Stikstof.pdf>.
- Ministerie LNV. (2017). "Programma Aanpak Stikstof." accessed 08-01-2020. <https://www.synbiosys.alterra.nl/natura2000/documenten/pas/algemeen/Programma%20Aanpak%20stikstof%2018%20december%202017.pdf>.
- Ministerie LNV. (2019). "Procedure Natura 2000." accessed 05-11-2019. <https://www.synbiosys.alterra.nl/natura2000/gebiedendatabase.aspx?subj=procedure>.
- Natural England. (2019). "Natura 2000: European wildlife sites." accessed 05-11-2019. https://consult.defra.gov.uk/natural-england/crouch-roach-estuaries/supporting_documents/European%20leaflet%20Natura%202000.pdf.
- Niewold, M., and E. Segaar. (2019). "Uitspraak stikstofbeleid: vergunning grote wegenbouwprojecten onzeker." RTLZ, accessed 19-10-2019. <https://www.rtlz.nl/algemeen/politiek/artikel/4728966/stikstofregels-vergunningen-grote-wegenbouwprojecten-onzeker>.
- Overheid.nl. n.d. "Wetenschappelijke en juridische inbedding toetsingskader ammoniak en Natura 2000." accessed 02-12-2019. <https://zoek.officielebekendmakingen.nl/kst-30654-43-b2.pdf>.
- Peerlings, J. (2003). "Quota tradability, yes or no? That is the question." *Tijdschrift voor sociaalwetenschappelijk onderzoek van de landbouw (en)*.

- Posner, Richard A. (1974). *Theories of economic regulation*. National Bureau of Economic Research Cambridge, Mass., USA.
- Provincie Drenthe. (2007). "Beleidsregel toetsingskader ammoniak en Natura 2000." accessed 02-12-2019 <http://decentrale.regelgeving.overheid.nl/cvdr/XHTMLoutput/Actueel/Drenthe/CVDR92681.html>.
- Raad van State. (2008). "Uitspraak 200800289/1." accessed 02-12-2019. <https://www.raadvanstate.nl/@29267/200800289-1/>.
- Raad van State. (2019). "Pro-gram-ma Aan-pak Stik-stof uitspraken." accessed 22-10-2020. <https://www.raadvanstate.nl/programma-aanpak/>.
- Remkes, J.W., E. Dijkgraaf, A. Freriks, G.J. Gerbrandy, W.H. Maij, A.G. Nijhof, E. Post, R. Rabbinge, M.C. Scholten, and L. Vet. (2019). Niet alles kan: Eerste advies van het Adviescollege Stikstofproblematiek: aanbevelingen voor korte termijn 25 september 2019. Adviescollege Stikstofproblematiek.
- Rijksoverheid. (2020). "Hoe is het stelsel van fosfaatrechten tot stand gekomen?", accessed 04-03-2020. <https://www.rijksoverheid.nl/onderwerpen/mest/fosfaatrechten/totstandkoming-fosfaatrechtenstelsel>.
- Rosa, H.D., and Jorg Marques Da Silva. (2005). "From environmental ethics to nature conservation policy: Natura 2000 and the burden of proof." *Journal of Agricultural and Environmental Ethics* 18 (2):107-130.
- Samson, G.S., C. Gardebroek, and R.A. Jongeneel. (2016). "Explaining production expansion decisions of Dutch dairy farmers." *NJAS-Wageningen Journal of Life Sciences* 76:87-98.
- Schoukens, H. (2017). "Nitrogen deposition, habitat restoration and the EU Habitats Directive: moving beyond the deadlock with the Dutch programmatic nitrogen approach?" *Biological Conservation* 212:484-492.
- Schoukens, H. (2018). "The Quest for the Holy Grail and the Dutch Integrated Approach to Nitrogen: How to Align Adaptive Management Strategies with the EU Nature Directives?" *Journal for European Environmental & Planning Law* 15 (2):171-217.
- Schouten, C. (2018). "Beantwoording vragen over verbod gebruik sleepvoet." accessed 06-01-2020. <https://www.rijksoverheid.nl/regering/bewindspersonen/carola-schouten/documenten/kamerstukken/2018/10/01/antwoorden-op-kamervragen-over-verbod-gebruik-sleepvoet>.
- Smits, N.A.C., and D. Bal. (2012). "Recovery strategies for nitrogen-sensitive habitats." accessed 14-01-2020. https://ec.europa.eu/environment/nature/natura2000/platform/documents/part-i-chapter-1_nov-2012_2013-09-10_en.pdf.
- The Economist. (2019). "Nitro dissidents." *The Economist*, 25.
- Trochet, A., and D. Schmeller. (2013). "Effectiveness of the Natura 2000 network to cover threatened species." *Nature Conservation* 4:35.
- Van der Peet, G., F. Leenstra, I. Vermeij, N. Bondt, L. Puister, and J. van Os. (2018). Feiten en cijfers over de Nederlandse veehouderijsectoren 2018. Wageningen Livestock Research.
- Vitousek, P.M., J.D. Aber, R.W. Howarth, G.E. Likens, P.A. Matson, D.W. Schindler, W.H. Schlesinger, and D.G. Tilman. (1997). "Human alteration of the global nitrogen cycle: sources and consequences." *Ecological applications* 7 (3):737-750.
- VNO-NCW. 2019. "'Natuurgebieden liggen te veel versnipperd' ". <https://www.vno-ncw.nl/nieuws/natuurgebieden-liggen-te-veel-versnipperd>.
- Water Over Mest. (2019). "Emissiearme mestaanwending: de stand van zaken." accessed 20-12-2019. <http://waterovermest.nl/water-mest/emissie-arme-aanwending-stand-van-zaken/>.
- Weber, N., and T. Christophersen. (2002). "The influence of non-governmental organisations on the creation of Natura 2000 during the European Policy process." *Forest policy and economics* 4 (1):1-12.

Annex

Annex I Natura 2000 areas in the Netherlands



Source: European Environmental Agency (2019)

Annex II Calculations regarding chapter 5

This annex will show all the calculations regarding the figures used in chapter 5. The calculations are split between the different animal sectors.

Dairy cattle (conventional)

The goal of chapter 5 is to compare the different shadow prices for the emission of nitrogen. To calculate this, the total nitrogen emission per animal sector is needed. For dairy cattle this is 289,900,000 kg in 2018 (CBS, 2020). The total amount of milk produced in the Netherlands equals 13,880,920,000 kg in 2018 (CBS, 2020). It is assumed that the dairy sector only produces milk for simplicity's sake. The kg of nitrogen emitted per kg milk produced is equal to $289,900,000/13,880,920,000 = 0.020884783$ kg. Meaning that for every kg of milk produced 0.021 kg of nitrogen is emitted. I assume that 1.6% of both the nitrogen emissions and the milk production is organic. This does not change the 0.021 kg since the ratio between nitrogen and milk productions stays the same. To calculate the shadow price of nitrogen emission the gross margin is needed. The gross margin for every 100 kg of milk produced is 27.43 euros (KWIN, 2019, p.154). The gross margin per kg milk is 0.2743 euro. Meaning that for 0.020884783 kg N the shadow price is 0.2743 euro. For 1 kg nitrogen the shadow price is $0.2743/0.020884783 = 13.13396457$ euros.

Dairy cattle (organic)

The gross margin for organic dairy production is 39.44 euros per 100kg of milk, which is 0.3944 euros per kg milk (KWIN, 2019, p.154). The amount of nitrogen emissions per kg of milk production is assumed to be the same as with conventional production, 0.020884783 kg. Meaning that the shadow price for 1 kg nitrogen is $0.3944/0.020884783 = 18.88456299$ euros.

Laying hens (cage)

The gross margins for different types of laying hens are available per 100 hens. Therefore, the nitrogen emitted per hen is needed. In the Netherlands, there are 4 types of eggs produced. They are cage, free-range (scharrel in Dutch), free-range plus (vrij-uitloop in Dutch) and organic. Since there are no figures on the amount of hens or the amount of nitrogen per type of eggs I assume that the amount of nitrogen per hen emitted is the same for all 4 types. The total amount of laying hens in the Netherlands is 47,302,100 (CBS, 2020). The amount of nitrogen emitted by the total laying hen sector is 31,700,000 kg (CBS, 2020). Meaning that the amount of nitrogen emitted per hen is $31,700,000/47,302,100 = 0.670160521$ kg. The gross margin for cage-produced eggs is 224 euros per 100 hens (KWIN, 2019, p.309). So the gross margin is 2.24 euros per hen. The shadow price for 1 kg nitrogen is $2.24/0.670160521 = 3.342482778$ euros.

Laying hens (free-range)

The amount of nitrogen emitted per hen is assumed to be the same as the cage type, namely 0.670160521 kg. The gross margin for 100 free-range hens is 339 euros (KWIN, 2019, p.309). The gross margin for free-range hens that produce white eggs is taken since KWIN (2019) it the standard. The gross margin for 1 free-range hen is 3.39 euros. The shadow price for 1 kg nitrogen is $3.39/0.670160521 = 5.058489561$ euros.

Laying hens (free-range plus)

The amount of nitrogen emitted per hen is assumed to be the same as the cage type, namely 0.670160521 kg. The gross margin for 100 free-range plus hens is 622 euros (KWIN, 2019, p.309). The gross margin for free-range hens that produce white eggs is taken. The gross margin for 1 free-range hen is 6.22 euros. The shadow price for 1 kg nitrogen is $6.22/0.670160521 = 9.281358428$ euros.

Laying hens (organic)

The amount of nitrogen emitted per hen is assumed to be the same as the cage type, namely 0.670160521 kg. The gross margin for 100 organic hens is 1309 euros (KWIN, 2019, p.309). The gross margin for 1 free-range hen is 13.09 euros. The shadow price for 1 kg nitrogen is $13.09/0.670160521 = 19.53263373$ euros.

Broilers

The gross margin for the broiler industry is 175.6 euros per 100 broilers (KWIN, 2019, p.344). The gross margin per broiler is 1.756 euros. The total amount of broilers in 2018 is 48,971,100 (CBS, 2020). The total nitrogen emission of this sector is 17,100,000 kg in 2018 (CBS, 2020). The amount of nitrogen per broiler is $17,100,000/48,971,100 = 0.34918554$ kg. Meaning that the shadow price of 1 kg nitrogen for broilers is $1.756/0.34918554 = 5.028845123$ euros.

Fattening pigs

The gross margin for the fattening pig industry is 66 euros per pig (KWIN, 2019, p.265). The total amount of pigs in 2018 is 5,630,910 (CBS, 2020). The total nitrogen emission of this sector is 65,400,000 kg in 2018 (CBS, 2020). The amount of nitrogen per pig is $65,400,000/5,630,910 = 11.61446374$ kg. Meaning that the shadow price of 1 kg nitrogen for fattening pigs is $66/11,61446374 = 5,682569723$ euros.

Breeding pigs

The gross margin for the breeding pig industry is 349 euros per sow (KWIN, 2019, p.255). The total amount of sows in 2018 is 922,610 (CBS, 2020). The piglets are not included in this figure. The total nitrogen emission of this sector is 31,400,000 kg in 2018 (CBS, 2020). The amount of nitrogen per sow is $31,400,000/922,610 = 34.03388214$ kg. Meaning that the shadow price of 1 kg nitrogen for breeding pigs is $349/34,03388214 = 10,25448694$ euros.

Female beef cattle

The gross margin for the female beef cattle industry is 31 euros per cow (KWIN, 2019, p.185). The total amount of female beef cows in 2012 is 28,600 (CBS, 2020). 2012 is the most recent available year. For this thesis it assumed that the amount of cows has remained constant since. Furthermore, the young cattle bred to become female beef cattle are not included. The total nitrogen emission of this sector is 10,900,000 kg in 2018 (CBS, 2020). The amount of nitrogen per cow is $10,900,000/28,600 = 381.1188811$ kg. Meaning that the shadow price of 1 kg nitrogen for female beef cattle is $31/381.1188811 = 0.08133945$ euros.

Beef bulls

The gross margin for the beef bull industry is 171 euros per bull (KWIN, 2019, p.179). The total amount of beef bulls in 2018 is 14,770 (CBS, 2020). The total nitrogen emission of this sector is 3,900,000 kg in 2018 (CBS, 2020). The amount of nitrogen per cow is $3,900,000/14,770 = 264.0487475$ kg. Meaning that the shadow price of 1 kg nitrogen for female beef cattle is $171/264.0487475 = 0.647607692$ euros.